ASCC
Adaptive Silviculture for Climate Change

Designing Forest Adaptation Treatments Across Taylor Park Through Manager-Scientist Partnerships

Adaptive Silviculture for Climate Change (ASCC)
Taylor Park ASCC Workshop

July 6, 7, & 8, 2022

FOREST AND RANGELAND STEWARDSHIP
COLORADO STATE UNIVERSITY

NIACS
Northern Institute of Applied Climate Science

ASCC
Adaptive Silviculture for Climate Change

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

WESTERN
COLORADO UNIVERSITY

Land Acknowledgement

Introductions

- Name
- Organization
- One thing you are looking forward to in this workshop

Workshop Goals

- Engage managers and scientists in the Adaptive Silviculture for Climate Change (ASCC) co-development framework to create a suite of adaptive experimental silvicultural treatments in lodgepole pine stands at Taylor Park that will be part of the ASCC Network;
- Develop specific management, research, and monitoring questions that can be addressed through the ASCC project.

Adaptive Silviculture for Climate Change (ASCC) Network

ASCC
Adaptive Silviculture for Climate Change

Project Goals:

1) Introduce managers to tools and approaches to integrate climate change into silvicultural decision making that meets management goals and objectives
2) 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

Adaptive Silviculture for Climate Change Network

Linda Nagel, Lead PI
Professor and Department Head
Colorado State University

Courtney Peterson, ASCC Coordinator
Colorado State University
NIACS

Chris Swanston, Co-PI
USFS, Director
Office of Sustainability and Climate

Maria Janowiak, Co-PI
USFS, Northern Research Station
Director, NIACS, NRS

ASCC Network Website: www.adaptivesilviculture.org

ASCC Collaborative Workshop

Developing the Experimental Treatments

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

DFC

↓

Management objectives

↓

Silvicultural practices (tactics)

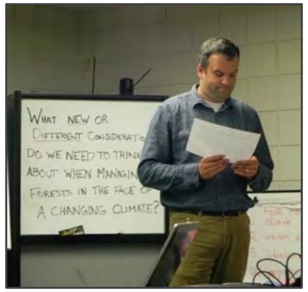
What is the desired structure and function (*desired future condition*)?

<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**



First workshop: MN, June 2013

Virtual workshop: Driftless Area, Dec. 2021

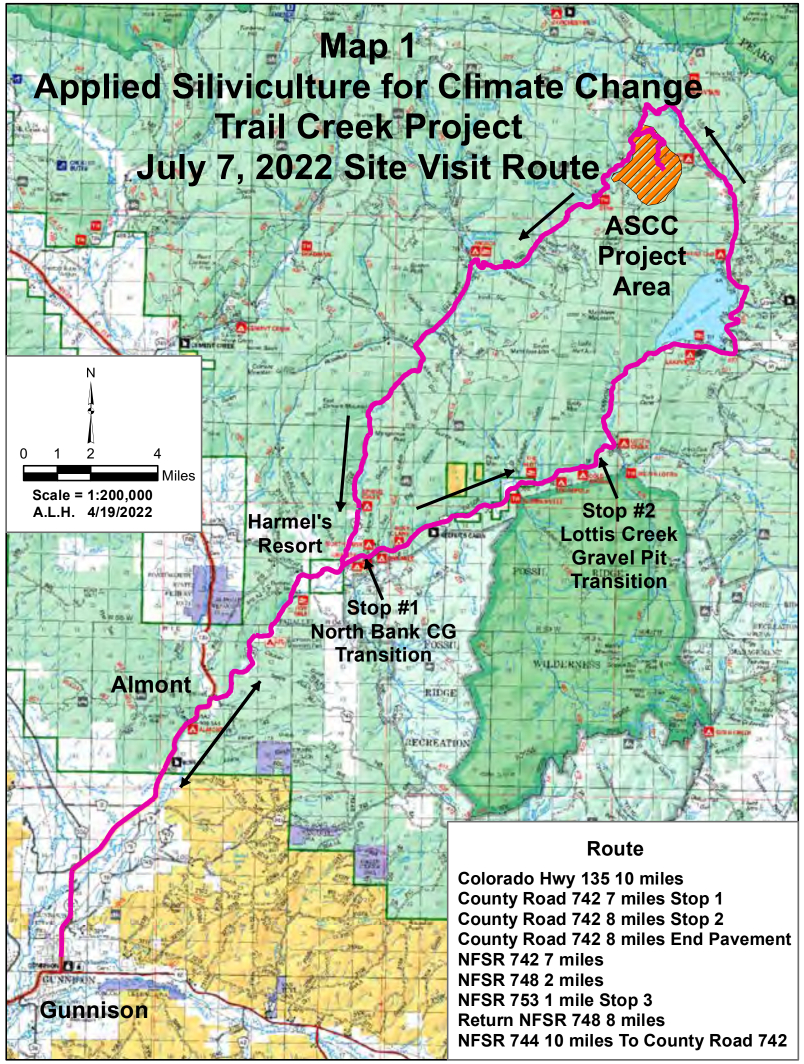
Workshop Agenda – Day 1, Wednesday, July 6

- **8:00 Welcome & Introductions – Jonathan Coop, Art Haines, & Mike Battaglia**
- **8:20 ASCC Overview & Workshop Agenda – Courtney Peterson**
- **8:45 Silvics, Forest Ecology, and Disturbances of Lodgepole Pine Forests - Jonathan Coop & Mike Battaglia**
- **9:15 Ecosystem Vulnerabilities of Lodgepole Pine Forests to Climate Change – Lauren Parker**
- **10:00 Break (15 min)**
- **10:15 What new or different considerations does climate change bring to making forest management decisions?**
- **11:00 Management of Lodgepole Pine Forests – Art Haines**
- **11:30 Taylor Park Management Goals, Objectives, and DFCs – Carlyn Perovich**
- **12:00 Climate Challenges & Opportunities to Achieving Taylor Park Management Goals**
- **12:45 Lunch (Bring your own)**
- **1:15 Adaptation Concepts & Developing an ASCC Study Site Presentation – Courtney Peterson & Maddy Baroli**
- **1:45 Identify Overarching Management Objectives and DFCs for the Taylor Park ASCC Site and Each Experimental Treatment: Overview of Process and Definitions**
- **1:55 Develop Resistance Treatment for Taylor Park ASCC Site (In Breakout Groups)**
- **2:55 Report Out on Resistance & Group Discussion**
- **3:40 Develop Resilience Treatment for Taylor Park ASCC Site (In Breakout Groups)**
- **4:15 Report Out on Resilience & Group Discussion**
- **4:55 Logistics for spending the next day in the field**
- **5:00 Join us for happy hour and dinner on Wednesday at 5pm on the Kelley Hall Patio.**

Worksheets!!!

Workshop Agenda – Day 2, Thursday, July 7

- **8:00 Meet at Western and Caravan to Taylor Park for ASCC Site Field Visit**
- **8:30 Stop 1: North Bank (Ponderosa Pine example)**
- **9:30 Stop 2: Lower Taylor Canyon Lottis Creek Gravel Pit**
- **11:00 Stop 3: Arrive at Taylor Park ASCC Site (By RAWs Station)**
- **12:00 Stop 4: Be at Lunch Spot/Working Lunch – Facilitated Discussion Revisiting Resistance and Resilience**
- *Bring your own sack lunch*
- **1:00 Develop DFC for Transition in Large Group**
- **1:30 Develop Objectives and Tactics for Transition Treatments in Breakout Groups**
- **2:00 Report Out on Transition & Group Discussion**
- **3:15 Head back to Gunnison**



Workshop Agenda – Day 3, Friday, July 8

- **8:30** Recap of Previous Two Days
- **8:45** Review Draft Silvicultural Treatments
- **10:15** Break
- **10:30** Next Steps, Evaluations, & Close-Out
  - What research or management questions are you excited about based on the ASCC treatments?
- **11:30** Large Group Adjourn
- **11:30** (*ASCC Site Leads Only*) Identify key implementation and monitoring next steps

Workshop Guidelines

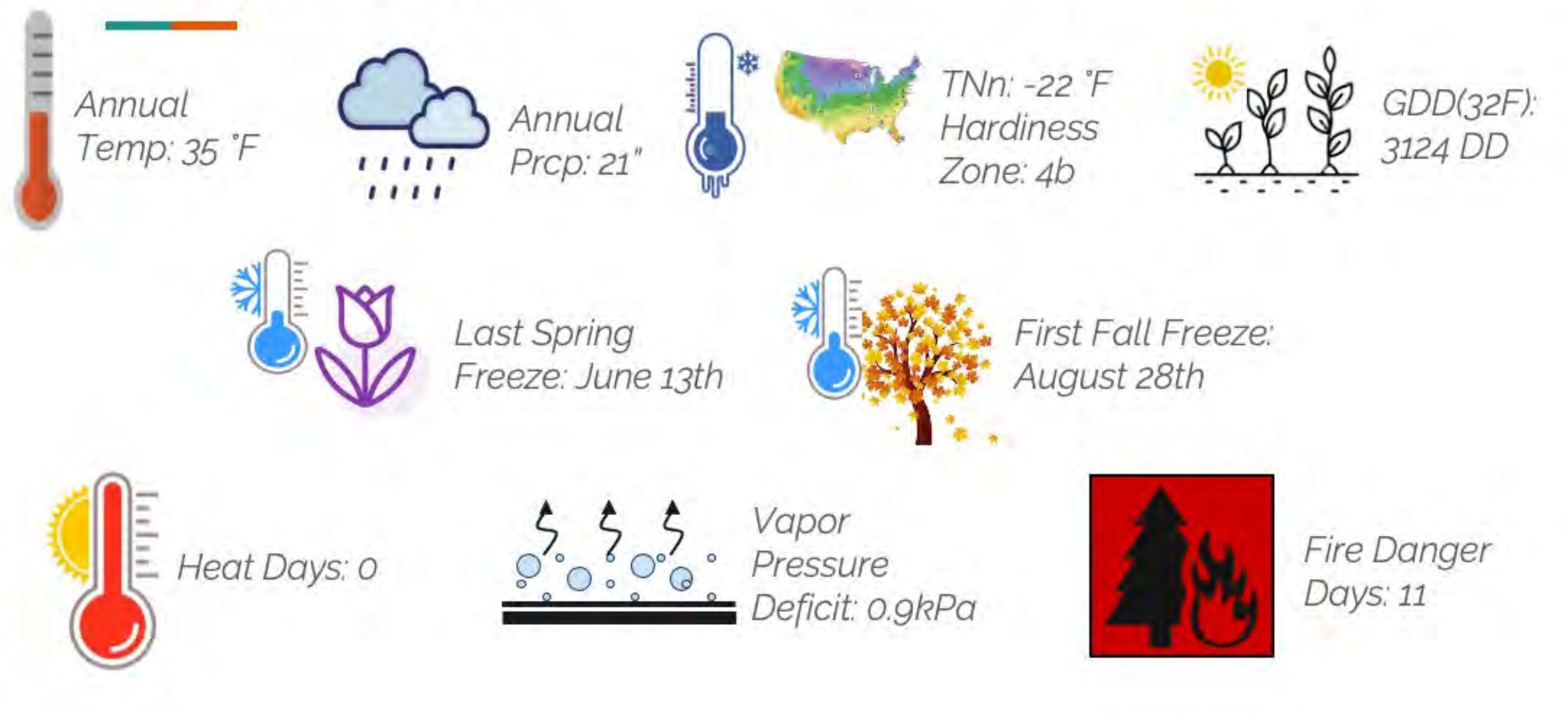
- Focus on what matters
- Contribute your thinking and experience
- Listen to understand
- Connect ideas
- Listen together for patterns, insights and deeper questions
- Honor everyone’s time
- Equal airtime - all participate, no one dominate
- Be present - mentally and physically

Silvics, Forest Ecology & Disturbance of Lodgepole Pine Forests

Jonathan Coop, Western Colorado University
Mike Battaglia, USFS Rocky Mountain Research Station

Ecosystem Vulnerabilities of Lodgepole Pine Forests to Climate Change

Lauren Parker, USDA California Climate Hub



Activity: Climate Change Considerations for Managing Lodgepole Pine Forests

What new or different considerations do we need to think about when managing forests in the face of climate change?

Photo: Gunnison National Forest, USDA Forest Service

Photo: https://www.fs.usda.gov/gmug

Management of Lodgepole Pine Forests

Art Haines, USFS
Grand Mesa Uncompahgre & Gunnison National Forests

Taylor Park Management Goals, Objectives, and DFCs

Carlyn Perovich, USFS Grand Mesa Uncompahgre & Gunnison National Forests

Goals & Objectives for Taylor Park ASCC Workshop

1. Increase the forest's ability to respond to multiple and interactive forest stressors including climate change, drought, insect attack, or disease
2. Treat stands to improve forest health using commercial harvest, non-commercial, and prescribed fire treatments, as appropriate, to the site-specific situation
3. Reduce fuels in the wildland-urban interface to allow for the facilitation of natural fire processes on the landscape
4. Provide wood products for the local economy, which relies on wood fiber harvested sustainably from public lands
5. Maintain ground cover, long-term stream health, riparian ecosystem condition, soil structure, water budgets, and flow patterns of wetlands
6. Limit roads and other disturbed sites to the minimum feasible number, width, and total length
7. Construct roads to minimize sediment discharge, stabilizing and maintaining roads during and after construction, and reclaiming roads, landings, and other disturbed sites
8. Design treatments to meet objectives and standards of the Southern Rockies Lynx Amendment and forest plan standards and guidelines related to wildlife
9. Seek opportunities to integrate wildlife habitat management objectives as part of treatment activities

Activity: Impacts of Climate Change on Management Goals for the Taylor Park ASCC Site

Challenges to Meeting Management Objectives with Climate Change: Things that will make it harder to achieve the management objectives due to climate change.

Opportunities to Meeting Management Objectives with Climate Change: Things that will make it easier to achieve the management objectives due to climate change.

***Focus on challenges that can be addressed through forest management (not global markets, policies, etc.)*

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Adaptive Silviculture for Climate Change

Adaptive Silviculture for Climate Change Network

Chippewa National Forest/Cutfoot Experimental Forest, MN
- Brian Palik, USFS Northern Research Station
- Tony D'Amato, University of Vermont

San Juan National Forest, CO
- Mike Battaglia, USFS Rocky Mountain Research Station
- Matt Tuten, San Juan National Forest

Second College Grant, NH
- Tony D'Amato, University of Vermont
- Chris Woodall, USFS Northern Research Station
- Kevin Evans, Dartmouth University

The Jones Center at Ichauway , GA
- Steven Brantley, The Jones Center at Ichauway
- Jeff Cannon, The Jones Center at Ichauway
- Andy Whelan, The Jones Center at Ichauway

Flathead National Forest/Coram Experimental Forest, MT
- Justin Crotteau, USFS Rocky Mountain Research Station
- Terrie Jain, USFS Rocky Mountain Research Station
- Amanda Rollwage, Flathead National Forest

Mississippi National River and Recreation Area, Saint Paul, MN
- Mary Hammes, Mississippi Park Connection
- Marcella Windmuller-Campione, University of Minnesota
- Leslie Brandt, USFS Northern Research Station

Petawawa Research Forest, ON, Canada
- Michael Hoepting, Natural Resources Canada
- Jeff Fera, Natural Resources Canada
- Trevor Jones, Natural Resources Canada

Southern New England Exurban Affiliate, CT
- Tom Worthley, University of Connecticut
- Bob Fahey, University of Connecticut
- Will Hochholzer, Mohegan State Forest
- Daniel Evans, Mohegan State Forest

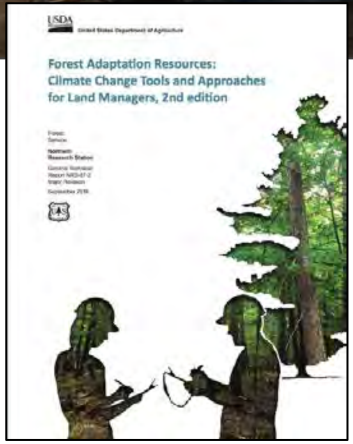
Colorado State Forest, CO
- Mike Battaglia, USFS Rocky Mountain Research Station
- Blair Rynearson, Colorado State Forest Service
- Ethan Bucholz, Colorado State Forest Service

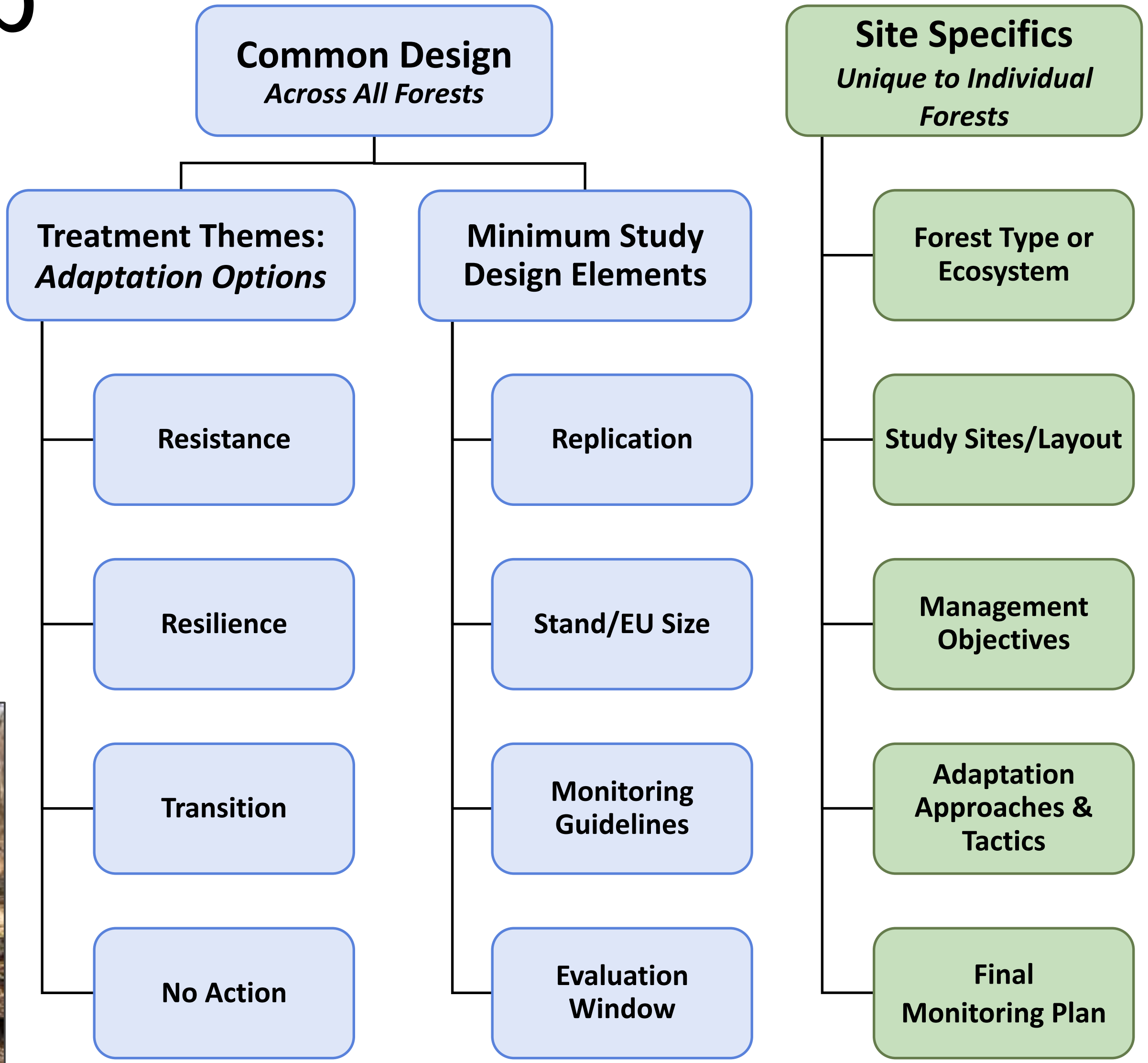
John Prince Research Forest, BC, Canada
- Che Elkin, University of Northern British Columbia
- Kristen Waring, University of Northern Arizona
- Sue Grainger, John Prince Research Forest

Driftless Area, IA, MN, WI
- Miranda Curzon, Iowa State University
- Bruce Blair, IA DNR
- Mike Reinikainen & Paul Dubuque, MN DNR
- Greg Edge & Brad Hutnik, WI DNR

Ohio Hills, OH
- Bryce Adams, USFS Northern Research Station
- Todd Hutchinson, USFS Northern Research Station
- Greg Guess, Ohio Division of Forestry

ASCC Study Design and Collaborative Workshop





Collaborative Workshop

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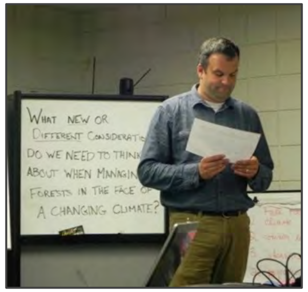
- **Practicality**



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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.

