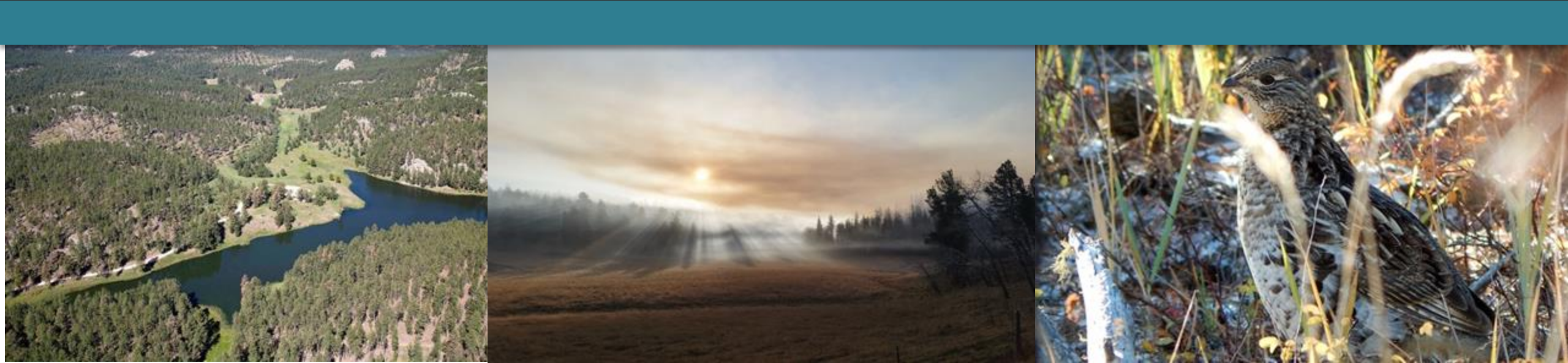


Forest Management Workshop: Managing Today's Forests for Tomorrow's Challenges

March 24, 2026

Outdoor Campus – Rapid City South Dakota Game, Fish, and Parks

8:00 AM – 4:00 PM



Photos: USDA Forest Service, Black Hills National Forest



Climate Hubs
U.S. DEPARTMENT OF AGRICULTURE



United States
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Agriculture

Natural Resources Conservation Service



Workshop Goals

- Consider climate change impacts and vulnerabilities specific to dry-mixed conifer forests in the Black Hills, and how those might affect the ability to meet project goals and objectives
- Identify actionable silvicultural strategies that increase resilience to expected future environmental shifts within Black Hills forests while meeting goals and objectives
- Explore silvicultural tactics across the resistance-resilience-transition adaptation spectrum
- Discuss how to monitor adaptation actions for success



Workshop Guidelines

- Focus on what matters
- Contribute your thinking and experience
- Listen to understand and connect ideas
- Honor everyone's time
- Equal airtime - all participate, no one dominate
- Be present - mentally and physically



Agenda for Today

- Morning:
 - Introductions
 - Current Conditions, Management Goals and Objectives
 - Climate Change Impacts
 - Adaptation Strategies and Approaches
 - Metrics for Monitoring and Evaluating Effectiveness
- 12:15: Lunch on your own
- Afternoon:
 - Developing Adaptation Actions for Forests - Create three prescriptions: to resist change, build resilience, and facilitate a transition to another forest type
 - Poster Presentations
 - Group Synthesis of Adaptation Treatments
 - Next Steps
 - Adjourn by 4:00 PM



Credit: Matt Stefanich, Black Hills National Forest

Introductions

- Name
- Position
- Location
- One thing hoping to get out of the workshop
- Your favorite thing about forests



Hello
my name is



Northern Institute of Applied Climate Science

The Northern Institute of Applied Climate Science (NIACS) develops synthesis products, fosters communication, pursues science, and provides technical assistance in climate change adaptation and carbon management.

Climate Change Adaptation

Forest Carbon Management

NIACS is a collaborative, multi-institutional partnership led by the USDA Forest Service and comprised of federal, forest sector, conservation, higher education, and tribal organizations.



USDA Northern Forests Climate Hub



Mission: To develop and deliver science-based, region-specific information and technologies, with USDA agencies and partners, to agricultural and natural resource managers that enable climate-informed decision-making, and to provide access to assistance to implement those decisions.

The Northern Forests Climate Hub provides additional capacity to two USDA Regional Climate Hubs the **Northeast and Midwest Hubs**—and works within their broader scope and organization.

The Northern Institute of Applied Climate Science is a multi-organizational collaborative led by the USDA Forest Service that provides additional capacity to the USDA Northern Forests Climate Hub.

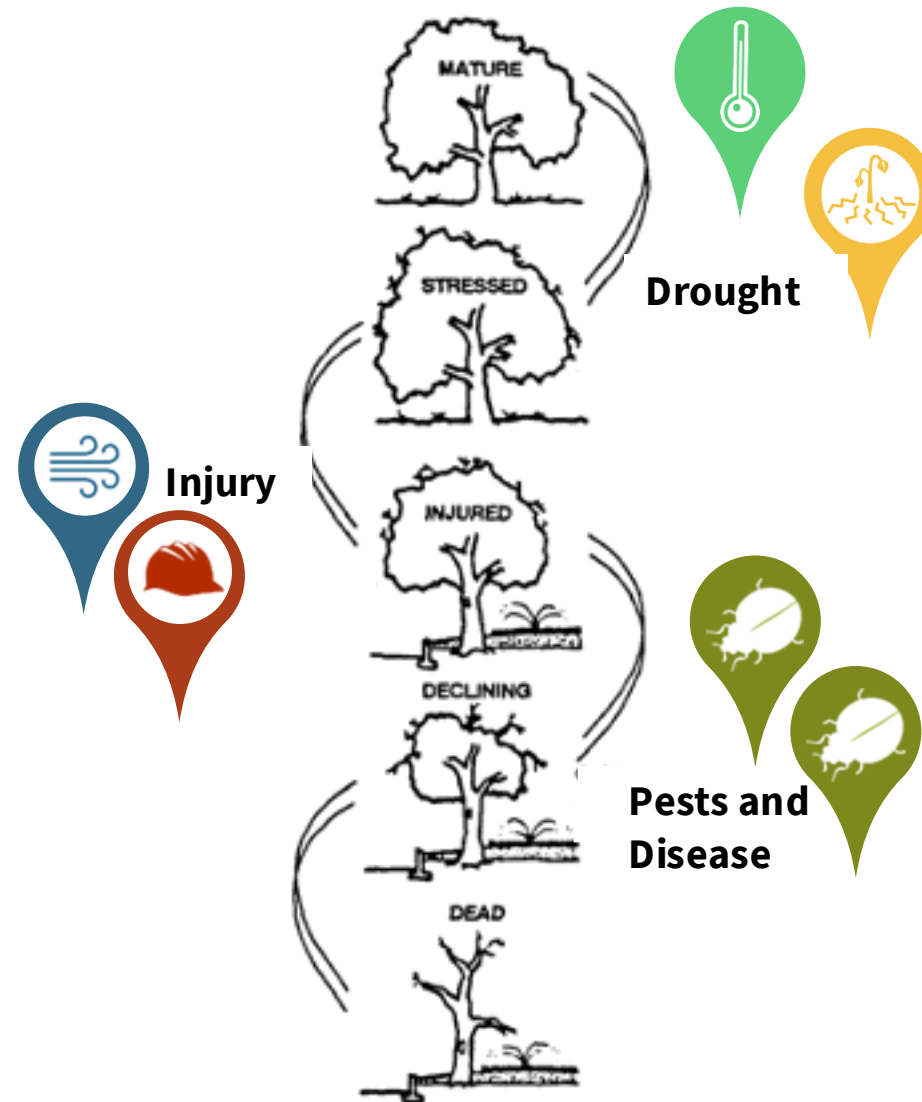
Why We Are Here Today

- ⑩ Forests provide essential ecosystem services, including spiritual and material benefits
- ⑩ Global change is creating increasingly dynamic, uncertain futures with shifting disturbance regimes and climate conditions



A Changing Climate Poses Risks to Forest Ecosystems (and the Carbon they Sequester)

- Altered climate
- Extreme weather
- Chronic stress
- Disturbances
- Insect pests
- Forest diseases
- Invasive species
- Altered habitat suitability



Adaptation: Our Approach

Starts with your existing work!

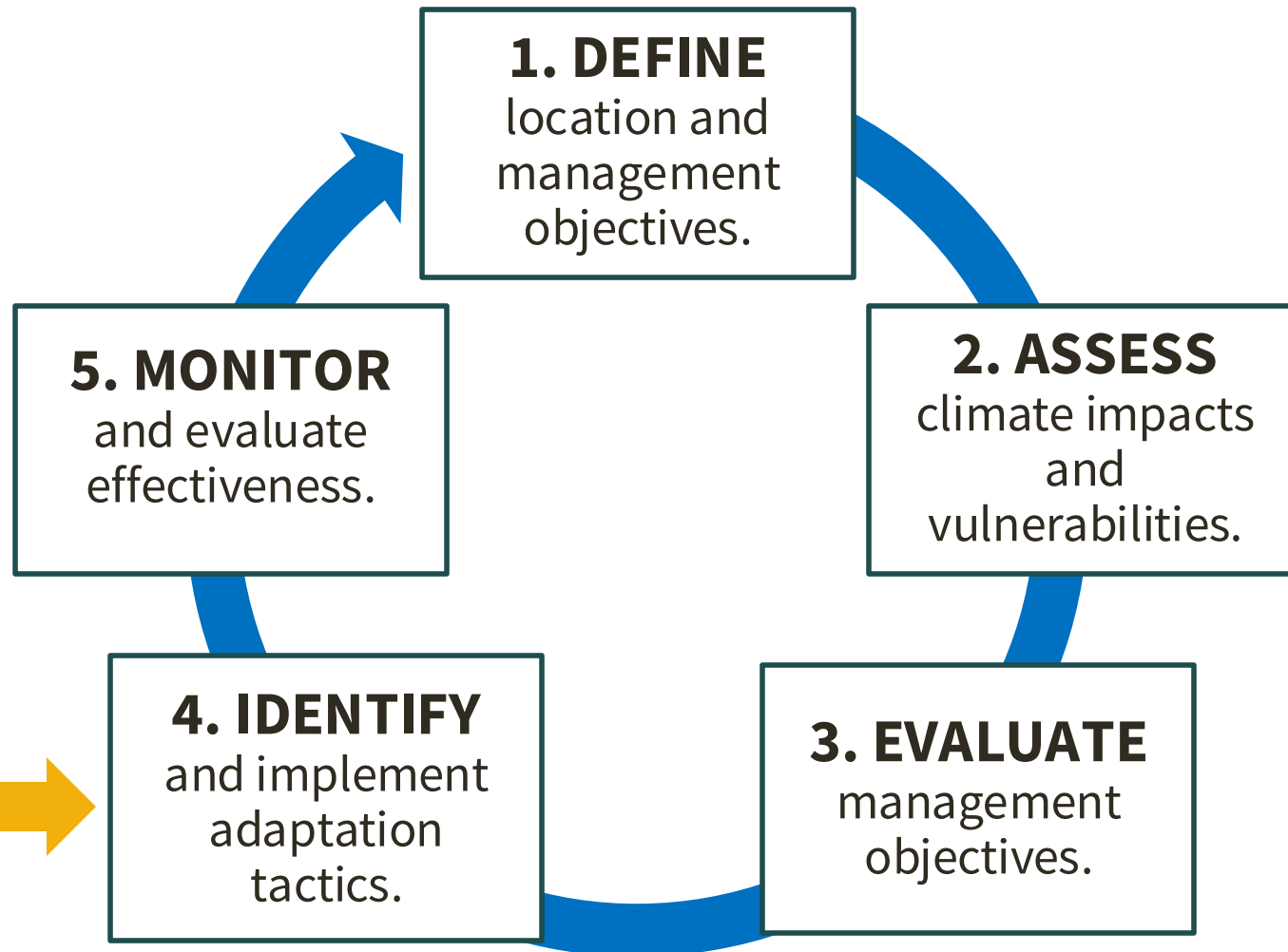
- Help you achieve your goals
- Put projects through a 'climate change filter'
- Make projects more robust by intentionally integrating climate into what you're already doing



Adaptation Workbook



Adaptation Strategies and Approaches



Vulnerability assessments, scientific literature, TEK, etc.



Intentionality

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





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Black Hills Pine Forest Ecology

Laura Bosworth

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Disturbance Regimes



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Role of Wildfire

- Historically, fire was a keystone ecological process that shaped the composition and structure of plant communities in the Black Hills.
 - Thinned out undergrowth
 - Created open spaces for new seedlings to establish
 - Prevented the forest from becoming too dense
- Less frequent but highly variable fire. When large crown fires did occur, they probably did not completely consume all trees within a landscape but left sources of seed for the eventual recolonization of the burned areas.



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Northern Hills vs Southern Hills

- Historical surface fire frequency was higher in the southern portion compared to the northern and central portions due to annual precipitation increasing from south to north.
 - 10 to 15 years in the southern Black Hills, to 30 to 33 years in the central and northern hills.
- Less frequent fire in the northern hills with a mixed severity dynamic of surface fire and group or patch torching.
 - Mixed-severity, with both surface and crown fires being important components of the ecosystem.
 - Evidence of a crown fire component in this system.
- Unlike other ponderosa pine forests, long fire-free periods were historically common in the hills.
 - This led to higher TPA compared to other pine systems.



Mountain Pine Bark Beetle



- The mountain pine beetle is a native insect that plays a significant role in the natural disturbance regime in the Black Hills
- Periodic mountain pine beetle outbreaks influence both forest structure and growth.
 - Thinned out the stand, improving growth rates of trees adjacent to beetle-killed trees.
 - Reduced competition for light, water, and nutrients.
 - Regeneration occurred in canopy gaps created by beetle killed trees.
- Epidemics typically had an 11 to 20 year cycle with an outbreak lasting from 2 to 14 years.



Wind

- Wind damage can range from a single tree to thousands of acres.
- Historical accounts of wind damage in the Black Hills indicate that tornados and derechos can cause severe damage.
 - August 4, 1953: An F1 tornado occurred in Spearfish
 - June 18, 1967: A tornado touched down west of Mount Rushmore.
 - July 23, 1966: A large tornado touched down near Sheridan Lake
- Tornadoes are most likely to occur in June and July, and typically in the afternoon and early evening.



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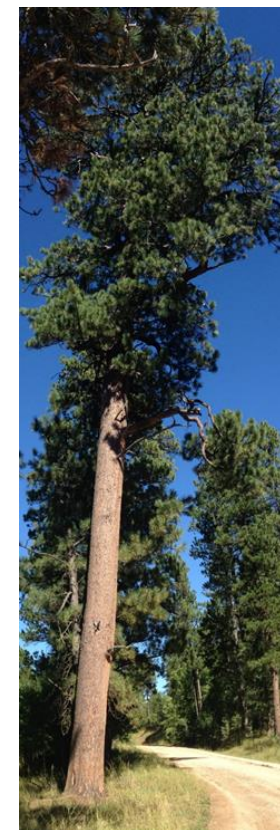
Distribution Patterns



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Groups of mature trees die, often due to bark beetle attack.



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Fire prepares a mineral soil seed bed.



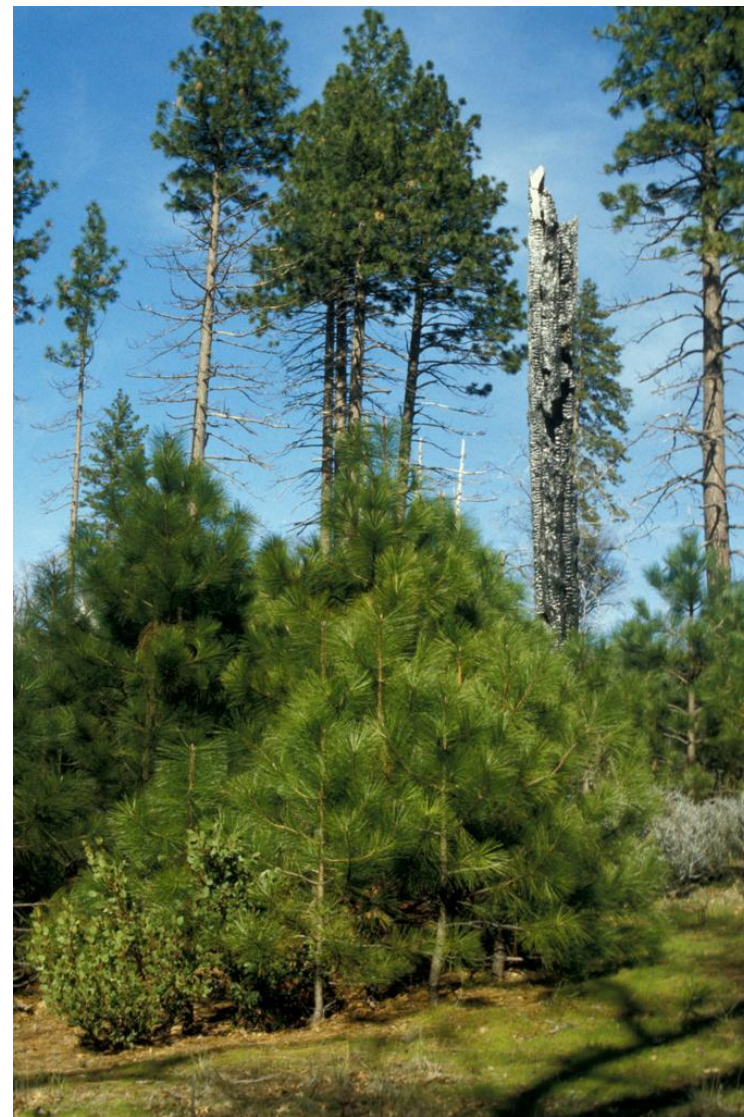
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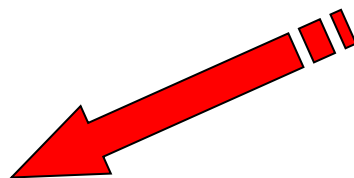
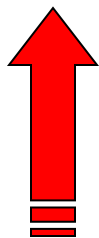




**Fire Creates
a fuel bed for
regeneration**



Low intensity fire **removes most saplings, leaving
stands dominated by large pines.**



**Low surface fuel load
initially protects seedlings.**

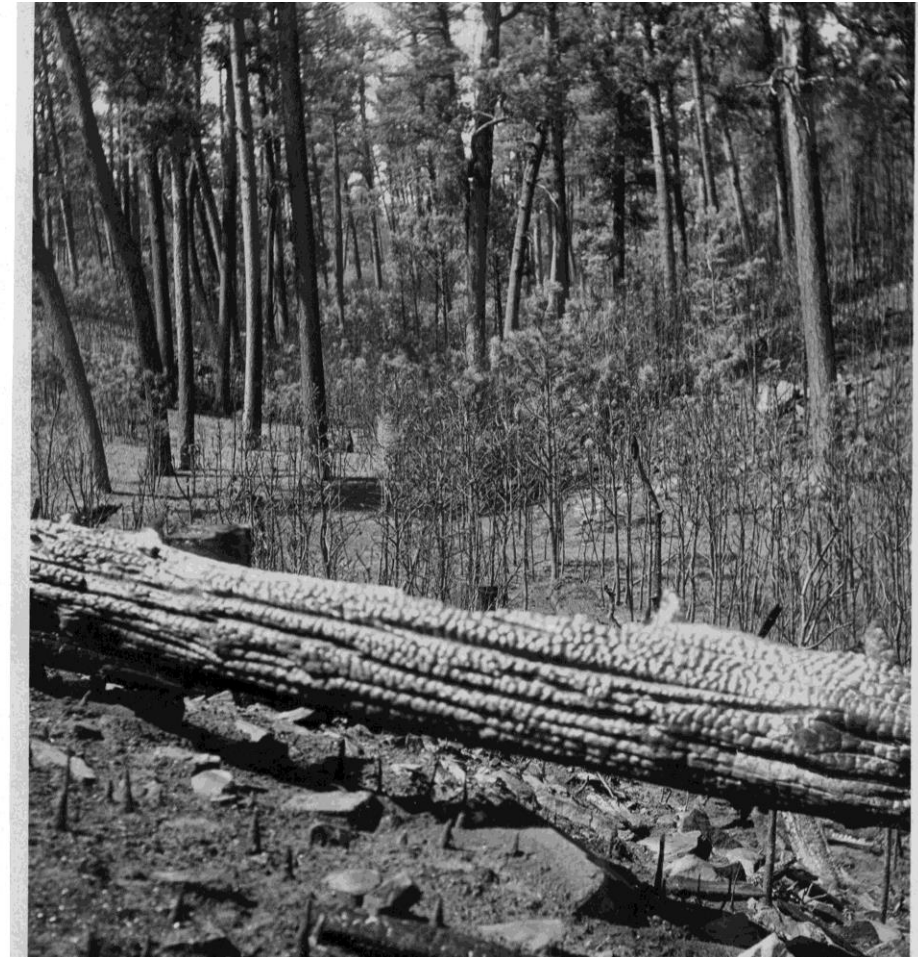
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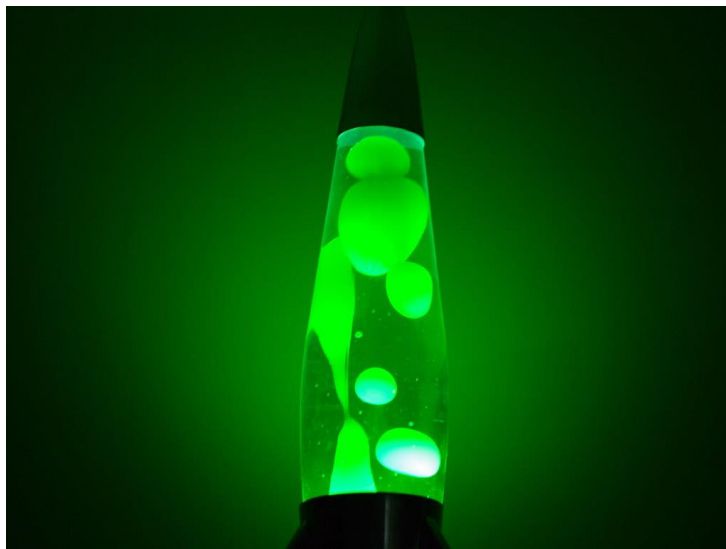
Remnant Structure

- Snags, coarse woody debris and large diameter old trees.
 - Constant presence on the landscape
- Provide key ecological functions
 - Recycle Nutrients
 - Retain Moisture
 - Provide Habitat
 - Support New Growth
 - Wildlife Food Source
 - Nesting & Roosting
 - Perches



Spatial Pattern

- The result was a mosaic of conditions ranging from openings to groups of young seedlings to clumps and groups of older trees, including large orange-barked relics.
- Trees amounts and sizes may stay steady in time but move throughout the landscape driven by fire and bugs.
- Change in the arrangement of patch, individuals, and openings but all elements ever present.



