



Connecticut Conference
ON NATURAL RESOURCES

Many Resources. One Environment

March 16-17, 2015
Storrs, CT

Climate Change and the Forests and Habitats of Southern New England



www.forestadaptation.org

Northern Institute of Applied Climate Science

Climate

Carbon

Bioenergy

- Provides practical information, resources, and technical assistance related to forests and climate change
- Supports the integration of climate change information into natural resource management



www.nrs.fs.fed.us/niacs/

Regional multi-institutional partnership among:



Michigan Tech

ncasi





NORTHERN FORESTS SUB HUB



**The Climate Is Changing.
How Will You Manage For It?**

The Northern Forests Sub Hub assists natural resource managers, woodland owners, and others interested in forests with integrating climate change information into planning, decision making, and management activities.

The region's forests are a national asset; they contain:

42% of U.S. forests

32% of U.S. timberland

41% of U.S. population

The climate is changing

The climate has changed and will

Science delivery

The USDA Climate Sub Hub delivers science-based tools and information to land managers so they can make climate-informed decisions now.

The Sub Hub is a collaborative effort between agencies, universities, states, tribes and other groups. Connecting land managers to the

The Sub Hub assists

- Professional Resource Managers
- Cooperative Extension agents
- Private Landowners
- USDA Technical Service Providers

March 16 – Agenda

- 1:45 **Forest Adaptation Resources: an Introduction Southern New England's Changing Climate**
- 2:55 Break
- 3:20 **Climate Change Effects on Forest Ecosystems**

March 17 – Hands-on Training

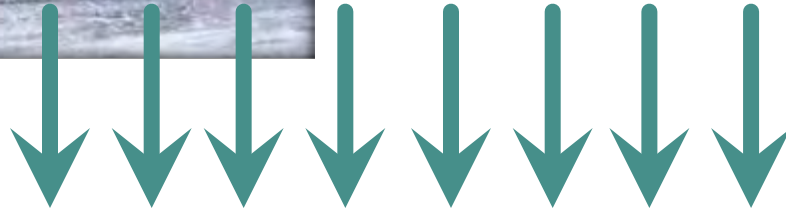
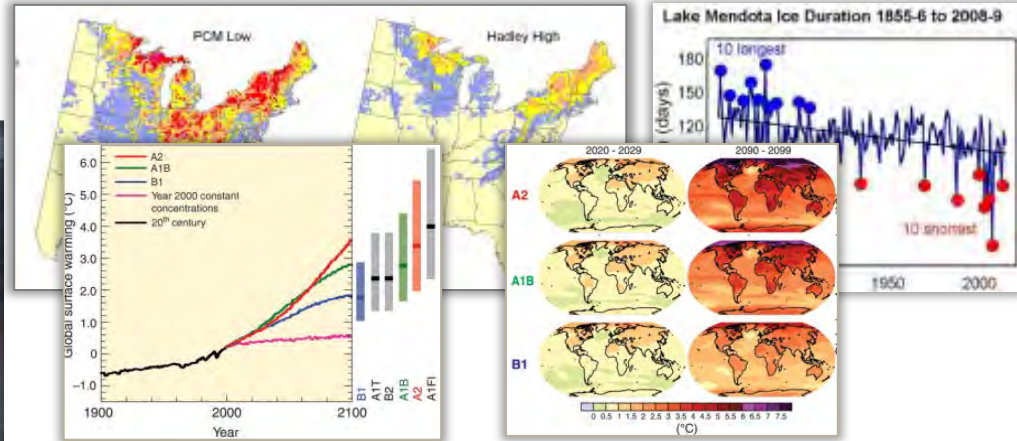
An active, hands-on training, to assist natural resource professionals in incorporating climate change considerations and identifying actions for adaptation into their own real-world management and conservation projects.
Join us tomorrow!

March 17 – Agenda

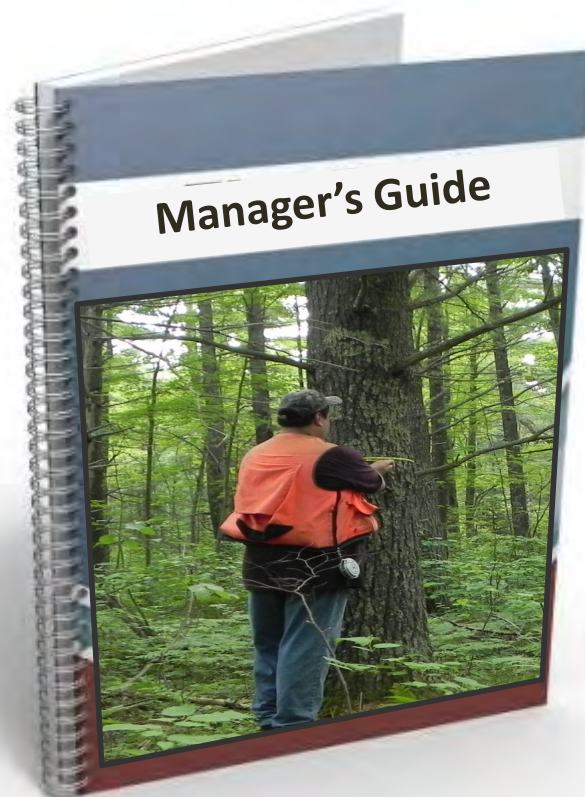
- 8:30 **Climate Change Impacts on Forest Management Projects (Step 2)**
- 10:00 Break
- 10:15 **Challenges/Opportunities for Management (Step 3)**
- 11:30 **Identifying Forest Adaptation Approaches and Tactics (Step 4)**
- 12:00 Lunch (BYO)
- 1:00 **Identifying Forest Adaptation Approaches and Tactics (Step 4)**
- 3:00 Break
- 3:15 **Identifying Forest Adaptation Approaches and Tactics**
- 4:00 **Next Steps & Wrap-up**
- 4:00 Adjourn



When we started...



Responding to Climate Change



Responding to Climate Change

There is not a single “answer”

~~Manager's Guide~~

~~Decision Tree~~

~~E-Z Whiz-bang Tool~~

Critical to start with:

The place

Management goals
& objectives

Invasives

Natural Forest
Dynamics

Desired
Conditions

Timber Sale
Revenue

Forest
Health

Past
Management
History

Plan & Project
Requirements

Wildlife
Habitat

Disturbance:
Past + Future

And more!!

Recreation

Climate
Change



Climate Change Response Framework

Structured, process oriented, works on multiple scales

Components:



Partnerships

Vulnerability Assessment

Forest Adaptation Resources

Adaptation Demonstrations

Progress:

75+ partner organizations
(and counting)

3 published assessments,
3 more in press/revision

Published in 2012, updated
and online versions in prep

50+ demonstrations
underway

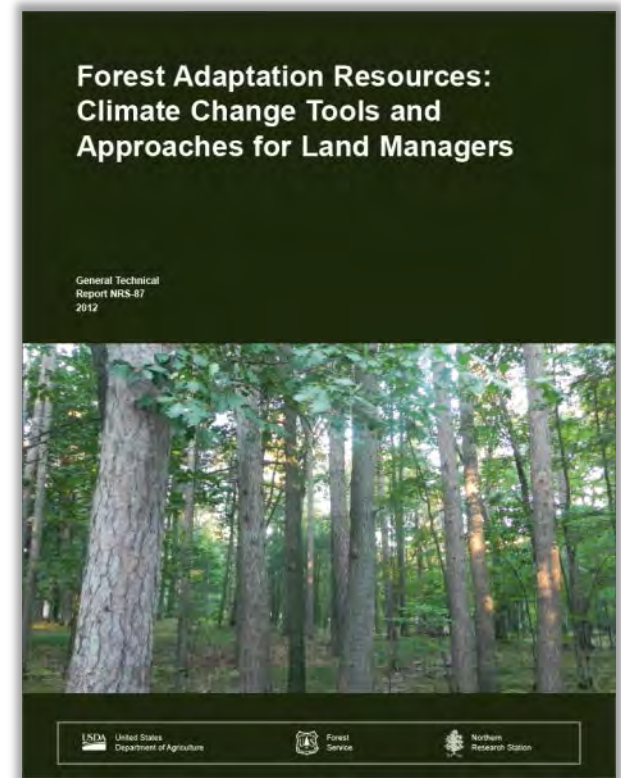
Vulnerability Assessments

- High-quality information about future change in climate and potential effects on forest ecosystems
- In New England, synthesizing current state and regional assessments to highlight greatest risks



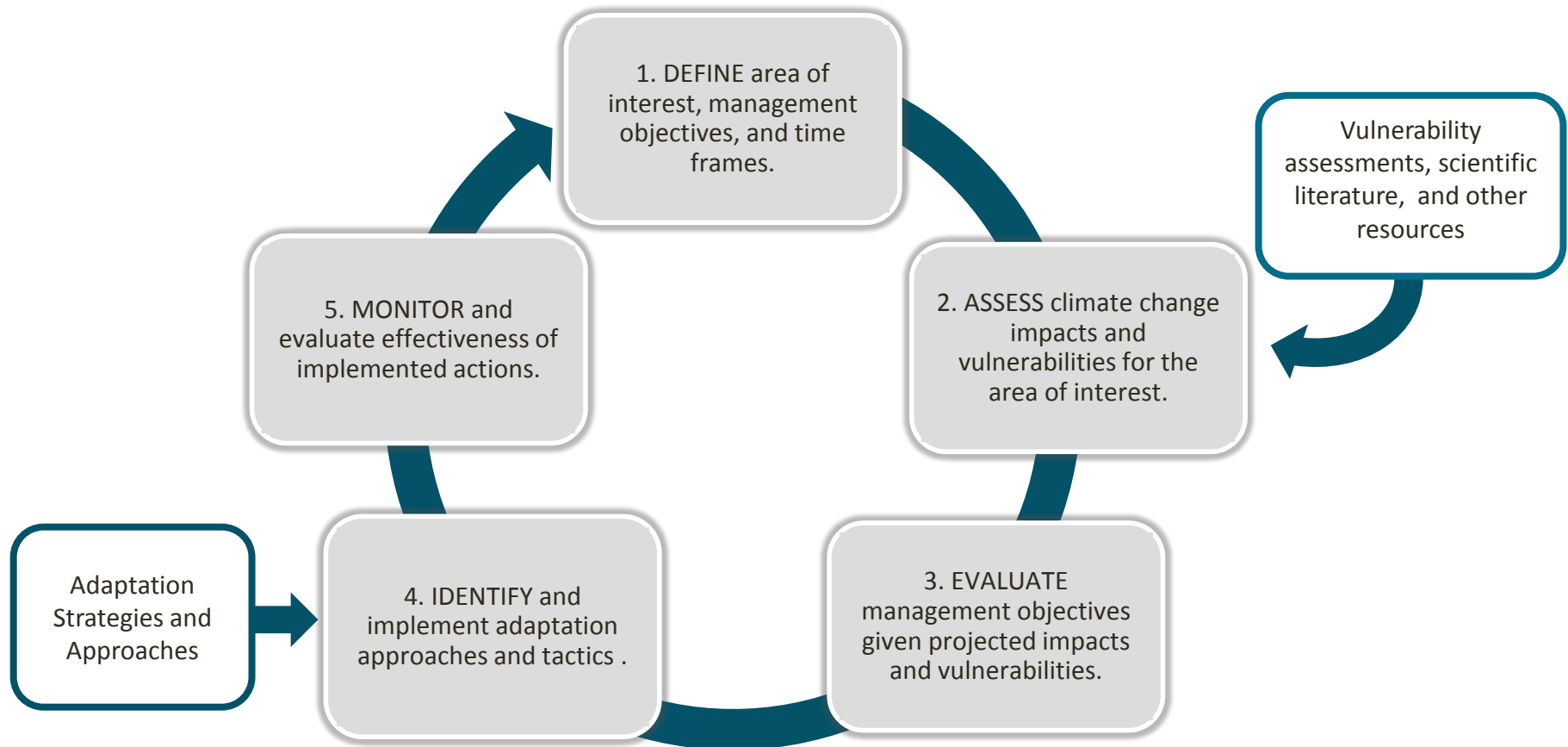
Forest Adaptation Resources

- Designed for a variety of land managers
- Does not make recommendations
- Menu of strategies & approaches for climate change adaptation
- Adaptation workbook process for implementation