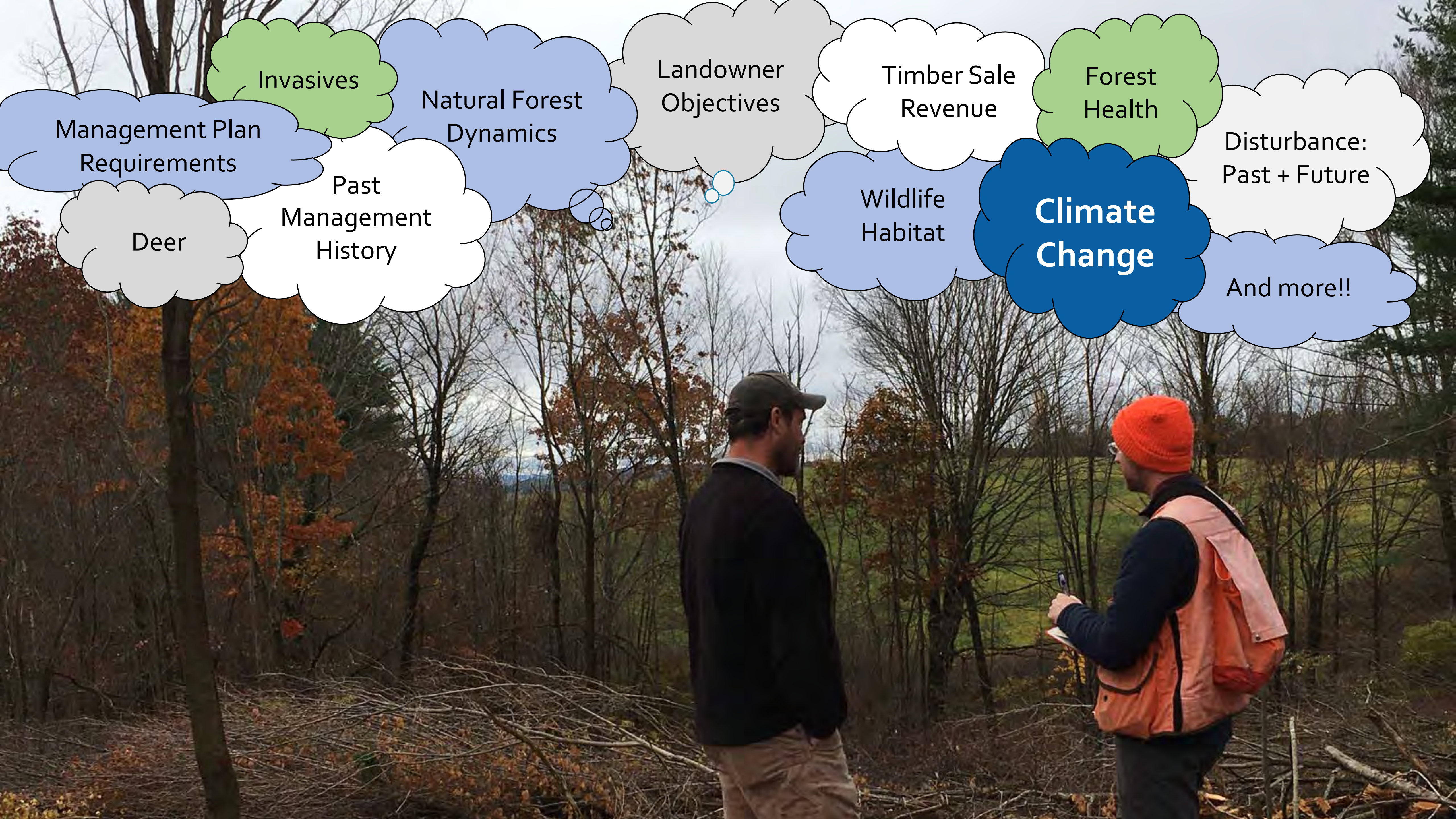
4. IDENTIFY and implement adaptation approaches and tactics.

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

Adapting to Climate Change


Invasives
Management Plan Requirements
Natural Forest Dynamics
Landowner Objectives
Timber Sale Revenue
Forest Health
Disturbance: Past + Future
Deer
Past Management History
Wildlife Habitat
Climate Change
And more!!

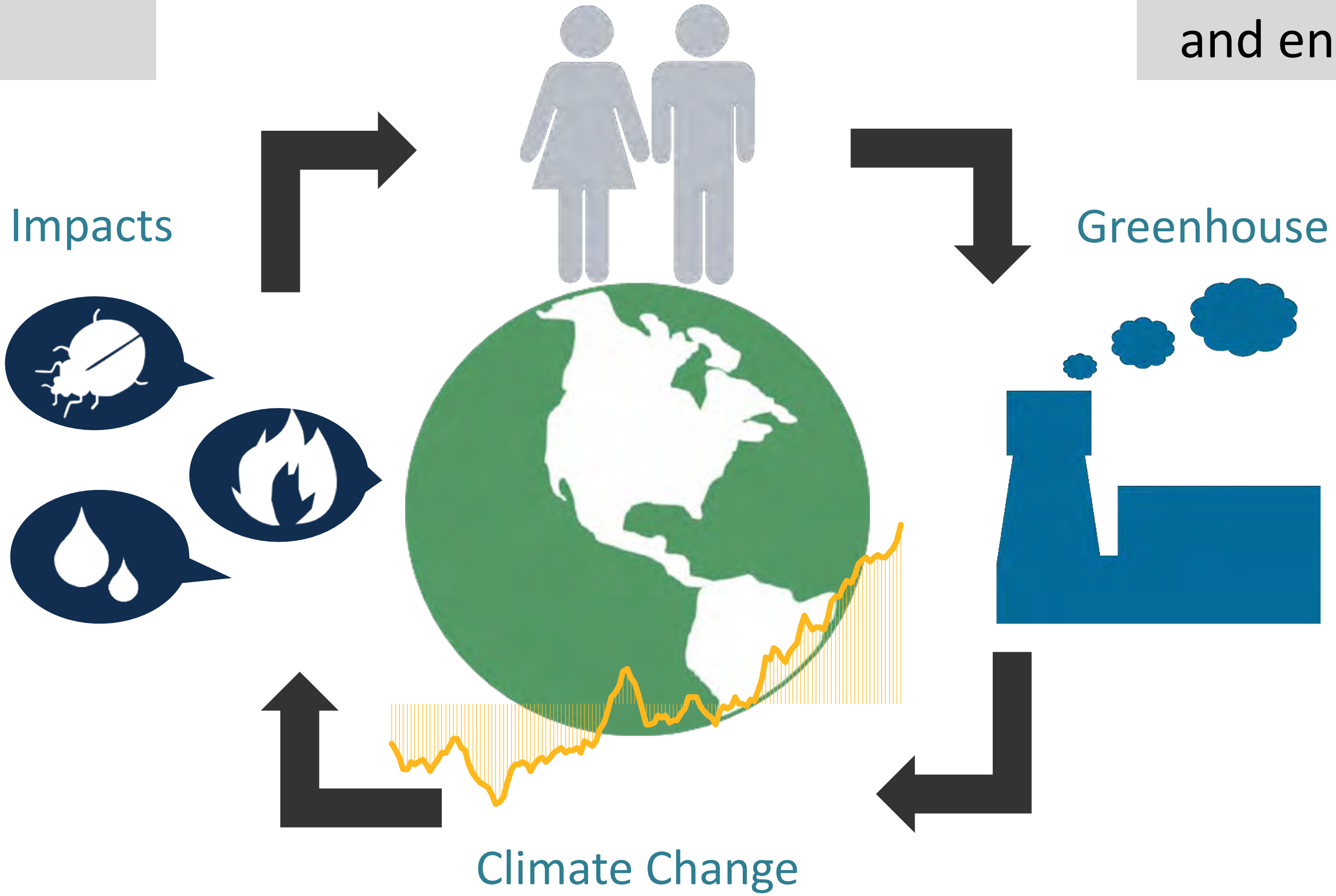
How can we respond to climate change?

Adaptation

Actions to reduce the vulnerability of systems to climate change effects.

Mitigation

Actions that reduce greenhouse gas emissions and enhance carbon sinks.



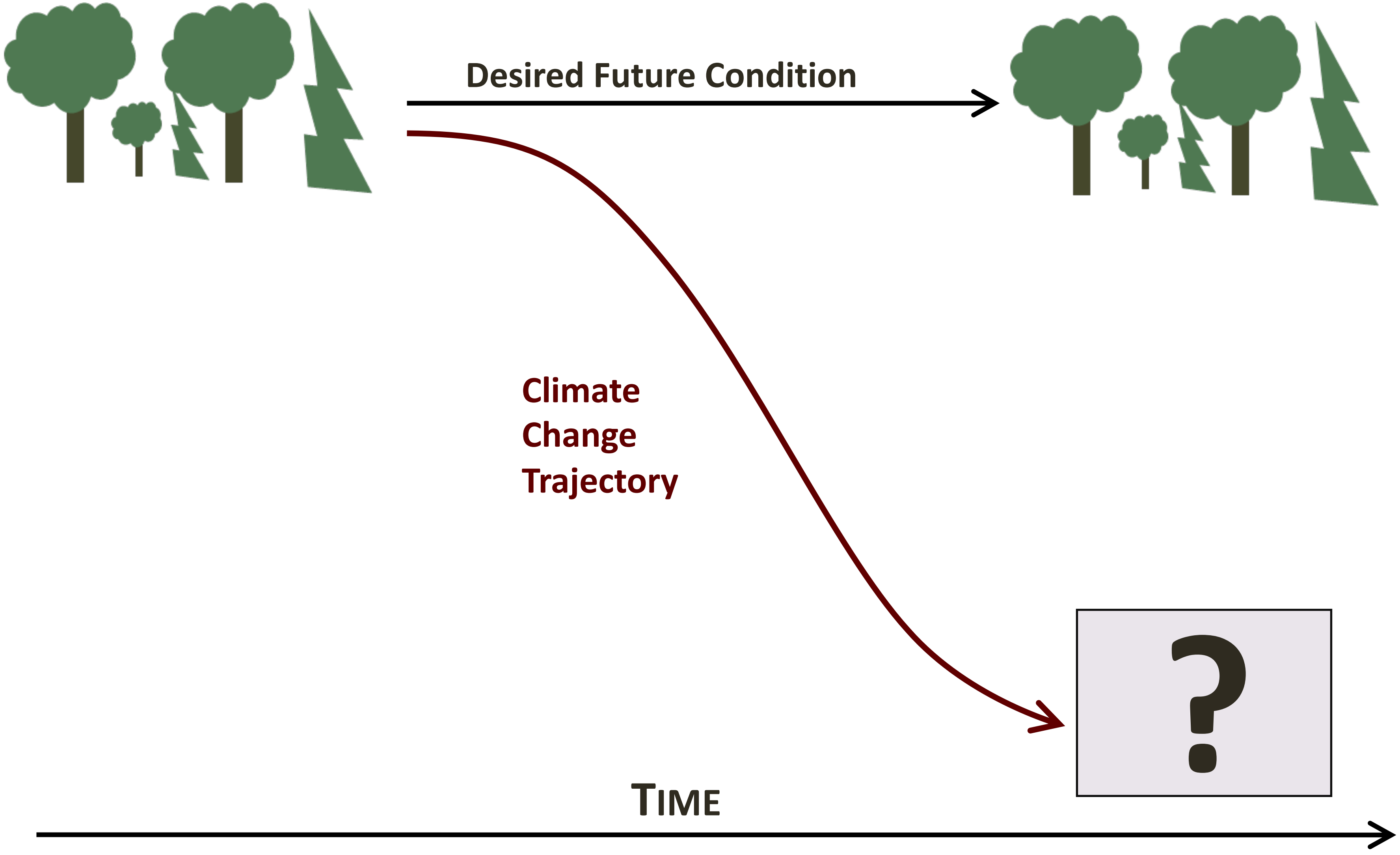
Adaptation - the adjustment of systems in response to climate change.

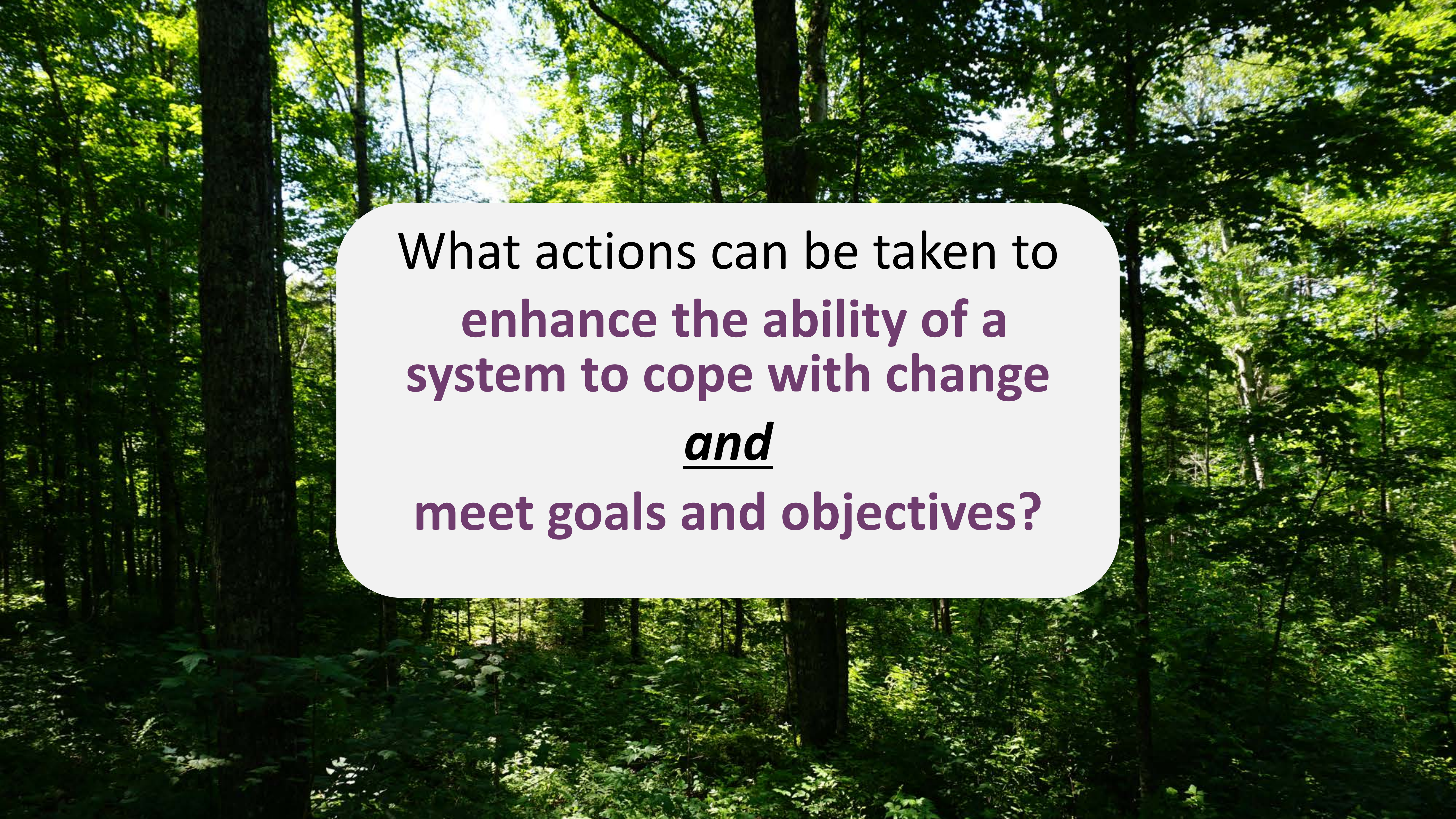



Ecosystem-based adaptation activities build on sustainable management, conservation, and restoration.

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

Climate-Driven Changes



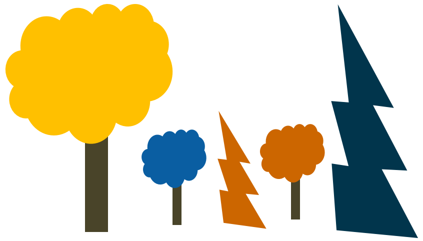

What actions can be taken to
enhance the ability of a system to cope with change
and
meet goals and objectives?

Adaptation Options

RESISTANCE

RESILIENCE

TRANSITION



Identify and implement actions that are

robust across a range of potential future conditions

Millar et al. 2007, Swanston et al. 2016, Nagel et al. 2017

Resistance

Improve the defenses of the system against anticipated changes or directly defending against disturbance in order to maintain relatively unchanged conditions.

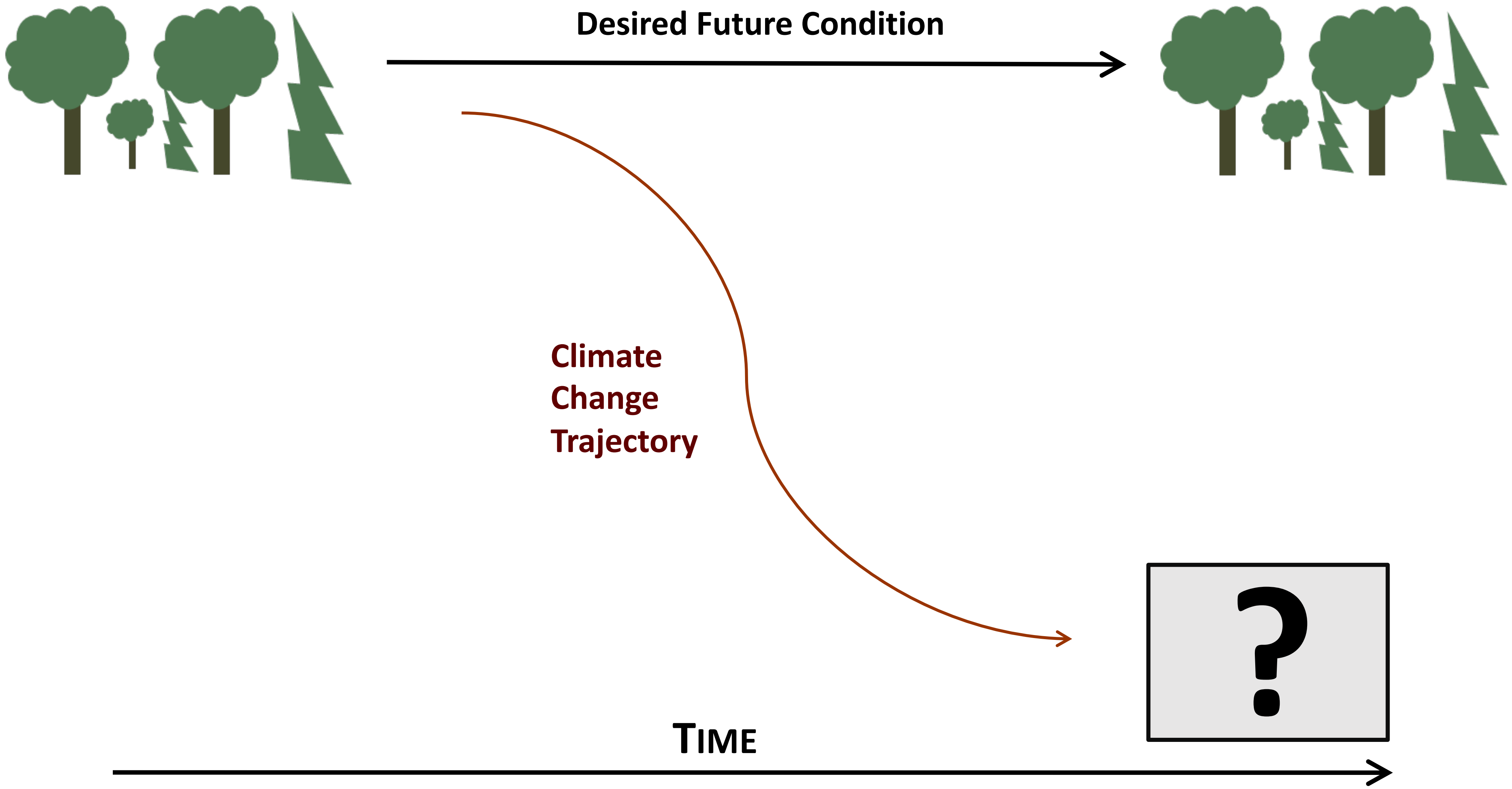
Road crossings that can withstand flood events (USFS, Monongahela NF)

Threatened Dwarf lake iris (FWS)