Picture: Andrew Larson University of Montana

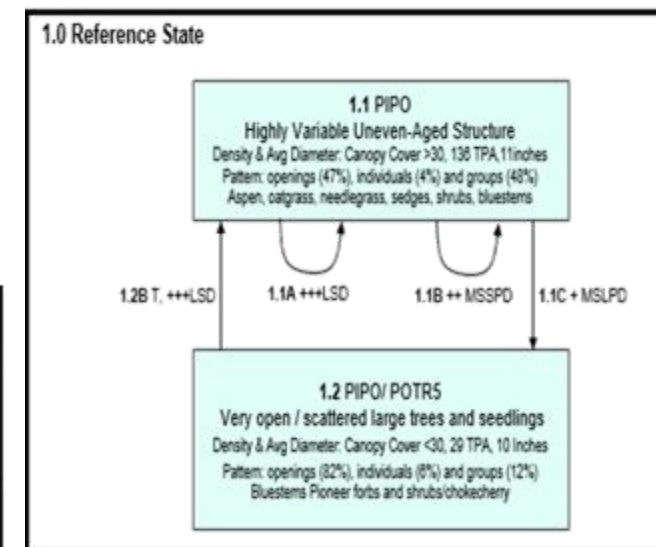
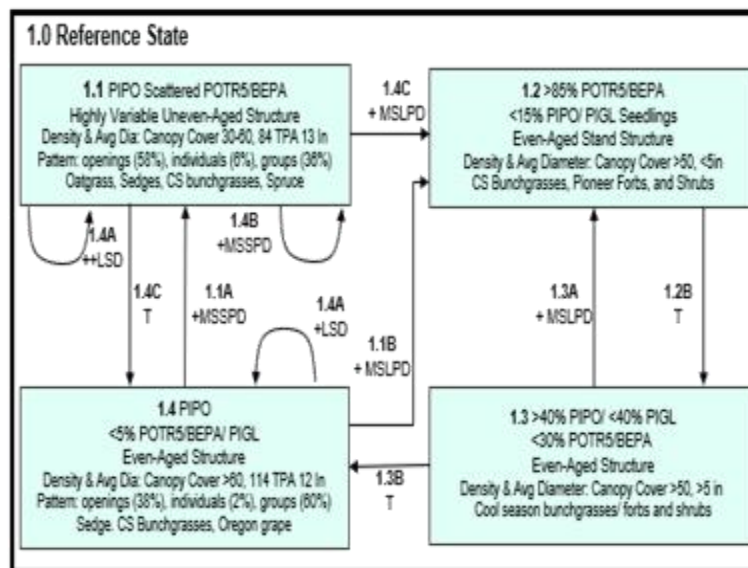
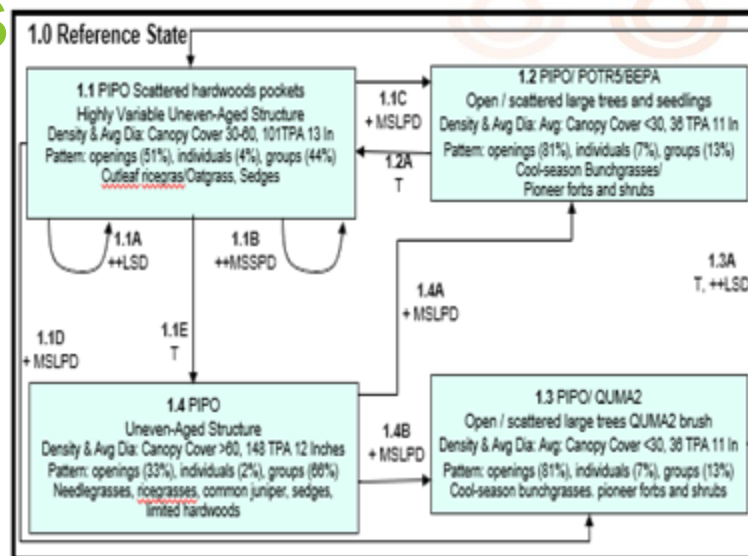
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Long Term Dynamics

- Reference state has multiple communities.
- Transitions in the form of time or disturbances can move an ecosystem from one community to another and back.
- There is a generally stable community where the system is in the longest, but it moves with absence of disturbance or larger disturbances.
- Community transitions are similar to the process of moving from an early seral state to a climax state.





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Changes in Structure



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Fire Suppression and More

- Fire suppression and exclusion were large drivers of changing structure.
 - Current fire-free periods are longer than the longest fire-free periods found in fire history studies.
 - Frequent surface fires maintained the ecotone between forest and grasslands by killing ponderosa pine seedlings and saplings before they could become established.
 - Early explorers accounted large tree-free areas, fewer of these areas exist today.
- Over grazing from sheep and cattle in the mid – late 1800s
- Much of the Black Hills was repeatedly logged during the 20th century.
 - As a result, old-growth forests are almost completely removed from the landscape
- Land use changes to more urban
- Today, the Black Hills are predominantly managed with an even-aged shelterwood silvicultural system













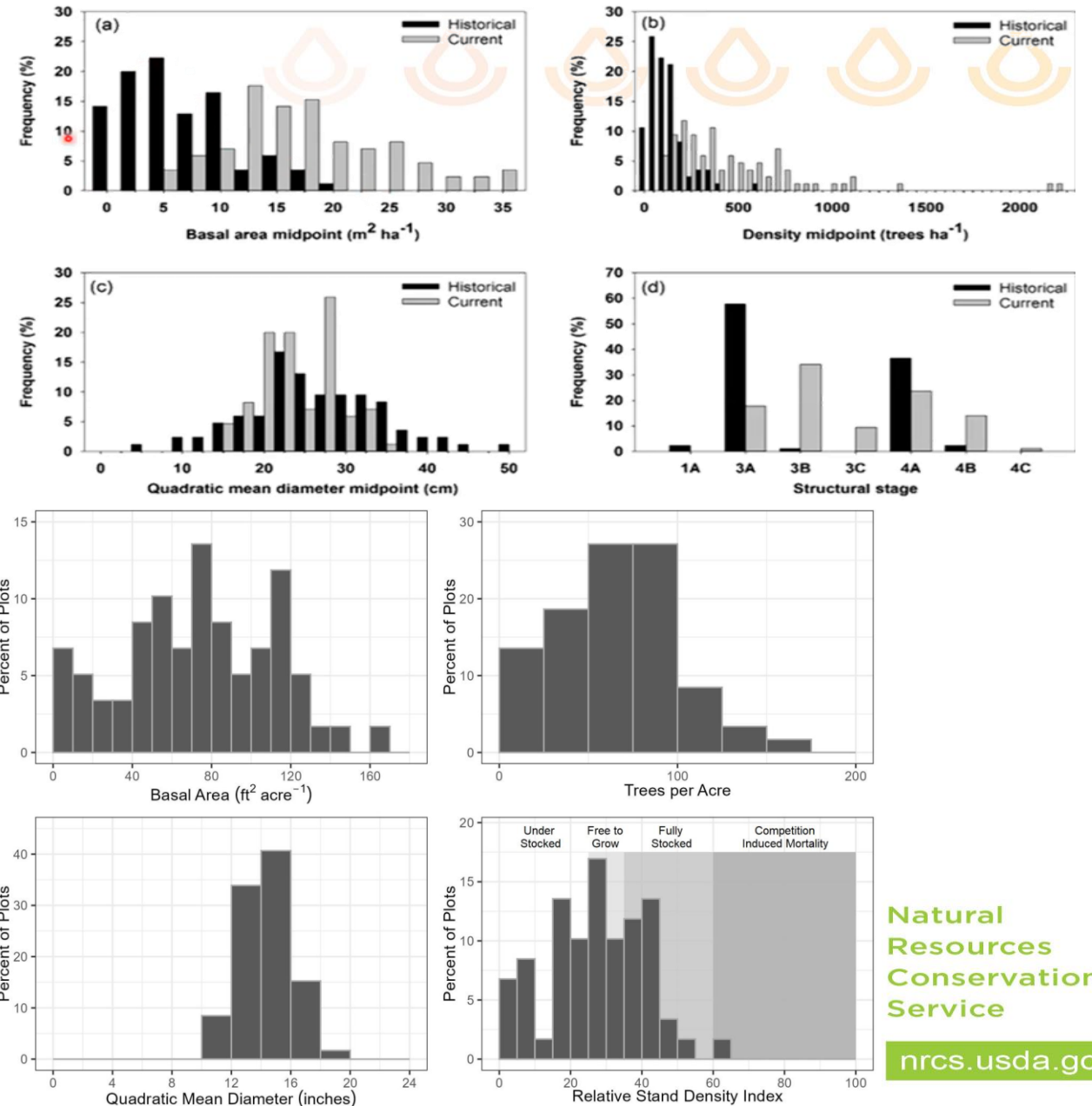






Current Structure

- Pockets of trees have grown together eliminating gaps
 - Historically low tree density are now very dense stands
- Simplification of structure too many middle-aged trees compared to historic.
- Current forest contains about the same basal area on average as the historic forest. The difference is that the historic forest was dominated by fewer, but much larger trees.
 - Evidence to suggest that current average tree size is lower than historical levels.
- Increased tree density leading to fewer gaps and more even spacing and size distributions within groups



Grasslands

- **Rangeland soils (Mollisols)**
 - Develop under grass and do not have an E horizon
 - Can be 2-3 times more productive than forested soils
- **Rangeland plant communities in the Black Hills range widely**
 - Mixed Grass Prairies (e.g., western wheatgrass and green needlegrass)
 - Black Hills Montane Grasslands. (e.g., cool-season bunchgrasses/dropseeds and shrubs)
- **Black Hills rangelands are shaped by fire, grazing, invasive species, and drought**
 - Loss of deep-rooted perennials are occurring through lack of fire and grazing pressure
 - Loss of soil structure and increases erosion risk, allows for encroachment and invasive species to increase
 - Encroachment of conifers and invasive grass species alters soil moisture distribution and nutrient cycling, and reduce forage production for grazing



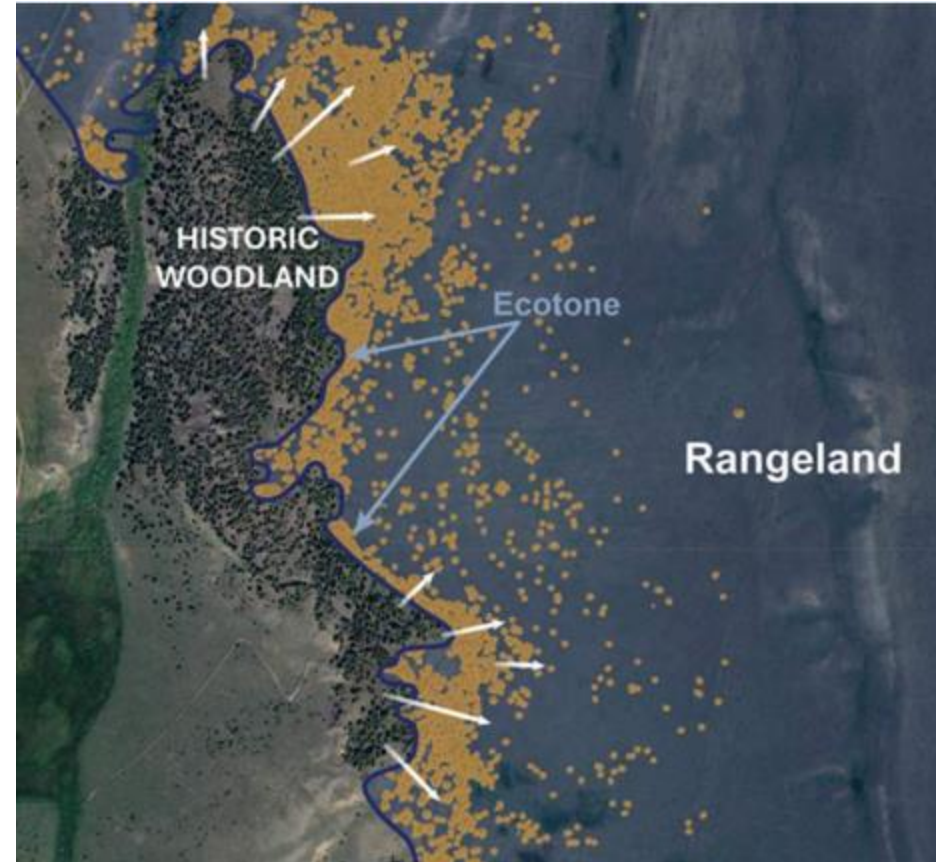
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Rangelands outside of the Black Hills

- South Dakota experiences encroachment of pine and spruce into meadows in the Black Hills and Eastern Red Cedar on the prairie
- Conifer encroachment is a leading cause of rangeland loss
- The proximity of rangelands to conifer seed sources is the best predictor of encroachment risk.
- The most efficient approach is to reduce vulnerability by defending intact core rangelands.
- Collaborative landscape-scale efforts greatly increase capacity, reduce costs, and improve outcomes compared to isolated actions



Over time, conifers can spread outward from historic woodlands into open rangelands (orange dots show location of encroaching trees). The transition area where woodland and open rangeland meet, is referred to as the ecotone. Credit Shea Coons

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Source: Reducing Conifer Encroachment in Western Rangelands Northwestern Plains, Middle Rockies, Northern Glaciated Plains, and Wyoming Basin- Pocket Guide





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Question?

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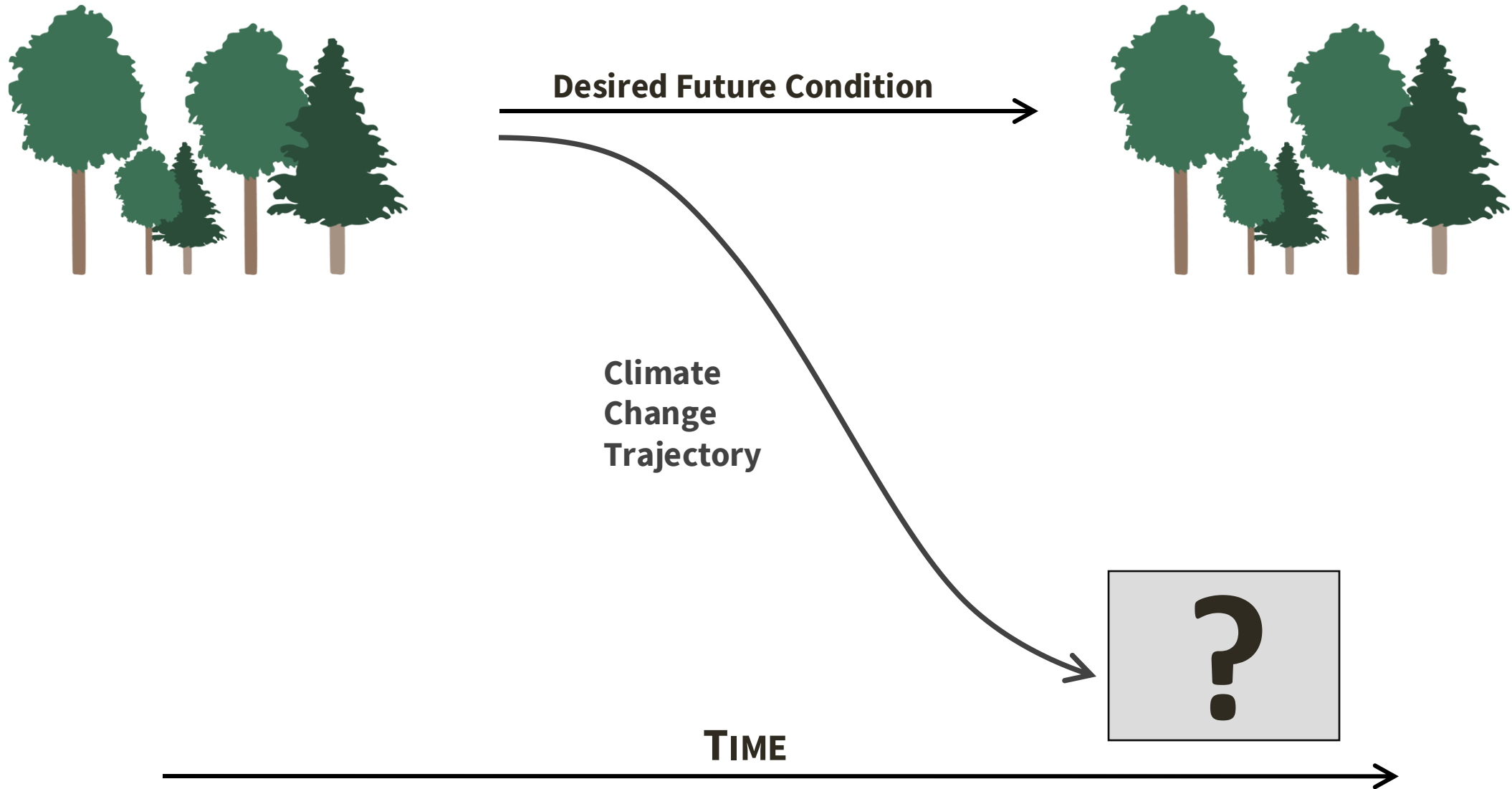
Adaptation - the adjustment of systems in response to climate change.

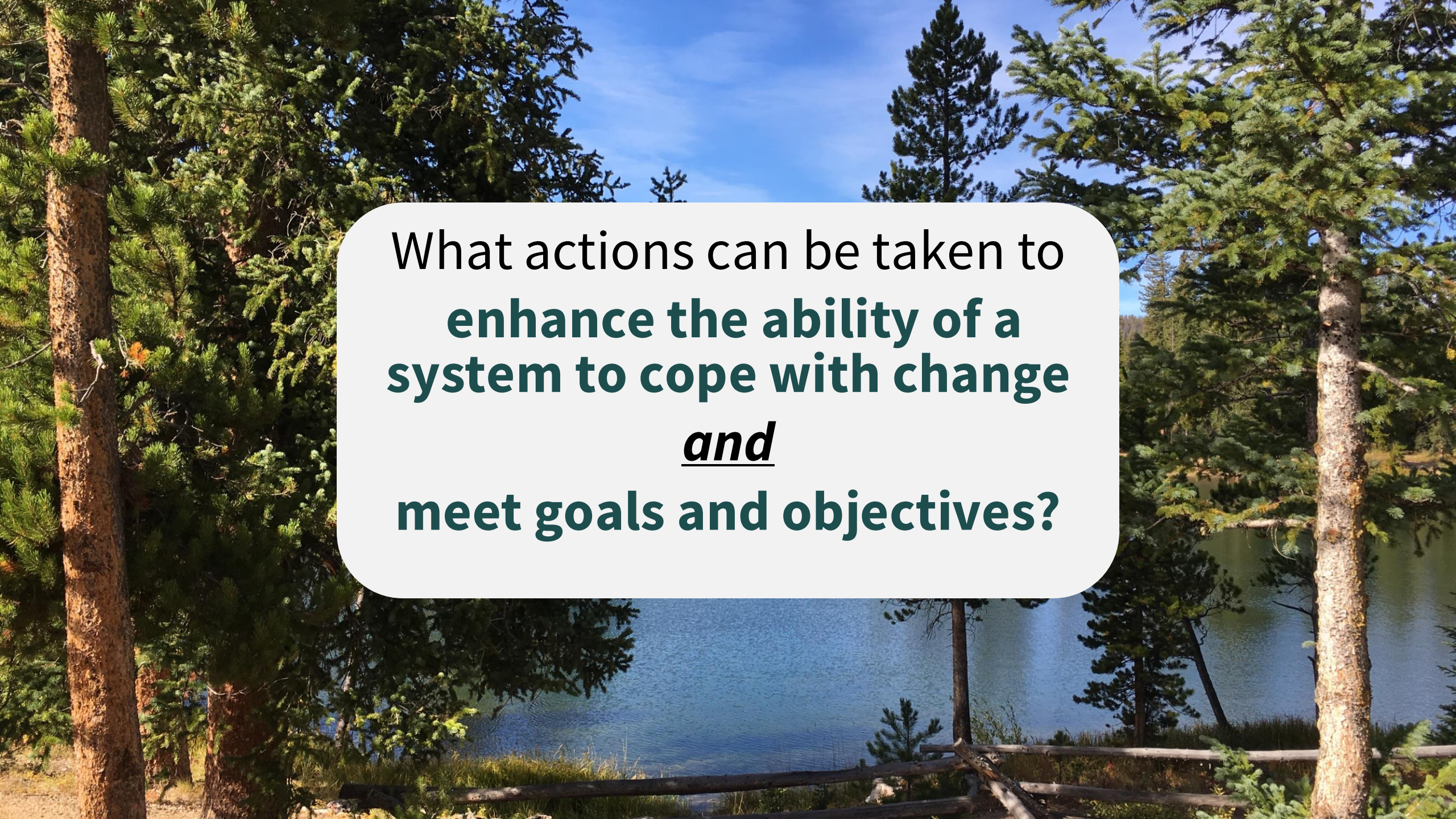


Ecosystem-based adaptation activities build on sustainable management, conservation, and restoration.

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

Climate-Driven Changes

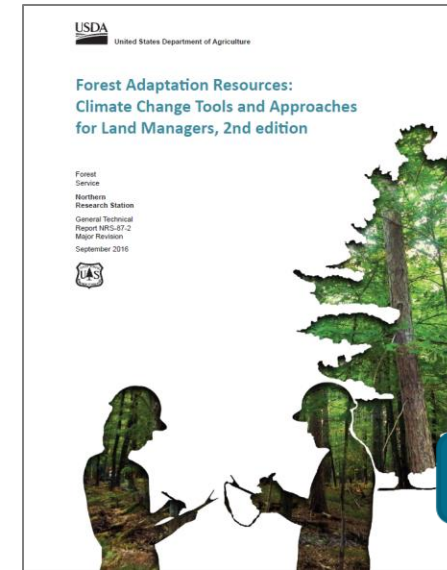




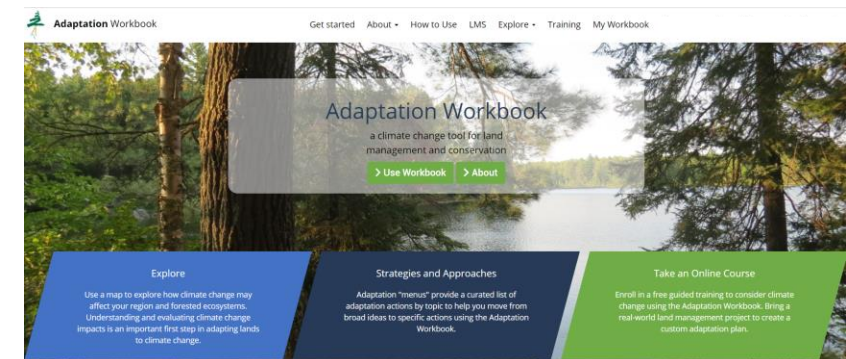
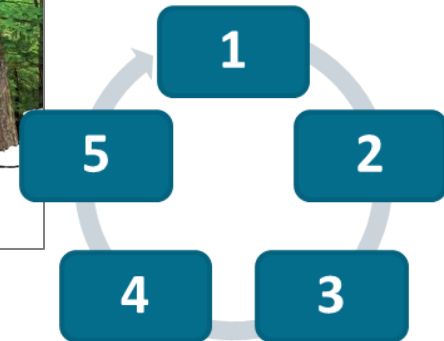
What actions can be taken to
**enhance the ability of a
system to cope with change
and
meet goals and objectives?**

Climate Adaptation Workbook and Adaptation Resources

- Flexible workbook designed for a variety of land owners with diverse goals
- Works at project-level
- Centers around manager's expertise, and judgement
- Adaptation resources and **menus of possible actions** to help you create **clear rationale** for your actions by connecting them to **broader adaptation ideas**
- **Does not make recommendations**



Swanston et al.
2016 (2nd edition)

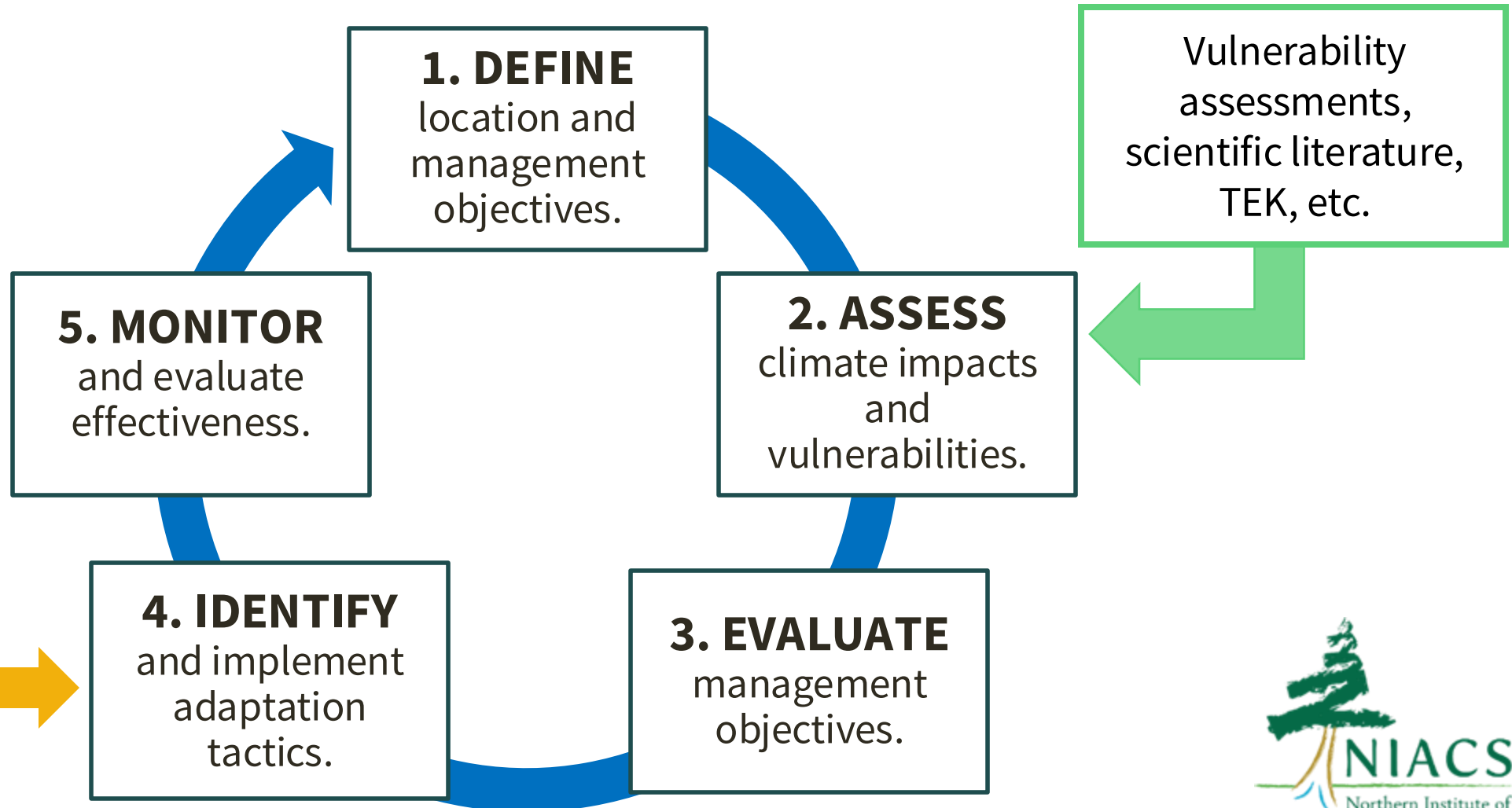


Download at: <https://research.fs.usda.gov/treesearch/52760> or use online at www.AdaptationWorkbook.org

Adaptation Workbook



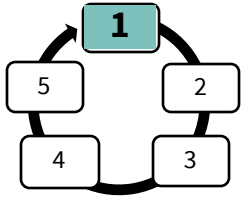
Adaptation Strategies and Approaches



Adaptation Workbook = Climate Change Filter



Use the Adaptation Workbook to ensure ALL of your goals and objectives are robust to climate change impacts.