Forest Adaptation Resources

Provides **structured process** to integrate climate change considerations into management planning and activities



Forest Adaptation Resources

Step-by-step **Adaptation Workbook** for planning

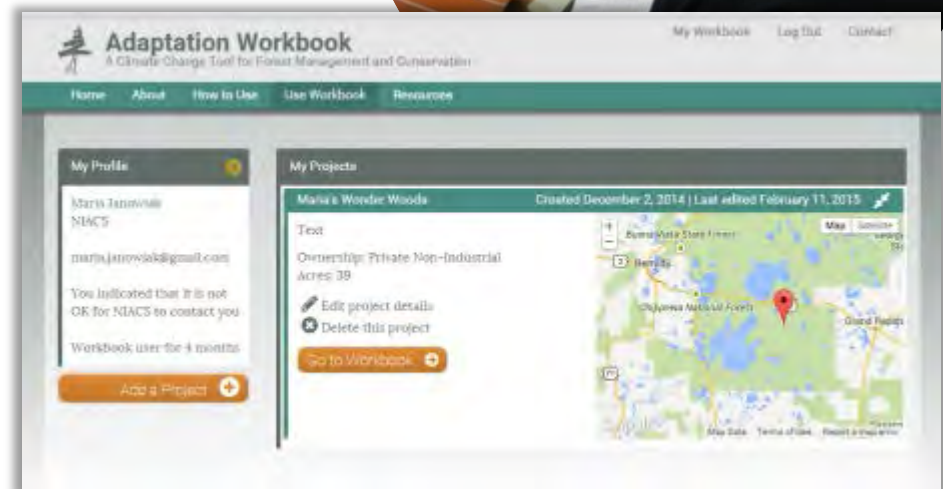
Management Objectives	Challenges	Opportunities	Feasibility	Other Considerations

Adaptation Actions			Benefits	Drawbacks/ Barriers	Recommend Tactic?
Approach (From Chapter 2)	Tactic	Time Frame			

Forest Adaptation Resources

Ways the **Adaptation Workbook** can be used:

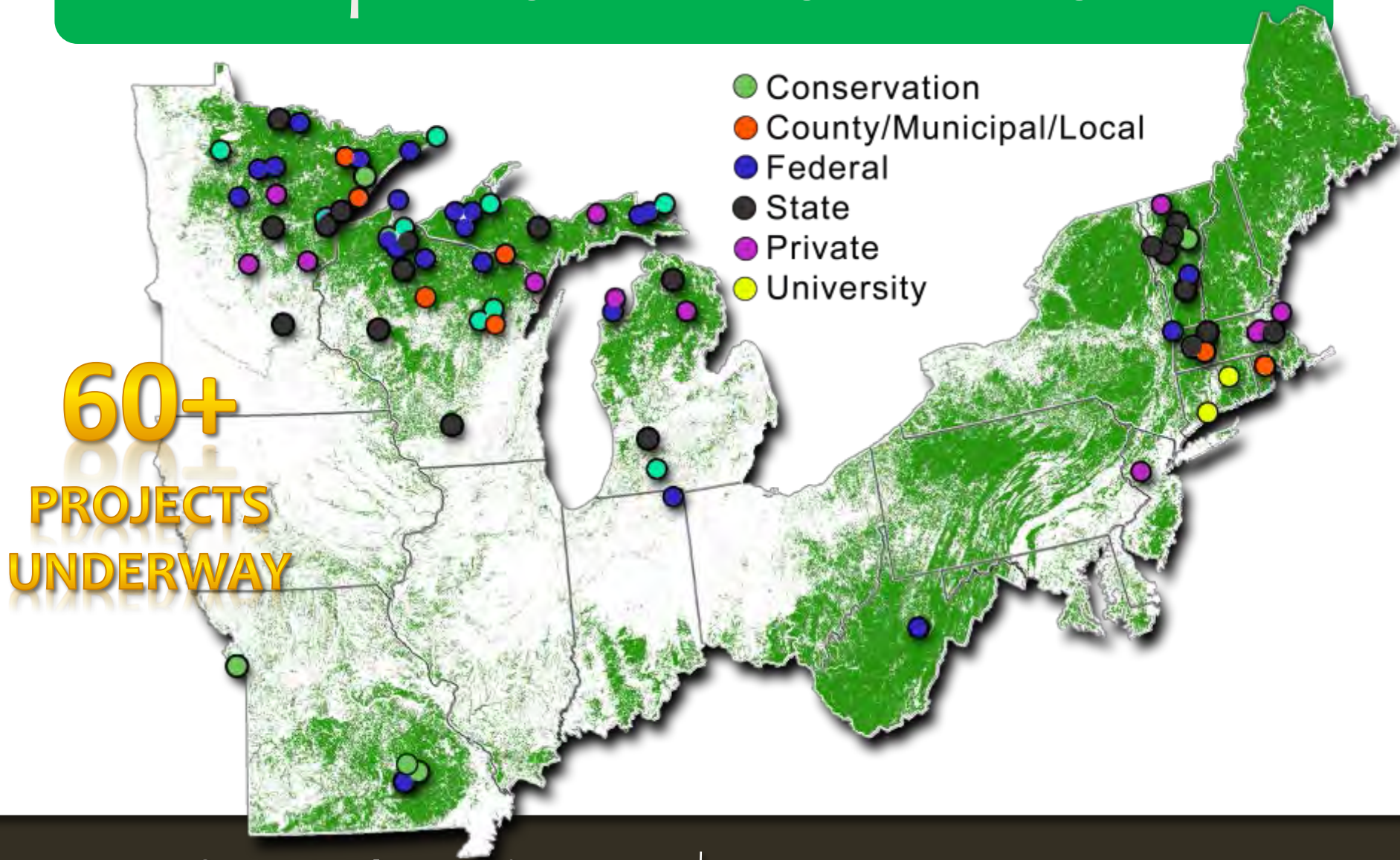
- Coordinator facilitates individual or small group
- Forest Adaptation Planning and Practices workshop
 - General (state agencies; SFEC)
 - Tribal (Sault; Menominee)
 - Conservation (WCS; DU)
- Managers use the workbook independently
 - Online version soon!!



Adaptation Demonstrations

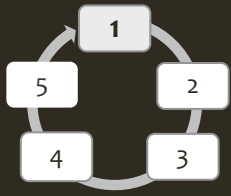
- Provide **real-world examples** of forest management activities that:
 - Enhance the ability of forests to cope with changing conditions
 - Achieve land owner management goals
- Foster **cross-ownership** dialogue and learning
- Illustrate **diverse goals** and approaches

Adaptation Demonstrations



Chequamegon-Nicolet NF: Aspen



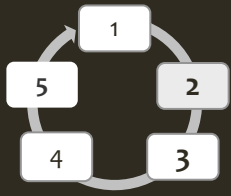


Step 1: DEFINE area of interest, management goals and objectives, and time frames.

Management Goals & Objectives

- Early-successional habitat
- Scenic Integrity

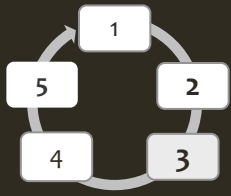




Step 2: ASSESS climate change impacts and vulnerabilities for the area of interest.



Impacts: Potentially drier growing season conditions



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

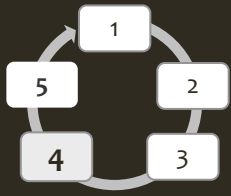
Challenges

- Aspen in long-term
- Few tree species
- Productivity issues
- Hazel competition
- Windthrow

Opportunities

- Site suitable for pine in future?

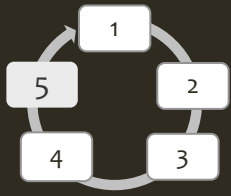




Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

Overall Approach: Enhance future options within existing management trajectory

- Aspen will regenerate now, but is likely to fare poorly over the long term.
- Maintain plans for clearcut for aspen regeneration
- Additional actions to promote diversity and provide future options: plant red oak and white pine
- Pro-active on invasives and disturbance planning



Step 5: MONITOR and evaluate effectiveness of implemented actions.



- Post clearcut stocking*
 - Survival of planted trees*
 - Species composition for trees* and seedlings/saplings
 - Intensified inventory (?)
- *existing monitoring item*

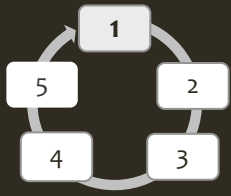
Chequamegon-Nicolet Aspen: Status



- Stands are marked
- Winter harvest –this winter
- Then: underplant native future-adapted species

Menominee Tribal Enterprises: Oak Wilt



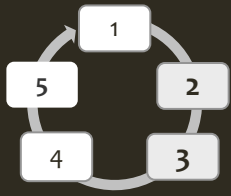


Step 1: DEFINE area of interest, management goals and objectives, and time frames.