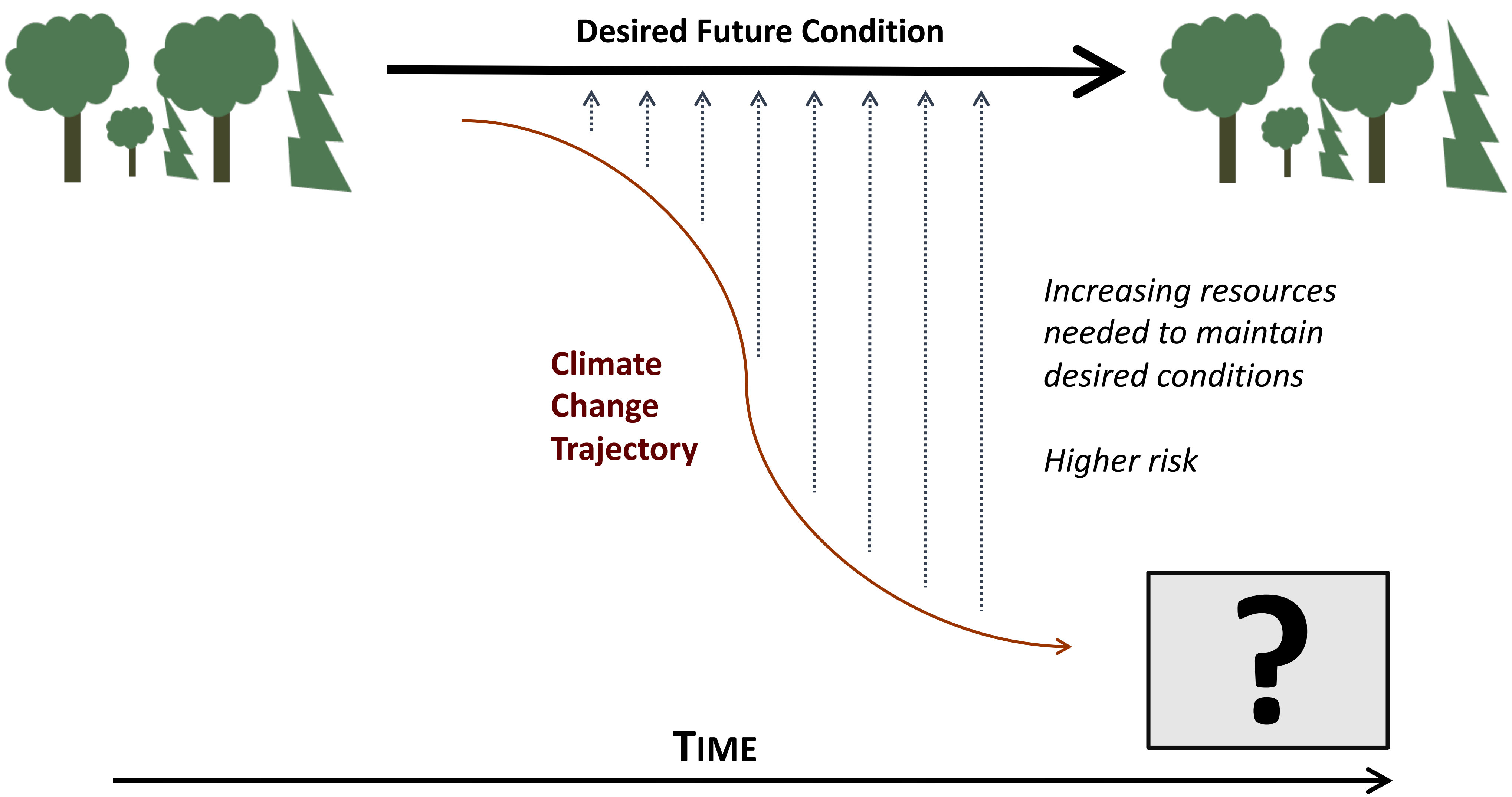
Invasive species management (USFS)

Millar et al. 2007, Swanston et al. 2016, Nagel et al. 2017

Resistance



Resistance


Desired Future Condition
Climate
Change
Trajectory
Increasing resources
needed to maintain
desired conditions
Higher risk
?
TIME

Resilience

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

- Improve overall health & vigor
- Management of vegetation following disturbance

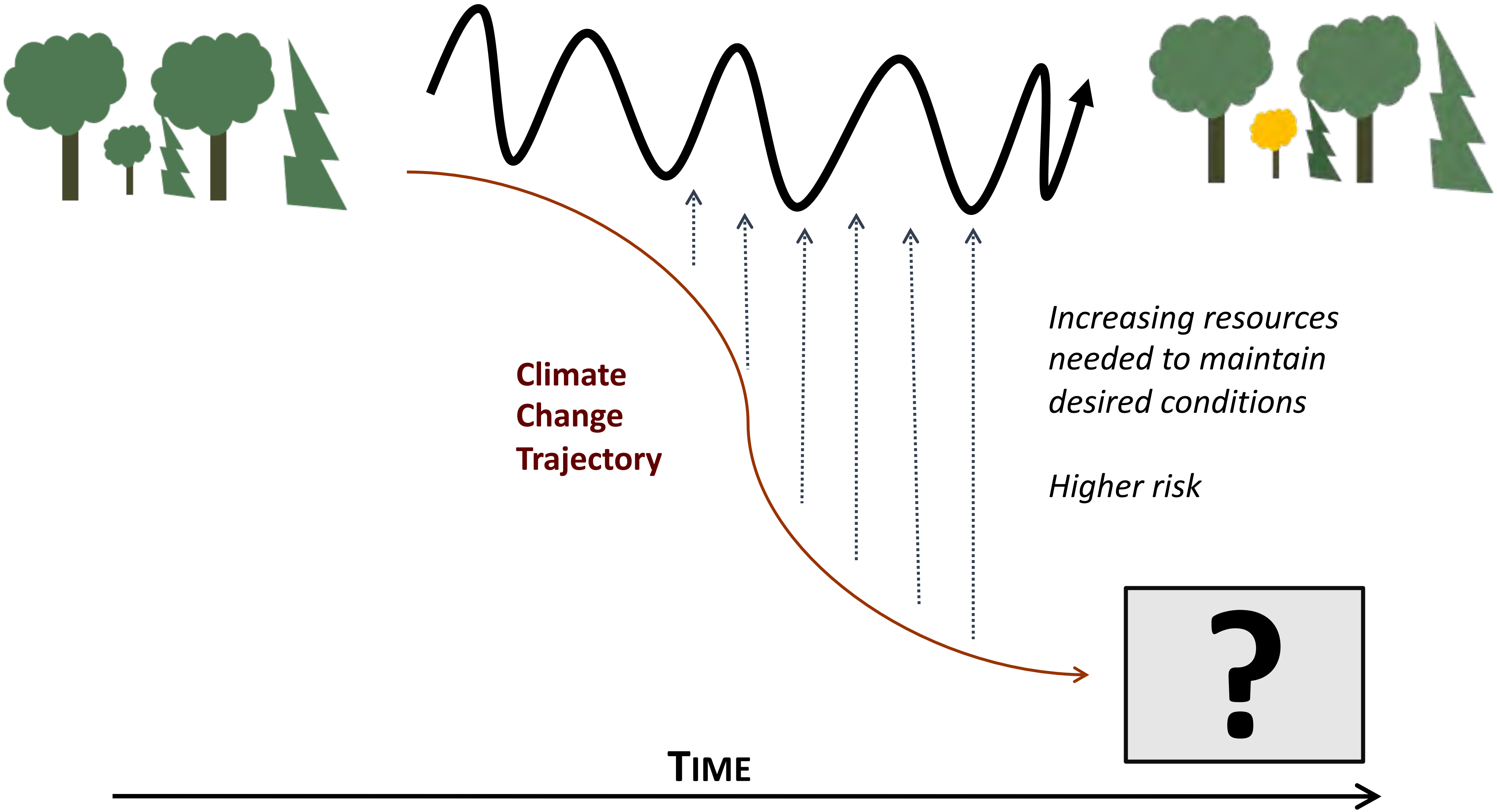
Prescribed burning to regenerate fire-adapted species

Reducing overstocked stands (Tahoe NF)

Increasing setbacks to allow for fluctuating water levels.

Holling 1973, Millar et al. 2007, Swanston et al. 2016
See also – Moser et al. 2019

Resilience

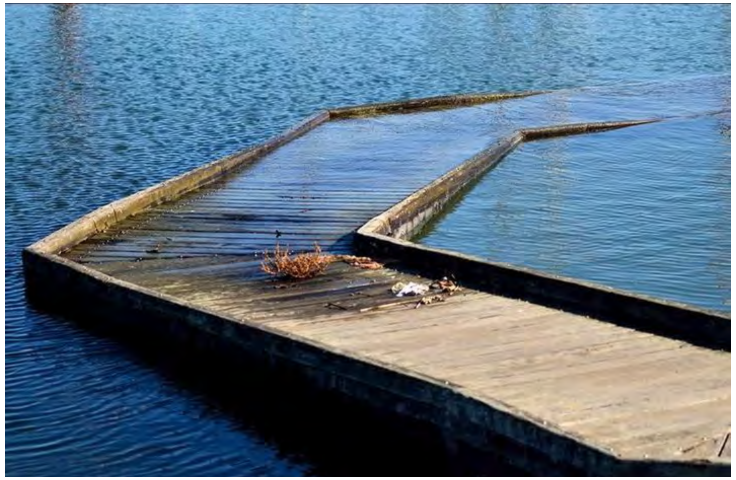

Climate
Change
Trajectory
Increasing resources
needed to maintain
desired conditions
Higher risk
?
TIME

Transition

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

- Foster well-adapted native species
- Relocate visitor and recreation infrastructure
- Accommodate new & altered hydrologic processes

Favoring native species that are expected to be adapted to future conditions.

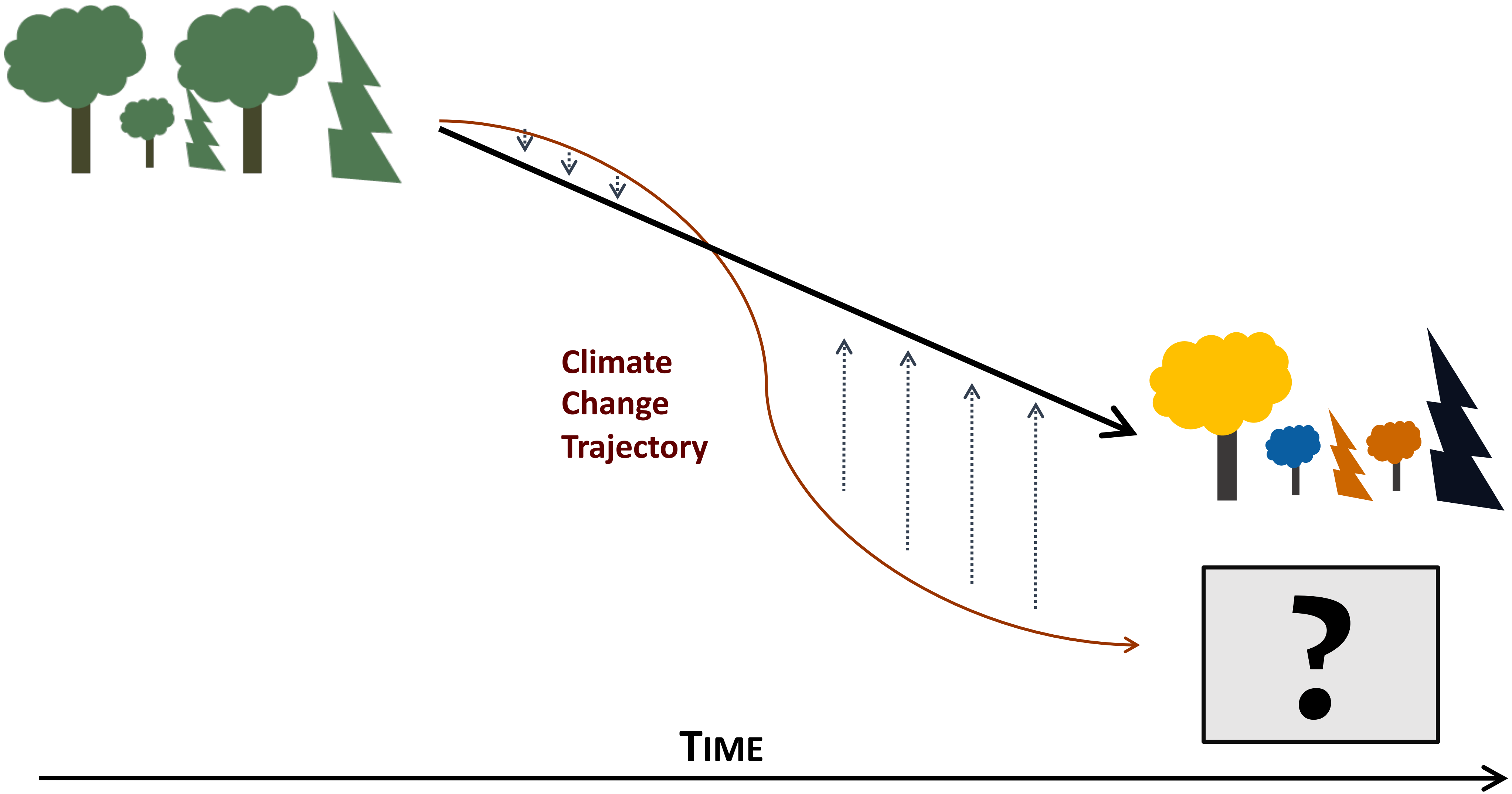


Relocate existing infrastructure to areas with less risk (P:Tom Hilton)

River & riparian area restoration in agricultural fields (P:Joann Kline)

Millar et al. 2007, Swanston et al. 2016, Nagel et al. 2017

Transition



ASCC is testing a spectrum of adaptation options

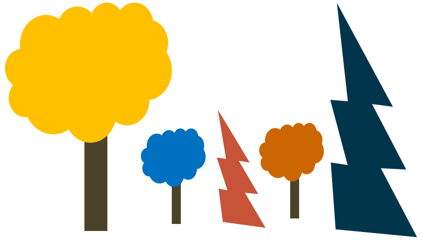
RESISTANCE

- Improve defenses of forest against change and disturbance
- Maintain relatively unchanged conditions

RESILIENCE

- Accommodate some degree of change
- Return to prior reference condition following disturbance

TRANSITION



- Intentionally facilitate change
- Enable ecosystem to respond to changing and new conditions

Reduce impacts/maintain current conditions ⟷ **Forward-looking/promote change**

Millar et al. 2007, Swanston et al. 2016, Nagel et al. 2017

Intentionality

- Explicitly consider and address climate change
- Sure we might get lucky…
- Intentionally assessing risk and vulnerabilities **makes our plans more robust!**

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 location and management objectives.

Vulnerability assessments, scientific literature, TEK, etc.

2. ASSESS climate impacts and vulnerabilities.

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

3. EVALUATE management objectives.

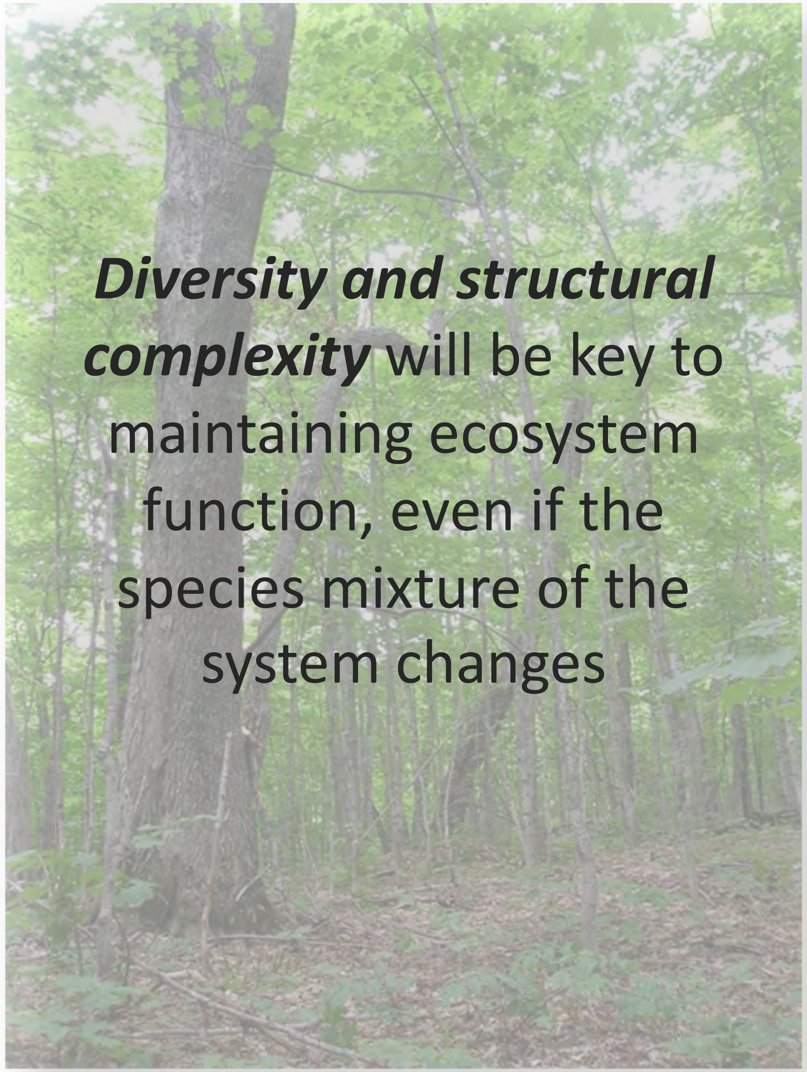
4. IDENTIFY and implement adaptation tactics.

Adaptation Strategies and Approaches

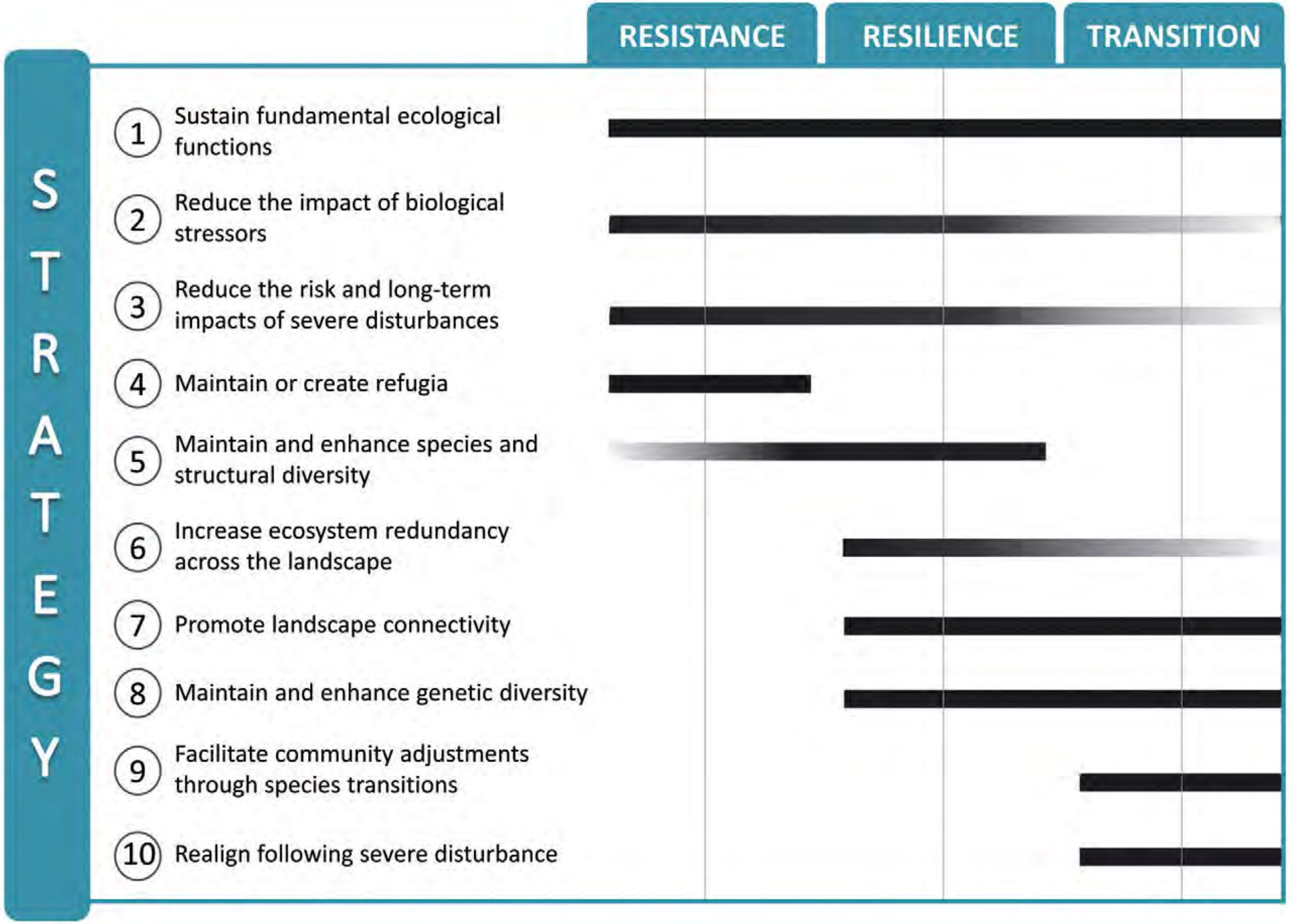
5. MONITOR and evaluate effectiveness.