Step 1: DEFINE location, project, and time frames.

1. Where are you working?
2. What are the current site conditions?
3. What are your management goals and objectives for this area?



Photo: Dixie National Forest, USDA Forest Service

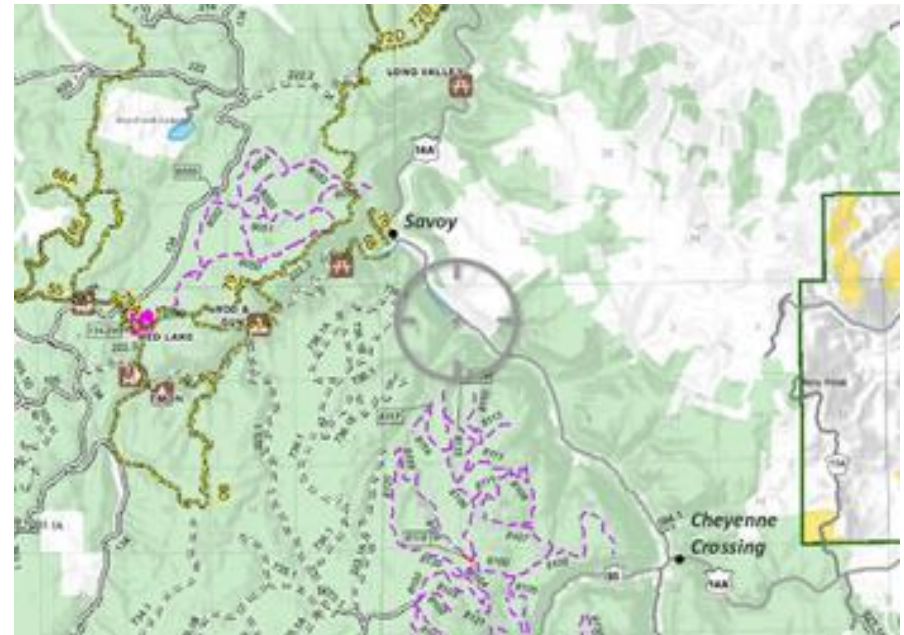


Photo: Black Hills National Forest, USDA Forest Service

Defining Goals

Goals: Big picture - What you want/ What you're trying to do

Management goals are broad, general statements, usually not quantifiable, that express a desired state or process to be achieved.

Objectives: More detailed description of how you're going to achieve your goals

Objectives are concise, measurable statements that form the basis for further planning to achieve the identified goals.

Examples

Goal: Maintain fire in fire-adapted ecosystems

Objective: Implement a prescribed burn every 15 years to reduce stand competition and remove ladder fuels

Goal: Improve visitor safety and experience

Objective: Reduce visual, line-of-sight barriers, especially along Highway 87

Breakout Group Assignments

Battle Creek	Friendshuh Game Production	Greyhound Fire Restoration	Rankin Ridge Grassland Restoration	Boxedler Creek
Stuart Adrian	David Mallett	Lee Imrey	Ian Torrence	Mike Ray
Scott Adrian	Kylie Hammett	Shamla Imrey	Jessica Sunderland	Jamie Dedic
Mike Beck	Karen Meston	Ken Kuhle	Nina Steinmetz	Scott Guffey
Lilly DeLange	Jerry Brammer	Kat Rowe	Nina Wajrowski	Laura Bosworth
Sterling Smith	Rayma Daigle	Harrison Brookes	Mike Baldwin	Robert Burns
Doak Nickerson	Dick Terry	Ian Lilya	Mary Zimmerman	Gabe Dirksen

Short Project Summaries

In 2 minutes, please share a little bit about the current conditions of your project area and your overarching management goals

Battle Creek



Friendshuh
Game
Production



Greyhound
Fire
Restoration



Rankin
Ridge



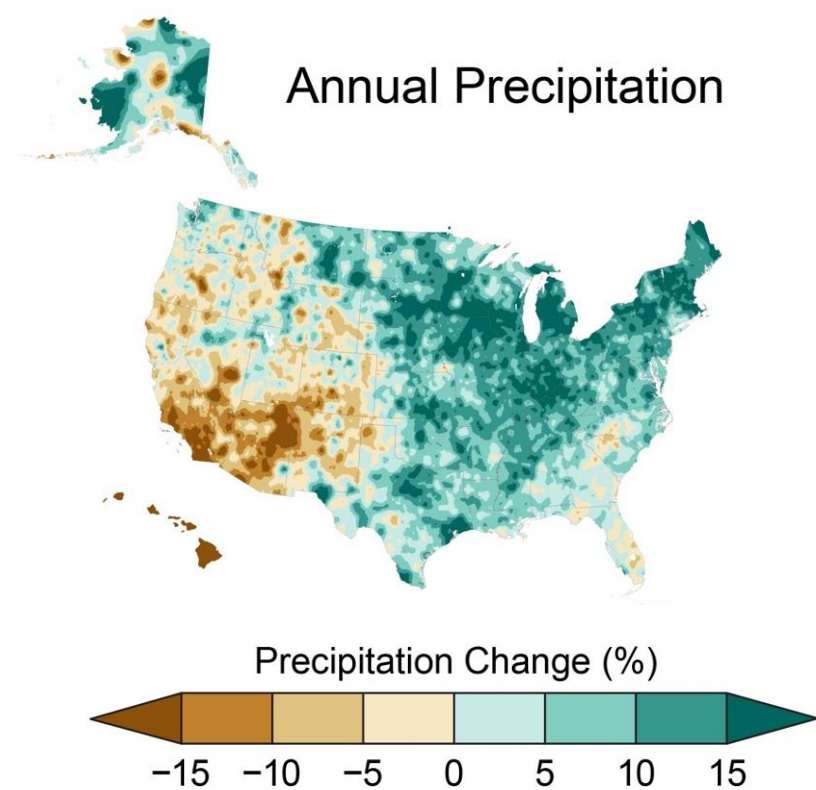
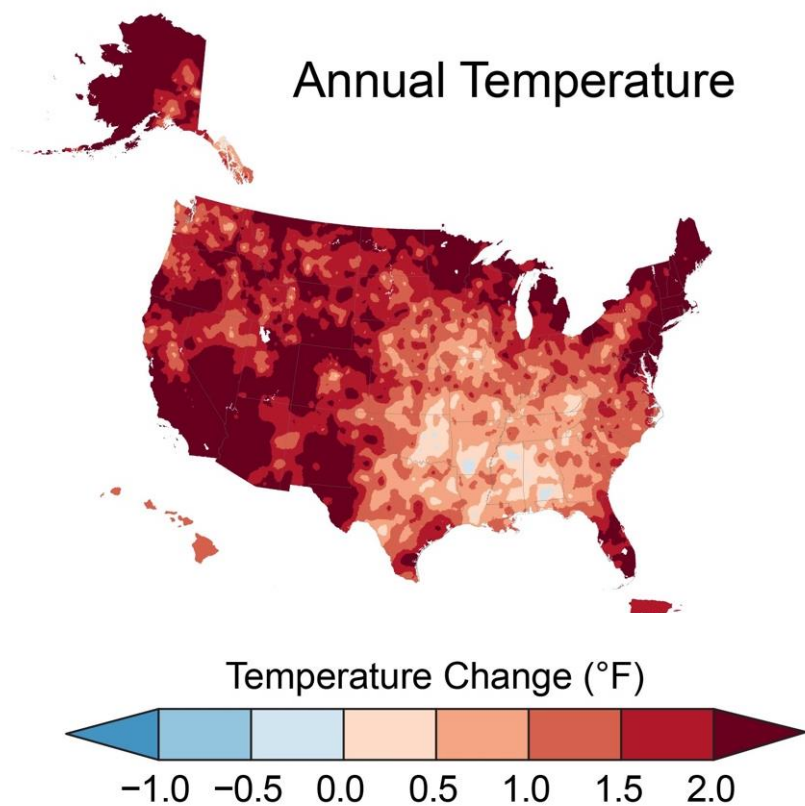
Boxelder
Creek



Break (15 min)

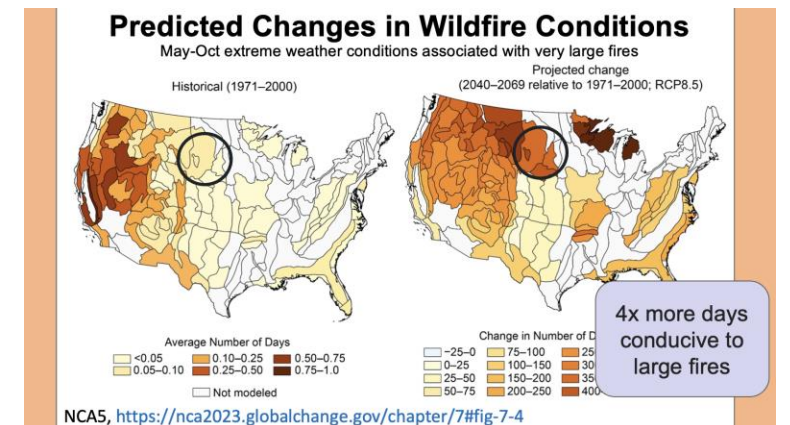
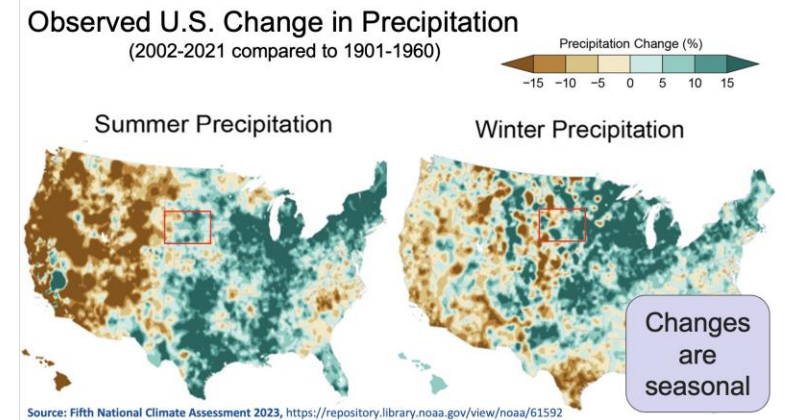


Identify Anticipated Future Stressors and Shifts in Dry-Mixed Conifer Forests



Key Messages from Hannah & Callie

- Temperature, precipitation (especially in winter and spring), and large storms are projected to rise
 - 24% increase in the heaviest rain events (2" or greater)
- Hail events are projected to increase and cause higher damage
 - Hail stones could increase about ¼ cm in size (e.g. penny to nickel or ping pong to golfball)
- 4x more days conducive to large wildfire events
- Increases in wind speed
- Increases in frost-free season length (15 days longer in Custer County)
- GrassCast – changes in annual net primary production
- Spiral of Silence – people are concerned about climate change, but we are not talking about it



Key Messages from Katie's Presentation

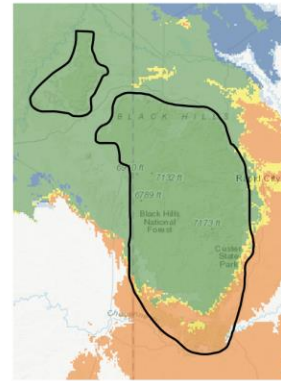
- Black Hills are cool and wet for ponderosa pine regeneration
 - If the climate water deficit reaches 400 mm, this is the point where regeneration will struggle
- Species Potential Habitat Tool shows a contraction of ponderosa pine range by the end of the century
- Vegetation Futures Tool projects a 29% chance of transitioning to another vegetation type, including non-forest (pine woodland to mixedgrass prairie)
- Moving seedlots upslope can increase future survival
 - Consider selecting genetics from 500 ft lower elevations

Species Potential Habitat Tool

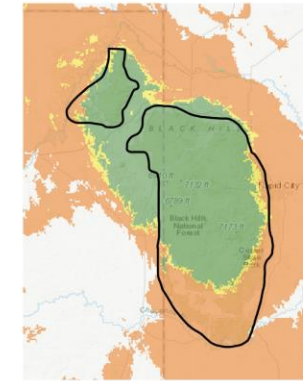
Emissions scenarios: ssp370 (upper-middle) vs ssp585 (upper end)



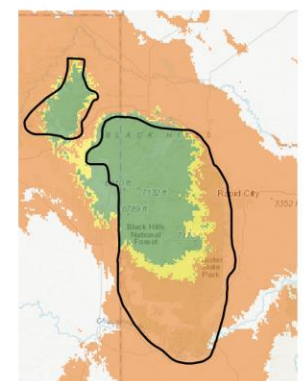
2011-2040



2041-2070



2071-2100



Report for Black Hills NF area

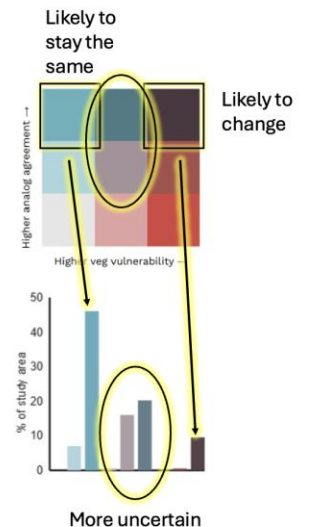
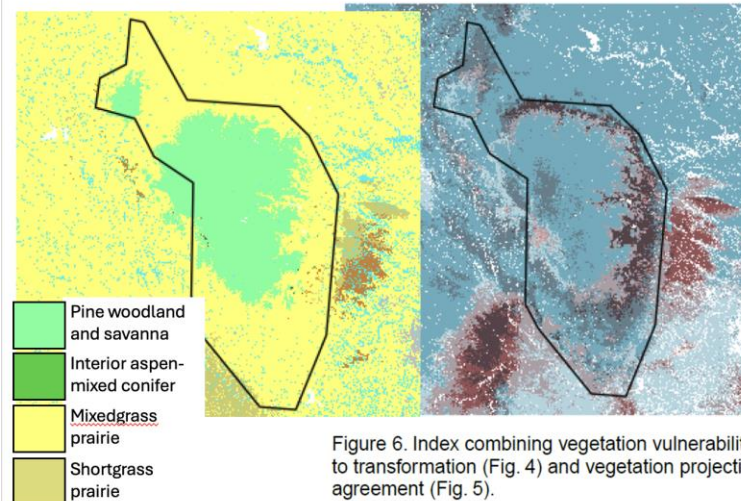
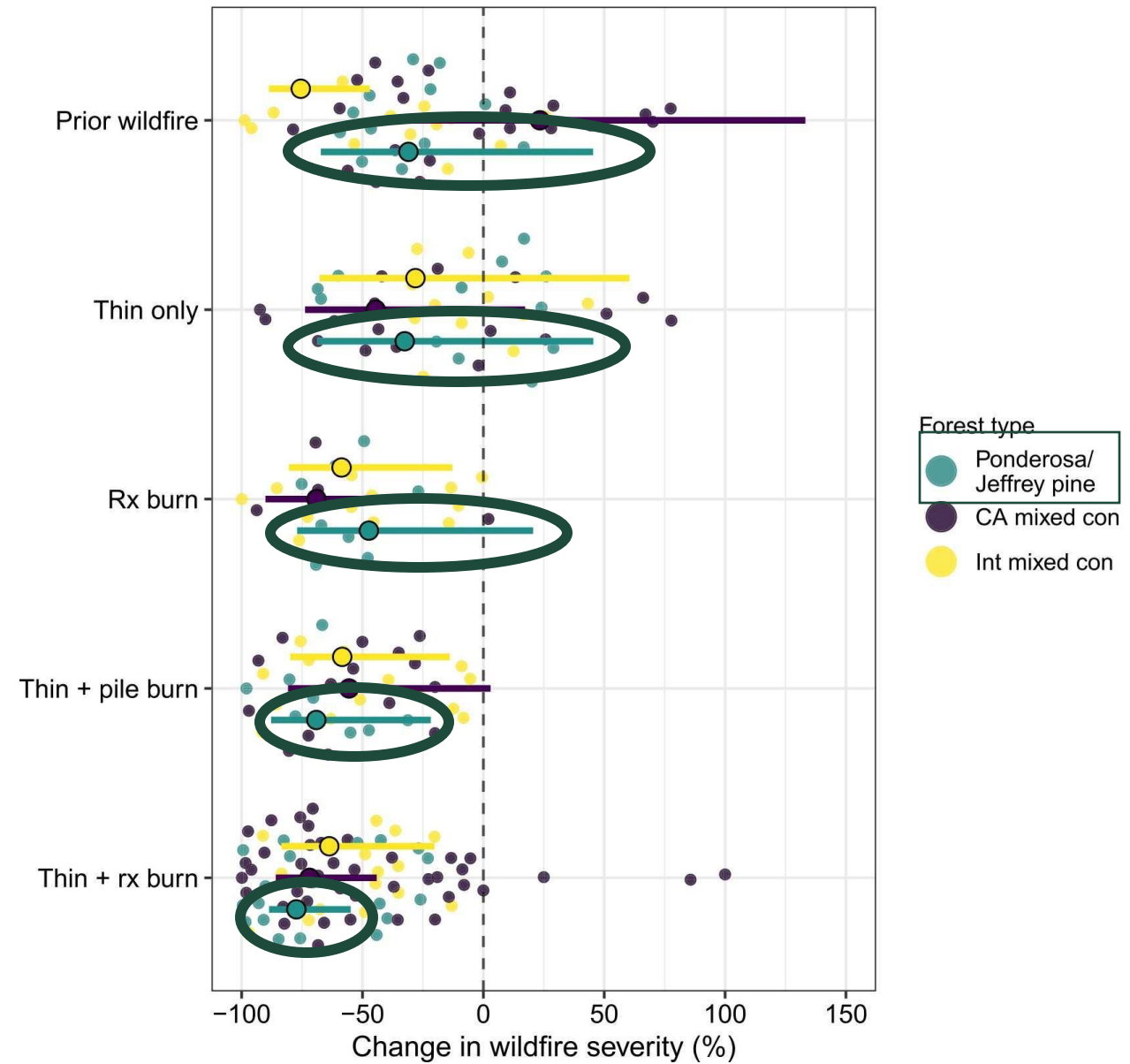


Figure 6. Index combining vegetation vulnerability to transformation (Fig. 4) and vegetation projection agreement (Fig. 5).