Management Goals

- Foster diversity
- Favor sawtimber species
- Provide cultural uses
- Restore oak wilt pockets



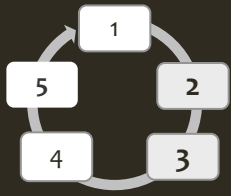
Step 2: ASSESS climate change impacts

Step 3: EVALUATE management objectives



Treatment

- Harvest affected & adjacent oaks
- Pull stumps
- Harvest other species in pocket



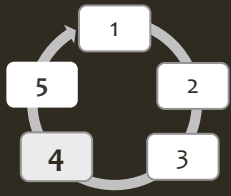
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Treatment

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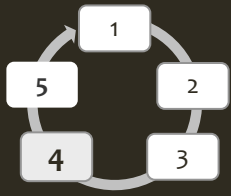
Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

Adaptation Approach

- Reduce biological stressors
- Maintain and enhance diversity
- Promote future-adapted species
- Enhance genetic diversity

Restore sites with future-adapted species





Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

Climate Change Tree Atlas

Projected Habitat Increases

American beech

American elm

American hornbeam

Bitternut hickory

Black cherry

Black locust

Black oak

Black willow

Boxelder

Bur oak

Eastern cottonwood

Silver maple

Slippery elm

White ash

White oak

Projected New Habitat

Black hickory

Black walnut

Blackjack oak

Chinkapin oak

Eastern red cedar

Eastern redbud

Flowering dogwood

Hackberry

Honeylocust

Mockernut hickory

Ohio buckeye

Osage-orange

Post oak

Shingle oak

**Also shrub &
understory
plants**

Menominee Oak Wilt: Status

Last Summer

- Selected sites
- Site prepped
- Oaks planted



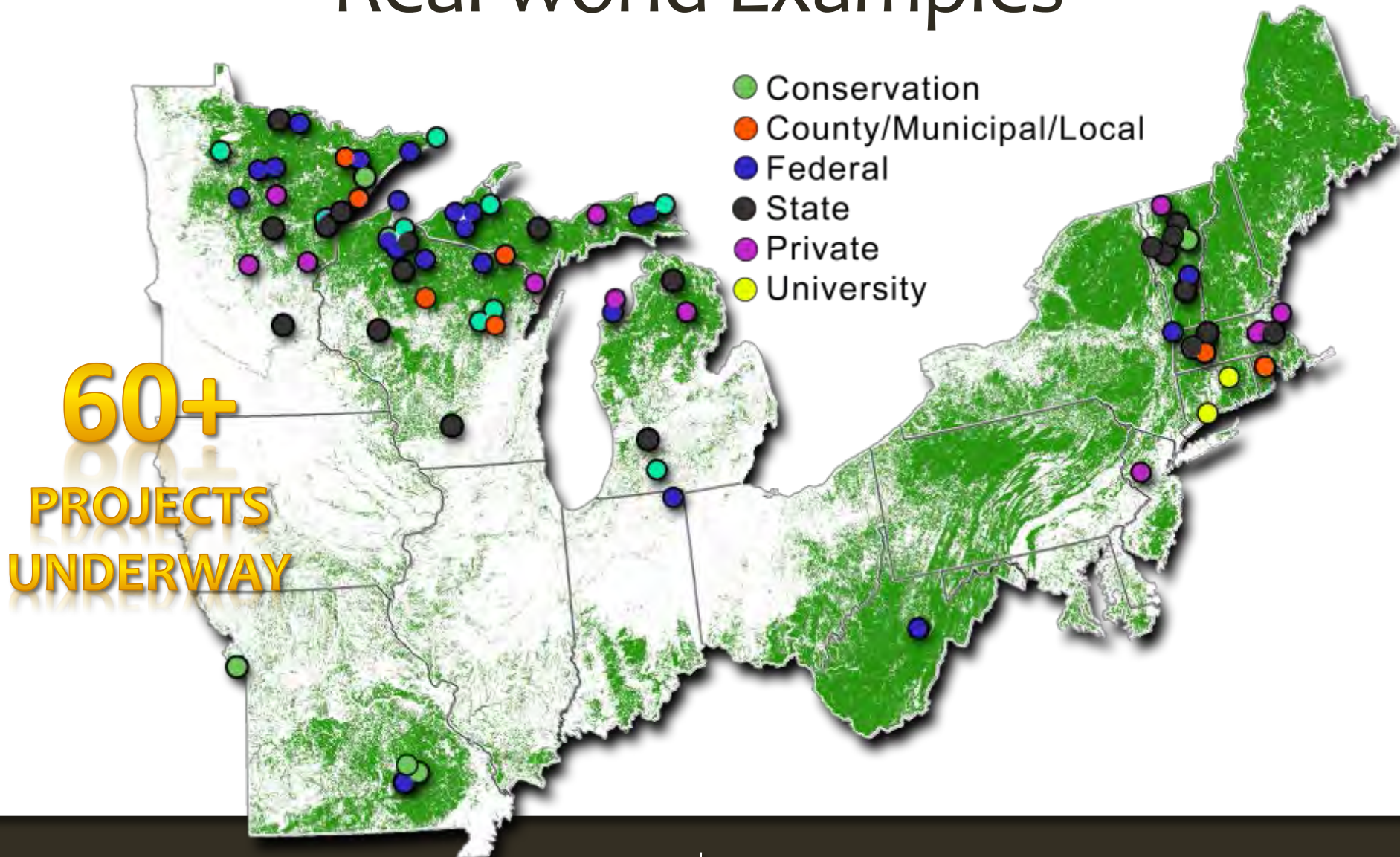
This Summer and Next

- Additional tree species
- Non-tree species of cultural value

Monitor

- Seedling success
- Forest health and stressors
- Forest composition
- Cost of treatment

Real-world Examples




Learning through Examples

- Diversity in lands, owners, and objectives
- Acknowledge difference, build on similarities
- Demonstrate shared perspectives




MPRnews Sections ▾ Members ▾ More ▾

A forest dilemma: What will grow in a changing climate?

Dan Kraker · Two Harbors, Minn. · Feb 3, 2015 · Environment



One of nine overlooks on Oberg Mountain near Tofta, Minn. The overlooks are a popular destination to view fall colors. *Derek Montgomery / For MPR News*

   **LISTEN Story audio**
Jan 30, 2015
7 min 32sec

Climate Change in Minnesota: An MPR News special report

Minnesota's iconic northern forests are undergoing a gradual shift as the climate warms. Spruce, fir, and hemlock are being replaced by more southern species like

Learning through Experimentation

Adaptive Silviculture for Climate Change (ASCC)

- Experimental silvicultural trials in multiple forest types across the US
- *How will forests respond to a range of climate change adaptation actions?*



What does adaptation look like?

Using new information and ideas

Beginning to take small steps

Being creative and flexible

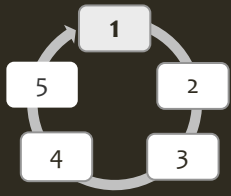
Working and learning with others





Atlas Timberlands





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



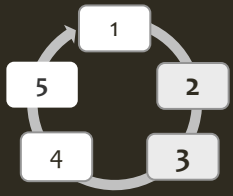
Management Goals

- Sustainable forestry
- Conservation



Current Management with Adaptation Benefits

- Follow BMPs for water quality
- Increase coarse woody material
- Increase tree species diversity
- Increase forest structural diversity
- Ensure adequate seedling regeneration
- Control invasives
- Minimize roads & trails

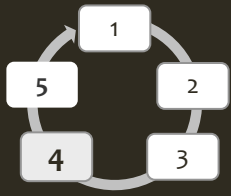


Step 2: ASSESS climate change impacts

Step 3: EVALUATE management objectives



Challenge: Shorter and more variable winter



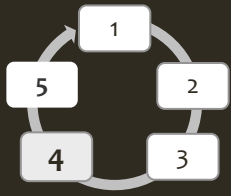
Step 4: IDENTIFY and adaptation approaches and tactics for implementation.



Adaptation Tactic: Summer harvest

Potential Barriers:

- More planning
- Higher cost
- Will it even work??



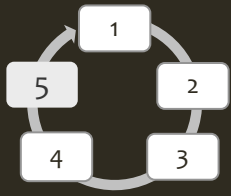
Step 4: IDENTIFY and adaptation approaches and tactics for implementation.



Spring/Early Summer 2014

- Timber marking
- Road layout
- Pre-sale road work
- Temporary bridge installation

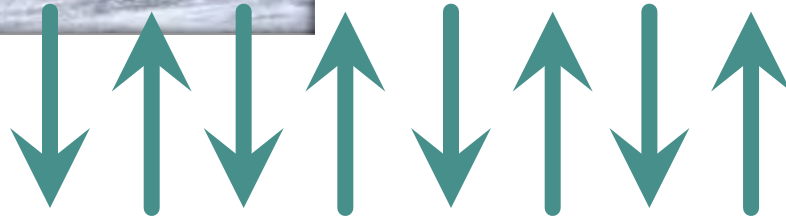
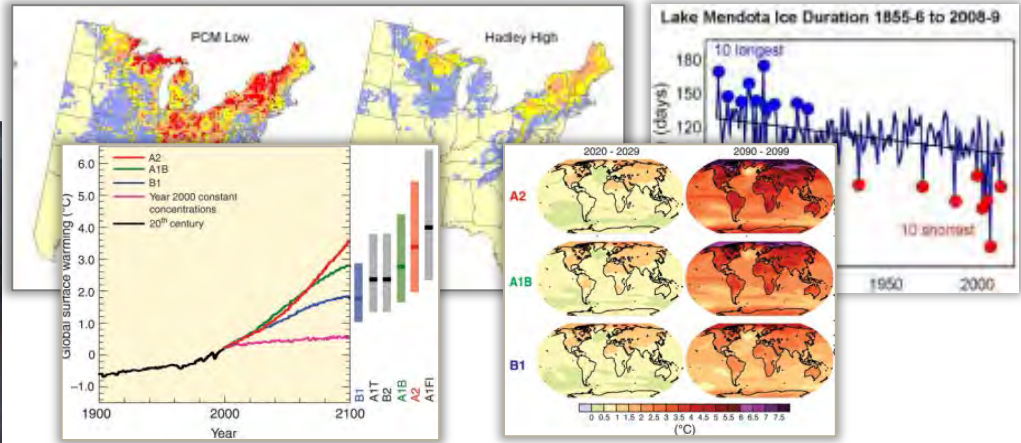
Harvested Summer 2014
(when the weather cooperated!)



Step 5: MONITOR and evaluate effectiveness of implemented actions.



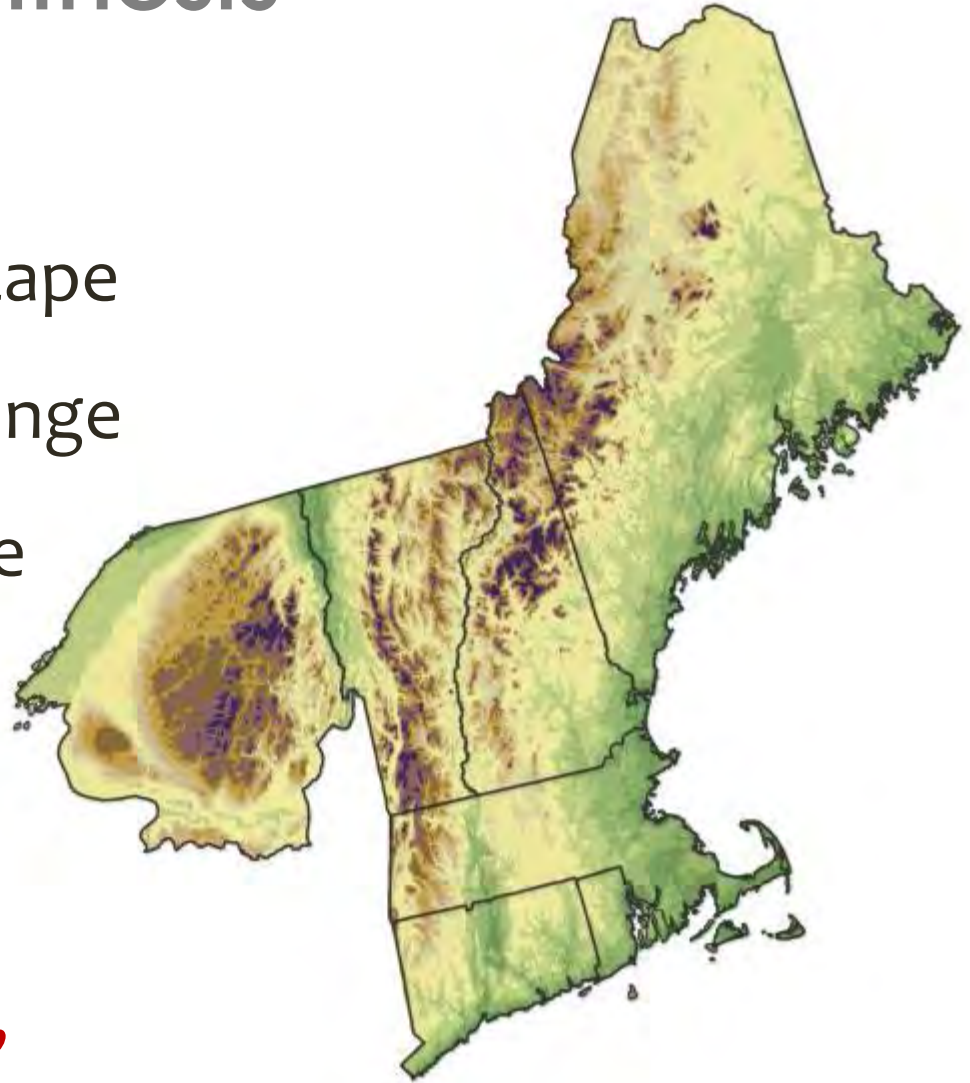
Gullying from a bad woods road (past management)