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

Adaptation Strategies



Diversity and structural complexity will be key to maintaining ecosystem function, even if the species mixture of the system changes



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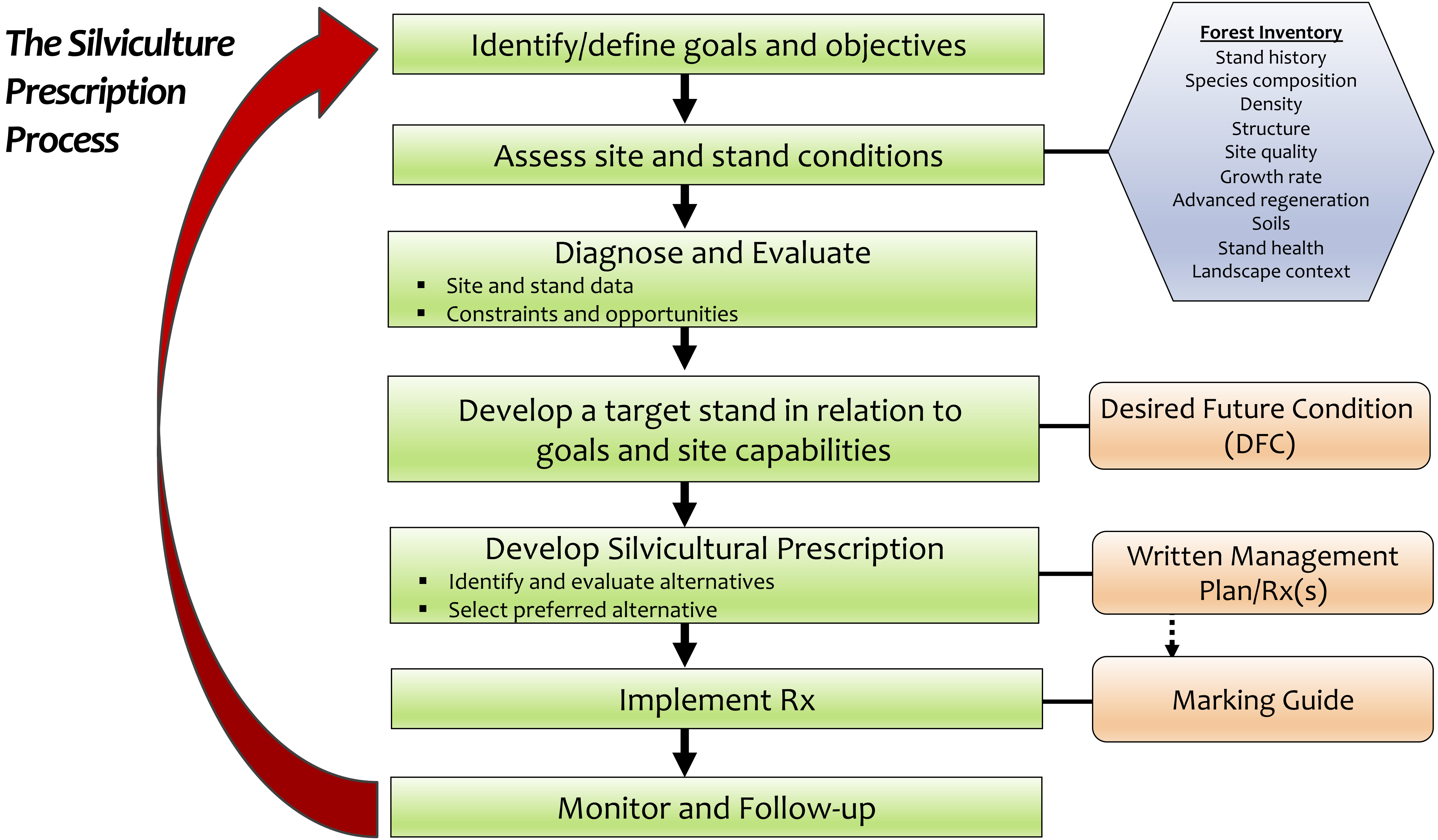
The Silviculture Prescription Process
Identify/define goals and objectives
Assess site and stand conditions
Forest Inventory
Stand history
Species composition
Density
Structure
Site quality
Growth rate
Advanced regeneration
Soils
Stand health
Landscape context
Diagnose and Evaluate
Site and stand data
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)
Marking Guide
Implement Rx
Monitor and Follow-up

Key Definitions (SAF Dictionary of Forestry, 2018)

- **Goal** = A broad, general statement, usually not quantifiable, that describes the desired outcomes of each adaptation treatment (*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 measurable 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, 2018)

- **Desired Future Condition (DFC)** = a description of the land or resource conditions that are believed necessary to fully meet the ***goals*** and ***objectives*** of each adaptation treatment
- **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**

Goals vs. Objectives

Goals

- The “what”
- General
- Intangible
- Broad
- Abstract
- Strategic

- Example:

Objectives

- The “how”
- Specific
- Measurable
- Narrow
- Concrete
- Tactical

- Example:

Goals vs. Objectives

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- Strategic

- Example: Manage for resilient forests

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- Specific
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- Tactical

- Example:

Goals vs. Objectives

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- Example: Manage for resilient forests

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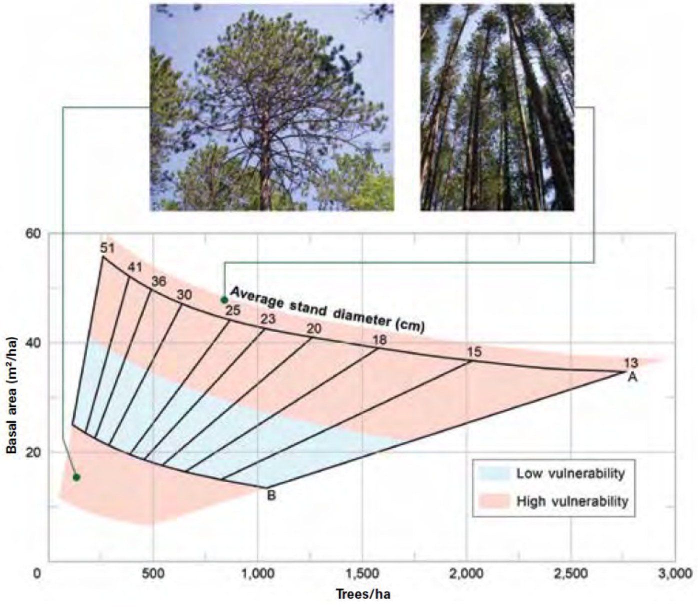


- Example: Reduce stand density to reduce competition and drought stress

Developing the Experimental Treatments

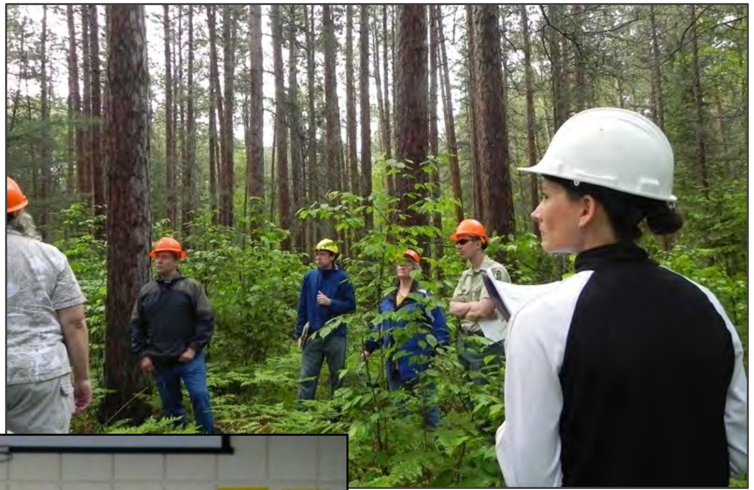
For each experimental treatment (Resistance, Resilience, Transition):

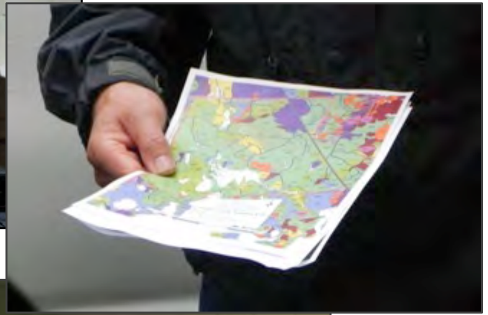
DFC → Management objectives → Silvicultural practices (tactics)

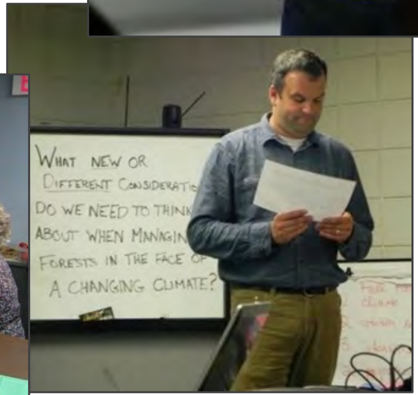
What do you want the stand to be and look like?