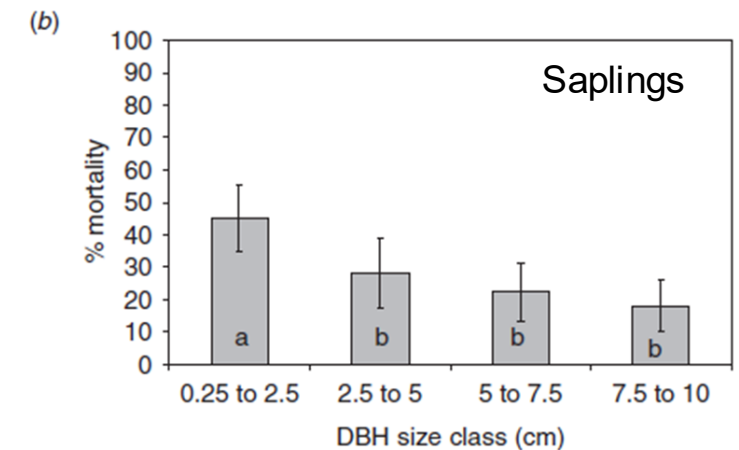
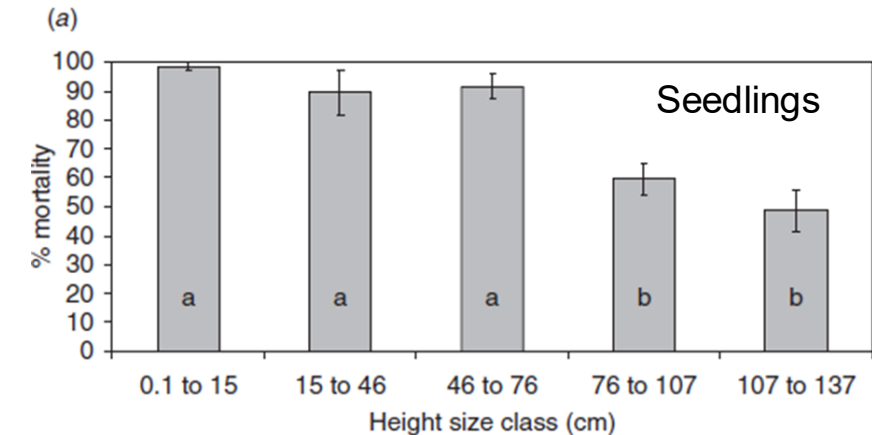
Thin + Rx Burn Reduces Wildfire Severity the Most



Battaglia et al., 2008 & 2009

- Rx fire kills:
 - ~90% ponderosa seedlings < 1 ft tall
 - ~50–60% seedlings 1 – 4.5 ft tall
 - ~18-46% saplings
- Need repeated treatments
 - **10 years post-Rx fire:** most regen still less than 1m
 - **20 years post-Rx fire:** ladder fuels present
 - **30 years post-Rx fire:** crown fire likely

Repeated Rx fire treatments are needed every 10 or so years to maintain reduced fire risk



Wider Spacing = Bigger Trees & More Drought Tolerance

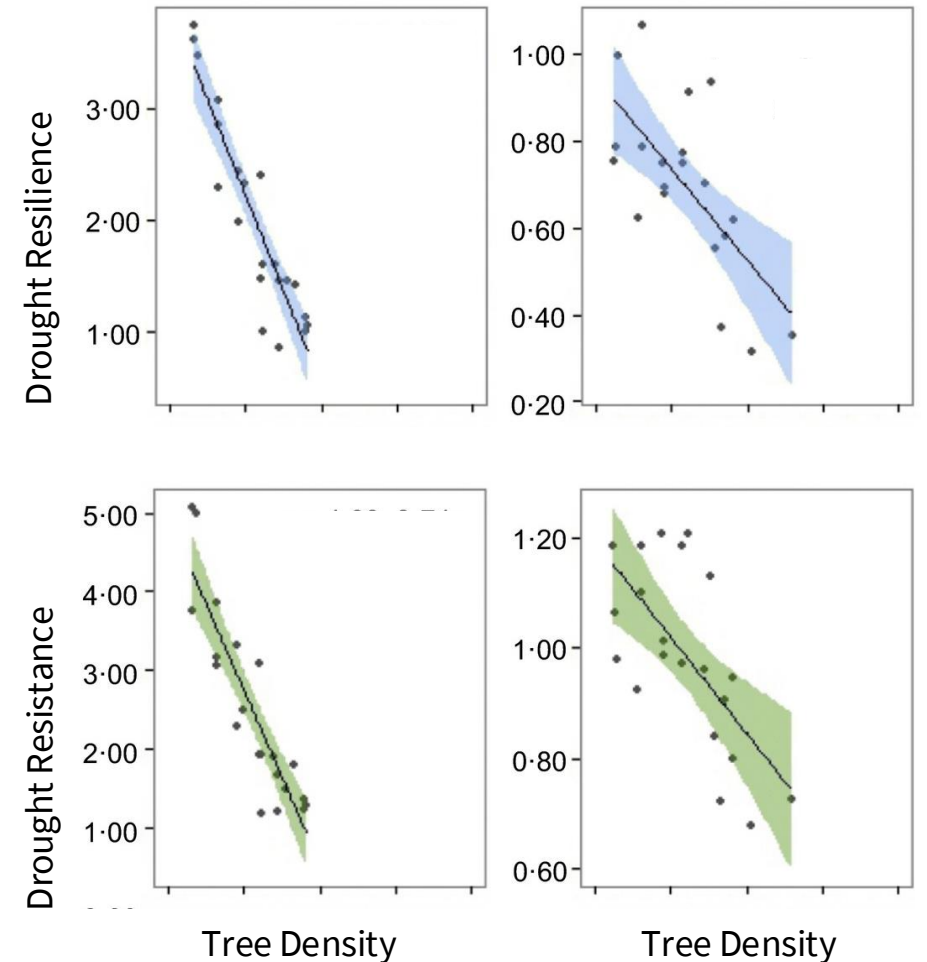


Figure 1—Aerial view of a Nelder plot on the Black Hills Experimental Forest around 1970.

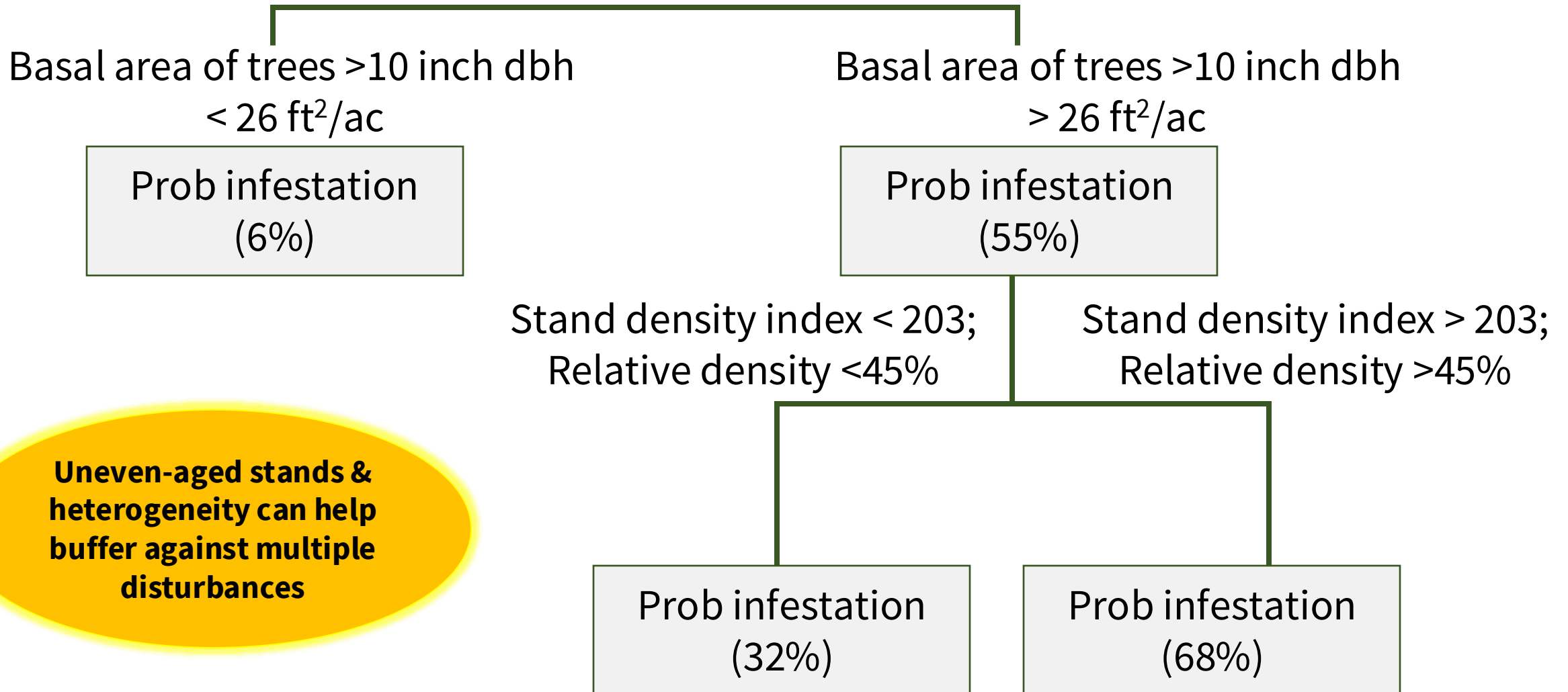


Figure 2—Cross-sections at d.b.h. of the ponderosa pine trees grown at different spacings in the Nelder plots after 45 years.

Black Hills Experimental Forest



Mountain pine beetle infestation




Uneven-aged stands & heterogeneity can help buffer against multiple disturbances

More regeneration closer to live trees and in cooler/wetter microsites

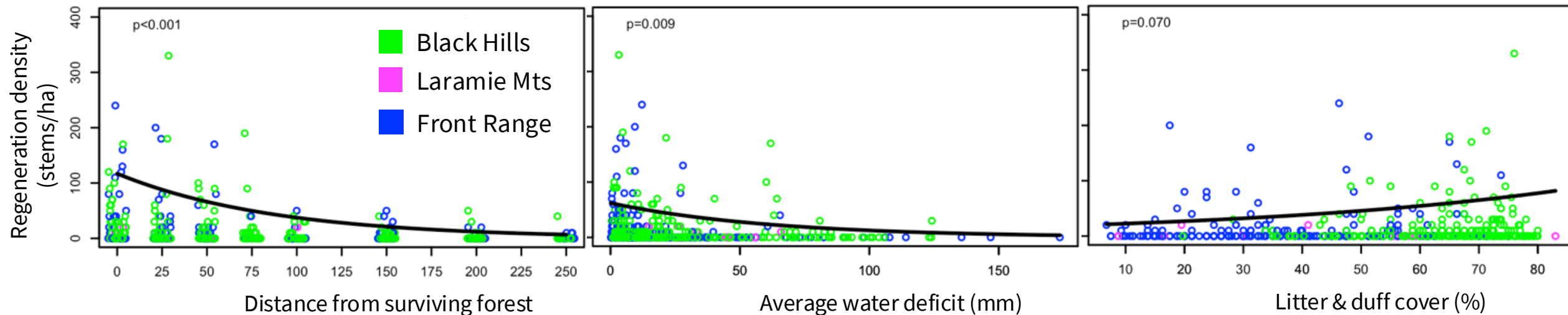


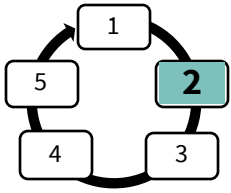
Bonnet et al., 2005 (Jasper fire)

- Closer to burn edge
- Scorched needles on mineral soil
- Less herbaceous cover

 More seedlings

Chambers, Fornwalt, et al., in prep





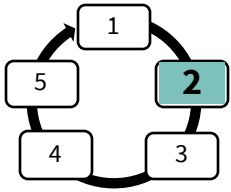
Step 2: ASSESS climate change impacts and vulnerabilities

Purpose: Consider how climate change may specifically affect the project area

Key Questions:

- How might the area be uniquely affected by climatic change and subsequent impacts?
- How might regional impacts be different in the project area?
- What are the climate impacts in the area if no action is taken?





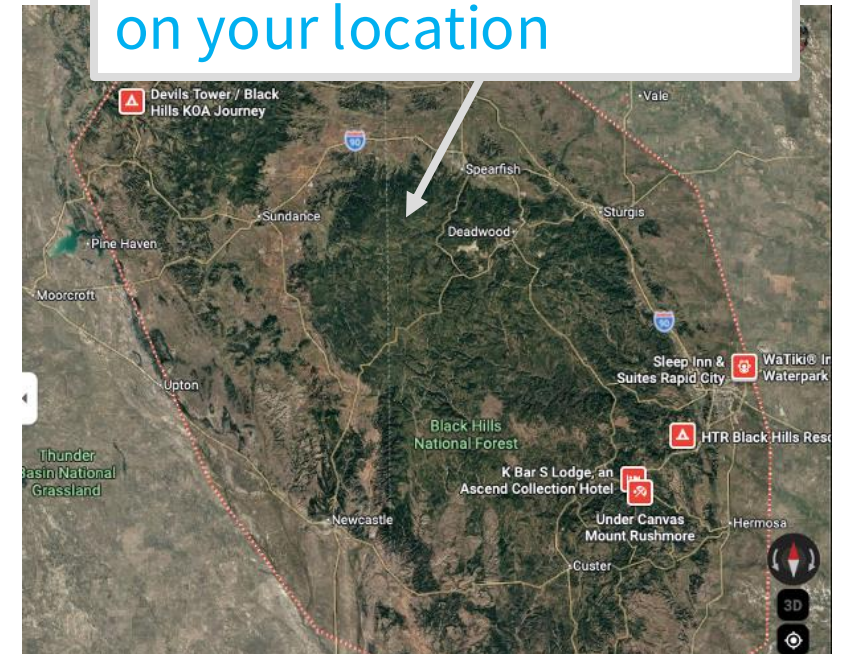
Step 2: ASSESS climate change impacts and vulnerabilities

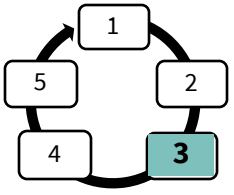
Regional Impacts:

- Warmer temperatures
- Longer growing season
- Less snow and shorter winters
- Altered seasonal precipitation and streamflows
- Increased summer moisture stress and drought
- More frequent heavy precipitation events
- Less suitable habitat for northern & alpine species
- More suitable habitat for southern species
- Increases in insect pests and forest pathogens
- Increases in non-native plants
- Potential changes in wildfire regimes

How will my site be uniquely affected???

List of impacts is based on your location





Step 3: Evaluate management objectives given climate change

Purpose: Realistically assess the ability to meet goals and objectives under current management.

Key Questions:

- What climate-related management challenges or opportunities might occur?
- How does climate change affect the community?
- Can ‘no action’ or ‘business as usual’ management meet your goals?
- Do goals and objectives need to change?



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

Climate Vulnerability vs. Challenges to Objectives

Step 2 is about the place:

- ⑩ Detailing site characteristics that may present climate-related vulnerabilities

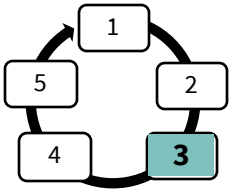


Step 3 is about your goals

- ⑩ Describe how climate change may affect your ability to achieve the project goals and objectives



Similar but different!



Step 3: Evaluate management objectives given climate change

Feasibility – Can you meet your management objectives using current (proposed actions) management actions?

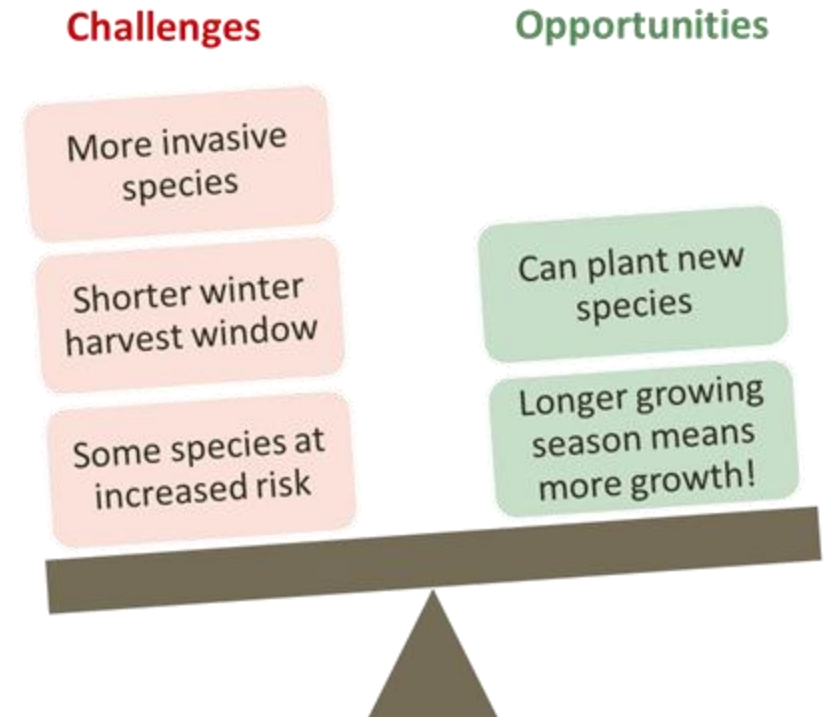
High: We can do it! *Opportunities > Challenges*

Moderate: Somewhere in the middle

Low: We'll need more resources or effort.

Challenges > Opportunities

Other Considerations – Social, financial, or other factors that also affect your ability to meet objectives.



Breakout Group Activity: Climate Impacts, Challenges, & Opportunities

1) Quick group introductions if needed

2) Make sure everyone is familiar with the assigned project area

- Conditions: Forest type, location, site conditions, species composition, stand structure, disturbance history and susceptibility, etc.
- Management goals and objectives

3) Discuss climate change impacts to your project location

- Select the top 5 impacts that are most likely to affect your project site
- Describe how those impacts will affect the local area, which present the greatest risk, and why

4) Discuss climate challenges and opportunities for achieving your management goals

- Describe the climate-related management challenges or opportunities that might occur
- Consider additional management constraints
- Consider the feasibility of achieving management objectives in the next 5-10 vs. 20-50 years



Report-Out on Climate Change Impacts



Instructions

Go to

www.menti.com

Enter the code

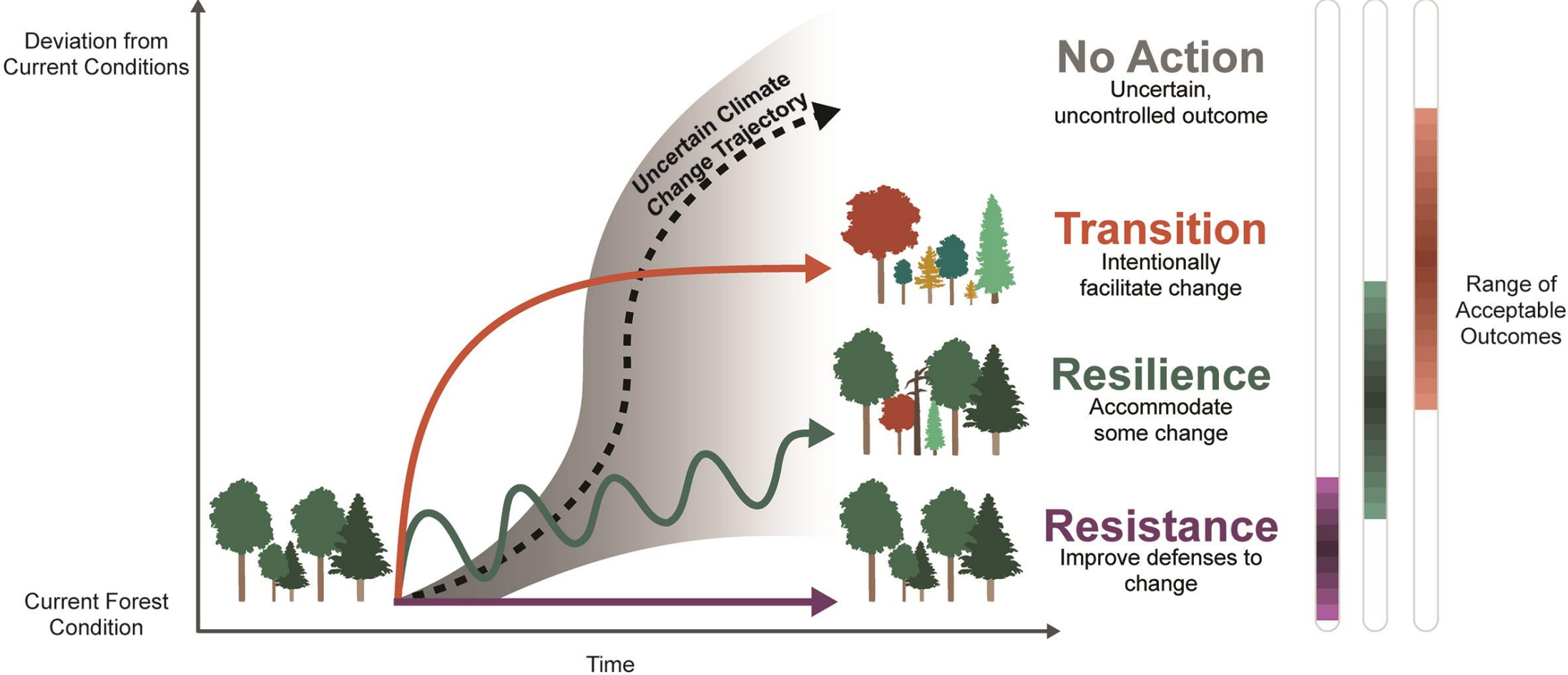
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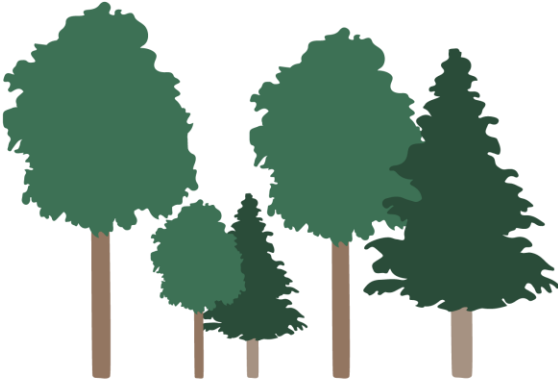
Or use QR code



Identifying Adaptation Strategies & Approaches



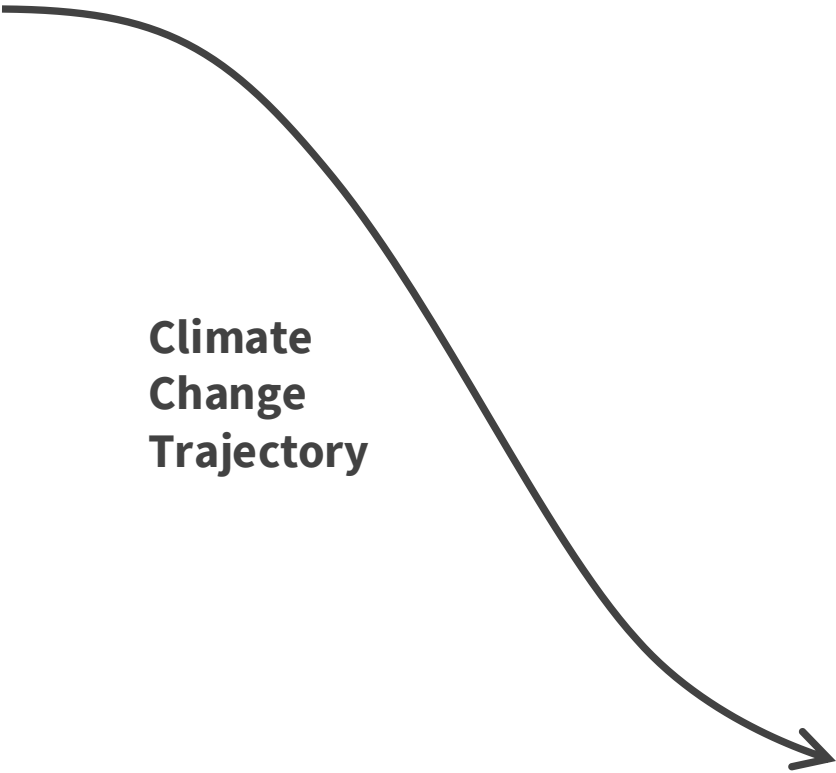
Climate-Driven Changes



Desired Future Condition →



Climate Change Trajectory



TIME



We Will Be Considering a Spectrum of Adaptation Options

RESISTANCE



RESILIENCE



TRANSITION



Identify and implement actions that are **robust across a range of potential future conditions**

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)