CLIMATE CHANGE EFFECTS ON NORTHEAST FOREST ECOSYSTEMS & HABITATS

New England Synthesis

- 1) Introduction
- 2) Contemporary Landscape
- 3) Observed Climate Change
- 4) Future Climate Change
- 5) Impacts on Forests
- 6) Conclusions



**Timeline = in progress,
draft this spring**

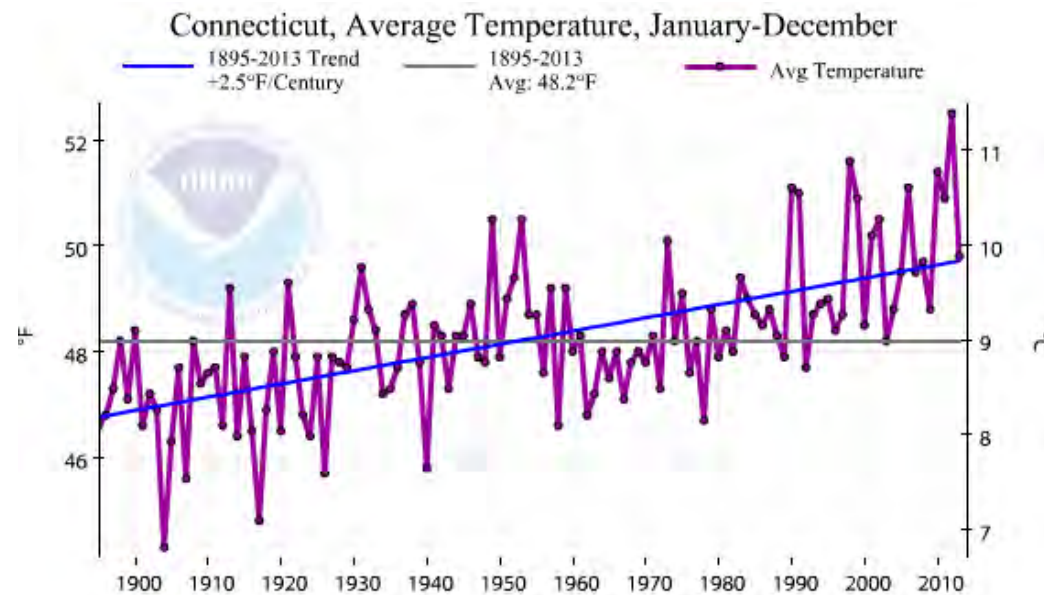
*How has climate changed
over the past century?*

Observed Climate Trends

Warmer temperatures

- CT temperatures increased more than 2.5°F since 1895
- Winter has warmed most
- Extremely hot days have increased
- Longer growing season
- Plants flowering more than a week earlier at Walden pond since 1880s

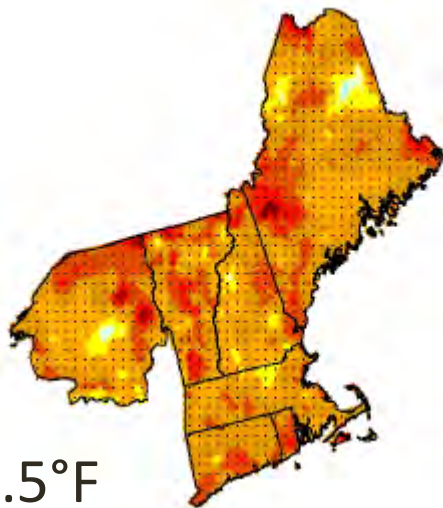
Annual Temperature Change since 1895



Seasonal Mean Temperature Change

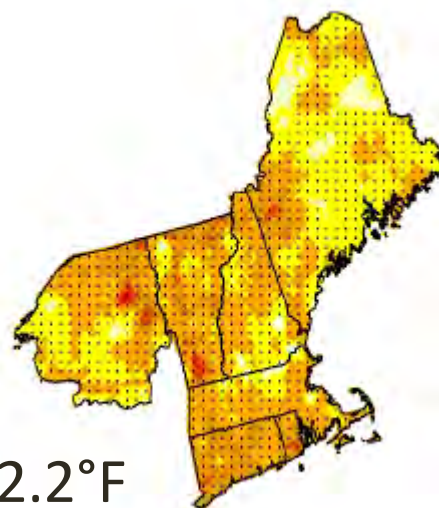
Winter
(Dec-Feb)

↑ 3.5°F



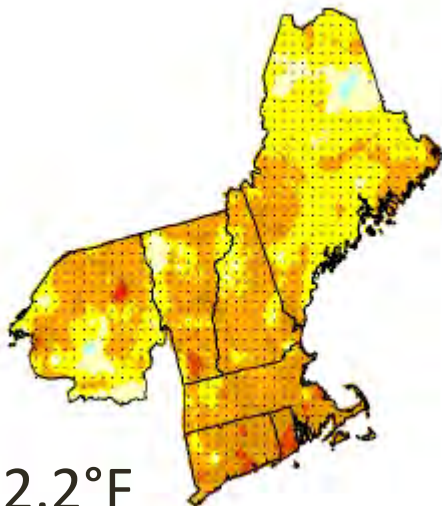
Spring
(Mar-May)

↑ 2.2°F



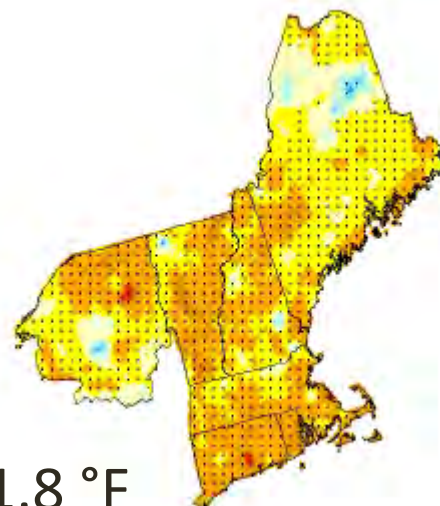
Summer
(Jun-Aug)

↑ 2.2°F

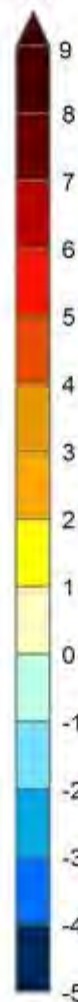


Fall
(Sep-Nov)

↑ 1.8°F



1901-2011
Temperature
change
(°F)

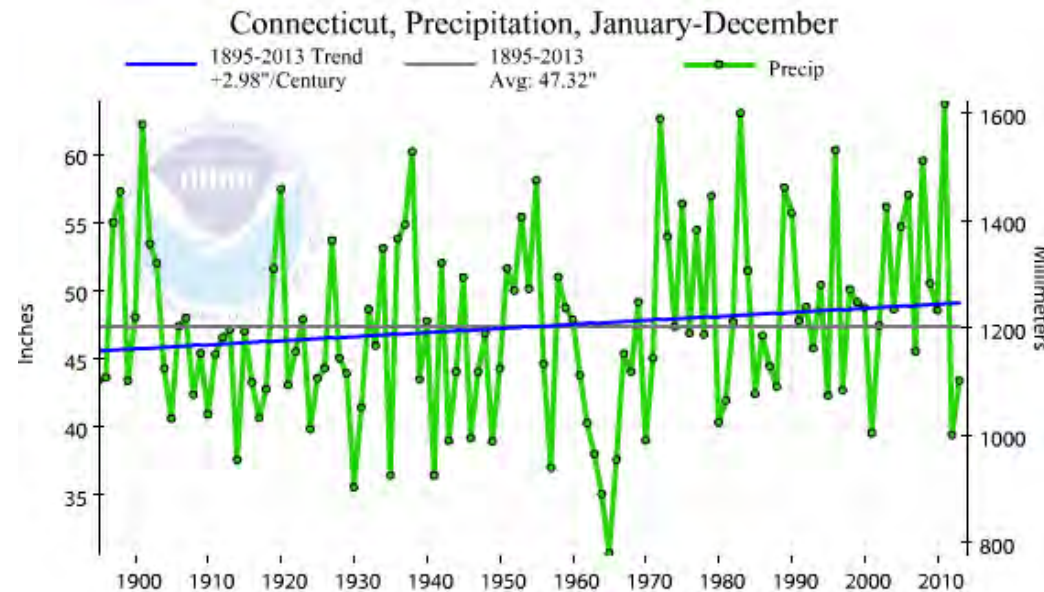


Observed Climate Trends

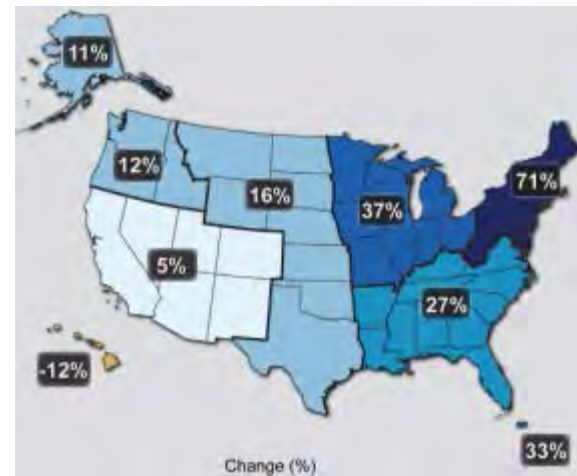
Altered Precipitation

- CT precipitation increased nearly 3" since 1895
- Extremely high variability from year to year
- Slight decrease in spring; increase of 2" in fall
- Substantial increases in extreme rain events: 71% increase across northeast since 1958