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?**

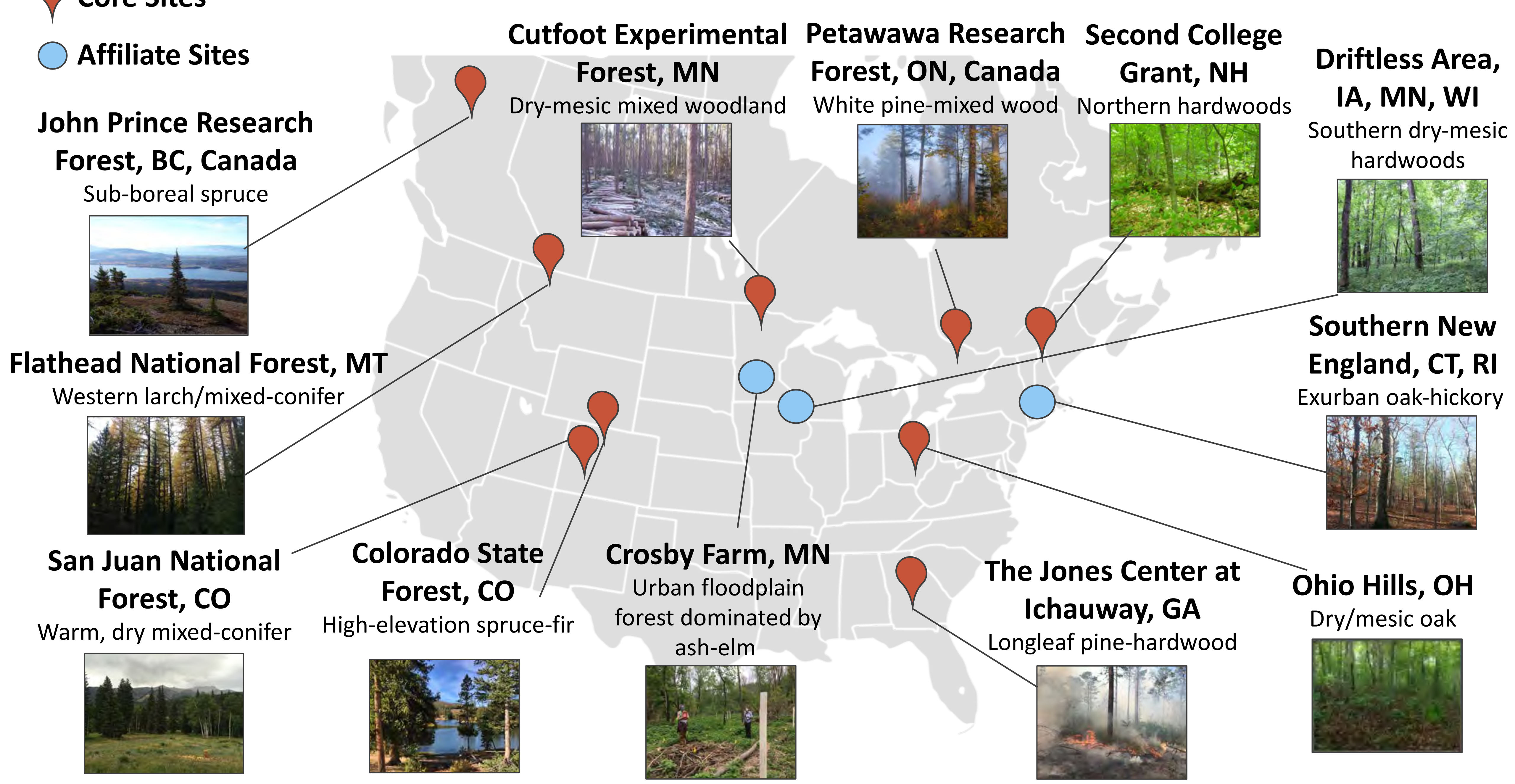




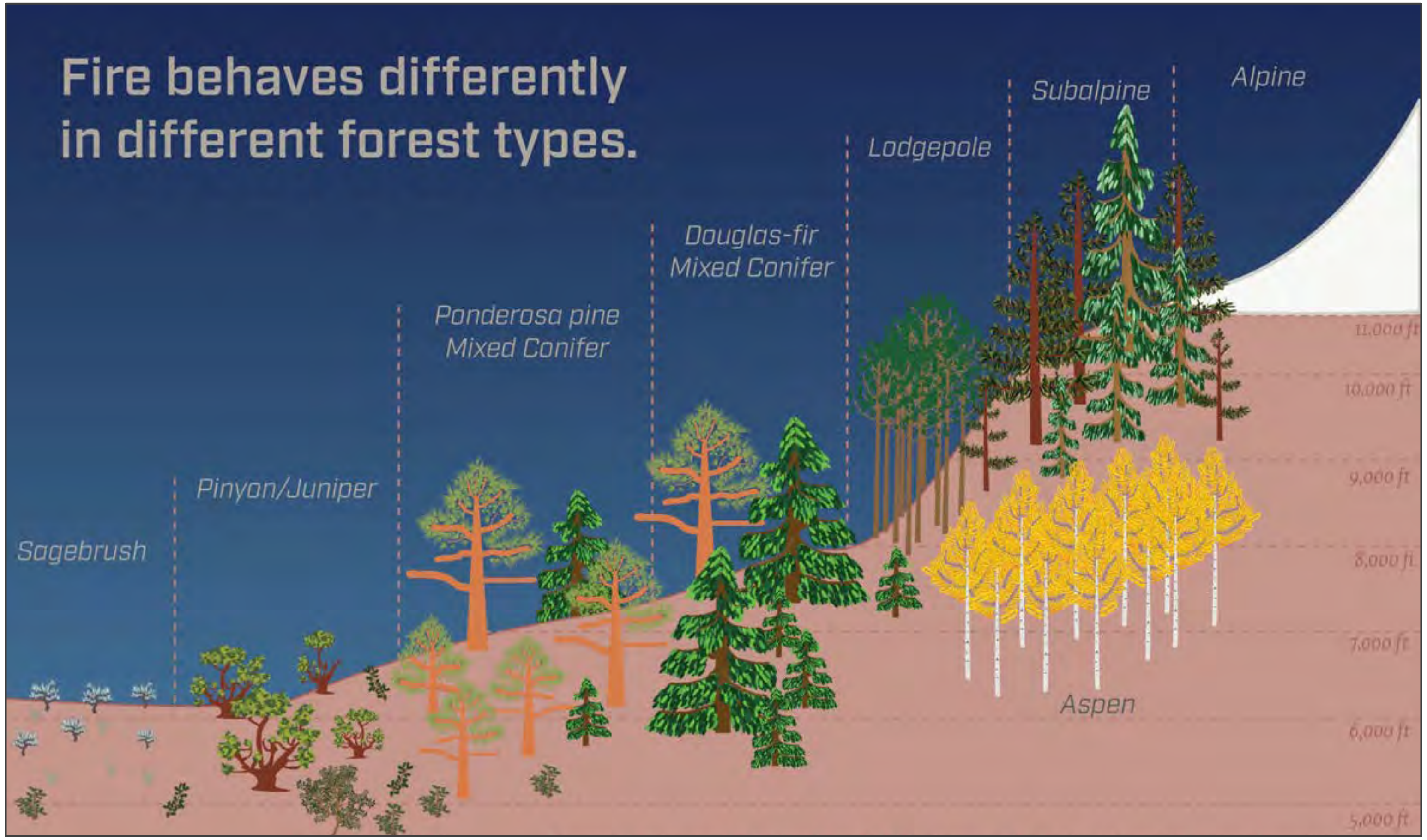


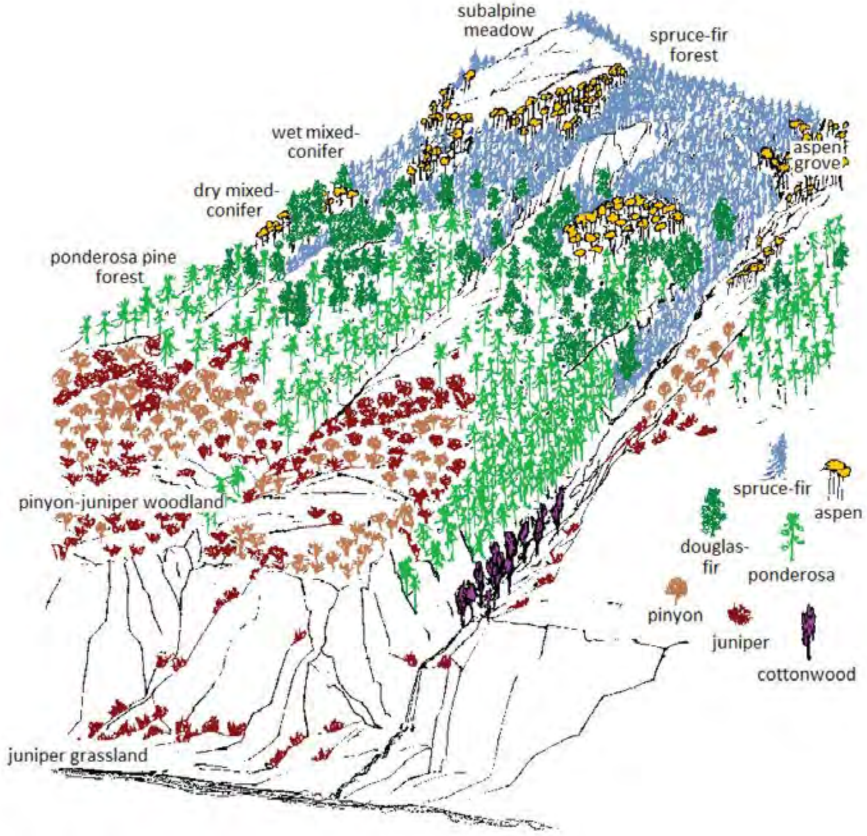
ASCC Network Site Examples

ASCC Network Locations



Forest Types of Colorado





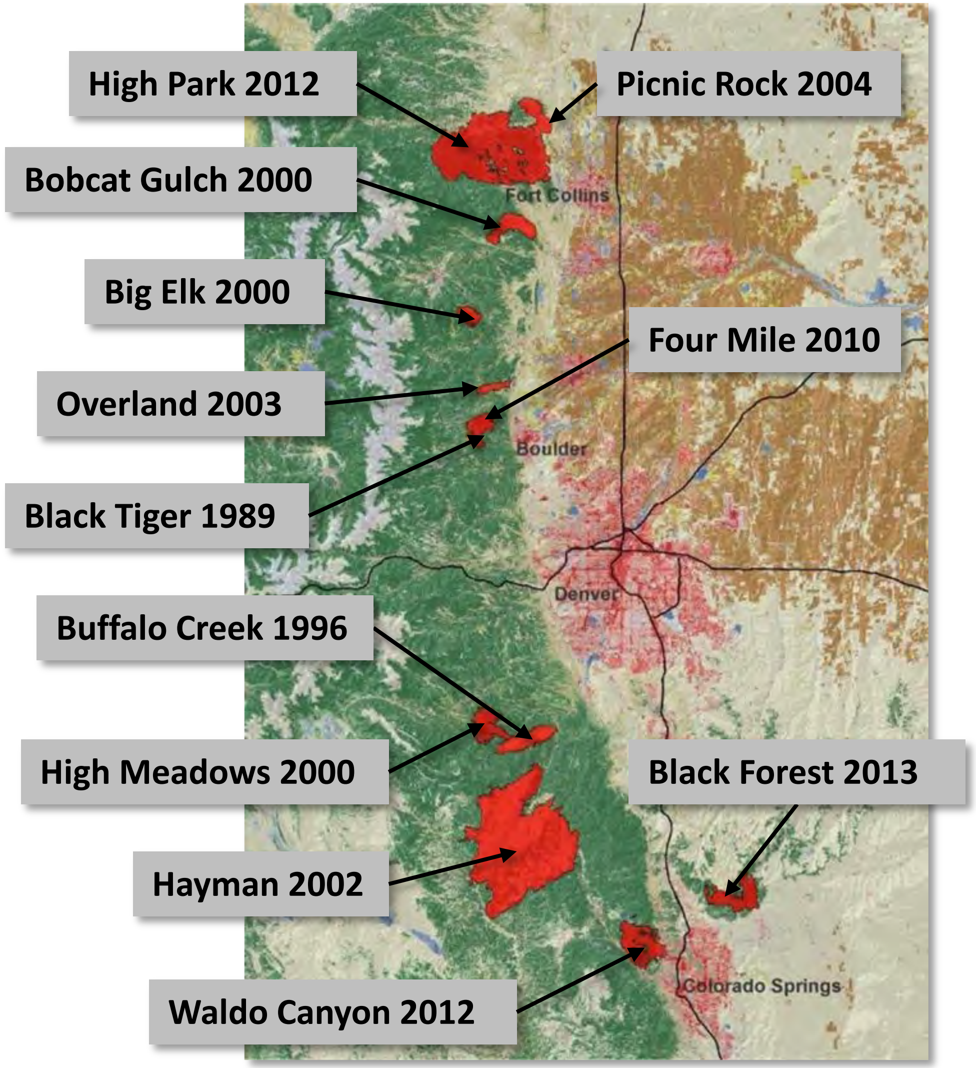
COLORADO FOREST
RESTORATION INSTITUTE

https://cfri.colostate.edu/; Brown, Chambers, Stevens-Rumann, Edwards 2020

Reynolds et al 2013, RMRS-GTR-310

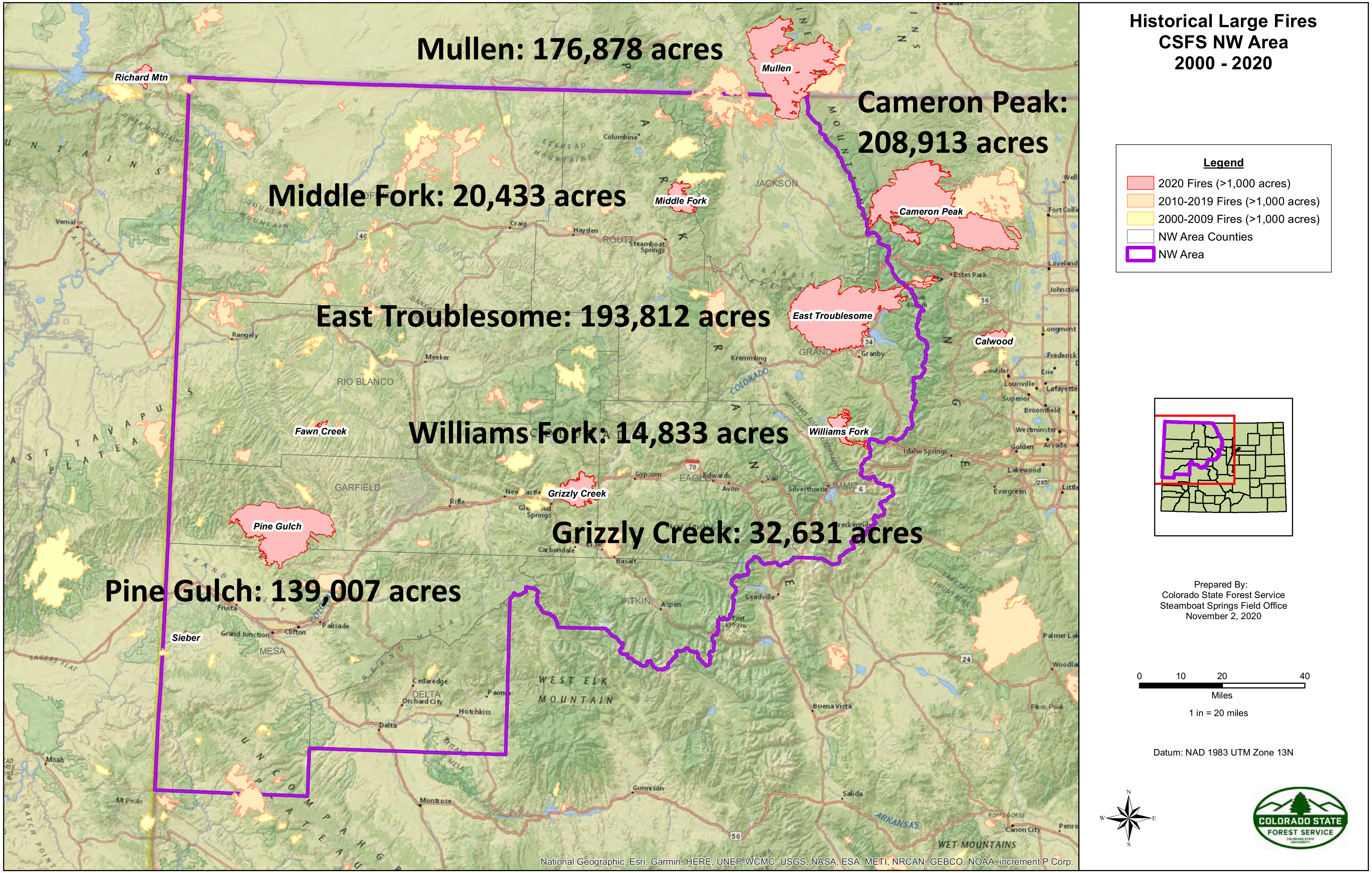
Recent Wildfires in Colorado

Recent Wildfires in Ponderosa Pine/Dry Mixed Conifer

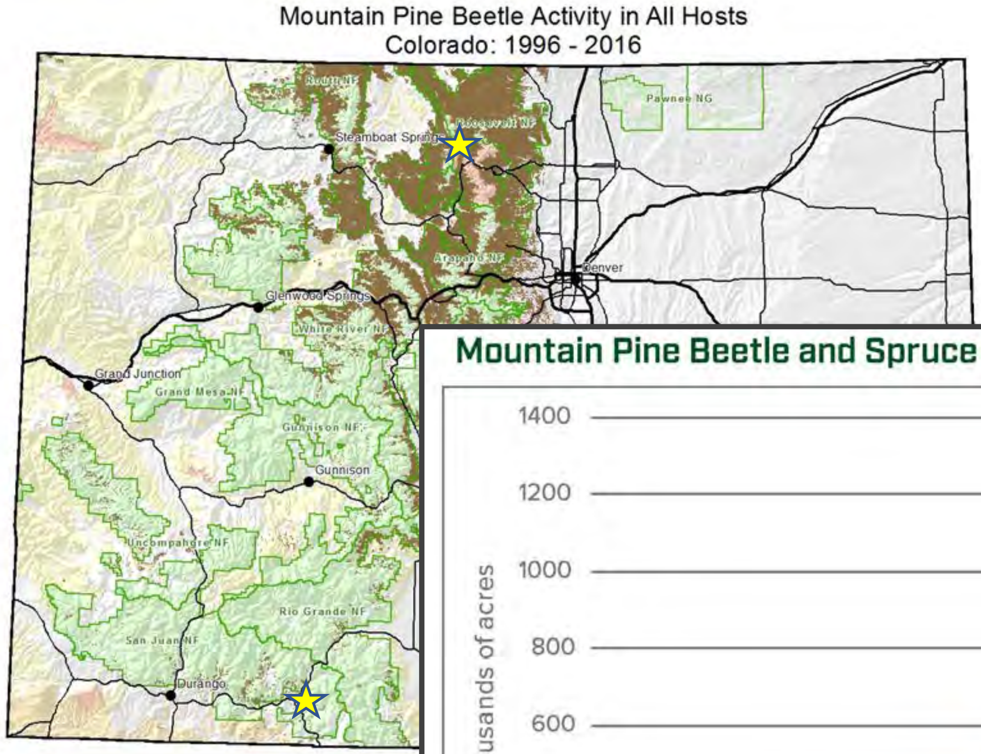


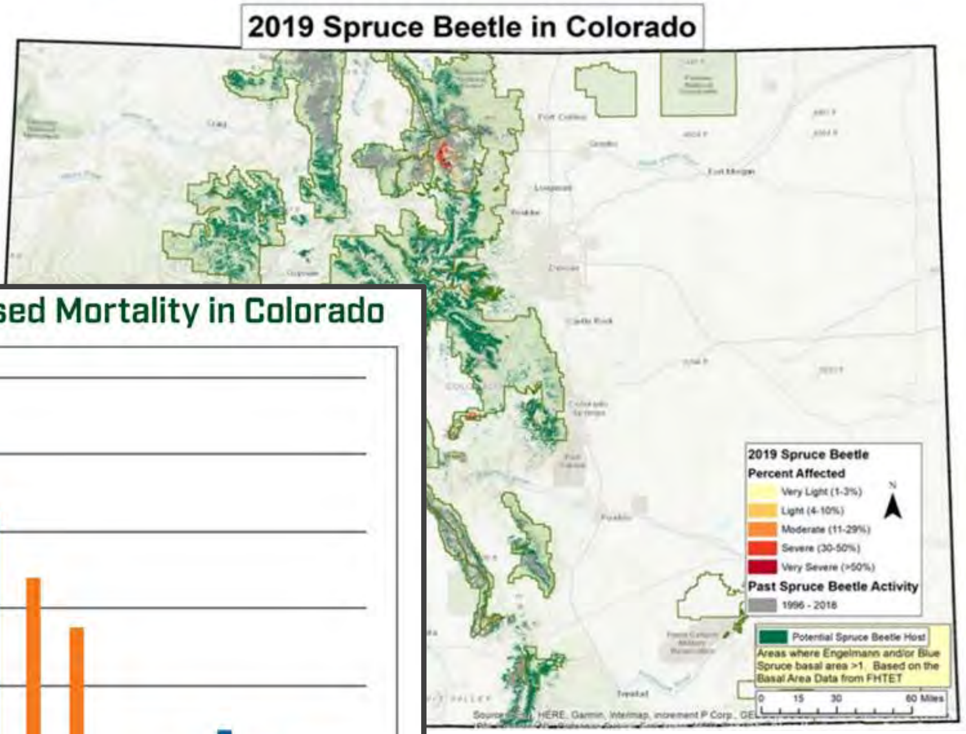
Slide courtesy of M Battaglia

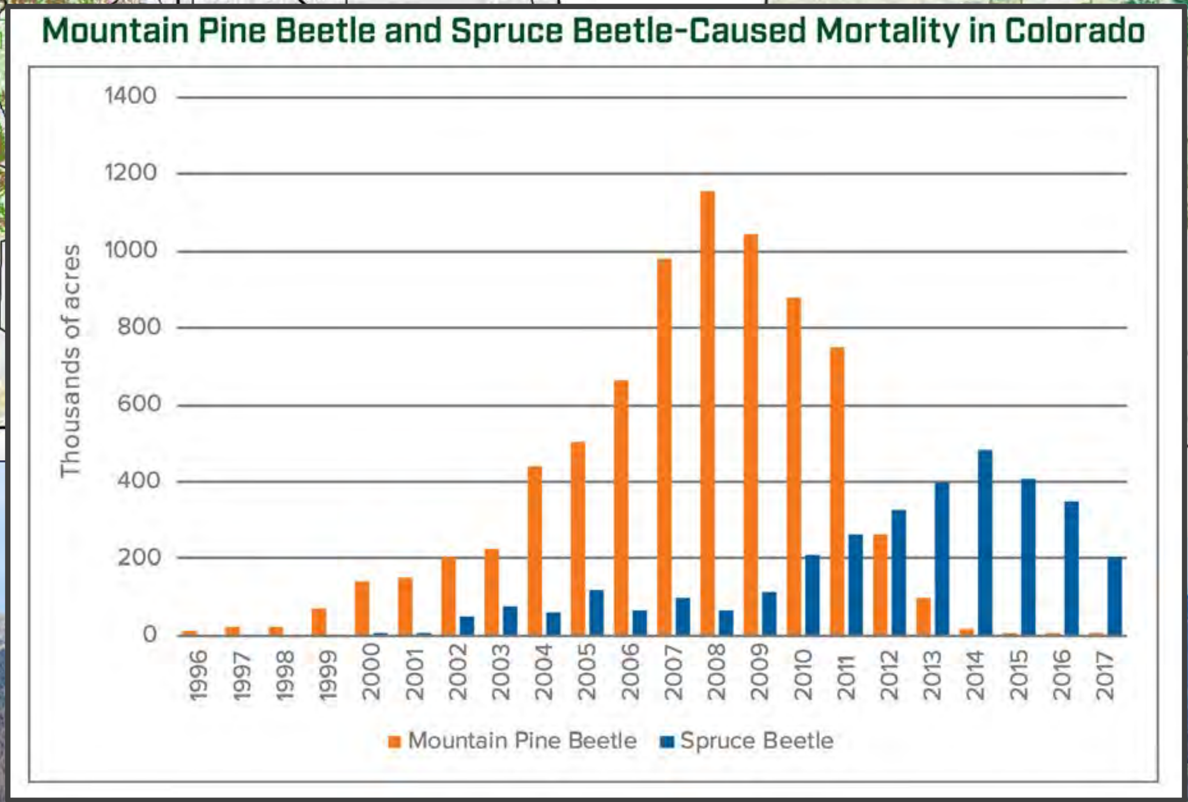
2020 Wildfires Northern Colorado



Mountain Pine Beetle
Spruce Beetle







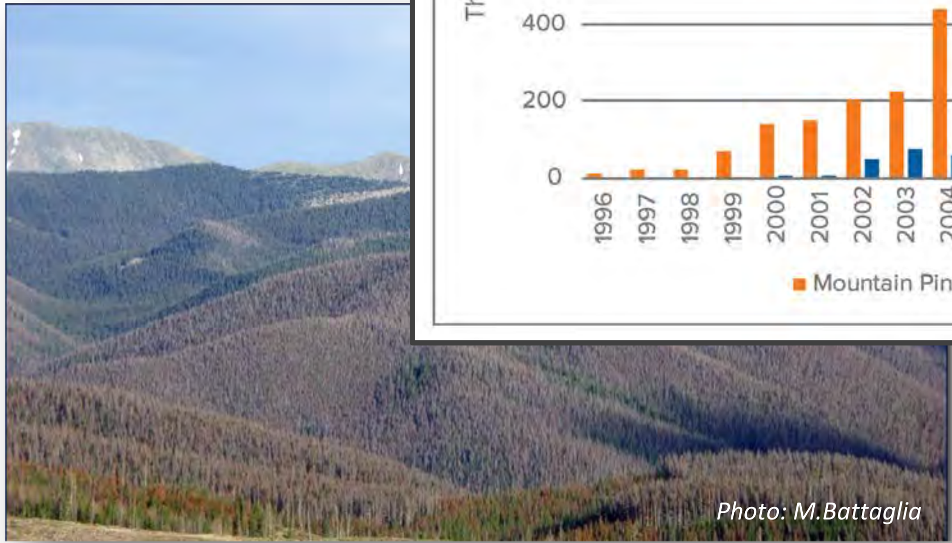


Photo: M.Battaglia

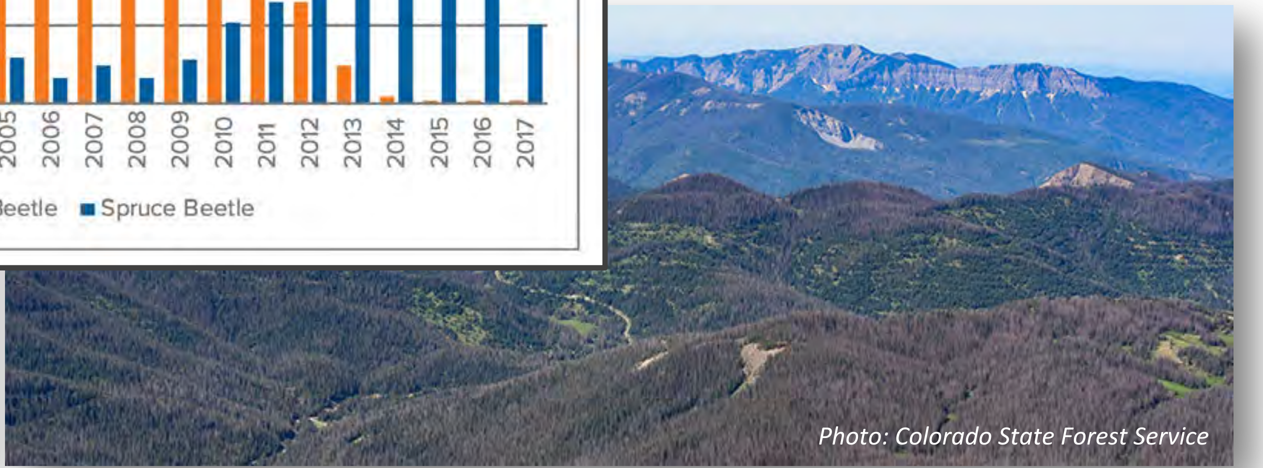
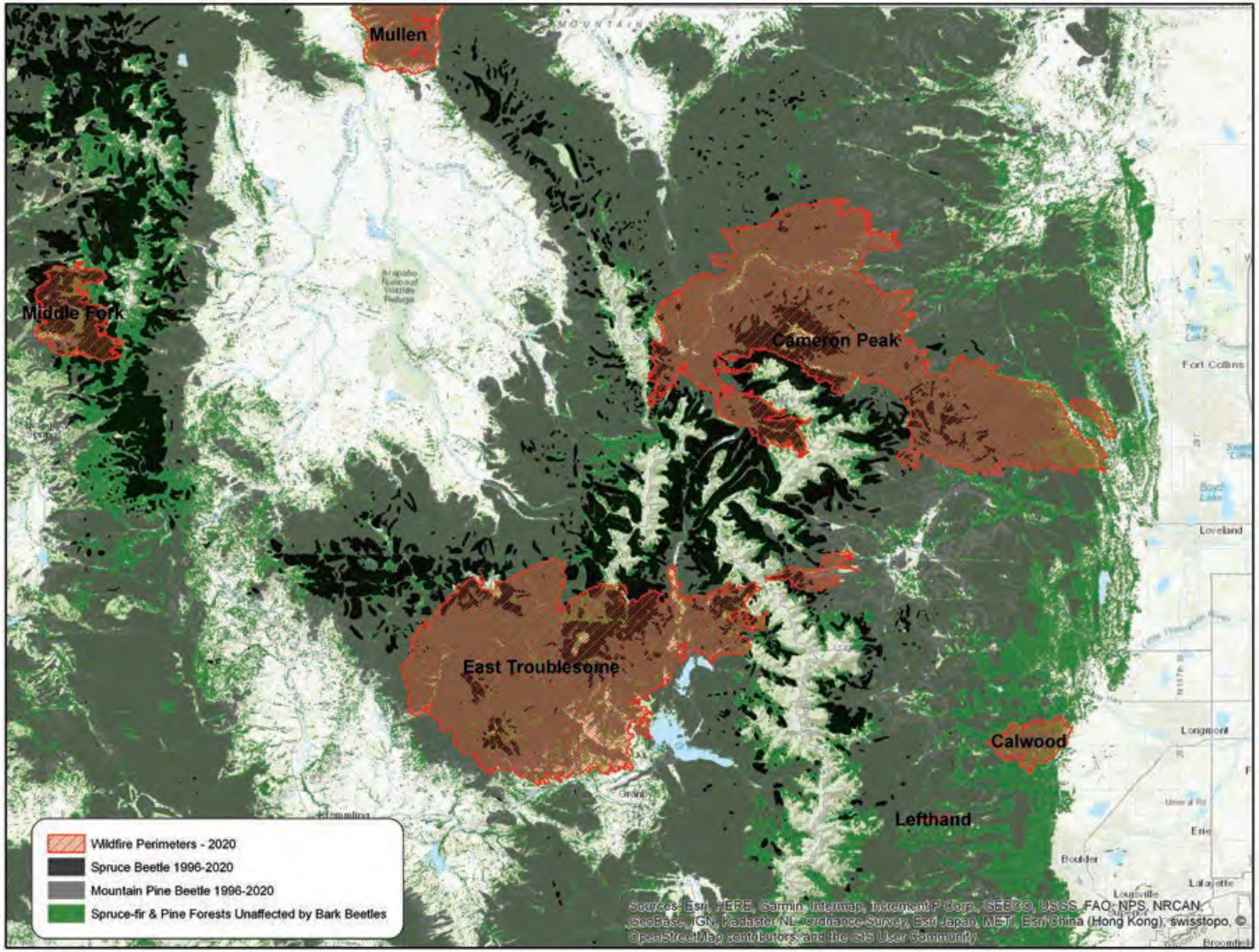