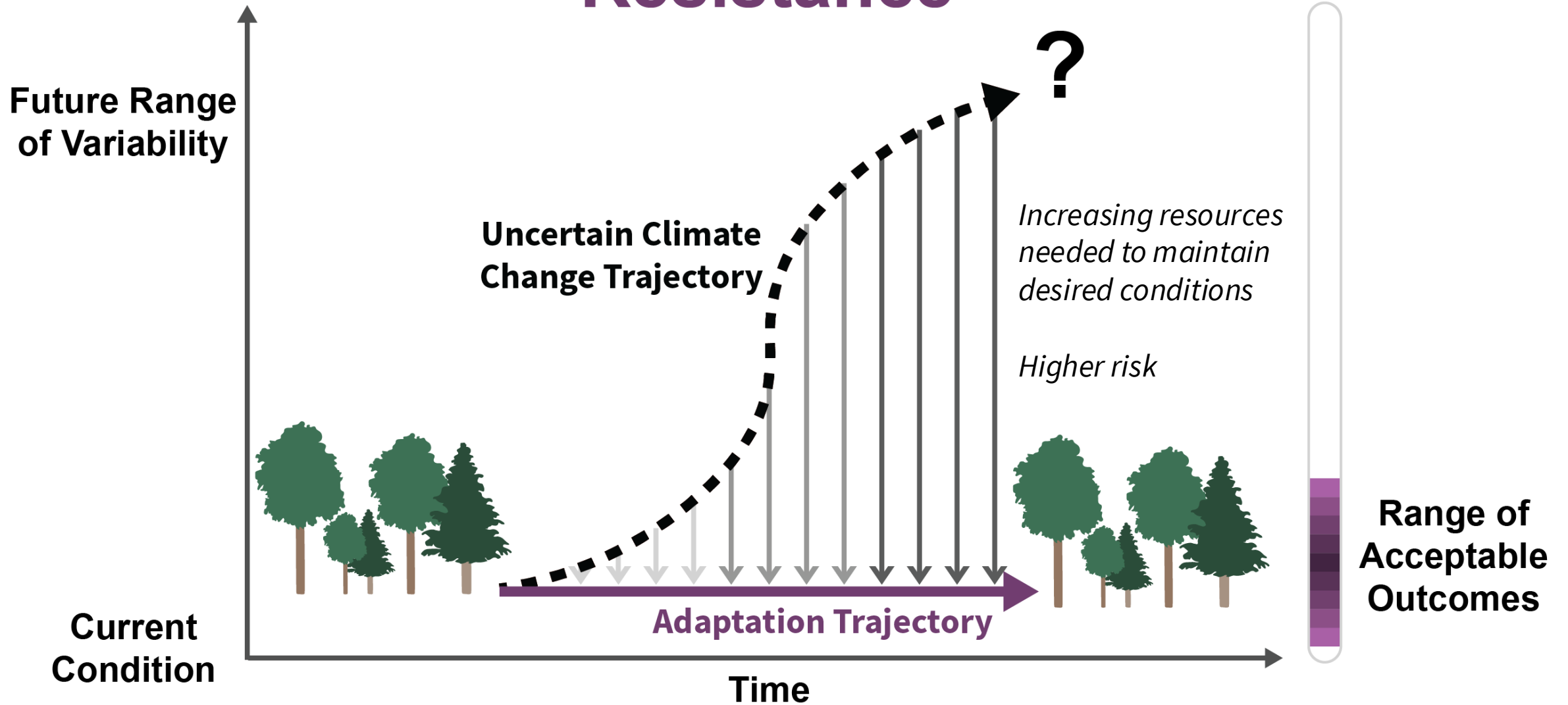


Threatened Dwarf lake iris (FWS)



Invasive species management (USFS)

Resistance



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)

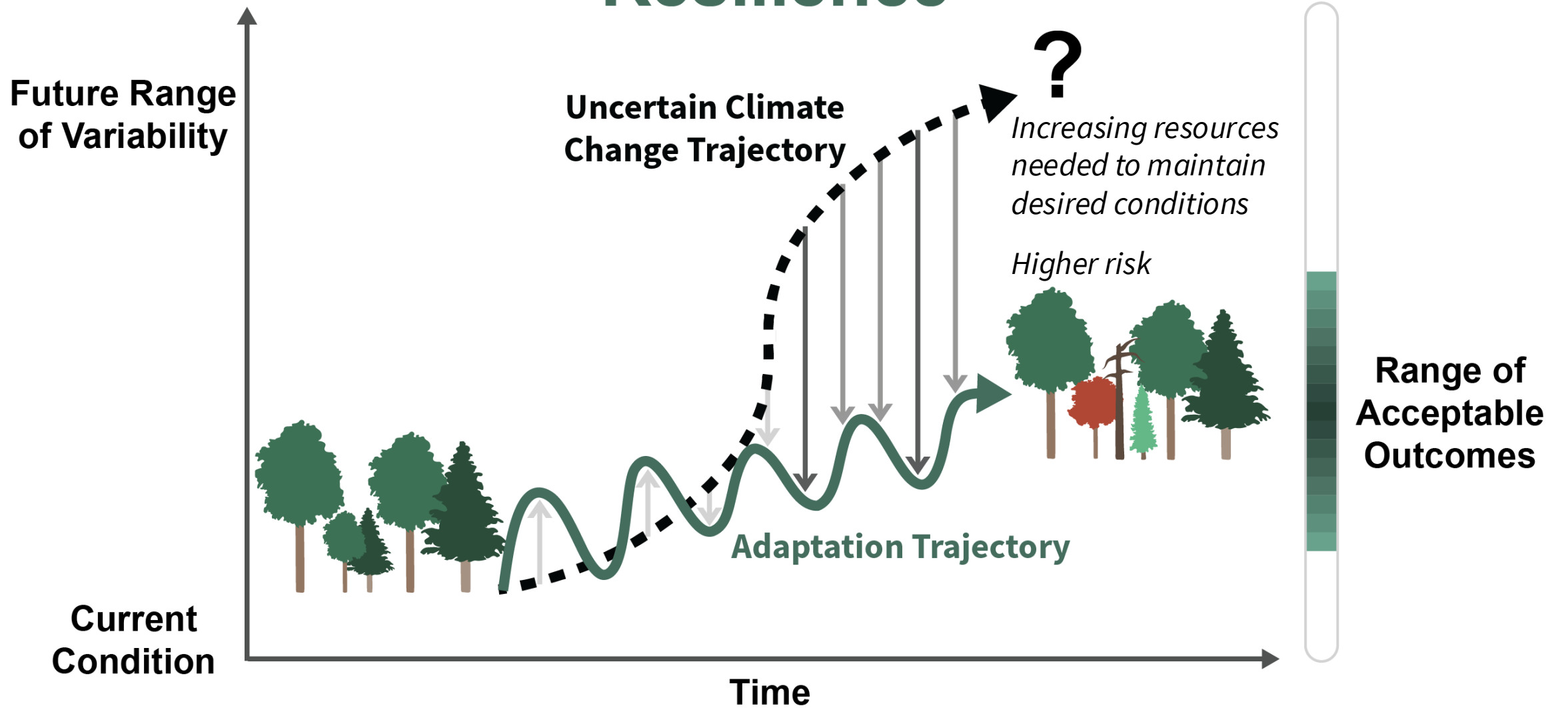


Increasing setbacks to allow for fluctuating water levels.

Holling 1973, Millar et al. 2007, Swanston et al. 2016

See also – Moser et al. 2019

Resilience



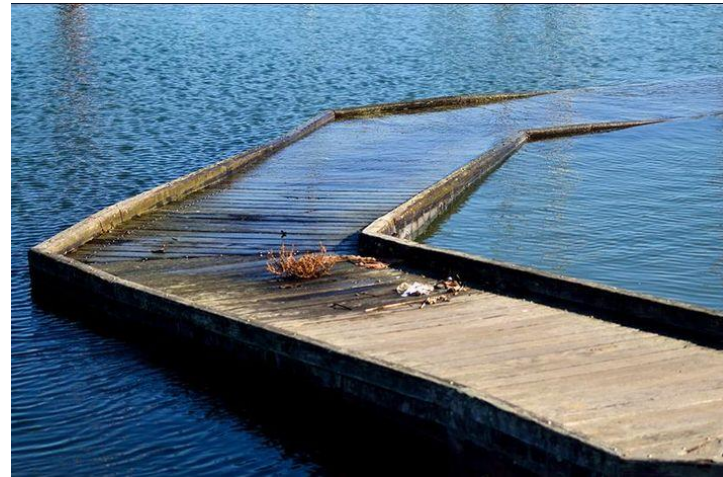
Transition

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)

**Forward-Looking/
Promote Change**

**Future Range
of Variability**

Transition

**Uncertain Climate
Change Trajectory**

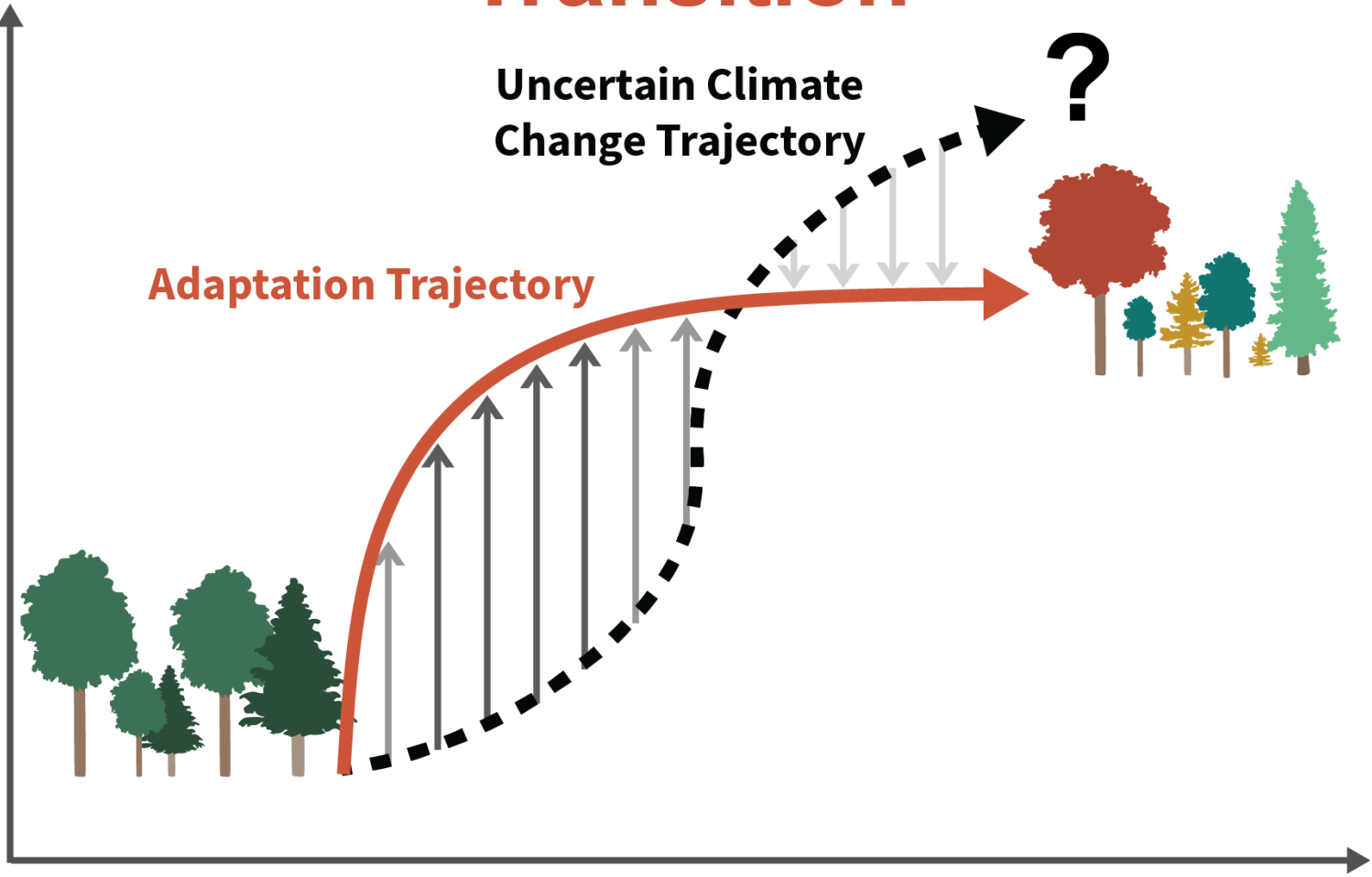
Adaptation Trajectory



**Range of
Acceptable
Outcomes**

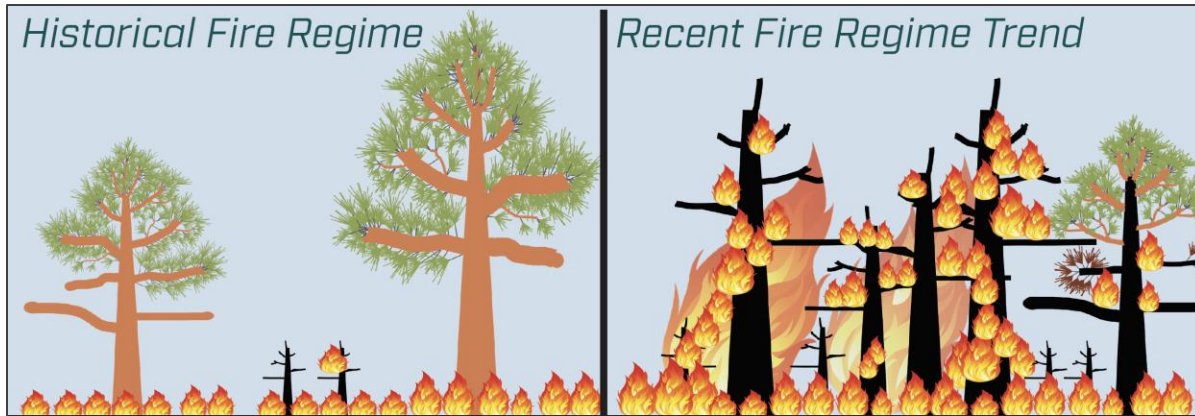
**Current
Condition**

Time



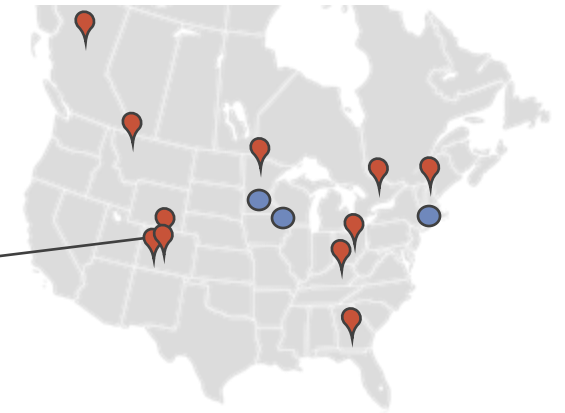
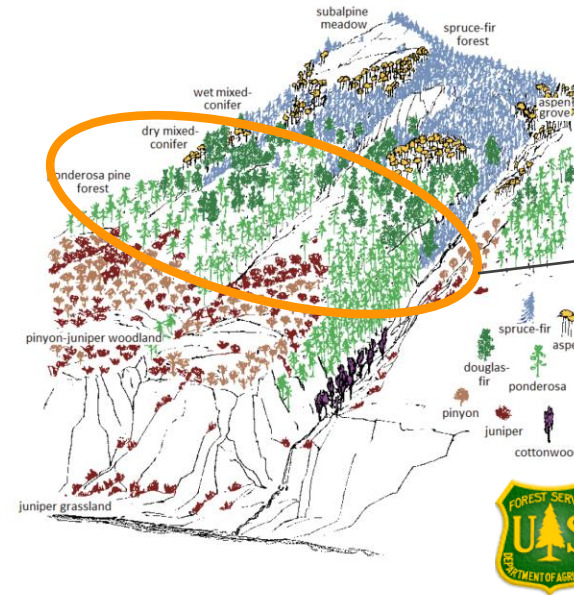
Example San Juan National Forest, CO, USA

- Warm-dry mixed conifer forest (ponderosa pine); white fir, ponderosa pine, Douglas-fir
- 30 m²/ha (130 ft²/ac)
- Deep, well-drained, loamy soils, and variability in aspect with deep drainages and slopes from 0 to 35%



Ponderosa Pine & Mixed Conifer Fire Regime

- Prior to 1880, frequent (10-30 yr) low-to-moderate fire severity with small patches of stand-replacing fire



Site Leads:

Mike Battaglia & Adam Tlachac (USDA Forest Service)

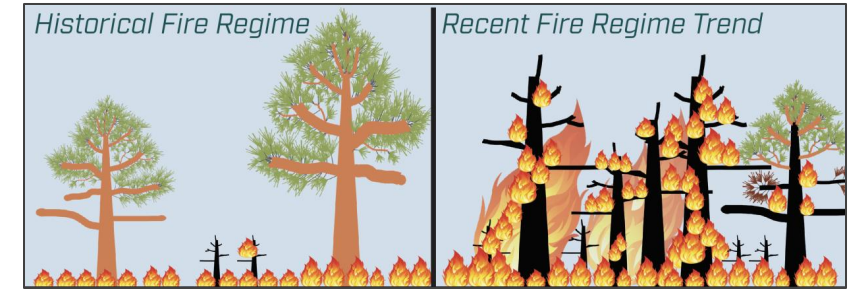


Climate Concerns:

- Warming temperatures
- Variable precipitation and earlier snowmelt
- Elevated drought risk driving increased risk of wildfire and insect outbreaks (mountain pine beetle, western pine beetle, fir engraver, Douglas-fir beetle, root disease, and dwarf mistletoe)

San Juan National Forest

- Warm-dry mixed conifer forest (ponderosa pine); white fir, ponderosa pine, Douglas-fir
- 30 m²/ha (130 ft²/ac)



Ponderosa Pine and Mixed Conifer Fire Regime

RESISTANCE



Maintain species composition with even and consistent spacing to prevent the encroachment of ladder fuels (Thin to 60-90 ft²/acre)

RESILIENCE



Expand openings (up to 1 ac), create a multi-cohort structure, and increase the presence of drought-tolerant & fire-adapted species (ponderosa & Doug-fir)

TRANSITION



Create high variability in spacing with a canopy openness target of 30-40%, 40 ft²/ac
Increase drought-tolerant & fire-adapted species (ponderosa, Doug-fir, aspen)



Reduce impacts/ maintain current conditions

Forward-looking/ promote change

Trends Across Adaptation Treatments



Adaptation Strategies

RESISTANCE



- More uniform application of intermediate treatments or regeneration methods focused on increasing tree vigor and maintaining current compositional conditions
- Density management (semi-arid) or regeneration harvests (humid) to resist impacts of disturbances

RESILIENCE



- Treatments increase ecosystem complexity
- Multi-cohort silvicultural methods that create diverse resource environments, spatially complex distributions of mature trees, and a range of size and age classes

TRANSITION



- Treatments intentionally facilitate change to a novel system
- Increasing focus on regeneration of future-adapted species through large canopy gaps or stand-wide harvests of most mature trees

← Reduce impacts/maintain current conditions

→ Forward-looking/promote change

Forest Assisted Migration (FAM)

The human-assisted movement of species, populations or genotypes to areas outside of their historical distributions to maintain biological diversity or ecosystem function in response to climate change is known as assisted migration (AM) (Richardson et al. 2009; Schwartz et al. 2012).

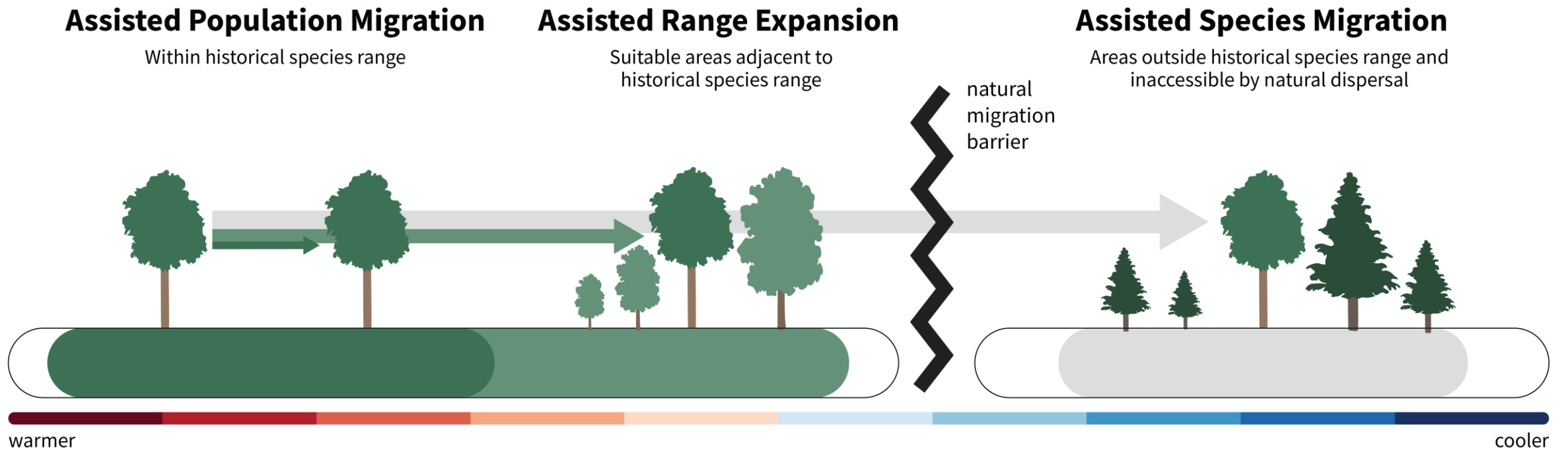


Figure: Kailey Marcinkowski, NIACS

Plants are Adapted to Local Climates



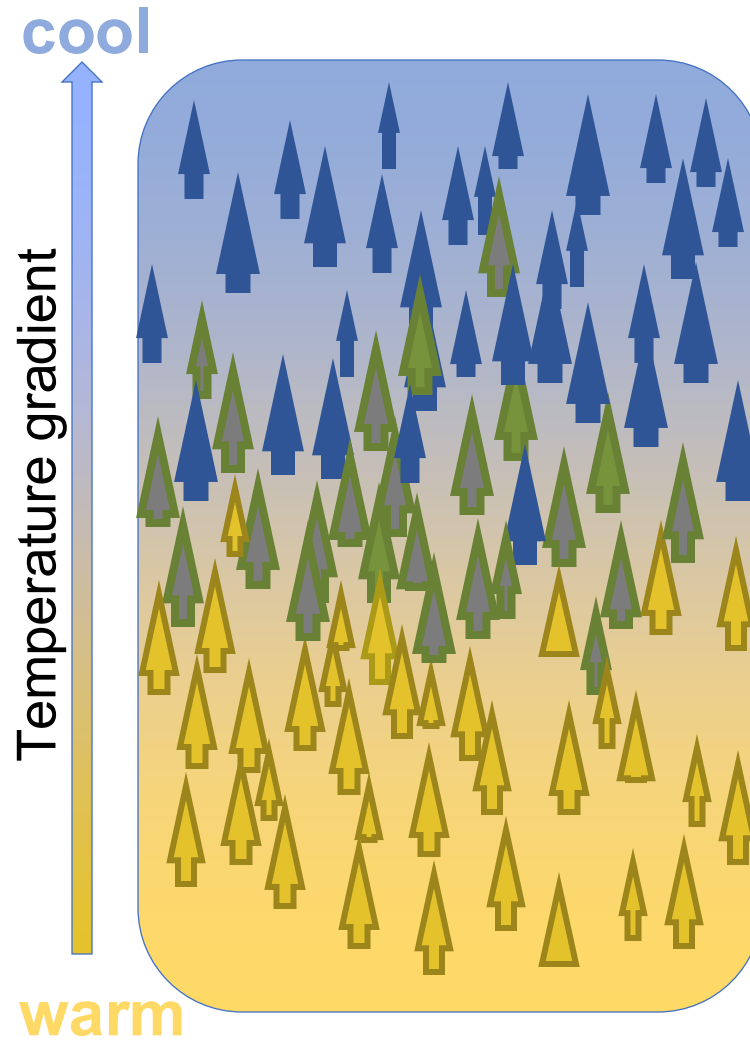
Every species, every population, every individual plant has a range of climates in which it can best survive, grow and reproduce