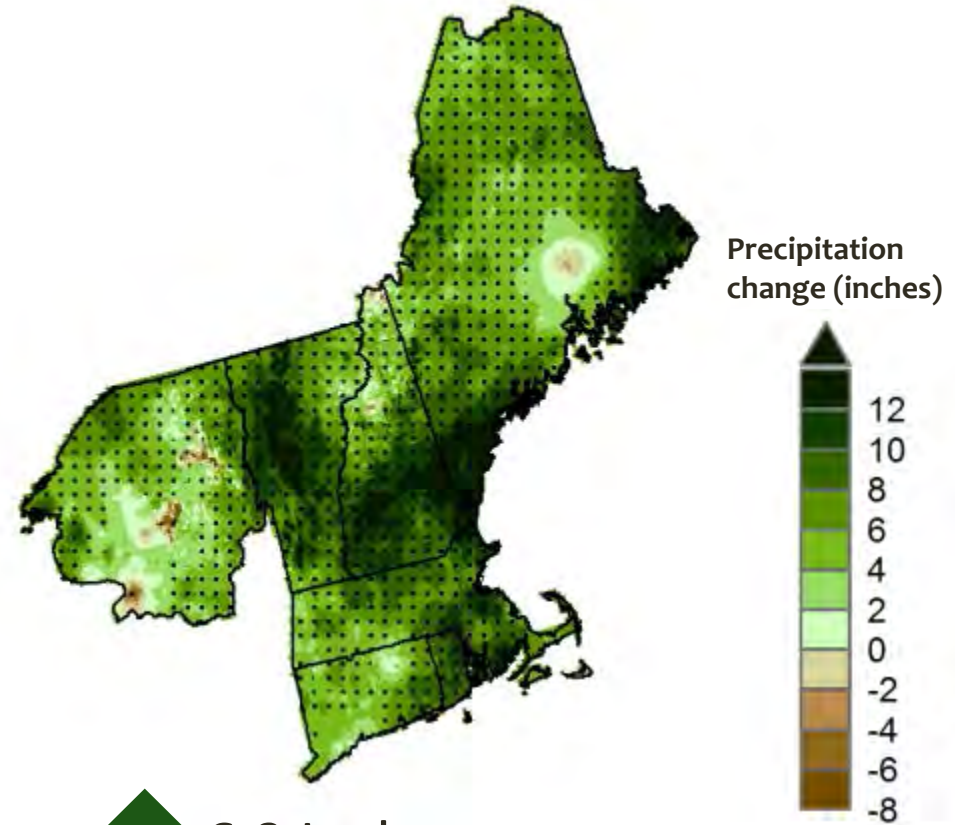
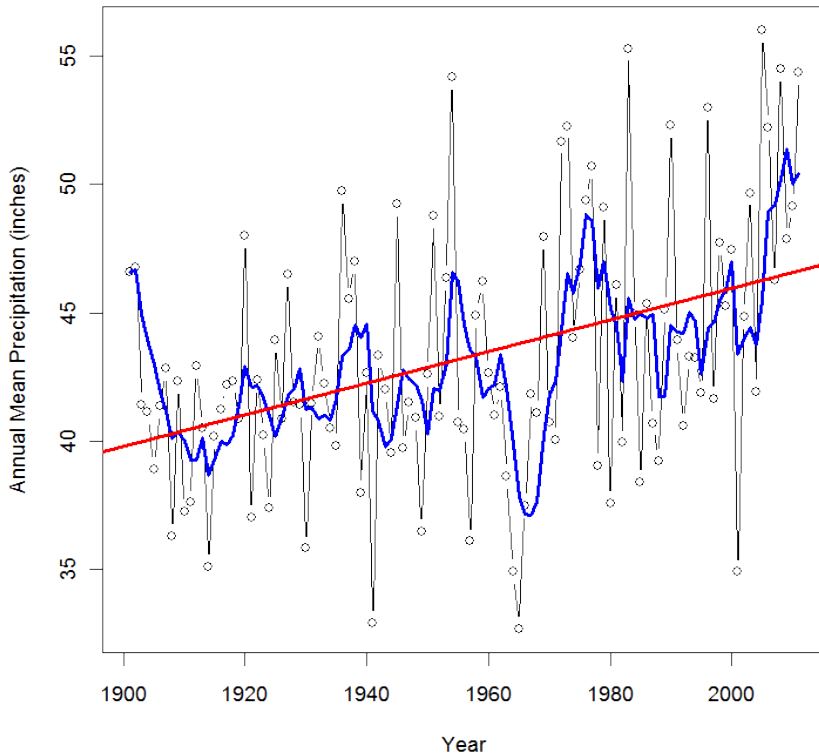
Annual Precipitation Change since 1895



Increase in Extreme Rain Events since 1958



Annual Precipitation Change (1901-2011)

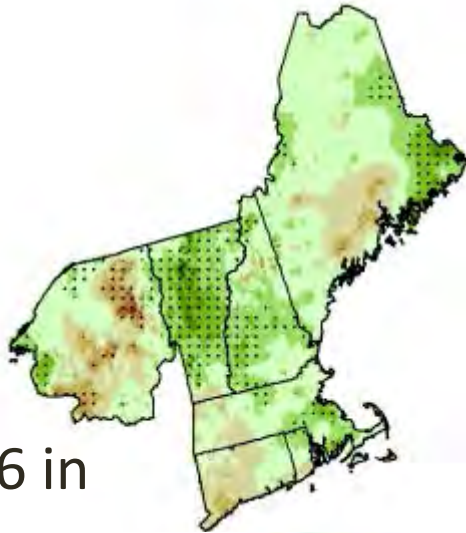


- 0.06 inches per year = 6.9 inches over 110 years
- Substantial inter-annual fluctuation

Seasonal Precipitation Change (1901-2011)

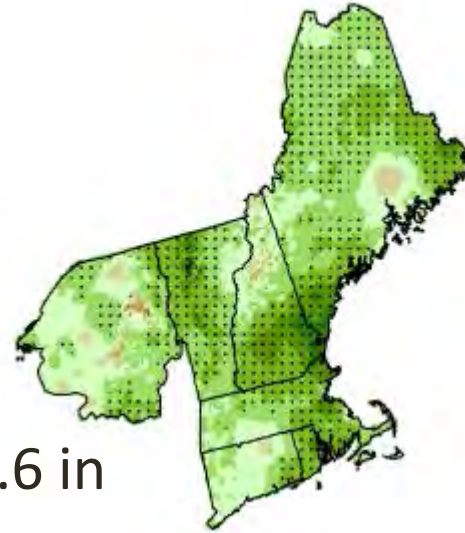
Winter
(Dec-Feb)

↑ 0.6 in



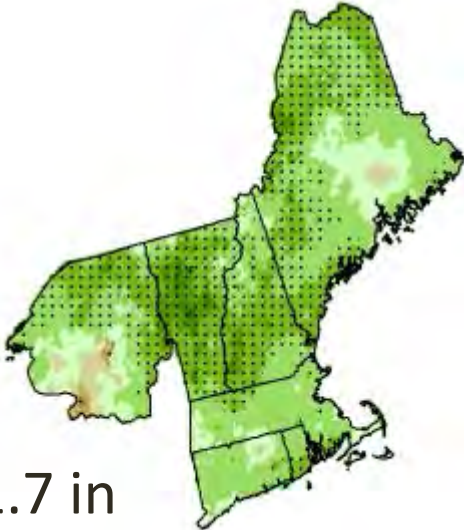
Spring
(Mar-May)

↑ 1.6 in



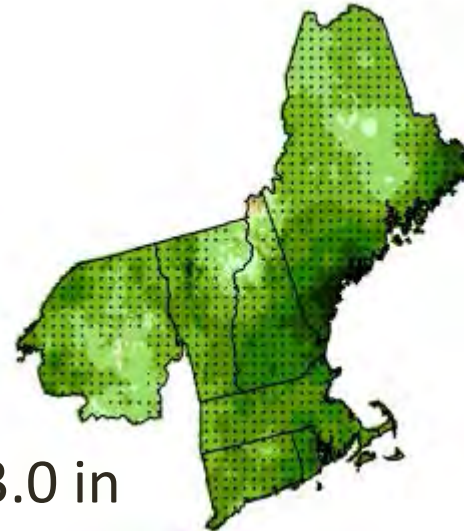
Summer
(Jun-Aug)

↑ 1.7 in

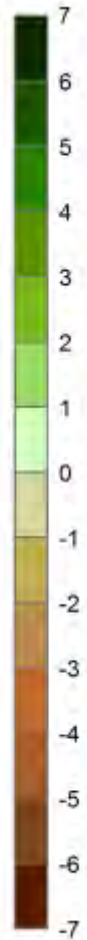


Fall
(Sep-Nov)

↑ 3.0 in

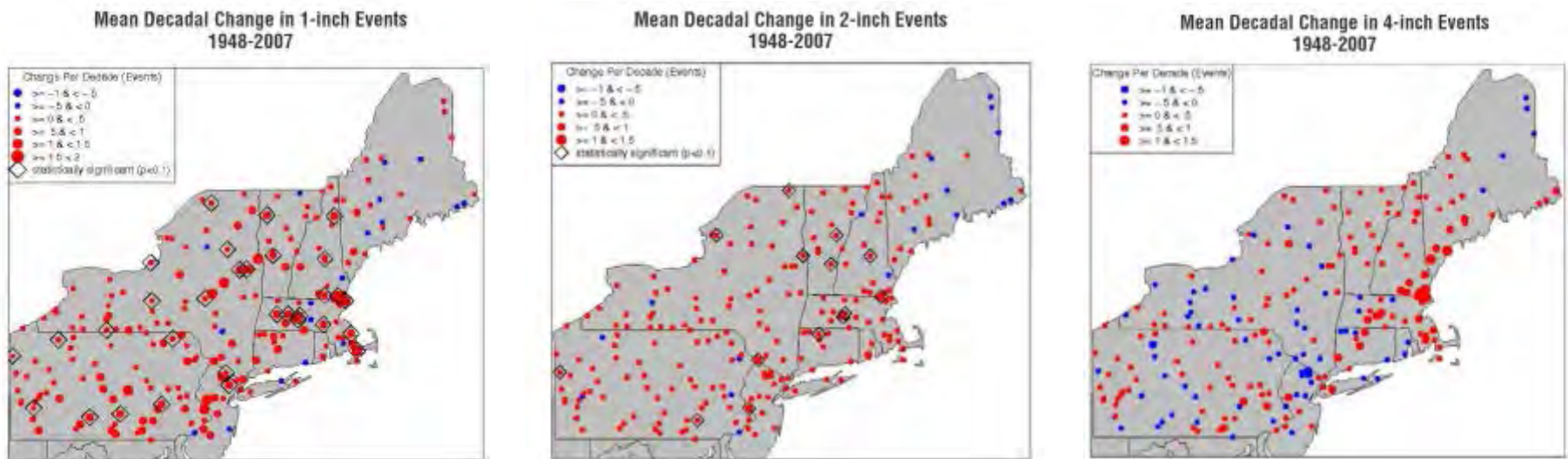


Precipitation
change (inches)