Photo: Colorado State Forest Service

Colorado State Forest Service, Forest Health Reports, 2018, 2019

Interactions Between Bark Beetles and Wildfire



2020 Wildfires in N Colorado

Mullen:
176,878 acres

Cameron Peak:
208,913 acres

Middle Fork:
20,433 acres

East Troublesome:
193,812 acres

Colorado State Forest Service, Forest Health Report 2020

Disturbances and Forest Resilience

Forest Challenges Related to Disturbances

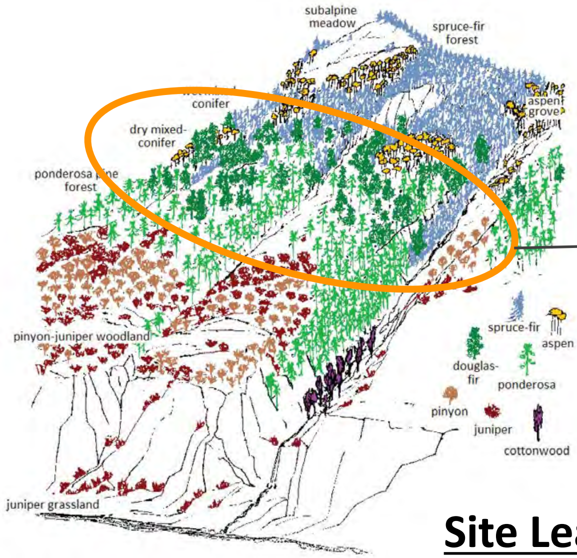
- Many areas are experiencing compound disturbances, *megadisturbances*
  - Increasing temperatures
  - Persistent and recurring drought
  - Insects and pathogens
  - Fire… repeated fire
  - Increasing frequency, extent, severity
- Post-disturbance regeneration/recovery:

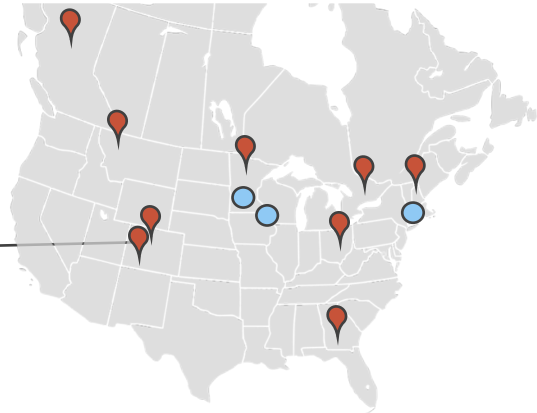
  ↓precip, ↑temp, reduced seed viability following beetle kill, loss of seed trees, lack of climate buffering for regen, competing veg
- Changing societal demands and growing population

San Juan National Forest, CO, USA

Adaptive Silviculture for Climate Change

- Warm-dry mixed conifer with gamble oak
- Fire origin 1905-1925
- 90-200 ft^2/ac (21-46 m^2/ha), overstocked
- Ponderosa pine, Douglas-fir, White fir, Aspen





Site Leads:
Mike Battaglia &
Tim Leishman (USDA Forest Service)

Climate Concerns:

- warming temperatures
- variable precipitation patterns
- earlier snowmelt
- increased risk of wildfire and insect outbreaks

ASCC
Adaptive Silviculture for Climate Change

San Juan National Forest, CO, USA

RESISTANCE

Thin to 60-90 ft^2/ac (14-21 m^2/ha)
PP > DF > WF
Even spacing

RESILIENCE

Thin to 60-80 ft^2/ac (14-18 m^2/ha)
↑ drought-tolerant spp
PP > DF > Aspen > WF
Clumpy, multi-cohort, openings up to 1 ac (0.4 ha)

TRANSITION

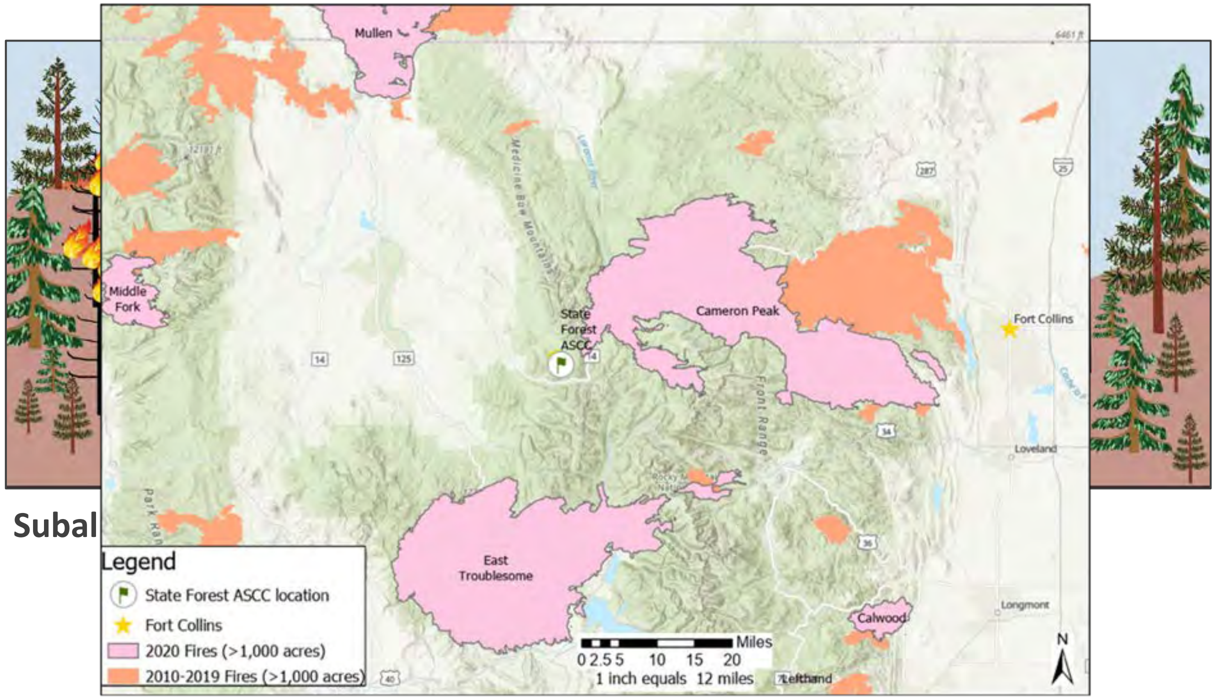
Canopy openness target 30-40%, expand existing gaps
↑ drought and fire-tolerant spp
Retain PP, Aspen in clumps, remove all WF

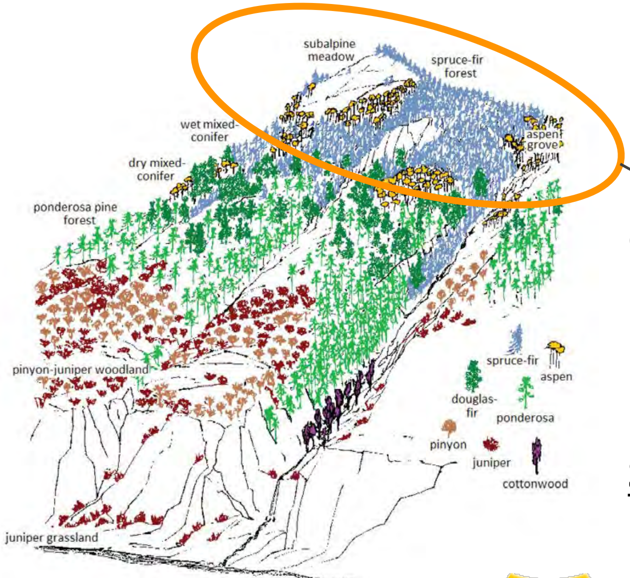
Reduce impacts/ maintain current conditions ⟷ Forward-looking/ promote change

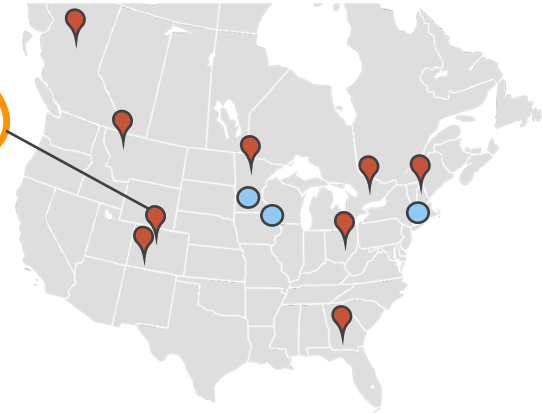
ASCC
Adaptive Silviculture for Climate Change

Colorado State Forest, CO, USA

- Subalpine spruce-fir forest (Engelmann spruce, subalpine fir, lodgepole pine)
- Logged (high-graded) 1940s-1960s
- 34-40 m^2/ha (150-170 ft^2/ac)
- Variable topography and soils
- Historically infrequent fire







Site Leads:
Mike Battaglia (USDA Forest Service); Ethan Bucholz, Blair Rynearson (Colorado State Forest Service)

COLORADO STATE FOREST SERVICE
COLORADO STATE UNIVERSITY

Climate Concerns:

- warming temperatures
- lower precipitation and earlier snowmelt
- elevated drought risk
- increased risk of wildfire and insect outbreaks (spruce and mountain pine beetle)

ASCC
Adaptive Silviculture for Climate Change

Colorado State Forest, CO, USA

RESISTANCE

Reduce stand density
Release advance regen
subalpine fir and spruce > lodgepole

RESILIENCE

Uneven-aged, heterogeneous structure
↑ drought-tolerant spp and genotypes
↑ lodgepole, limber pine, Douglas-fir

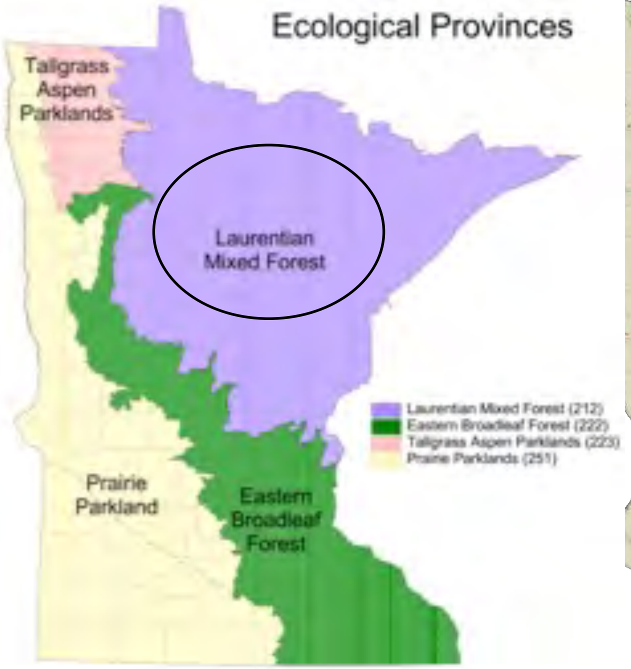
TRANSITION

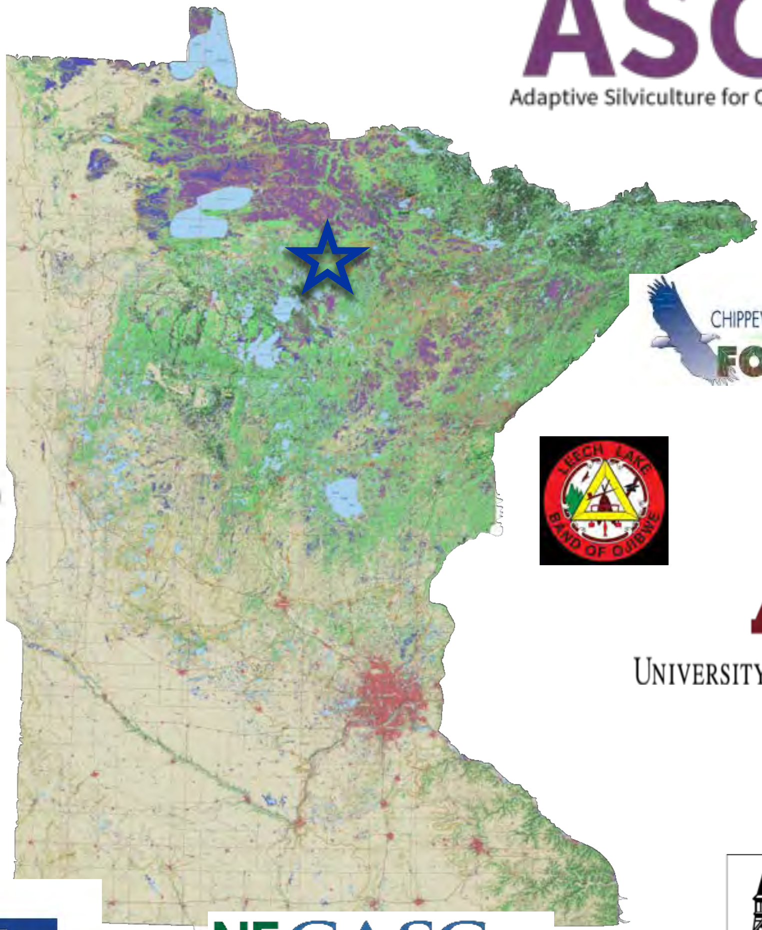
Uneven-aged with large openings
Transition to upper montane forest type with future-adapted spp - Douglas-fir, ponderosa, blue spruce

Reduce impacts/ maintain current conditions ↔ Forward-looking/ promote change

Red Pine ASCC

- Chippewa National Forest, MN
- Cutfoot Experimental Forest
- Workshop: June 25-27, 2013
- Follow-up@Climate Change Summit
- First ASCC site implemented (2014)





ASCC
Adaptive Silviculture for Climate Change

CHIPPEWA NATIONAL FOREST

UNIVERSITY OF MINNESOTA

The University of Vermont

NE CASC Northeast Climate Adaptation Science Center

FOREST AND RANGELAND STEWARDSHIP
COLORADO STATE UNIVERSITY

USGS science for a changing world

NIACS Northern Institute of Applied Climate Science

College of Agriculture, Food and Environment
Forestry and Natural Resources

USDA Forest Service
Northern Research Station

Laurentian-Acadian Northern Pine/Oak Woodlands

-1.4 million ha pre-European settlement

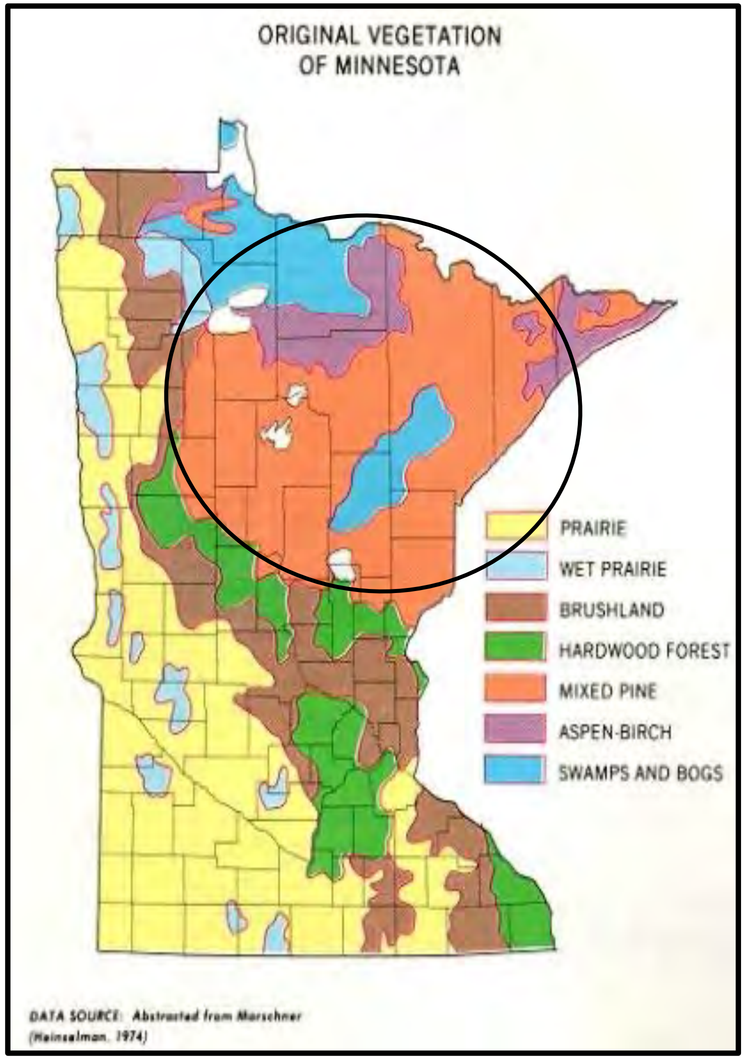
-Mixed-species: *red pine, eastern white pine, balsam fir, white spruce, jack pine, trembling and bigtooth aspens, red maple, northern red oak, bur oak, paper birch*

-Northern Dry-Mesic Mixed Woodland (FDn33a)

-Fire dependent (mixed-severity fire regime)

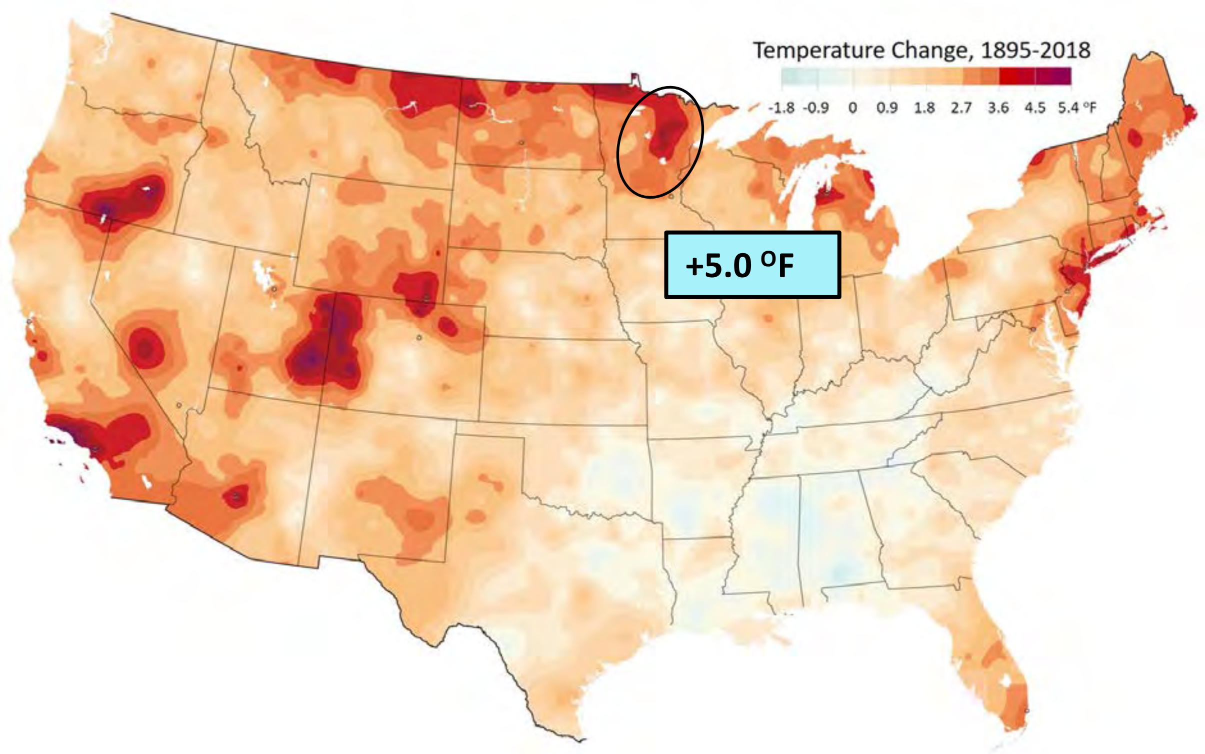
-Variably open tree canopy

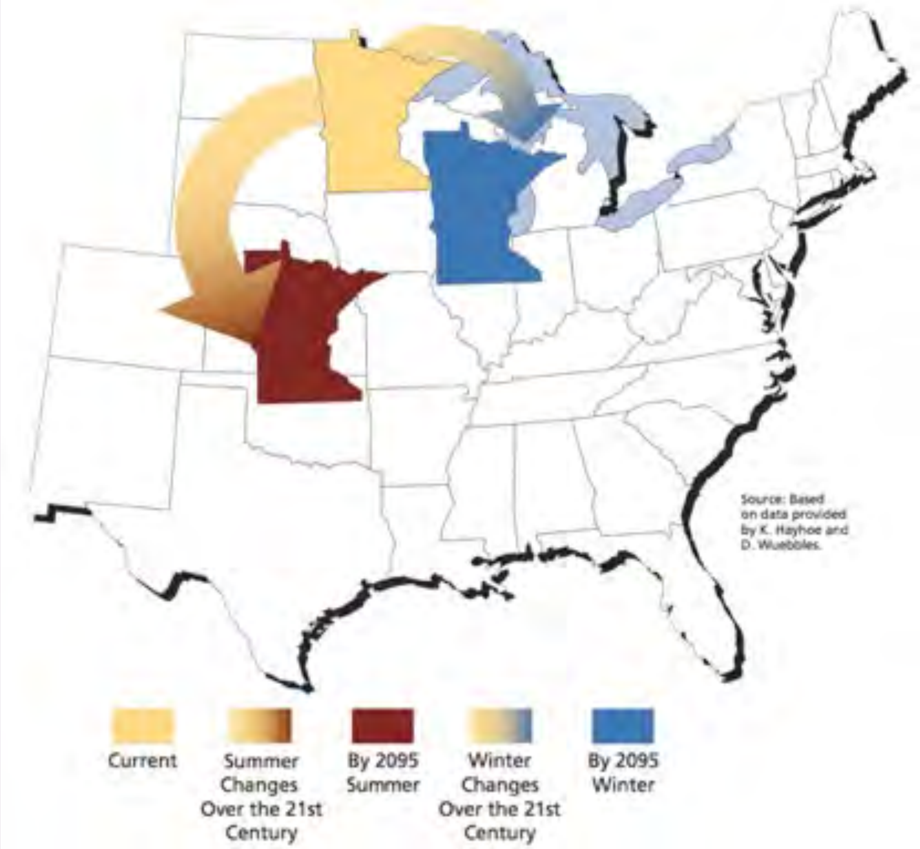
-Occupy sandy, drought prone soils



Climate Change

- Increased growing season drought
- Warmer, wetter winters
- Increased threat from new pests (e.g., mountain pine beetle)