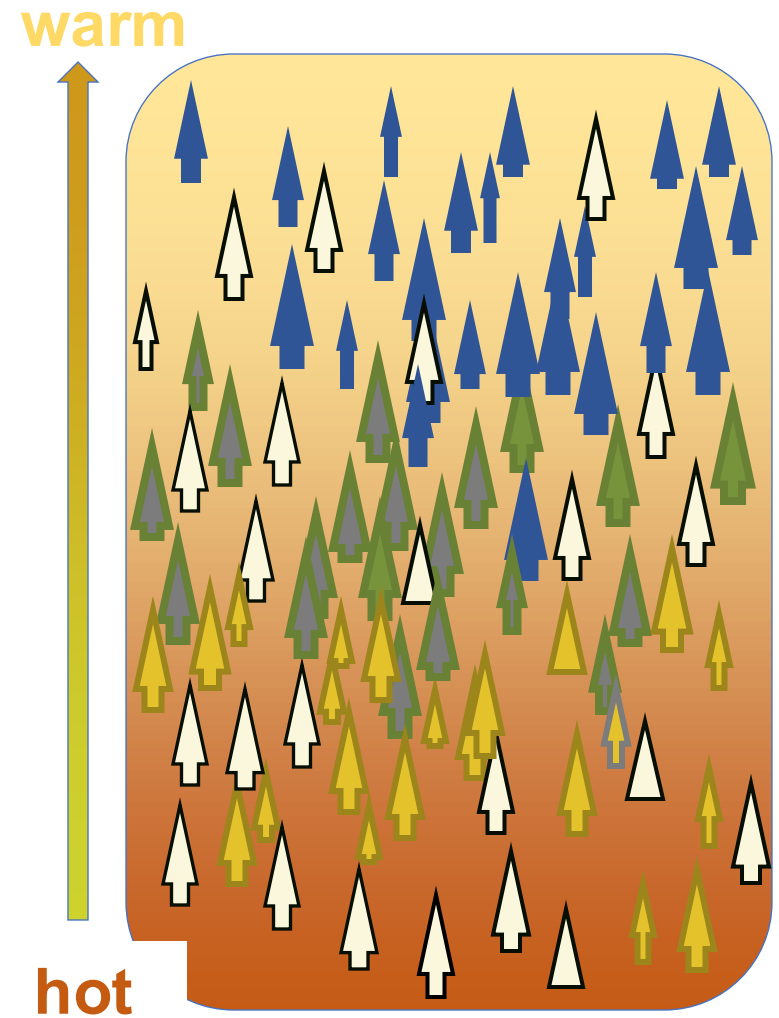
Because of natural selection at a location, we can assume that plants are adapted to their local climate

**But climates
are changing,
which affects
adaptation**

Populations are genetically
adapted to historic climate

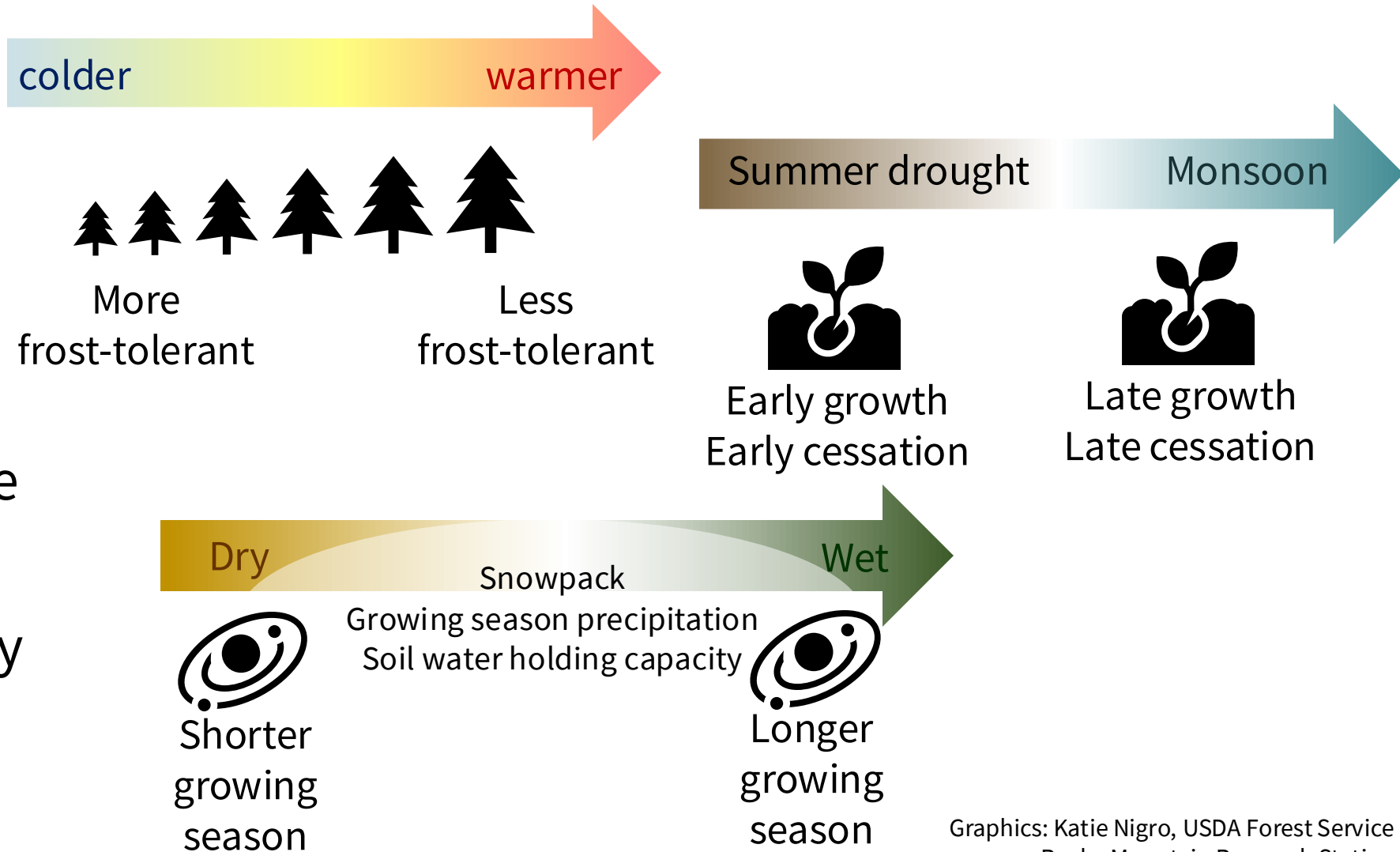


And mismatched with
future climate



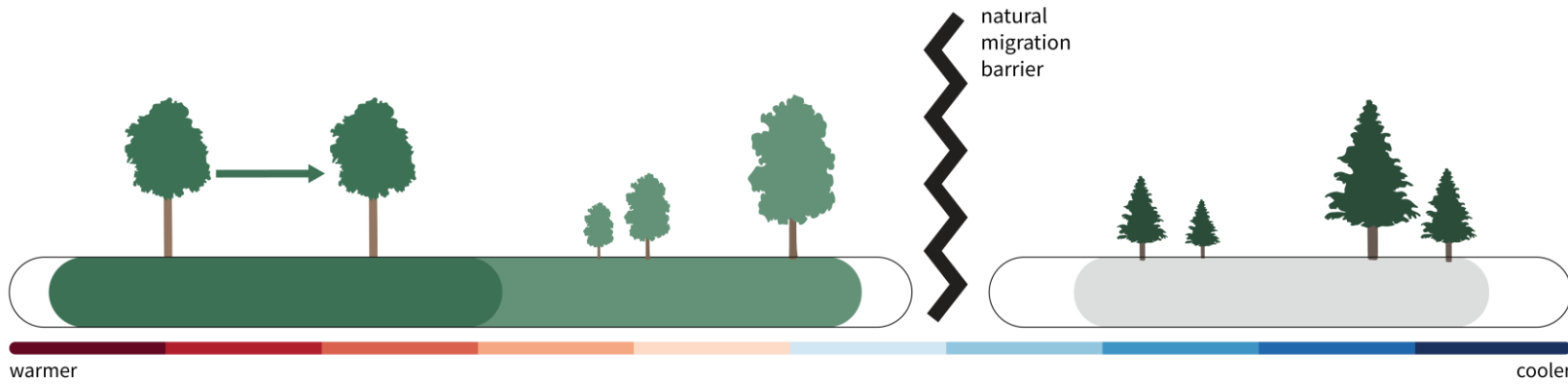
Species Sensitivity to Climate Change Depends On:

- Shade tolerance
- Fire tolerance
- Drought tolerance
- Climatic tolerance
- Genetic plasticity
- Current abundance
- Level of stress
- Dispersal capability
- Adaptive capacity



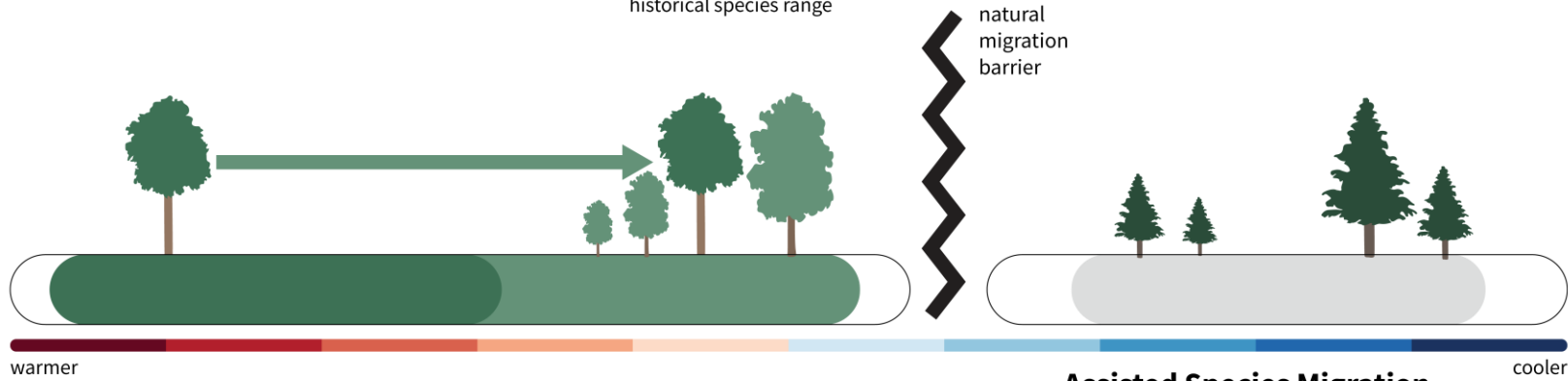
Assisted Population Migration

Within historical species range



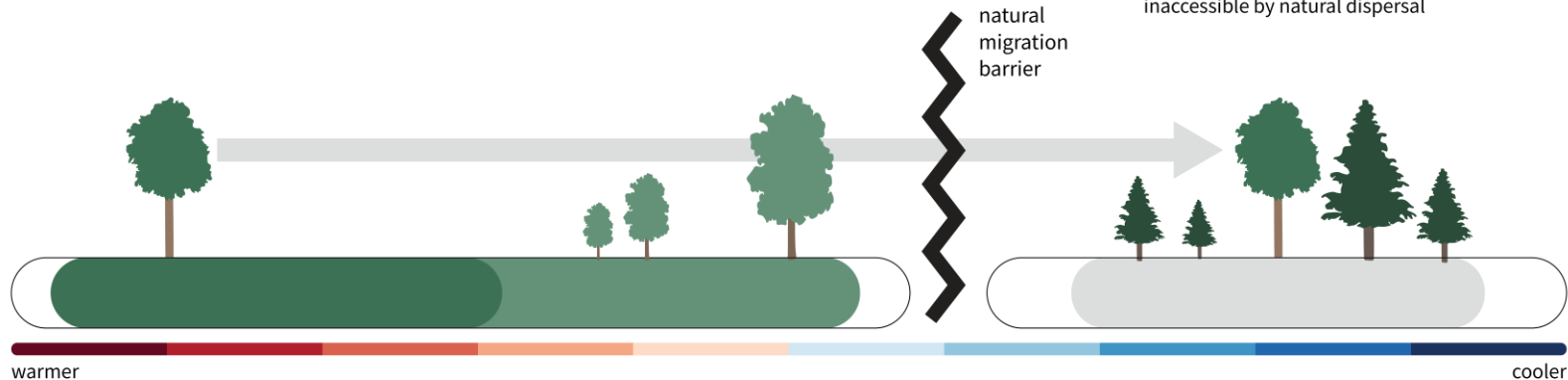
Assisted Range Expansion

Suitable areas adjacent to historical species range



Assisted Species Migration

Areas outside historical species range and inaccessible by natural dispersal



3 Types of Forest Assisted Migration

Assisted Population Migration

movement of species or genotypes relatively short distances, with the expansion occurring contiguously within the current distribution

Assisted Range Expansion

movement of species to suitable locations adjacent to (but outside of) the current range most often done to keep pace with changing conditions

Assisted Species Migration

assisted long-distance migration (e.g., interregional, transcontinental, intercontinental) of a species beyond areas accessible via natural dispersal

Potential Risks with Forest Assisted Migration & Mitigations

Risks to target population

- Poor match to site and low fitness
- Failure to establish
- Undesirable genetic impacts

Utilize decision support tools (e.g. SST)

Risks to non-target populations

- Invasiveness
- Introduction of pests or diseases
- Impacts to wildlife, pollinators, etc.

Focus on lower risk APM and ARE

Socioeconomic risks

- Increased cost (\$ and time)
- Lack (or loss) of public trust
- Cultural loss

Document & monitor to facilitate adaptive management

Risk of doing nothing

- Decreased forest health and productivity
- Loss of ecosystem services

What is your risk tolerance with Forest Assisted Migration?

Plant species that are currently abundant or common on the landscape, **source seed from one seed zone south**

Increase the abundance of rare (already present), climate-adapted species through planting efforts

Plant species currently absent from your area but **found within close proximity at the edge of their range**

Plant species currently absent from the landscape **and distant from their current range edge**



Forest Assisted Migration Resources

- Reforestation Guide - <https://forestadaptation.org/reforestation-guide>
- Seedlot Selection Tool - <https://seedlotselectiontool.org/sst/>
- Climate Smart Restoration Tool - <https://climaterestorationtool.org/>



Tree Planting to Enrich, Restore, and Adapt Northern Forests

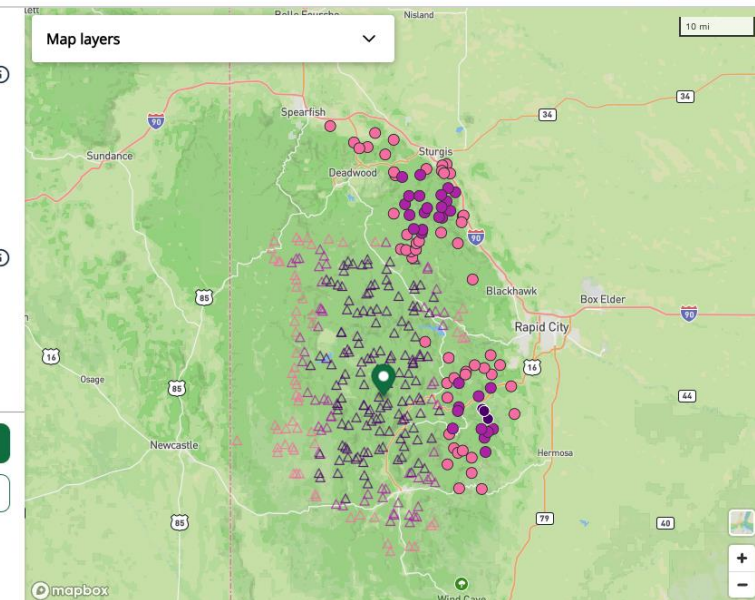
PETE CLARK | TONY D'AMATO | PAUL CATANZARO



Climate Smart Restoration Tool

Help About Español

- ▼ Results
- △ HISTORICAL MATCHES (1961-1990)
 - ✓ △ Strong
 - ✓ △ Moderate
 - ✓ △ Weak
 - MID-CENTURY MATCHES (2041-2070)
 - ✓ ● Strong
 - ✓ ● Moderate
 - ✓ ● Weak
- [View data table](#)
- [Download map](#)



Forest Assisted Migration at ASCC Sites

Adaptation Strategies

RESISTANCE



- Maintain relatively unchanged conditions

RESILIENCE



- Accommodate some degree of change

TRANSITION



- Intentionally facilitate change

Reduce impacts/maintain current conditions

Forward-looking/promote change

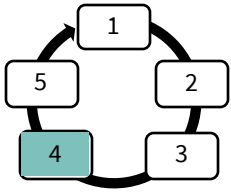
Role of FAM

- Limited FAM used
- Focused on maintaining current composition

- May incorporate assisted population expansion
- Limited assisted range expansion used

- Heavily incorporates assisted population expansion and range expansion
- May include assisted species migration

Importance of FAM



Step 4: Identify and select adaptation approaches and tactics for implementation

- ⑩ What actions can help cope with change and help meet the project goals and objectives?
- ⑩ How will future planners know what you were trying to do?
- ⑩ Consider a variety of actions, including:
 - ⑩ **Things you already do** that are even more important because of climate change.
 - ⑩ **Small tweaks or enhancements** that improve upon what you are already doing.
 - ⑩ **Major changes**, or wild and crazy ideas, from the current way of doing things.



Adaptation Menus of Strategies and Approaches

A list (“menu”) of **possible actions** that allows you to decide what is **most relevant for a particular location and set of conditions.**



- Flexible, not prescriptive
- Provide a starting point for new ideas- like yours!

<i>Brunch Classics</i>			
Lemon Ricotta Pancakes Whipped Mascarpone Maple, Berries	15	AJ's Omelet Fontal Cheese, Spinach, Mushrooms	14
Cornflake Crusted French Toast Berries, Maple Syrup	15	Eggs Florentine Spicy Capicola, House-Made Cheddar Biscuit, Spinach	15
Bacon, Egg & Cheese Bacon, Two Eggs, Taleggio Cheese, Cabbatta	14	Porchetta Hash Poached Egg, Caledonian Chit Hollandaise	16
Avocado Toast Poached Eggs, Tomatoes, Chili Flakes, Sea Salt	15	Chia Pudding Chia Seeds, Toasted Coconut, Banana, Strawberry	14
Chicken Parmigiana Spicy Marinara, Fresh Mozzarella	22	Farmhouse Breakfast Two Eggs, House-Made Cheddar Biscuit, Chicken Sausage	14
Squid Ink fettuccine Vongole Little Neck Clams, Garlic, White Wine, Butter, Chili	22	Chicken Kale Caesar Chicken, Kale, Croutons	16
<i>Create Your Own Pasta</i>			
Rigatoni Semolina, All-Purpose Flour, Olive Oil	14	Marinara San Marzano tomatoes, Garlic, White Wine, Basil, Chili	14
Cavatelli All-Purpose Flour, Durum Flour, Eggs, Ricotta	15	Arrabiata All-Purpose Flour, Durum Flour, Eggs, Ricotta	+1
Tagliatelle All-Purpose Flour, Durum Flour, Eggs	15	Broken Meatball House Tomato Sauce with the Addition of Broken Meatballs	+4
Gluten-Free Rigatoni Gluten-Free All-Purpose Flour, Olive Oil, Eggs	16	Sunday Sauce House Tomato Sauce with Short Rib, Sausage, Veal	+4
Spaghetti Semolina, Durum Flour, Olive Oil	15	Roasted Garlic Pecorino Semolina, Durum Flour, Olive Oil	+2
Four Cheese Herb Ravioli Fontal, Ricotta, Parmesan, Pecorino	18	Carbonara Pancetta, Eggs, Peas, Pecorino	+3
<i>Sides</i>		<i>Brunch Cocktails</i>	
Pecorino Truffle Fries	8	Bloody Mary Vodka, Spiced Fresh DOP Tomato Juice, Horseradish	10/45
Potato Hash	6	Cointreau Spritz Cointreau Spritz, Aperol, Crème de Peche, Sparkling Wine	12/55
Bacon	6	Green Side Relya Vodka, Green Juice, Lemon	12/55
Turkey Sausage	6	Morning Derby Bourbon, Grapefruit, Ginger, Carrot Juice	12/55
Field Greens	7	Sangria Red Wine, Fresh Fruit, Pisco, Crème de Peche	10/45
Two Eggs Any Style	6	Firing Squad Milagros Tequila, Cointreau, Fresh Lime, Grenadine	12/55
Belignets	8	Tall Mimosa Relya Vodka, Cointreau, Jake's Mimosa Juice, Sparkling Wine	12/55
Baked Goods	10		

Translating broad **concepts** to specific **actions**



Options:

- **Foundational adaptation concepts:**
- **R**esistance, **R**esilience, **T**ransition

Strategies:

- Broad adaptation responses that consider:
 - Regional ecological conditions
 - Overarching management goals

Approaches:

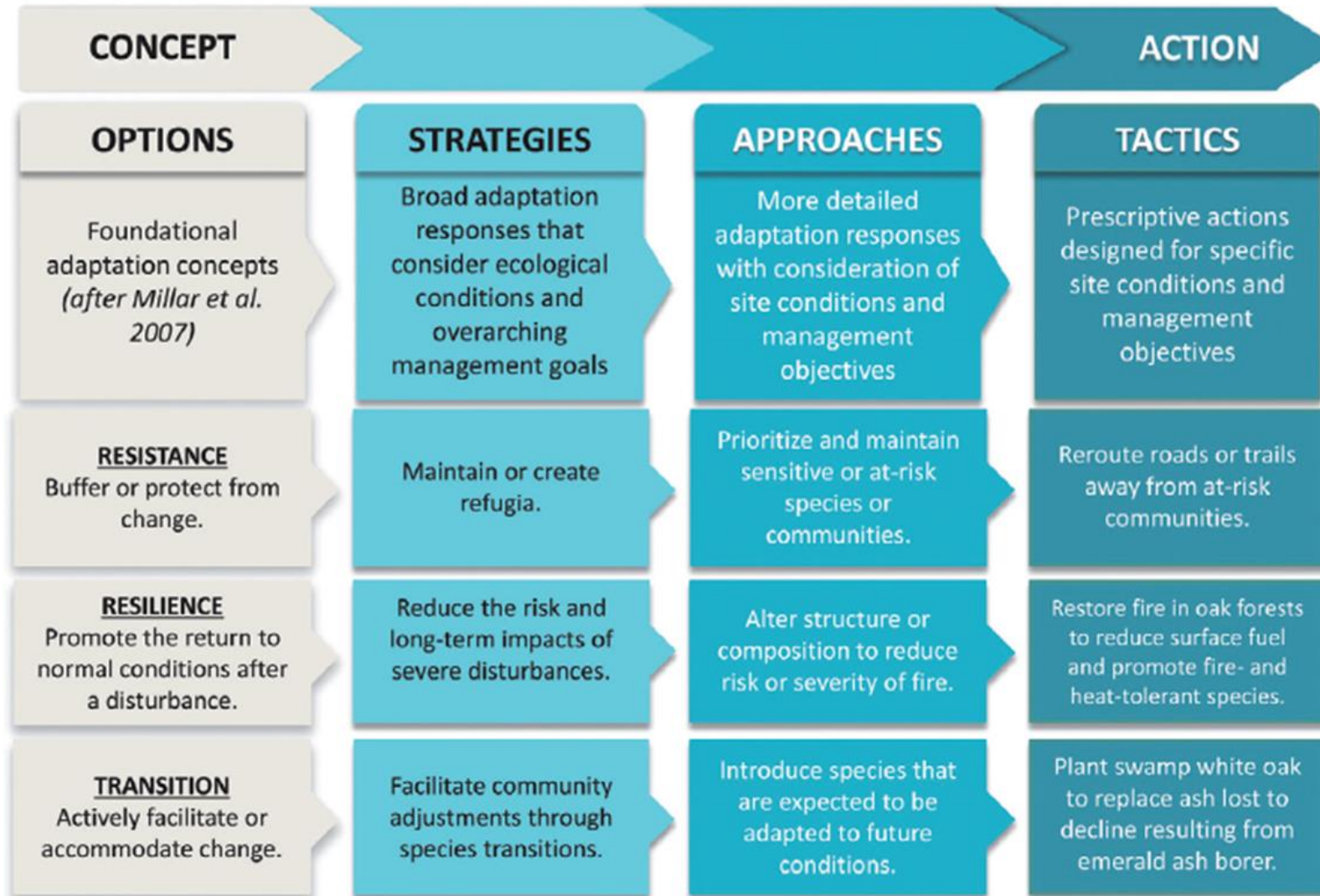
- More detailed responses that consider:
 - Site-level conditions
 - Site-level management objectives

Tactics:

- Prescriptive actions designed for:
 - Specific site conditions
 - Specific management objectives

Adaptation Menu of Strategies and Approaches

Structured to connect big concepts and intentions to specific actions



Published Adaptation Menus

2012: **Forests** (Midwest/NE focus)

2016: **Urban Forestry**

2016: **Agriculture**

2019: **Forested Watersheds**

2019: **Recreation**

2019: **Non-Forested Wetlands**

2019: **Inland Glacial Lake Fisheries**

2019: **Tribal Perspectives**

2020: **California Forests**

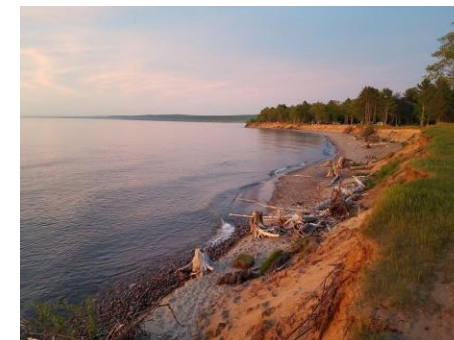
2020: **Forest Carbon Management**

2022: **Fire Management**

2022: **Wildlife Management**

2022: **Great Lakes Coastal Ecosystems**

2025: **Grasslands**



Adaptation menus available at: www.forestadaptation.org/strategies

Kaibab Plateau Ecological Restoration Project Example

1. DEFINE
management
goals/objectives

2. ASSESS
climate impacts

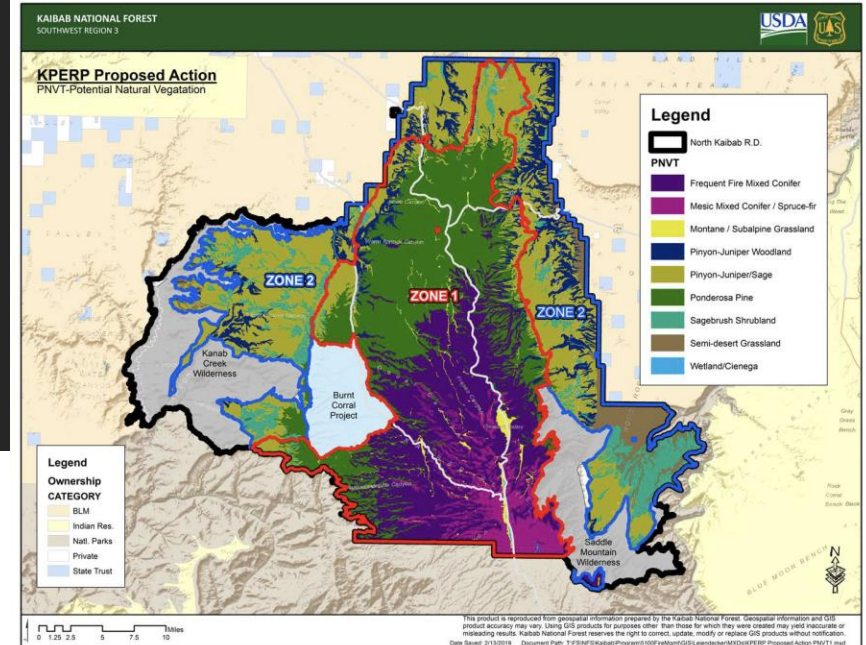
3. EVALUATE
management
objectives.