Extreme Precipitation Events

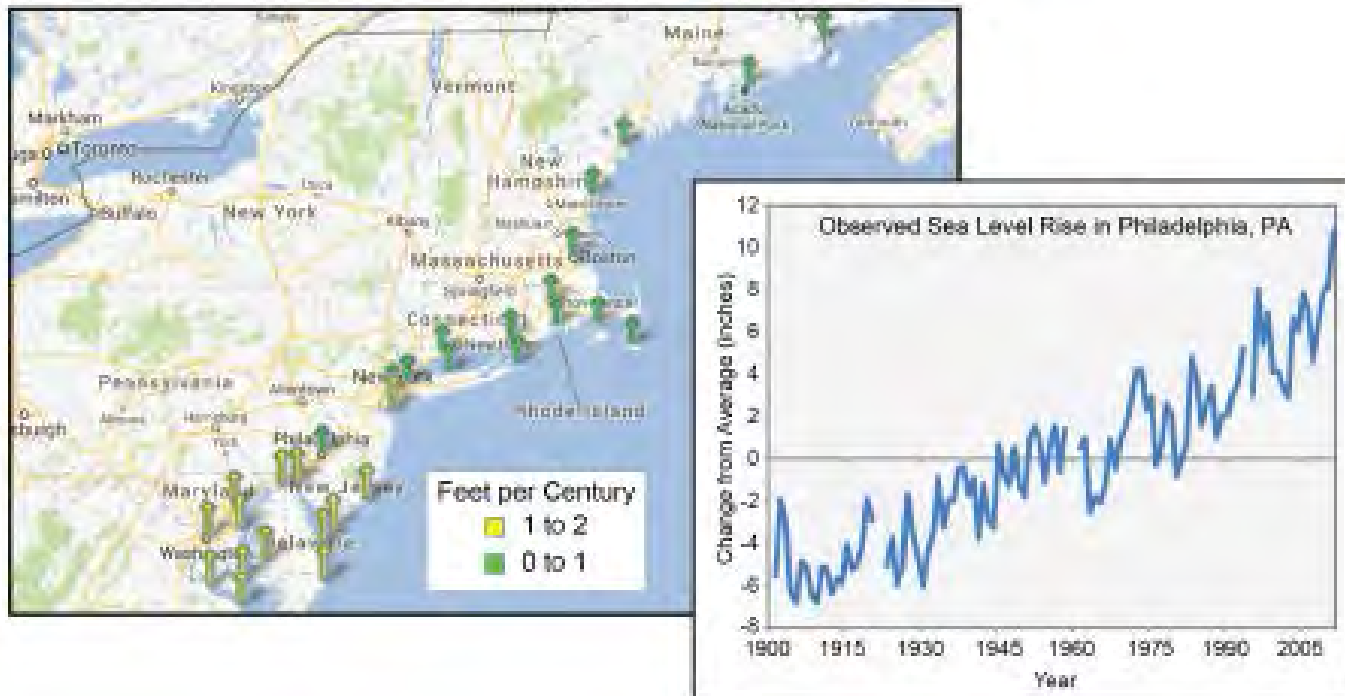
The amount of precipitation falling in single events increased between 1948 and 2007



Sea-level Rise

Sea-level Rise

- Sea level rose about 1 foot since 1900
- Increases in coastal flooding



Phenological Changes

Bird Range Expansion

Migratory birds are arriving earlier and breeding earlier, and several species have shifted their ranges northward (Rahbeck et al. 2007, Waite and Strickland 2006).

Lake Ice

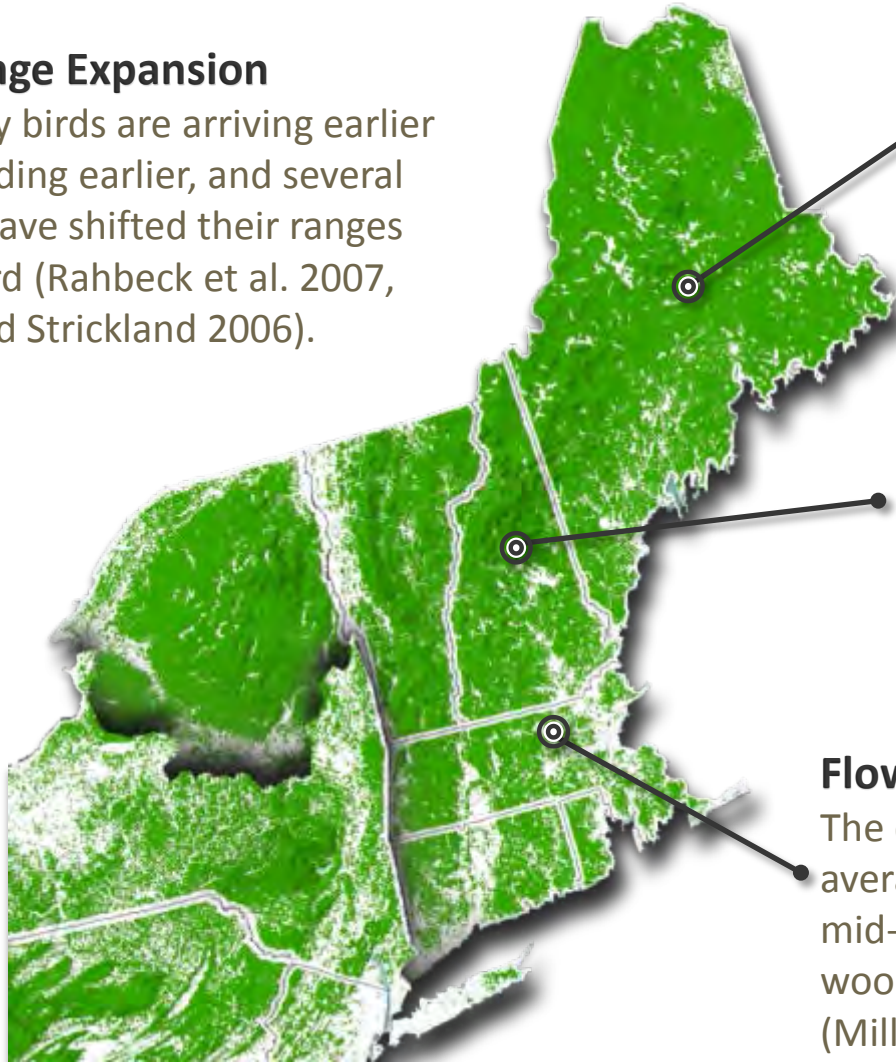
Lake ice-out dates have advanced across Maine, with many dates now two weeks earlier than in the 1800s (Jacobson et al. 2009)

Green Canopy Duration

Trees at Hubbard Brook Experimental Forest have about 10 more days per year of green canopy (Richardson et al. 2006)

Flowering Dates

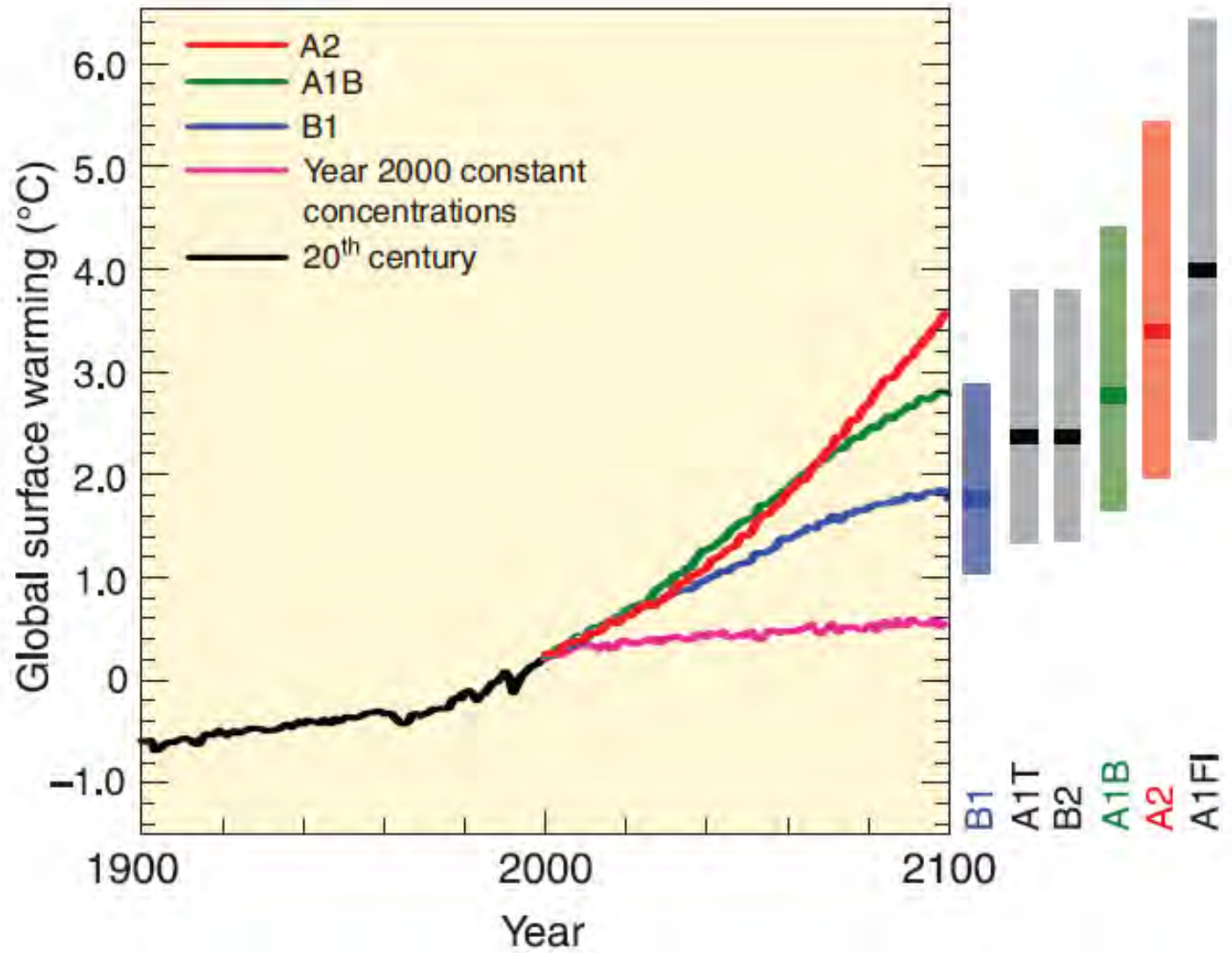
The date of first flowering is a week earlier on average compared to Thoreau's records from the mid-1800s. Highbush blueberries and yellow wood sorrel are flowering several weeks earlier (Miller-Rushing and Primack 2009)



How is the climate expected to change over the next century?

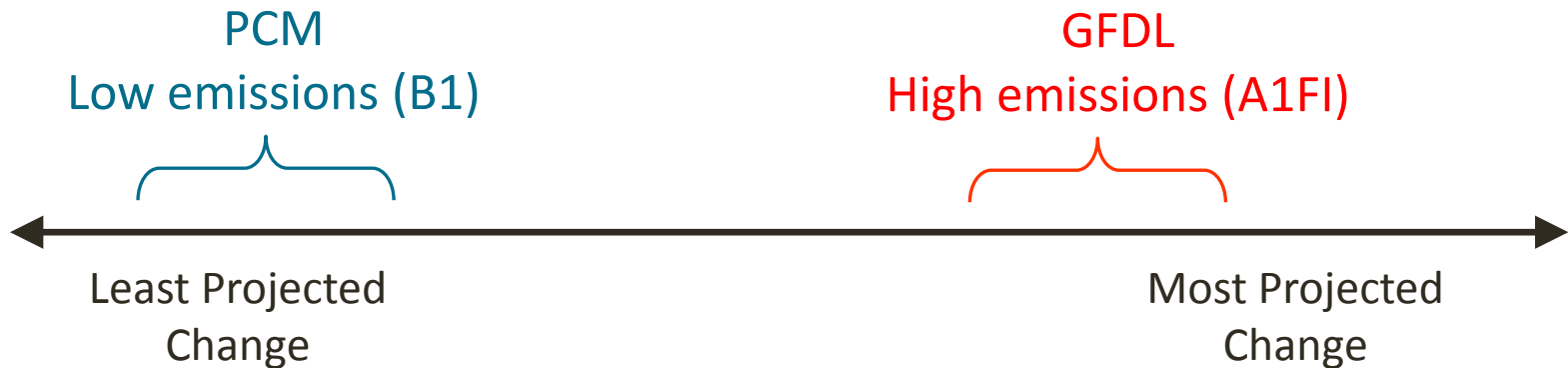
How is the climate expected to change over the next century?