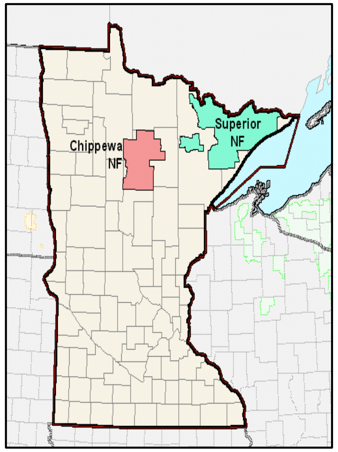


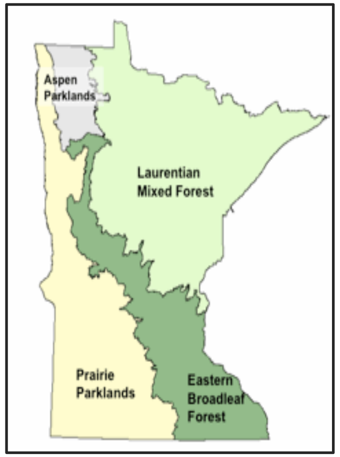


http://www.ucsusa.org/greatlakes/glchallengereport.html

Changes in habitat suitability for most northern tree species

Chippewa NF – Tree Atlas Version 4





Change in Habitat Suitability

Species	RCP45	RCP85
Quaking aspen	Sm Dec	Sm Dec
Balsam fir	Sm Dec	NC
Black spruce	Sm Dec	Sm Dec
Paper birch	NC	NC
Jack pine	Sm Dec	NC
Bigtooth aspen	Sm Inc	NC
White spruce	NC	Sm Inc
Red pine*	**Sm Dec**	**Sm Dec**
Northern red oak	Lg Inc	Lg Inc

****Potential for increasing issues from insects and diseases; Red pine growth is very sensitive to drought***

Change in Habitat Suitability

Species	RCP45	RCP85
Bur oak	**Lg Inc**	**Lg Inc**
Red maple	**Lg Inc**	**Lg Inc**
Eastern white pine	**Lg Inc**	**Lg Inc**
White oak	**Lg Inc**	**Lg Inc**
Black cherry	**Lg Inc**	**Lg Inc**
Bitternut hickory	**New**	**New**

Red Pine-ASCC

Red Pine-ASCC

- **Strongly red pine dominated**
- **Dense understory of *Corylus* (hazel)**
- **Average basal area 41 m^2/ha (180 ft^2/ac) (*over-stocked*)**
- **Fire-origin 1918; fire exclusion since**
- **Largely single cohort (historically multi-cohort)**
- **Vulnerable to environmental and climatic changes and associated forest health issues**

Red Pine-ASCC

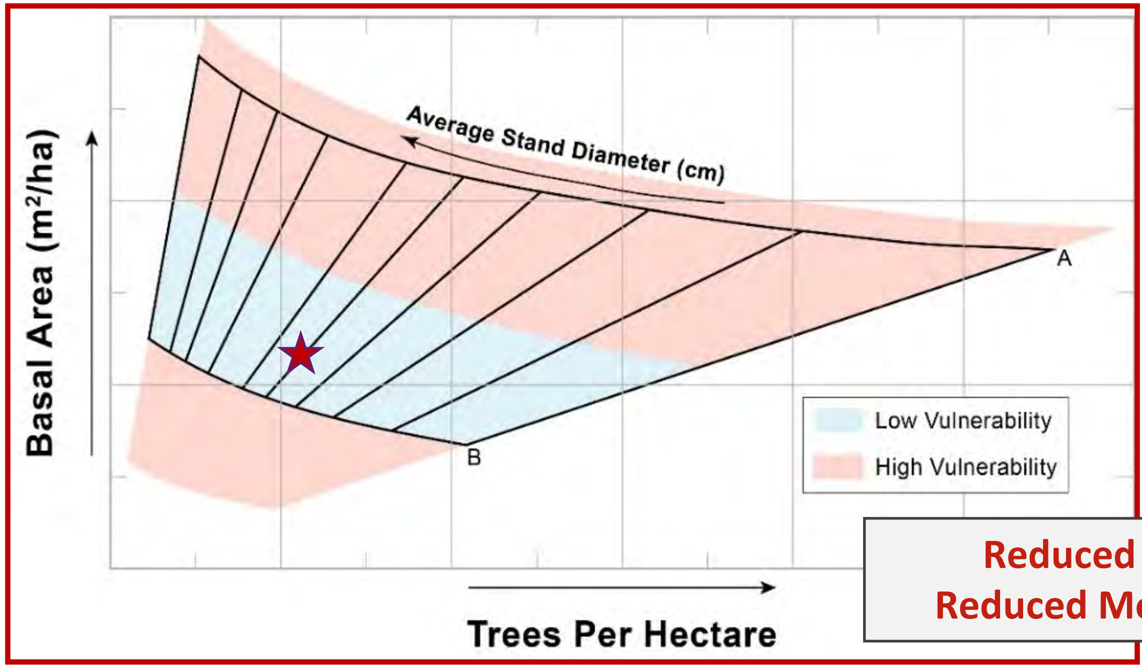
RESISTANCE maintain relatively unchanged composition

<u>DFC/Goal (near-term)</u>

- Maintain RP dominance (90% BA)
- Reduced stocking closer to historical condition

<u>Tactics</u>

- Free thin to 100-120 ft^2/ac (closer to B-line)
- Harvest RP largely
- Reserve large-diameter trees



Reduced Stocking =
Reduced Moisture Stress

Red Pine-ASCC

RESILIENCE allow some change within range of natural variability

DFC/Goal (mid-term)
- RP dominated (50-75% BA)
- Increase heterogeneity and complexity of structure
- 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	RCP45	RCP85
Bur oak	Lg Inc	Lg Inc
Red maple	Lg Inc	Lg Inc
Northern red oak	Lg Inc	Lg Inc
Eastern white pine	Lg Inc	Lg Inc
Jack pine	Sm Dec	NC

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

Red Pine-ASCC

TRANSITION enable ecosystems to respond to changing conditions

DFC/Goal (longer-term)

- Reduce red pine to 20-50%, multi-cohort structure
- Increase future-adapted species

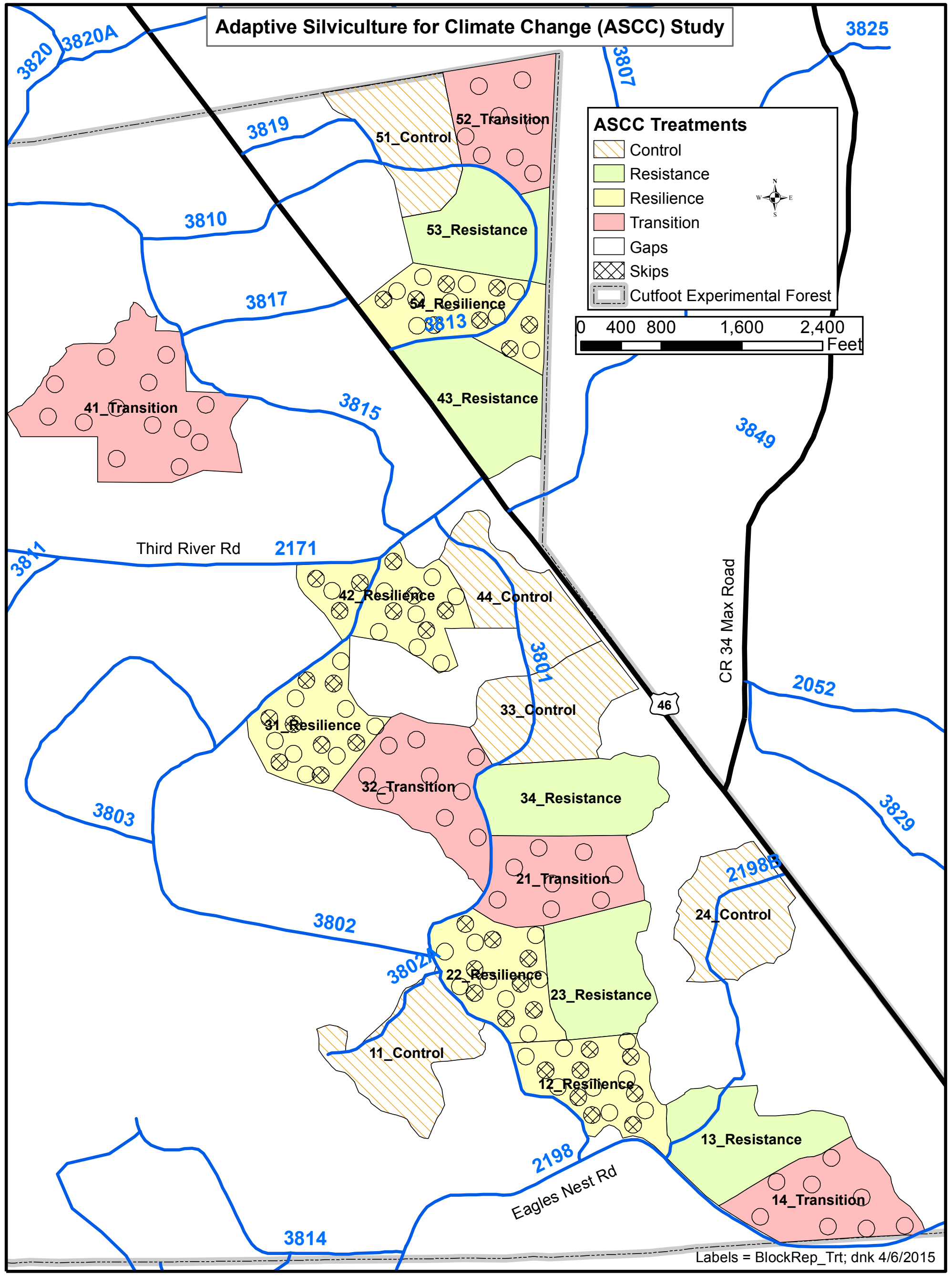
Tactics

- Expanding gap irregular shelterwood
  - 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)

Species	RCP45	RCP85
Bur oak	Lg Inc	Lg Inc
Red maple	Lg Inc	Lg Inc
Eastern white pine	Lg Inc	Lg Inc
Northern red oak	Lg Inc	Lg Inc
White oak	Lg Inc	Lg Inc
Black cherry	Lg Inc	Lg Inc
Bitternut hickory	New	New
Ponderosa pine	?	?

Species choices based on Tree Atlas modeling and expert experience

Red Pine-ASCC



Red Pine ASCC Layout

-4 Treatments (~10 ha each): R,R,T, Passive

-5 blocks

-170 vegetation plots

Passive / Resistance 7 plots (per rep)

Resilience (per rep)

3 in gaps

3 in skips

5 in matrix

Transition (per rep)

3 in gaps

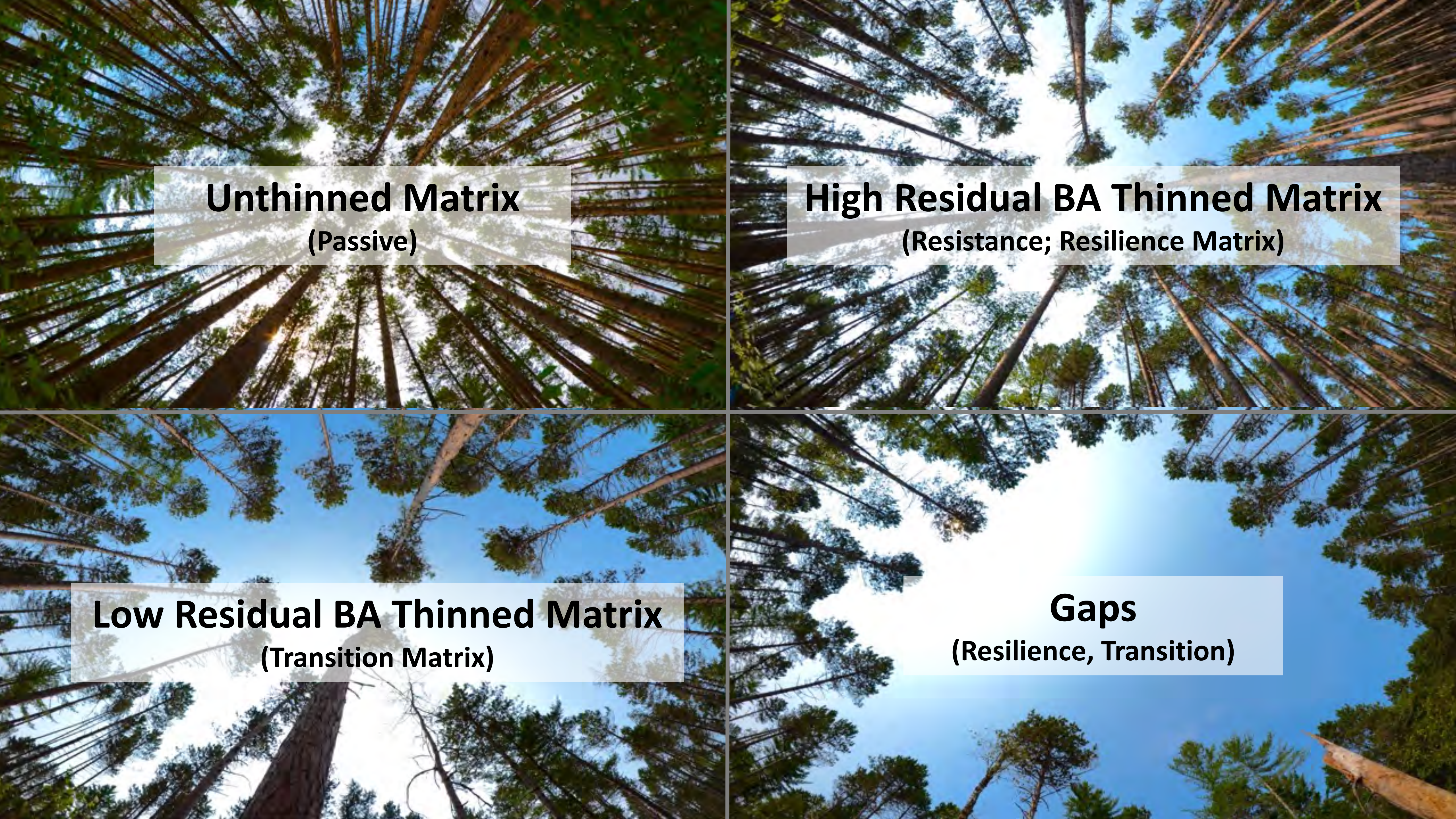
6 in matrix

-Site preparation in resilience gaps and entire transition treatment

-Artificial regeneration (275,000 seedlings in resilience and transition)

-Herbivore protection on pines

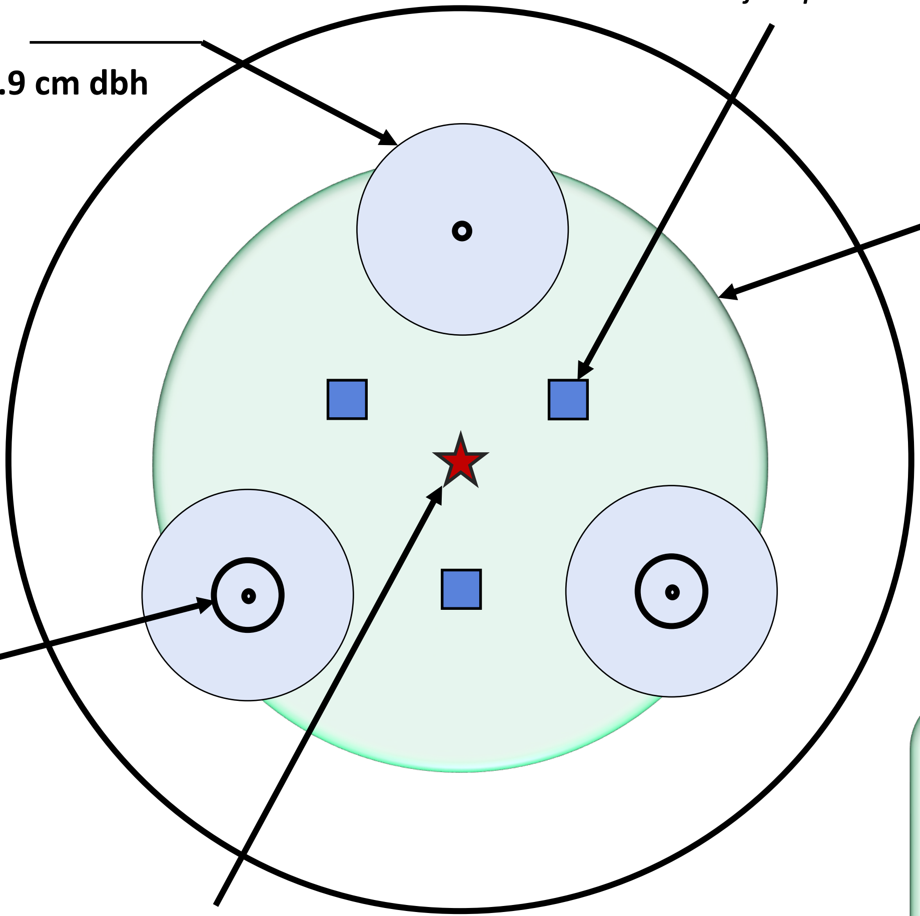
-Mechanical competition control


Unthinned Matrix
(Passive)
High Residual BA Thinned Matrix
(Resistance; Resilience Matrix)
Low Residual BA Thinned Matrix
(Transition Matrix)
Gaps
(Resilience, Transition)

ASCC Plot Design

Ground Layer Plot (3)
1 m^2
Measuring herbaceous and woody spp
< 30 cm (1 ft) tall
4m from plot center at 60, 180, and 300°

Small Tree Plot (Adv Regen) (3)
0.004 ha (1/100th ac)
Radius 3.59 m (11.8 ft)
Measuring ≥ 30cm tall to ≤ 8.9 cm dbh
(≥ 1 ft tall to ≤ 3.5 in dbh)
8m from plot center at 0, 120 and 240°



Sapling Sub-Plot
0.04 ha (1/10th ac)
Radius 11.34 m / 37.2 ft
Measuring 8.9 to 12.6 cm dbh
(3.5 to 7.4 in dbh)

Annular Plot
0.08 ha (1/5th ac)
Radius 16.1 m / 52.7 ft
Measuring ≥ 12.7 cm / 7.5 in dbh
Species, Ht, DBH, snags + decay class, forest health metrics

Shrub Plot (2)
5 m^2
Radius 1.26 m (4.13 ft)
Tally by species

LAI and Photos
Microclimate stations on sub-set of plots

Key Response Variables Monitored Across All Sites (Overstory and Understory):

- Species composition, density, diversity, etc.
- Forest health (mortality, local indices)
- Productivity (increment, biomass)

What Are We Studying?