Goals:

- Restoring natural fire regimes
- Maintaining resilient forests by reducing the risk of high intensity wildfire
- Protecting the wildland urban interface
- Promoting heterogeneity

Climate considerations:

- Variable burn windows could create conflicts with hunting season and goshawk nesting season, and the potential to move out of prescription on hotter, drier days
- Capacity issues may occur trying to match the workforce with treatment needs with longer fire seasons
- Changing fire regimes may result in a loss of the mesic mixed conifer ecosystems



Photos: <https://www.fs.usda.gov/main/kaibab/fire>

Example: Kaibab Plateau Restoration Project

Fire Menu Approaches Examples	Adaptation Tactics (Developed by Workshop Participants)
1.1: Restore or maintain fire in fire-adapted ecosystems	<ul style="list-style-type: none">• Use prescribed fire and mechanical treatments to manipulate structure and fuels• Increase intentional use of wildfires whenever possible
5.2: Maintain or increase structural diversity at the landscape scale	<ul style="list-style-type: none">• Identify keystone species and roles in fire adapted systems, maintain or restore where possible• Use silvicultural treatments to promote and enhance diverse regeneration of native species
7.2: Consider using fire as a tool to align vegetation communities with changing climate regimes	<ul style="list-style-type: none">• Shift prescribed burn seasons to align with projected climatic changes• Consider using managed and/or prescribed fire to facilitate transition to new fire regimes• Consider increasing acreage treated with prescribed fire in the short-term in areas where current regeneration responses are desirable (and future regeneration trends are uncertain)



Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

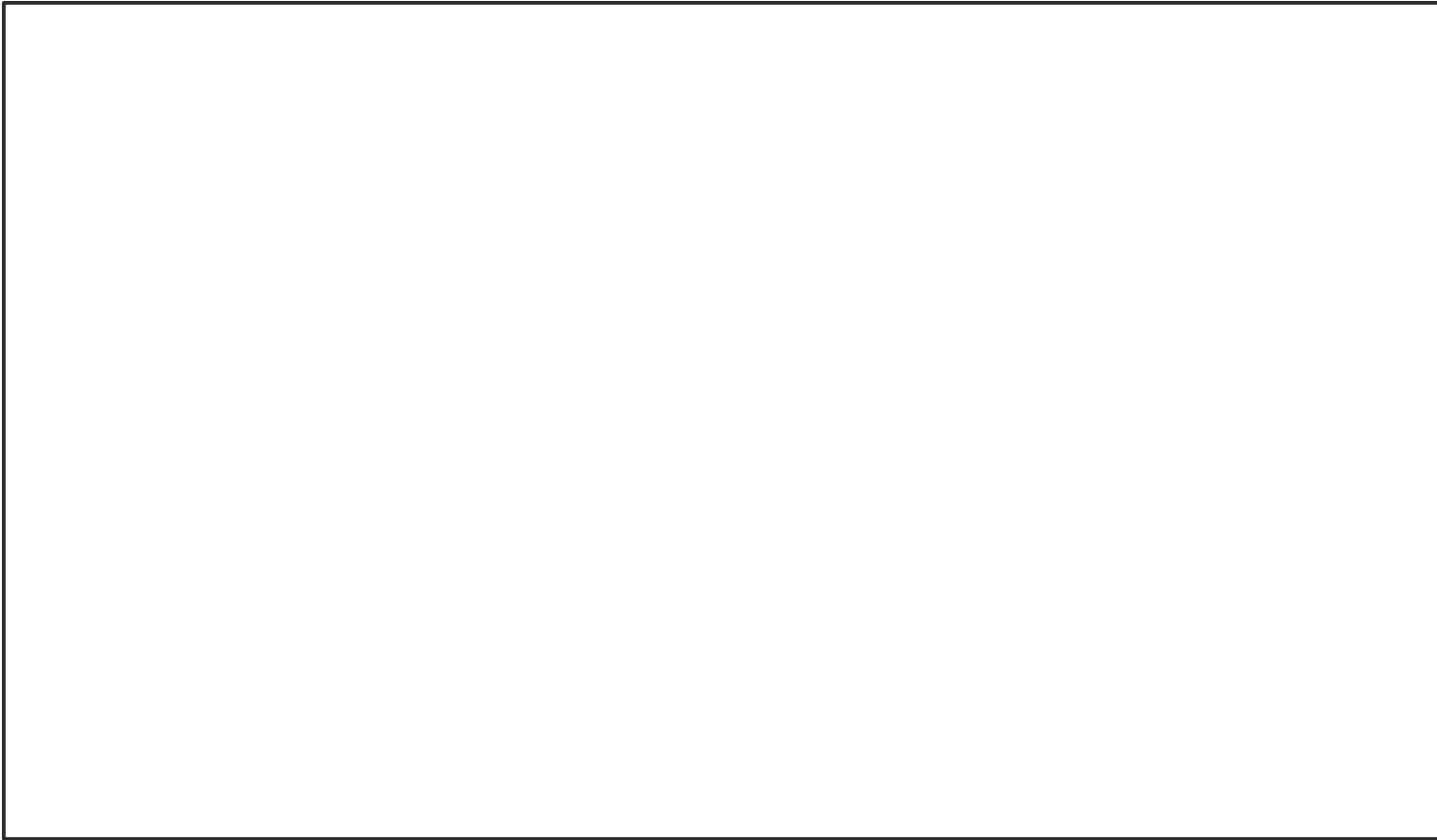


Adaptation Actions for Black Hills and Surrounding Areas

FARM PRODUCTION AND CONSERVATION
FSA | NRCS | RMA | Business Center

What might we integrate into our forestry prescriptions to mitigate the effects of anticipated vulnerabilities?

- Vulnerability**
- Increased Temperatures**
- More Hot Days**
- Less Cool Days**
- Increase in Wildfire Occurrence**
- Precipitation Changes**
- Increase in High Precipitation Events**
- Increase in Freeze-Free Season**
- Longer Growing Seasons**
- Existing Stressors Exacerbated**
- Homogeneous Systems Less Fit**
- Disturbance Adapted Systems More Fit**
- Fragmentation**
- More Drought**



What might we integrate into our forestry prescriptions to mitigate the effects of anticipated vulnerabilities?*

- Leave fewer trees
- Increase heterogeneity
- Use ICO (individuals, clumps, and openings)
- Reduce ladder fuels
- Increase crown base height
- Maintain ground cover
- Use prescribed fire following mechanical treatments, when feasible
- Assist with genetic migration
- Assist with species migration
- Accept that forested area will shrink

*Also see NIACS' *Menu of Adaptation Strategies and Approaches – Developed for forests* handout

Other Resources: Ecological Silviculture

Elements of an Ecological Silviculture System for Interior Ponderosa Pine and Dry Mixed-Conifer Ecosystems

1. Regenerate fire-tolerant tree species.
2. Recruit and perpetuate large and old (fire-resistant) tree populations.
3. Retain some dying and dead large-diameter trees as snags and logs.
4. Maintain low tree density with few ladder fuels.
5. Perpetuate a fine-grained spatial mosaic.
6. Maintain surface fuel loads conducive to low-severity fire.
7. Conserve native understory plant communities and broadleaf tree species.

Courtesy of Dr. Andrew Larson, presented September 3, 2025, at the Dakotas Society of American Foresters conference in Rapid City

Other Resources: Ecological Silviculture

Even-aged, high-density initial condition

Generic Rx: VDT with explicit guidance to create spatial variability.

Individuals, Clumps, & Openings Method

1. Consider skips and special areas
2. Consider openings
3. Determine target stand density
4. Set clump distance (6 m/20 ft)
5. Set clump proportions
6. Calculate clump targets for whole unit
7. Set leave tree criteria: species, size, age, crown form, etc.



Courtesy of Dr. Andrew Larson, presented September 3, 2025, at the Dakotas Society of American Foresters conference in Rapid City

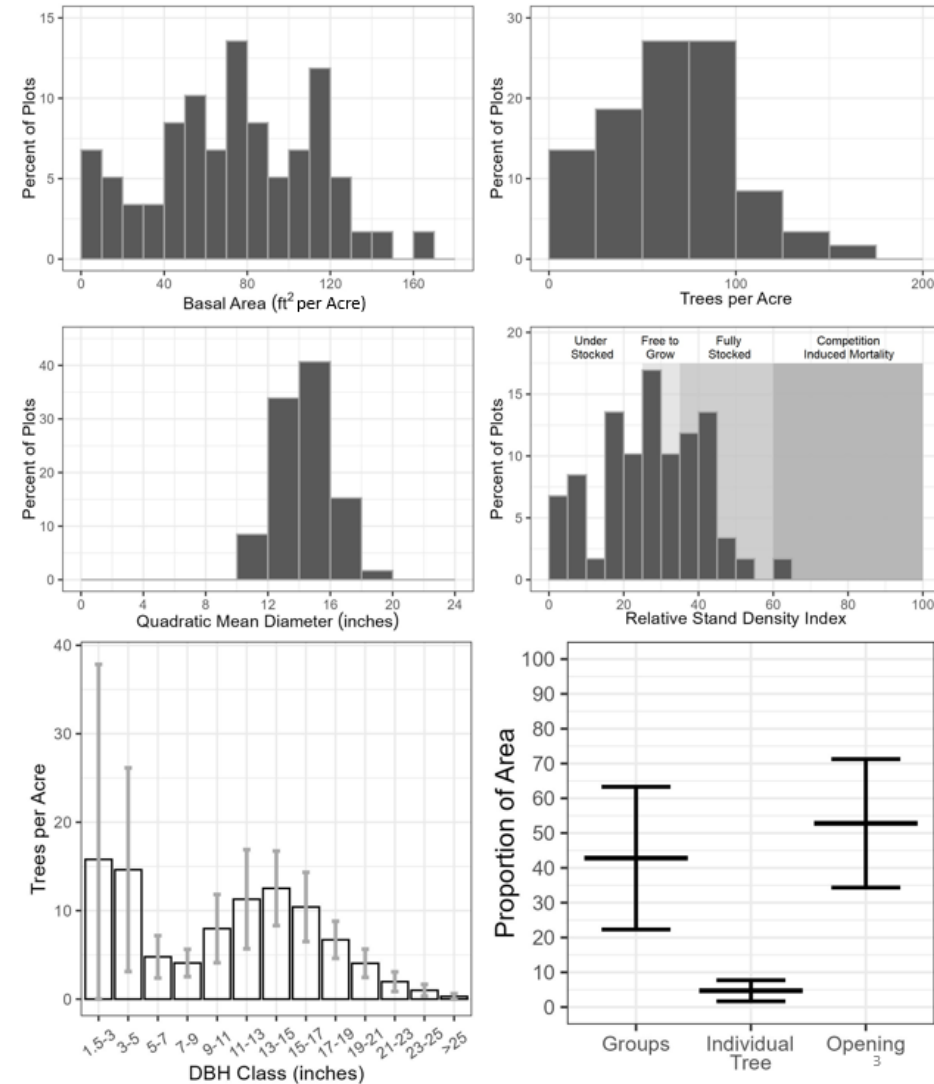
Other Resources: Historic Stand Structure

How does historic forest structure differ from our forests today?

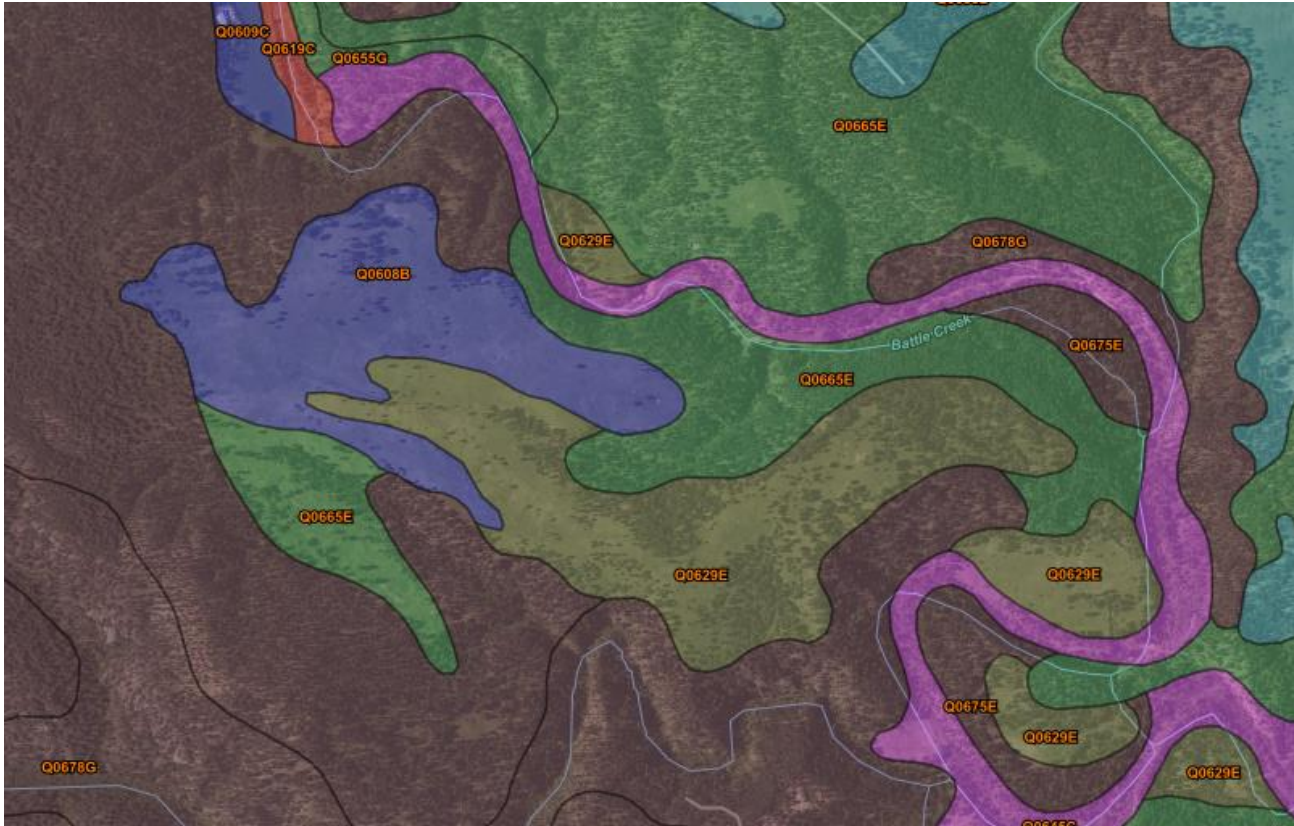
Why does that matter?

Courtesy of Dr. Mike Battaglia, presented September 4, 2025, at the Dakotas Society of American Foresters conference field trip on the Black Hills Experimental Forest

**Black Hills Historical Forest Structure – 1875
For Trees > 5-inch DBH**



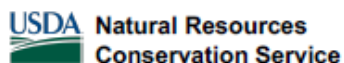
Other Resources: Ecological Site Descriptions



An **ecological site** is a distinctive land unit with specific soil and physical characteristics that produces unique vegetative communities and ecological processes.

- ESD's can be found on the Ecosystem Dynamics Interpretive Tool (EDIT) at <https://edit.jornada.nmsu.edu/>
- It is best accessed from Web Soil Survey to find the ESD specific to your project

Other Resources: Ecological Site Descriptions



Ecological site F062XA051SD Low Elevation Northern Hills Pine Forest(0-15% Slope)

Last updated: 2/06/2025
Accessed: 02/27/2026

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 062X–Black Hills

The Black Hills (MLRA 62) is a unique, low lying mountain range situated in the midst of a mixed short and mid-grass prairie. It is a true Island in the Plains, as it has geophysical and biological attributes that are unlike the surrounding area. The Black Hills have strong floristic ties to four of the North American biomes: Cordilleran (Rocky Mountain) Forest, Northern Coniferous Forest, Eastern Deciduous Forest, and Grasslands.

An **ecological site description** is the document that describes the ecological site.

Other Resources: Ecological Site Descriptions

Ecological dynamics

Dominated by ponderosa pine, the Low Elevation Northern Hills Pine Forest (0-15% Slope) ecological site occupies much of the territory of LRU A. There exists a historic reference state, and a managed/invaded state. Given the history of intensive use of the Black Hills and its forestry resources, much of the area today would be found in a managed /invaded state with few areas remaining in the reference state.

The ecological site is characterized by a highly variable uneven age structure canopy of ponderosa pine. Often this site will maintain a hardwood component such as quaking aspen, paper birch or bur oak. Understory species such as western serviceberry, woods

rose, common juniper, bearberry (kinnikinnick), ironwood (hop-hornbeam), and russet buffaloberry are common (Hoffman and Alexander 1987; Thilenius 1972). The herbaceous layer is highly diverse with ricegrasses, oatgrasses, yarrow, pasqueflower, sedges, pussytoes, or bluebell species.

Community 1.1

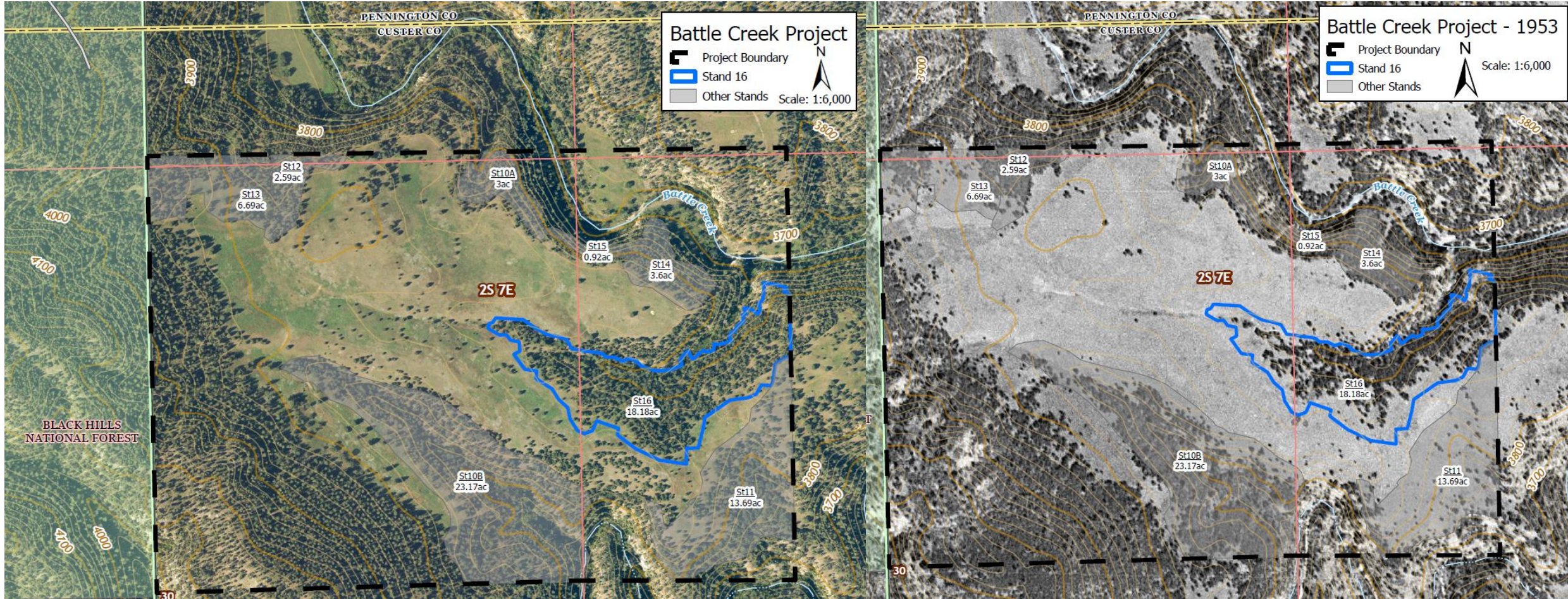
Reference Community

This community evolved with periodic severe drought, episodic insect and disease outbreaks, low-intensity surface and mixed severity small patch (1-20 acres) fires with a return interval of 10 to 20 years, rare mixed severity large patch (20-200 acre) fires that occurred on a greater than 100-year interval. Severe weather events that include hailstorms, tornados, and microbursts would also contribute to forest structure. Light to moderate levels of wildlife browsing and grazing also occurred on this site prior to European-American settlement. The expected forest canopy cover ranges from 30-60% with approximately 100 TPA around 13 inches DBH. The spatial arrangement of ponderosa pine consists of 44% groupings, 4% individual trees, and 51% openings. The dominant tree species on this site is ponderosa pine with a diameter at breast height (DBH) ranging from 9 to 15 inches. In the lower elevations, a community may form consisting of a scattered bur oak understory, while in the higher elevations, quaking aspen, /paper birch, or ironwood can be present throughout the site.. The dominant grasses and grass-like species include rough-leaf ricegrass, oatgrasses, slender wheatgrass, Hood's sedge, and Richardson's sedge. The dominant shrubs include western serviceberry, common juniper, bearberry (kinnikinnick), chokecherry, and russet buffaloberry. As the canopy cover increases the herbaceous understory will decrease in production and species diversity. Shrubs may tend to increase initially then decrease as the canopy closes. This plant community is diverse, stable, productive, and is well adapted to the Black Hills, Bear Lodge Mountains, and Dakota Hogback. Community dynamics, nutrient cycle, water cycle, and energy flow are functioning properly. Plant litter is properly distributed with very little movement offsite, and natural plant mortality is very low. This is a sustainable plant community in terms of soil stability, watershed function, and biologic integrity. This community self-sustained though moderate frequency low severity disturbances and mixed severity small patch disturbances (1-20 acres).