Future Changes – inherent uncertainty

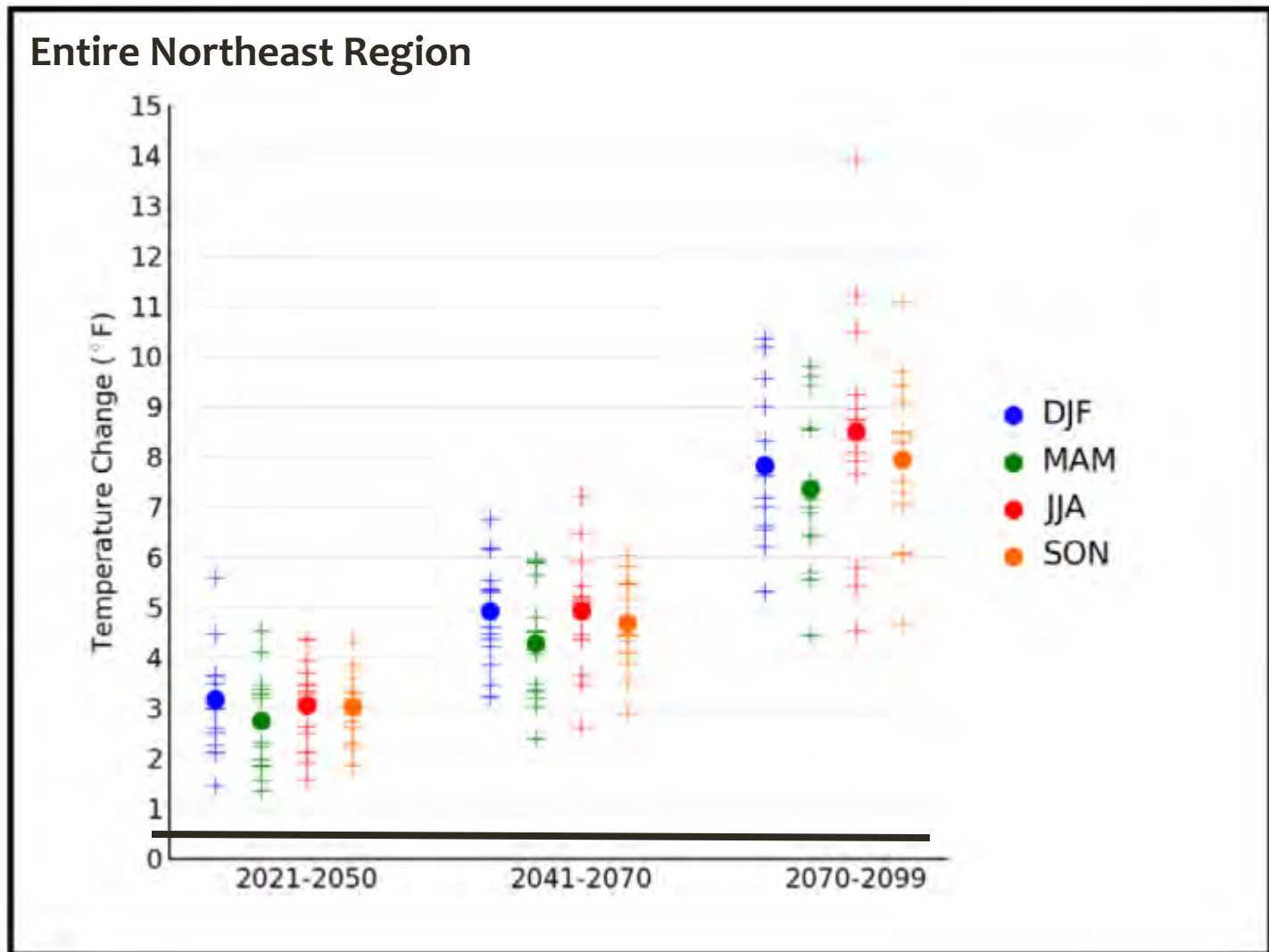


Climate Scenarios Used

- Two scenarios show the range of possible change
 - PCM B1: Low emissions scenario + less sensitive GCM
 - GFDL A1FI: High emissions + more sensitive GCM
- Projections are consistent with other data sets
- Think of them like bookends:

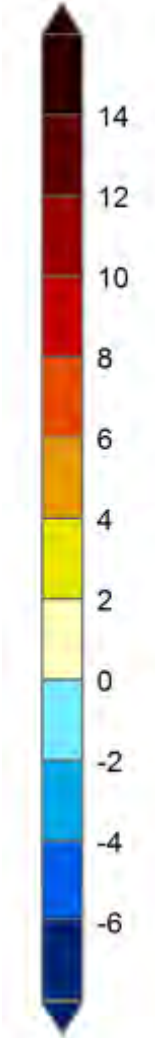


Temperature Change Projections

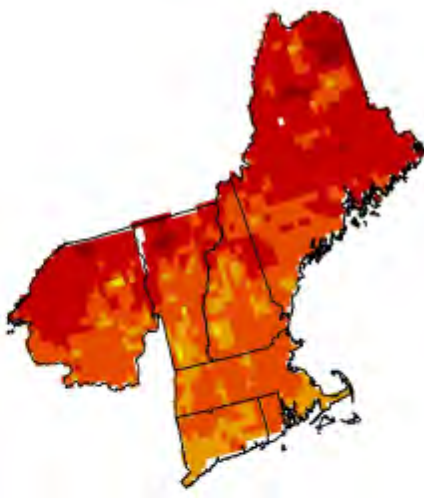
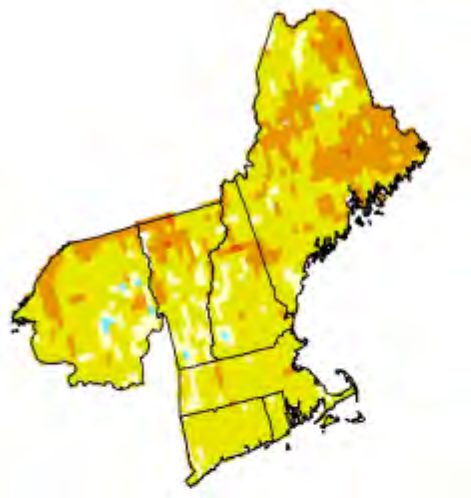


Seasonal Temperature Projections

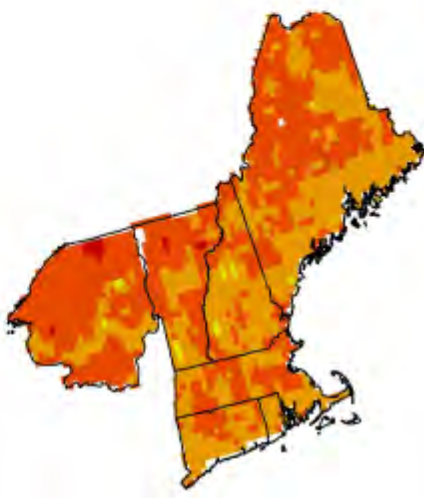
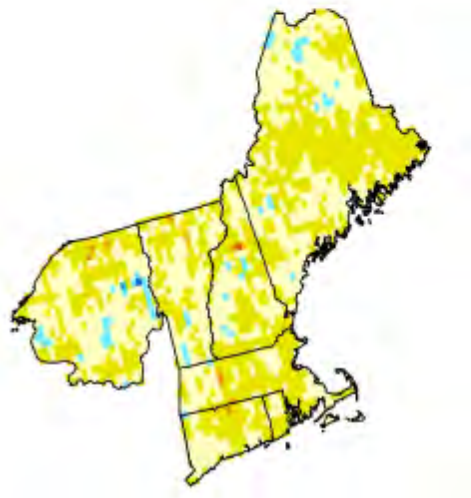
Change in
30-year average (°F)
2070-2099 vs. 1971-2000



Winter



Spring

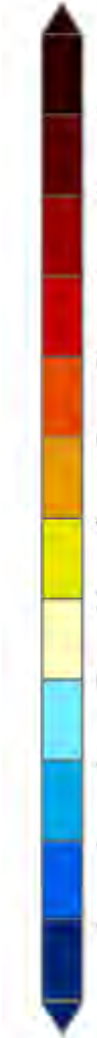


Low

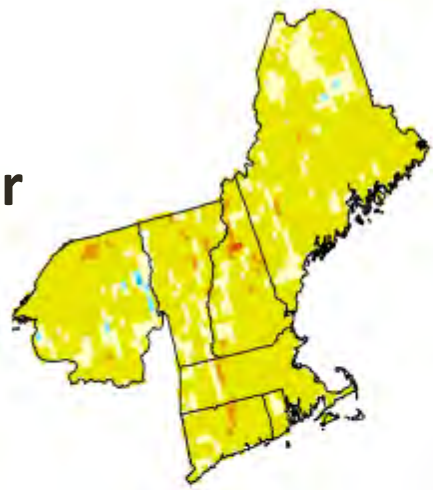
High

Seasonal Temperature Projections

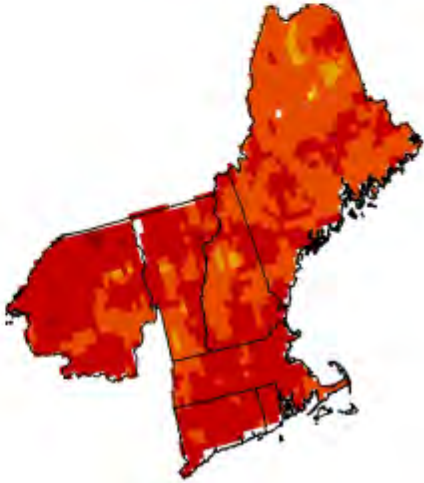
Change in
30-year average (°F)
2070-2099 vs. 1971-2000