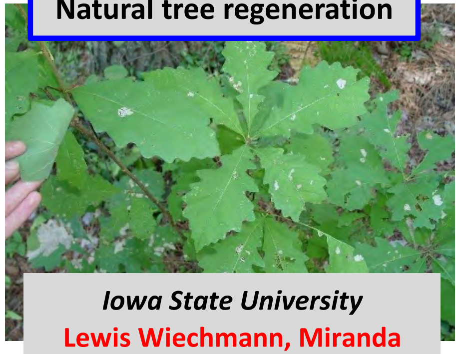
Planted tree regeneration

University of Minnesota, Colorado State University
Jacob Muller, Linda Nagel, Lucia Fitz Vargas

Small mammals

USGS NECSAC
Toni Lyn Morelli, Alexej Siren
Jamie Mosel

Natural tree regeneration

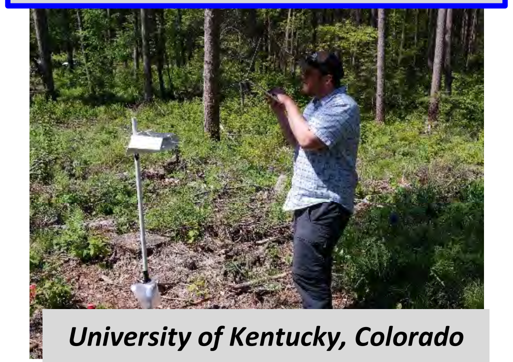


Iowa State University
Lewis Wiechmann, Miranda Curzon

Blueberry response

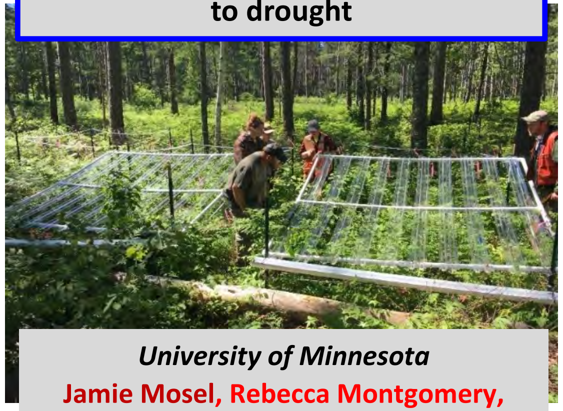
University of Minnesota
Sara de Sobrino, Jamie Mosel, Rebecca Montgomery

Microclimate



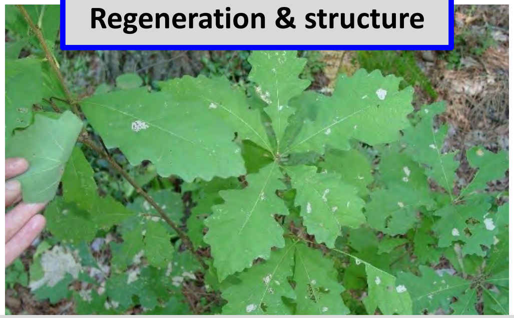
University of Kentucky, Colorado State University
Jacob Muller, Linda Nagel

Physiological responses of seedlings to drought



University of Minnesota
Jamie Mosel, Rebecca Montgomery, Matt Russel

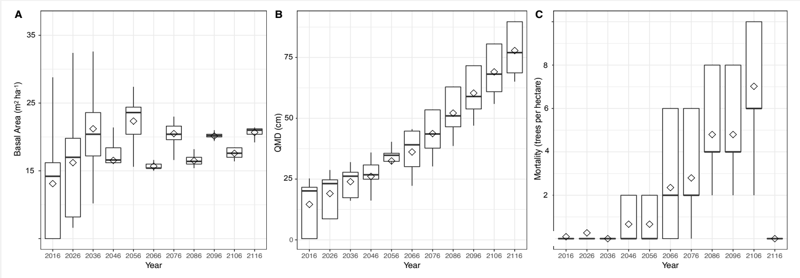
Regeneration & structure



University of Vermont
Tony D'Amato

Bird responses to forest structure

FVS modeling



University of Kentucky, Colorado State University
Jacob Muller, Linda Nagel

Ojibwe Interpretation
University of Minnesota, Leech Lake Tribal College
Jamie Mosel, Rebecca Montgomery

Also:
Ground layer plant communities, Forest productivity

Developing the Experimental Treatments

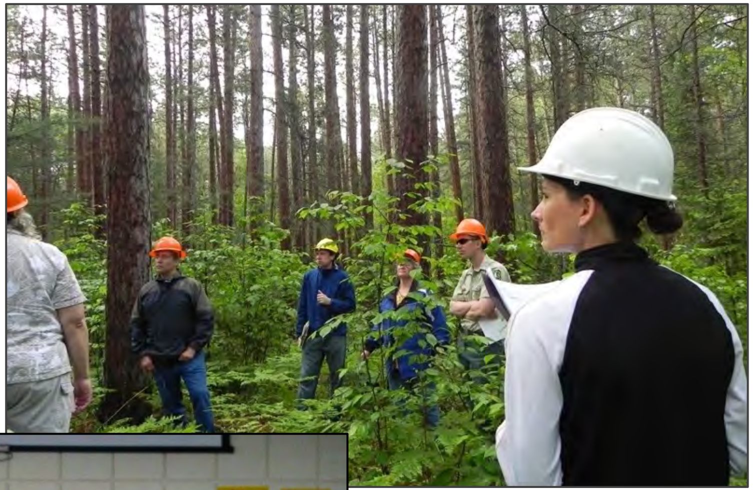
For each experimental treatment (Resistance, Resilience, Transition):

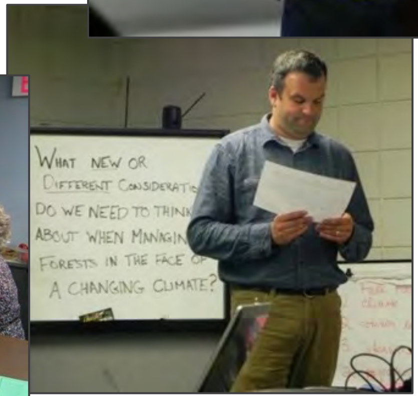
DFC
↓
Management objectives
↓
Silvicultural practices (tactics)

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?**





Workshop Guidelines

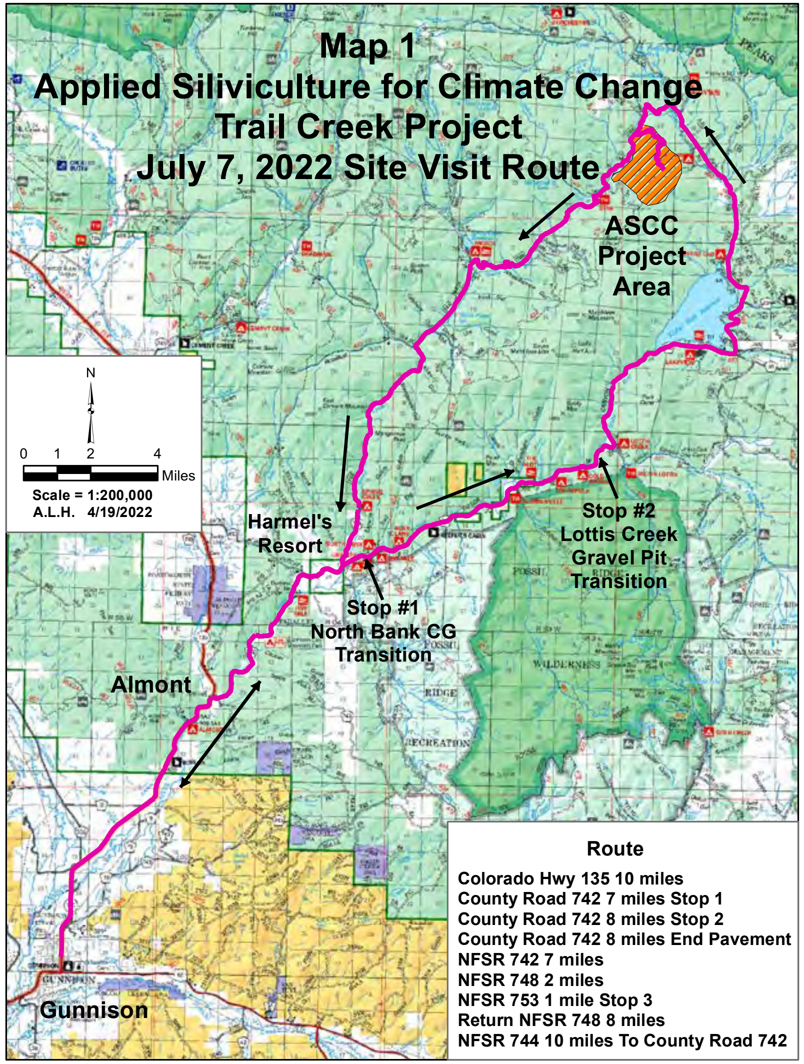
- Focus on what matters
- Contribute your thinking and experience
- Listen to understand
- Connect ideas
- Listen together for patterns, insights and deeper questions
- Honor everyone’s time
- Equal airtime - all participate, no one dominate
- Be present - mentally and physically

Breakout Groups

Group 1	Group 2	Group 3
Mike Battaglia - Facilitator	Maddy Baroli - Facilitator	Kirsten Martin - Facilitator
Carlyn Perovich	Art Haines	Michael Salazar
Camryn Uetz	Tobias Nickel	Jonathan Coop
Matt Vasquez	Gina Rone	Dave Carr
Micah Russell	Pam King	Lance Asherin
Amy Lockner	Mike Tarantino	George Sibley
Matt Reed	Tim Kyllo	Lauren Parker
Ken Williams	Amanda Sanchez	Dayle Funka

Workshop Agenda – Day 2, Thursday, July 7

- **8:00 Meet at Western and Caravan to Taylor Park for ASCC Site Field Visit**
- **8:30 Stop 1: North Bank (Ponderosa Pine example)**
- **9:30 Stop 2: Lower Taylor Canyon Lottis Creek Gravel Pit**
- **11:00 Stop 3: Arrive at Taylor Park ASCC Site (By RAWs Station)**
- **12:00 Stop 4: Be at Lunch Spot/Working Lunch – Facilitated Discussion Revisiting Resistance and Resilience**
- *Bring your own sack lunch*
- **1:00 Develop DFC for Transition in Large Group**
- **1:30 Develop Objectives and Tactics for Transition Treatments in Breakout Groups**
- **2:00 Report Out on Transition & Group Discussion**
- **3:15 Head back to Gunnison**



Adaptive Silviculture for Climate Change

Designing Forest Adaptation Treatments Across Taylor Park Through Manager-Scientist Partnerships

Adaptive Silviculture for Climate Change (ASCC)
Taylor Park ASCC Workshop

July 6, 7, & 8, 2022

FOREST AND RANGELAND STEWARDSHIP
COLORADO STATE UNIVERSITY

NIACS
Northern Institute of Applied Climate Science

Adaptive Silviculture for Climate Change

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

WESTERN COLORADO UNIVERSITY

Workshop Agenda – Day 3, Friday, July 8

- **8:30** Recap of Previous Two Days
- **8:45** Review Draft Silvicultural Treatments
- **10:15** Break
- **10:30** Next Steps, Evaluations, & Close-Out
  - What research or management questions are you excited about based on the ASCC treatments?
- **11:30** Large Group Adjourn
- **11:30** (*ASCC Site Leads Only*) Identify key implementation and monitoring next steps

https://www.recreation.gov/camping/gateways/1052

https://www.fs.fed.us/database/feis/animals/bird/acge/all.html

What research or management questions are you excited to ask based on the ASCC treatments?

Thank you for your participation! We appreciate your feedback!

ASCC Data Collection and Implementation Timeline

Photo Credit: Tony D'Amato

GUIDING PRINCIPLES

- ASCC is a multi-site project
- ASCC's primary experimental objectives and core study questions apply to every site
  - Some level of standardization is required for basic sampling
- Additional, system-specific or regionally-specific experimental objectives and questions are encouraged at individual sites
  - Some relevant data may be collected to address primary experimental objectives
  - Additional data may be needed to answer secondary questions
- The core study design has some flexibility, but general principles should be maintained across all sites

Core Management Questions

Concept-Driven

- Will adaptation approaches and treatments work in a real-world context to **meet local management goals** and objectives?
- How **feasible** are the treatments silviculturally, as well as in terms of financial, social, or other management constraints?
- How does our **idea of desired future conditions** (DFCs) **change with each treatment type**?
- What does it mean to deliberately create a future-adapted ecosystem, and **why would a manager choose to do this**?
- **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

- Do the treatments create significant changes to forest conditions over time at a particular site, and **how do treatments compare across sites**?
- How do hypothesized treatment responses (DFCs) compare with actual **responses observed in the future**?
- Do these treatments achieve what they were designed for?
- What **criteria** emerge to enable managers to identify which treatments perform best?
- Does one type of treatment (resistance, resilience, transition, or no action) consistently **perform better across all sites**?

Nagel et al. 2017

Key Monitoring Variables across the Network

Key Response Variables to be collected at each ASCC site

	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

Other Suggested Variables for Monitoring:

- Leaf area index (plot center)
- Down woody debris
- Archived soil cores
- Forest floor samples
- Wildlife

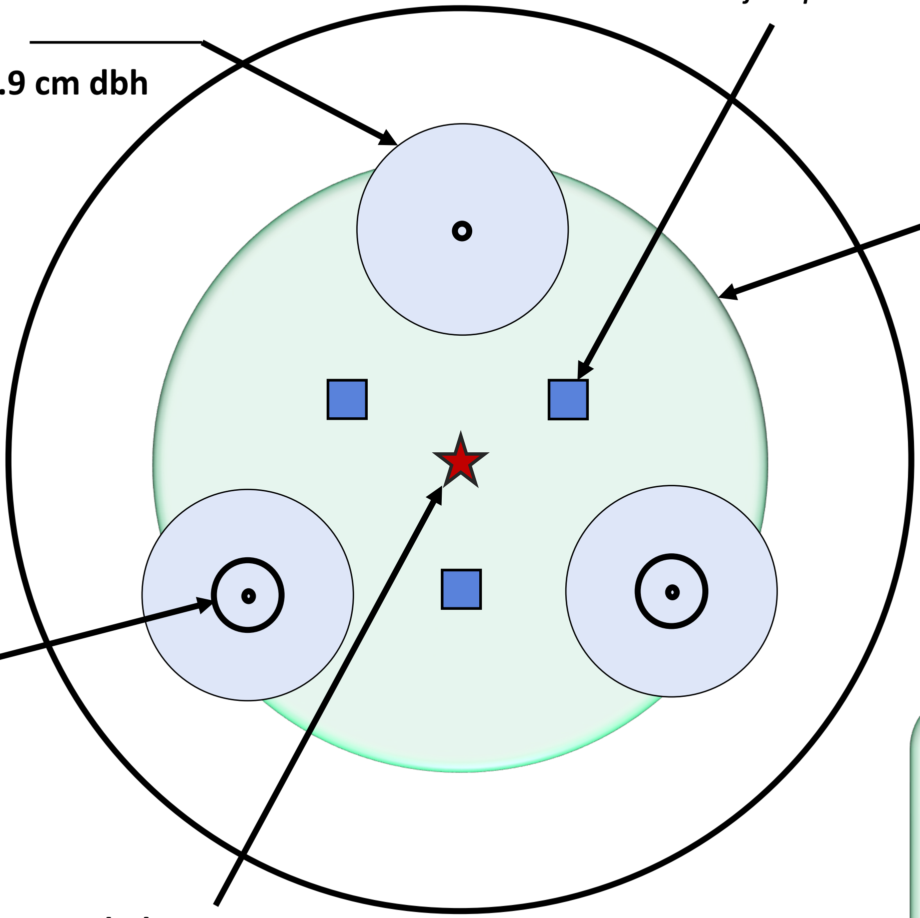
Photo Credit: Chris Woodall

ASCC Plot Design

Small Tree Plot (Adv Regen) (3)
0.004 ha (1/100th ac)
Radius 3.59 m (11.8 ft)
Measuring ≥ 30cm tall to ≤ 8.9 cm dbh
(≥ 1 ft tall to ≤ 3.5 in dbh)
8m from plot center at 0, 120 and 240°

Class I	1 – 4.5 ft in ht
Class II	> 4.5 ft ht – 0.5 in DBH
Class III	0.6 – 1.5 in DBH
Class IV	1.6 – 2.5 in DBH
Class V	2.6 – 3.5 in DBH

Ground Layer Plot (3)
1 m^2
Measuring herbaceous and woody spp
< 30 cm (1 ft) tall
4m from plot center at 60, 180, and 300°



Mid-Tree Plot (Sapling) (1)
0.04 ha (1/10th ac)
Radius 11.34 m / 37.2 ft
Measuring 8.9 to 12.6 cm dbh
(3.5 to 7.4 in dbh)

Annular Plot (1)
0.08 ha (1/5th ac)
Radius 16.1 m / 52.7 ft
Measuring ≥ 12.7 cm / 7.5 in dbh
Species, Ht, DBH, snags + decay class, forest health metrics

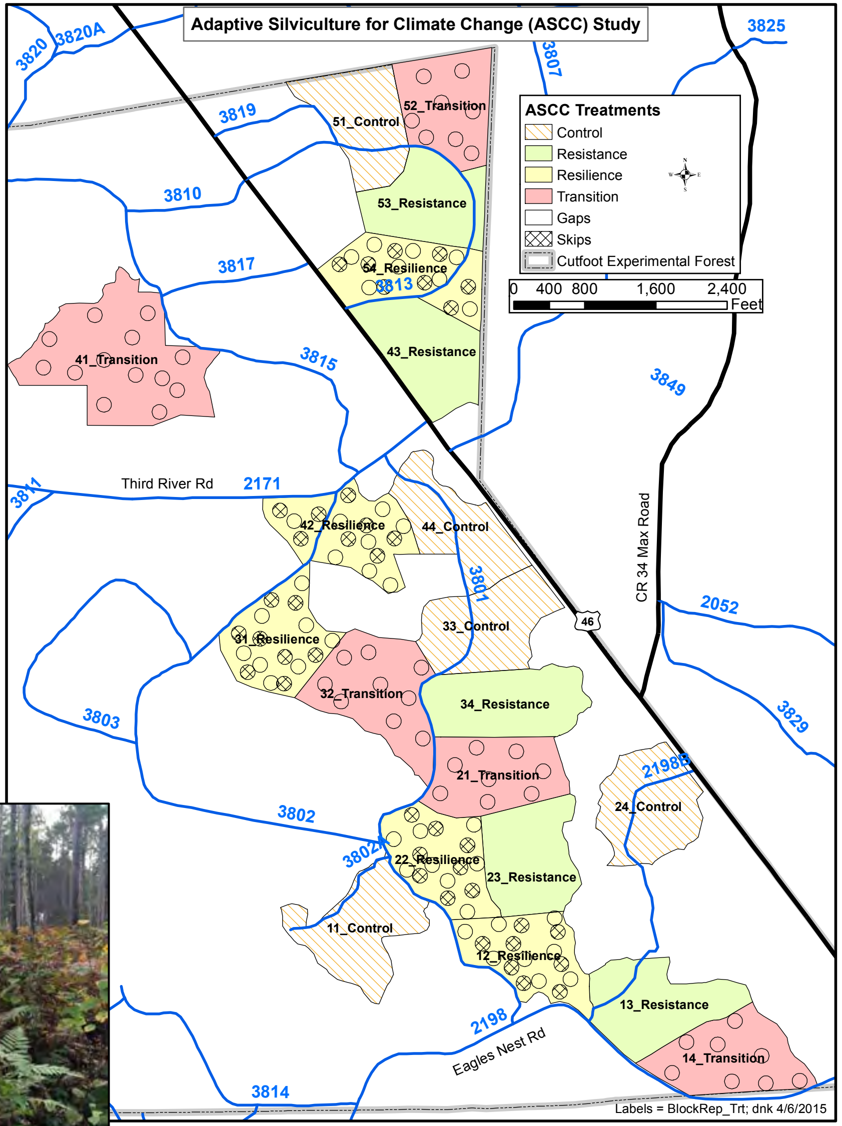
Shrub Plot (2)
5 m^2
Radius 1.26 m (4.13 ft)
Tally by species

LAI and Photos

Key Response Variables Monitored Across All Sites (Overstory and Understory):
- Species composition, density, diversity, etc.
- Forest health (mortality, local indices)
- Productivity (increment, biomass)

Cutfoot Experimental Forest, MN

- 4 treatments
  - ~10 ha each, 202 ha total (500 ac)
- 5 replicated blocks
- 170 vegetation plots
  - No Action and Resistance: 7 each
  - Resilience: 3 gaps, 3 skips, 5 matrix
  - Transition: 3 gaps, 6 matrix
- 40 microclimate plots
- 4 predominant overstory conditions
  - Skips, High residual BA thinned, Low residual BA thinned, Gaps
- 9 species planted (resilience gaps and throughout entire transition treatment)



Measurement Frequency

Variable	ASCC Suggestion	Group Ideas
Overstory Layer	1, 3, 5, 10, 15, 20, etc.	
Sapling Layer	1, 3, 5, 10, 15, 20, etc	
Shrub & Seedling Layers	1, 3, 5, 10, 15, 20, etc	
Ground Layer	1, 2, 3, 5, 10, 15, 20, etc	
Forest Health Indicators	1, 2, 3, 5, 10, 15, 20, etc	
LAI	1, 5, 10, 15, 20, etc	

Note: Times listed indicate post-treatment measurements.
A pre-treatment measurement may also be required for many variables.

ASCC Project Timeline – Key Events

Event	Timeframe
Finalize ASCC treatment details	
Is pre-treatment data needed at this stage?	
Select final treatment locations	
Assign treatments to locations	
Develop formal prescriptions	
Environmental assessments	
Order tree seedlings	
Finalize monitoring details	
Pre-treatment sampling (research focus)	
Implement silvicultural treatments (detail steps)	
Year 1 post-treatment sampling	