Dominant plant species

- ponderosa pine (*Pinus ponderosa*), tree
- common juniper (*Juniperus communis*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- roughleaf ricegrass (*Oryzopsis asperifolia*), grass

Other Resources: Historic Imagery



I use EarthExplorer to source historic aerial imagery, typically back to 1952: <https://earthexplorer.usgs.gov/>

Other Resources: Historic Imagery



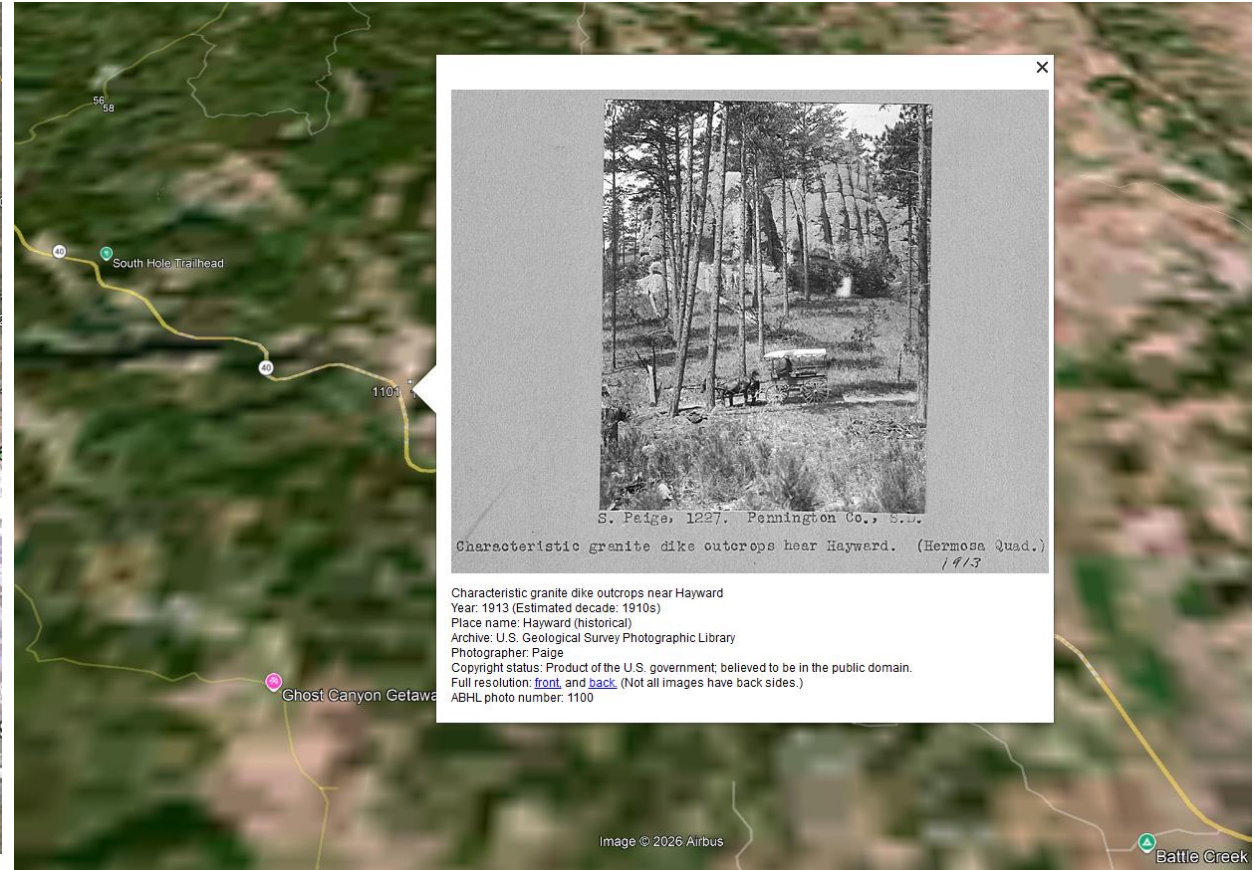
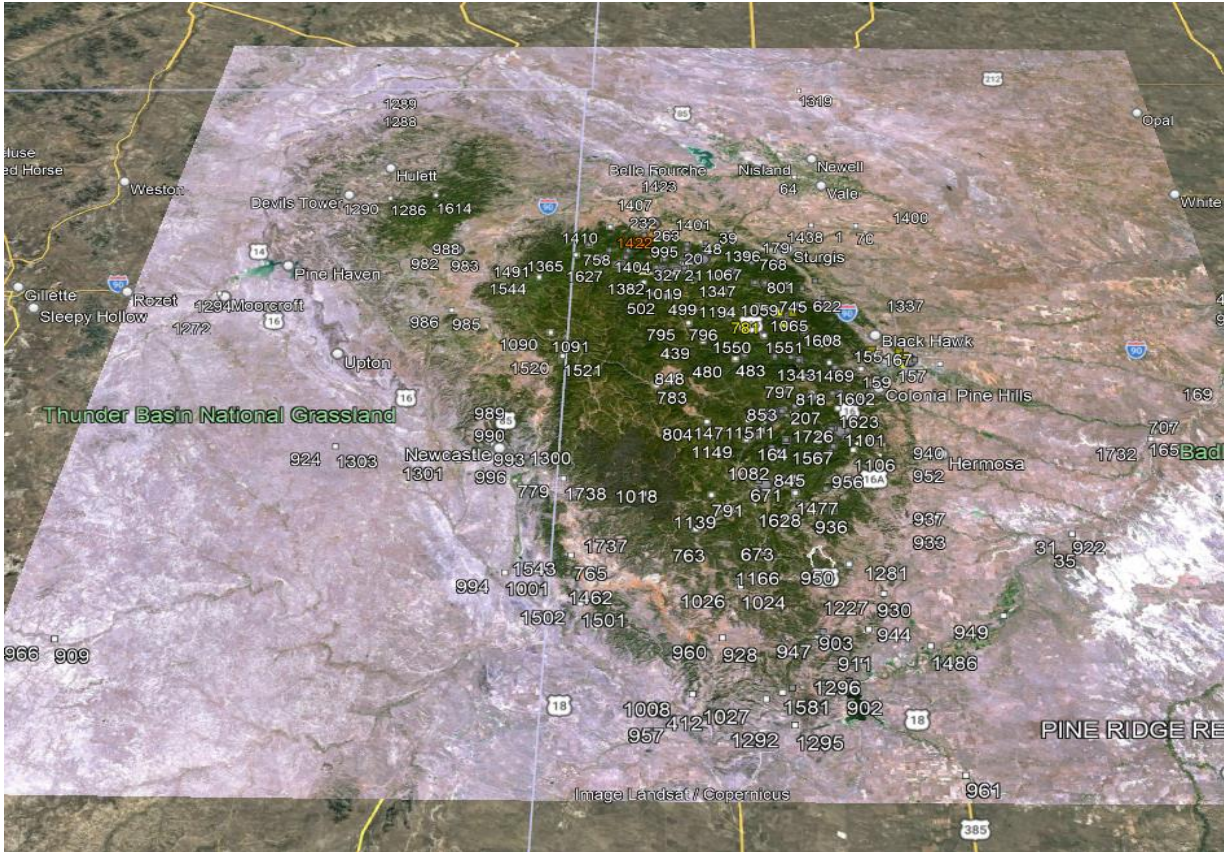
If you don't use ArcGIS, then Landscape Explorer might be a better fit: <https://www.landscapeexplorer.org/>

Other Resources: Historic Imagery



This example is from the Bitterroot NF but still demonstrates changed conditions similar to the Black Hills.

Other Resources: Historic Imagery



Historic photos can be sourced by using the Google Earth file from <https://whereinthehills.com/>, the Black Hills 1874 Expedition photos from <https://explore.digitalsd.org/digital/collection/BHNF>, and from the excellent array of historical books that have been written about the Black Hills, including *Black Hills Forestry: A History*, by John F. Freeman, *The Black Hills: Yesterday & Today*, by Paul Horsted, and more.

**What other resources/tools
might you use to make your
forests more adaptive to
uncertainty?**



Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

Questions?

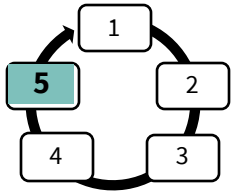


FARM PRODUCTION AND CONSERVATION
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Identifying Metrics for Monitoring & Evaluating Effectiveness



John Korfmacher, physical scientist, conducting ozone monitoring at Pike-San Isabel National Forest, Colorado. (*USDA Forest Service photo*)

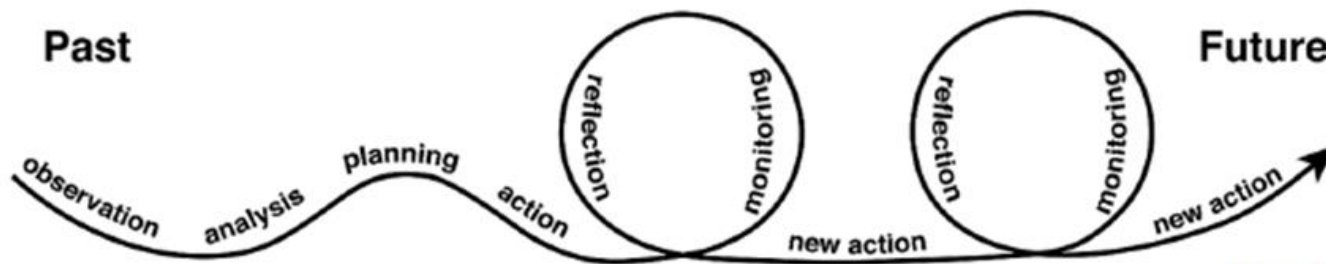


Step 5: MONITOR and evaluate effectiveness of implemented actions.

Purpose: Practice adaptive management

Key Questions:

- How will you know if your actions were effective?
- What can you learn to inform future management?



Adapted from Colfer 2005.

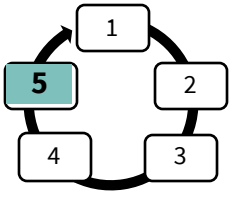


Adaptation monitoring considerations

Developing a monitoring question

How did **[adaptation action from Step 4]** change the **[focal species, process, or ecosystem condition related to goal from Step 1]** at my site?

- This is not a yes/no question – gather robust information to inform future efforts
- Should help determine what variable you need to measure that will answer the question



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Examples

Adaptation Monitoring Variable	Criteria for Evaluation	Monitoring Implementation
Invasive species abundance	Areas identified for control have <20% cover from invasive species	Annual invasive species surveys (late fall)
Regeneration success	More than 50% of desirable species in 0.5-2” class	Regeneration survey 2-4 years after harvest
Early-successional bird species abundance	Target bird populations have increased by >50%	Annual point counts pre-harvest and post-harvest
Total suspended solids	Reduction of 30% of current solids at basin outflow	Monthly for first two years; then annual

How effective are my methods for eradicating oriental bittersweet?

How do patch cuts affect oak regeneration on my property?

How do patch cuts change focal wildlife species abundance on my property?

How does trail re-routing impact erosion in nearby coldwater stream?

STOP and consider:

- **Existing monitoring efforts:** Can my annual monitoring plan or community science observations help evaluate my adaptation actions?
- **New or existing partnerships:** Can I plan monitoring around seasonal volunteer crews or reach out to local university research faculty?
- **Existing protocols:** Are there standardized protocols for the resource I'm monitoring?
- **Scale:** Can I scale down my monitoring to fewer sites and still answer my monitoring question?

Prioritize: Select variables to monitor that can evaluate multiple management actions and/or goals.



Colorado Forest Restoration Institute



SD Game, Fish, & Parks

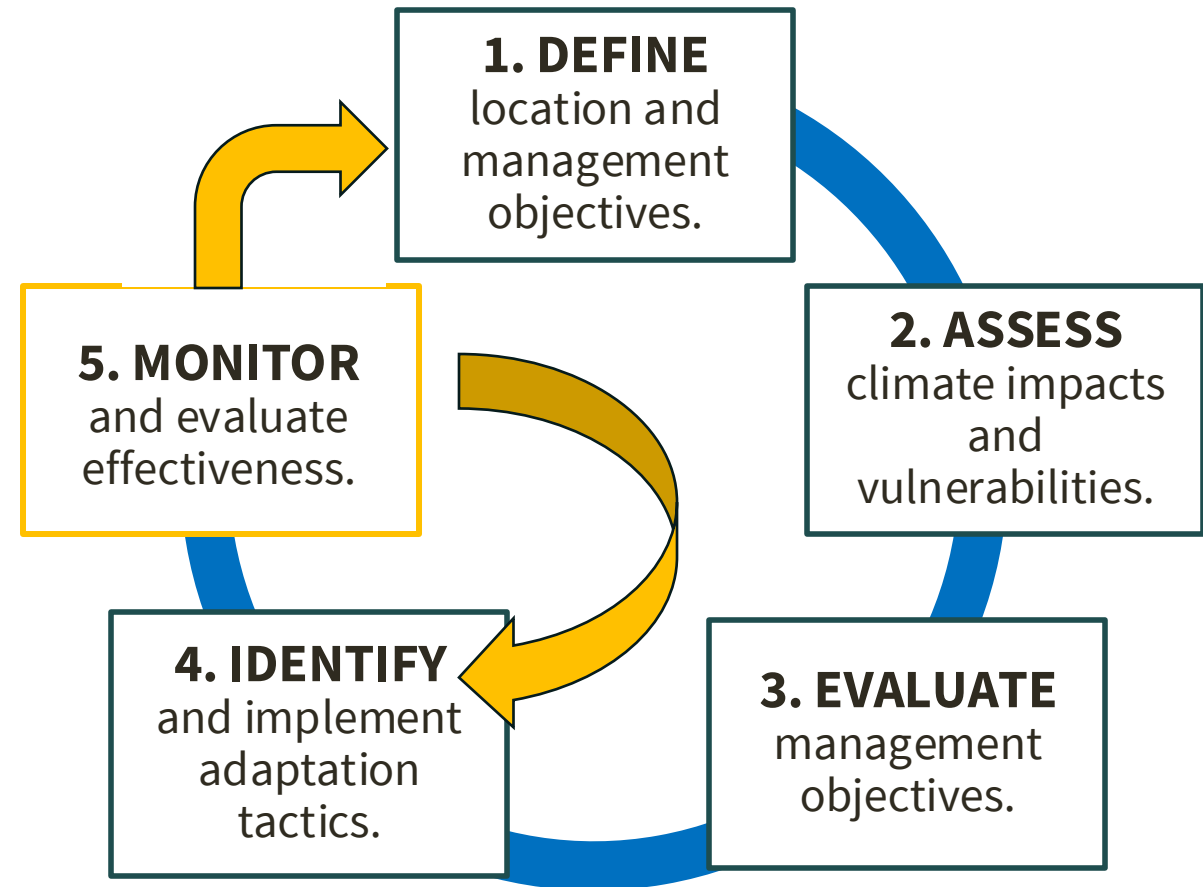
Adaptive management process

How might you adapt your
management goals

OR

adaptation actions

if you don't achieve your
desired outcome?



Monitoring in the Black Hills

Black Hills National Forest

- Invasive species and noxious weeds
- Habitat management and species viability
- Physical and other resources

Other Partners

- National Park Service
- USGS
- South Dakota Wildlife Action Plan
- South Dakota School of Mines and Technology and Black Hills State University

United States
Department of
Agriculture

Forest
Service

Black Hills
National
Forest

August 2015

BLACK HILLS NATIONAL FOREST



**FY 2013-14 MONITORING
AND EVALUATION REPORT**

Citizen Science Projects

Black Hills Parks & Forests Association collaboratives engage in:

- The annual **Christmas Bird Count** engages volunteers in documenting winter bird populations, contributing to one of the longest-running citizen science projects in the nation
- **Stream monitoring programs** train volunteers to collect water quality data from forest streams, tracking parameters like temperature, clarity, and aquatic invertebrate populations that indicate ecosystem health
- **Wildflower monitoring** projects document blooming times and locations, providing data on how climate change may be affecting plant phenology
- **Wildlife camera projects** enlist volunteers in maintaining remote cameras and cataloging the resulting images, building understanding of wildlife distribution and behavior

Lunch – Be Back at 1:15 PM



Breakout Groups: Climate-Informed Prescriptions

Create treatments for each adaptation option (3 total)

RESISTANCE



RESILIENCE



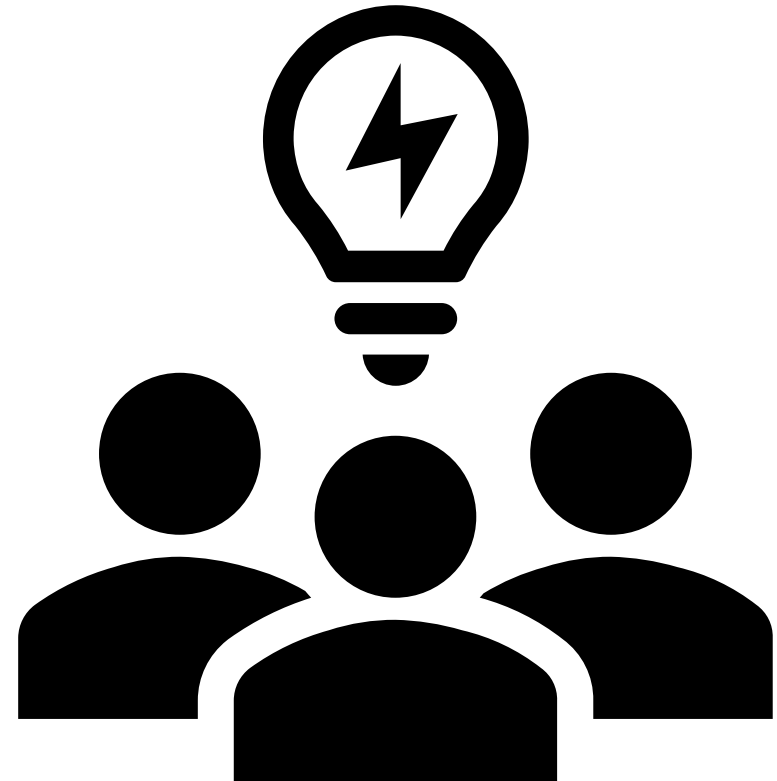
TRANSITION



What actions can be taken to enhance the ability of the area to adapt to anticipated changes and meet management goals?

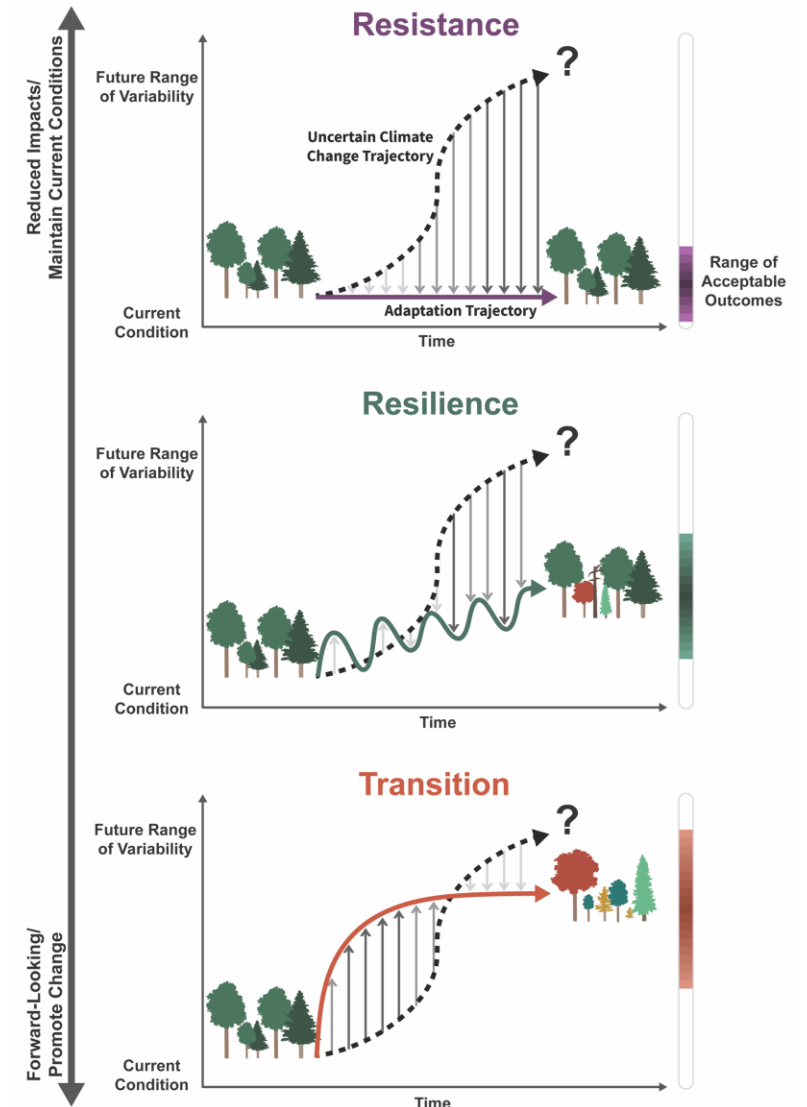
Breakout Groups – Instructions

- Develop an example of adaptation actions for your project area as close to the stand level as possible.
- Make sure all group members understand desired future conditions for your project.
- Review your selected climate impacts, challenges, and opportunities.
- Explore the menus of adaptation actions to consider actions that increase the ability of the forest to adapt to climate change in the future.



Develop 3 Climate-Informed Prescriptions

- Create three prescriptions:
 - to **resist** change,
 - build **resilience**, and
 - facilitate a **transition** to another forest type
- Create objectives for each adaptation option
- Describe the future condition of each of these adaptation options
- Describe how each strategy will address a specific anticipated future stressor
- Outline the silvicultural actions that you would implement to pursue each option
- Describe one way you would consider monitoring each adaptation option into the future – how will you measure success?



Time To Apply: Tell Your Adaptation Story

- Present in 5 min or less!
- For each prescription (RRT):
 - Overarching management goals
 - Key climate impacts you are addressing
 - Describe the future condition of each of these adaptation options
 - Outline the silvicultural actions that you would implement to pursue each option
 - Describe one way you would consider monitoring each adaptation option into the future



Be creative and
expand your
management toolbox!

Instructions

Go to

www.menti.com

Enter the code

8357 3475



Or use QR code



Group Synthesis on Adaptation Options

- Which of the RRT treatments that you created feels most like business-as-usual management?
 - Resistance
 - Resilience
 - Transition
 - None/Other
- Which RRT treatment do you think is most likely to succeed over the next 20 years? Over the next century?
- Would you feel comfortable implementing the TRANSITION treatment? Describe any aspects that feel uncertain or concerning to you.
- Were you stumped about how to respond to any particular climate change impacts?
- Did this activity raise any questions for you?



Workshop Evaluation

We appreciate your feedback!



Thank you!



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