Summer



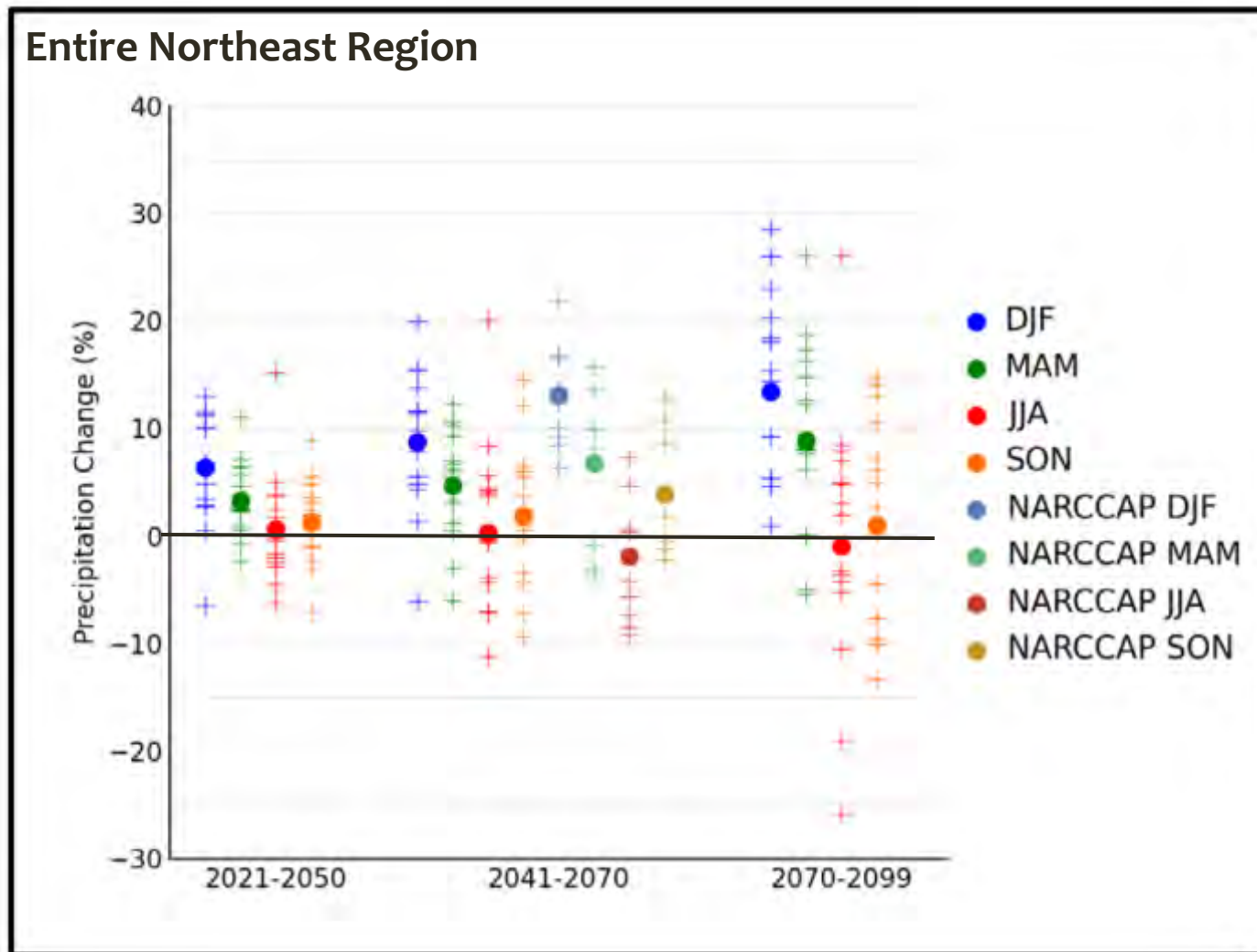
Fall



Low

High

Precipitation Change Projections



Seasonal Precipitation Projections

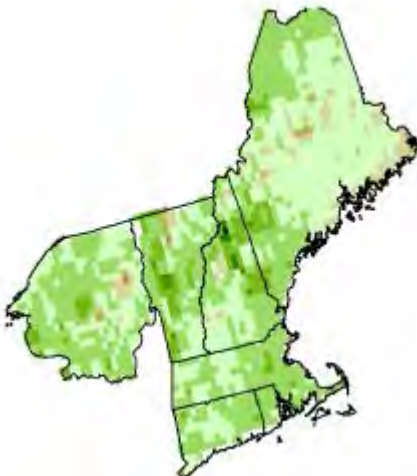
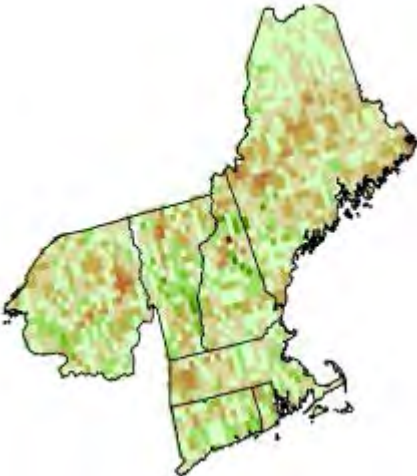
Change in
30-year average (°F)
2070-2099 vs. 1971-2000



Winter



Spring



Low

High

Seasonal Precipitation Projections

Change in
30-year average (°F)
2070-2099 vs. 1971-2000

Summer



Fall



Low

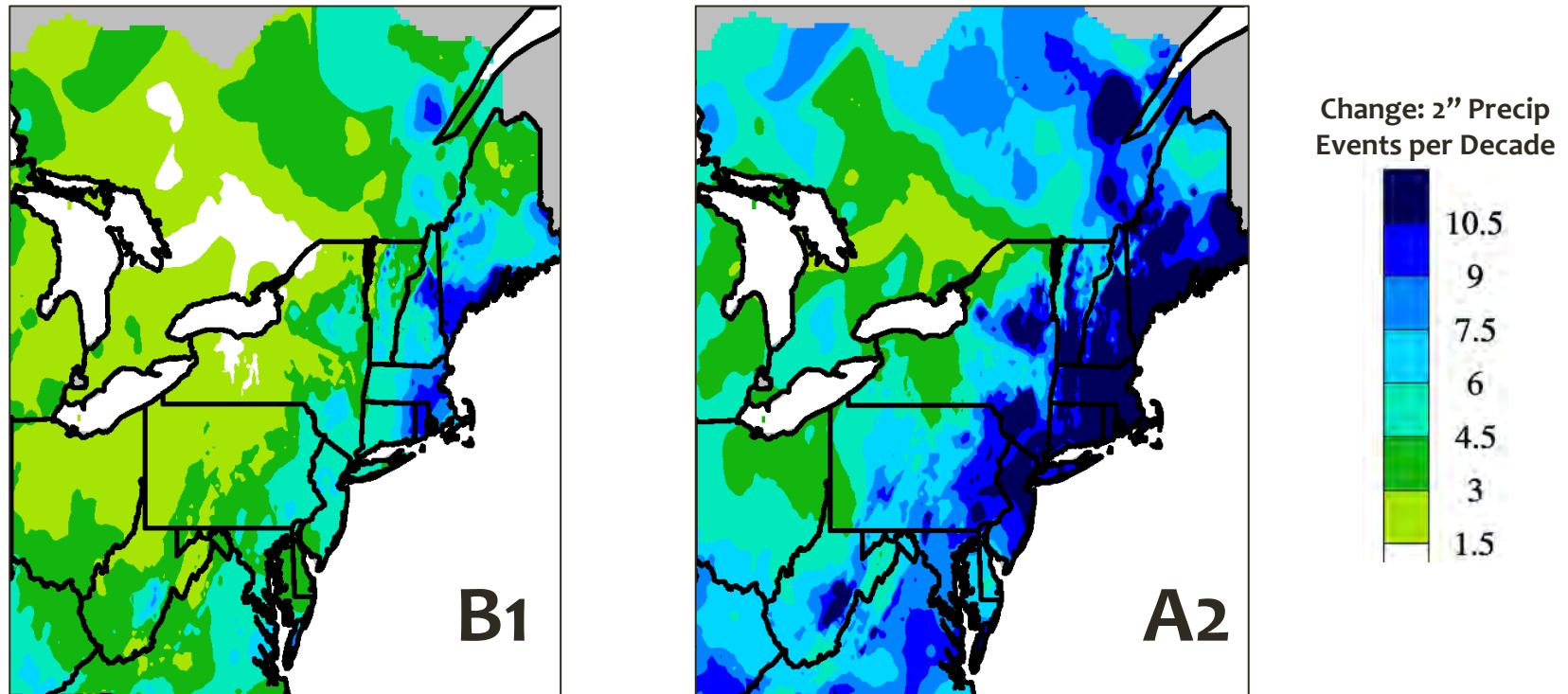
High



Extreme Precipitation Events

- Extreme precipitation has increased dramatically
 - Precip in heaviest 1% of events increased 71% between 1958 to 2012
- Trend expected to continue/increase

Change in 2-inch Precipitation Events (late 21st century)



Anticipated Climate Changes

Warmer temperatures

- 3-9°F increase annually

Altered precipitation

- High variability: slight decrease to more than 15% increase
- Generally increasing in winter & spring
- Potential decreases or less substantial increases in summer & fall
- More extreme rain

Sea-level Rise

- 12 to 23” by end of century



Hammonasset Beach State Park will be mostly inundated by sea level rise by the end of the century. (Photo Credit: CT DEEP)

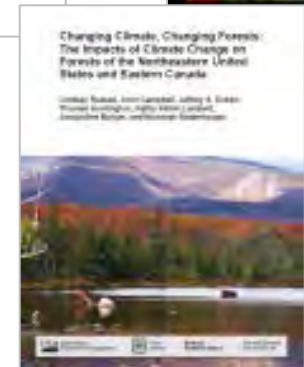
How could ecosystems be affected?

9 WAYS THAT CLIMATE CHANGE WILL AFFECT FORESTS

A Synthesis of Anticipated Impacts

Climate Change Impacts

- 1) Longer Growing Season
- 2) Shorter Winters
- 3) Potential for Summer Drought
- 4) CO₂ Fertilization
- 5) Changes in Suitable Habitat
- 6) Extreme Events
- 7) Wildfire Risk
- 8) Forest Pests and Diseases
- 9) Invasive Plants

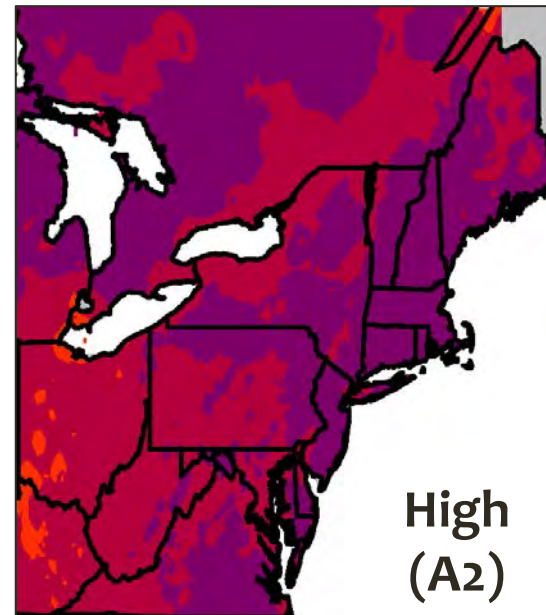
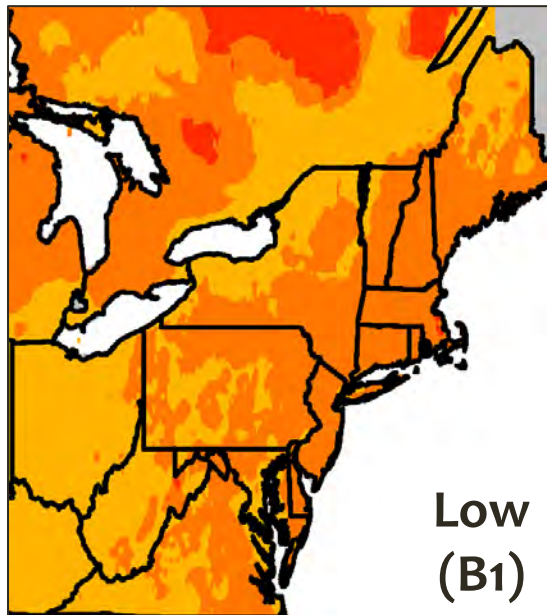


1: Longer Growing Seasons

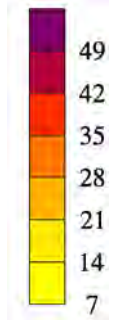
Warmer temps result in longer growing seasons

- Projected to increase 3-7+ weeks by 2100

Growing Season– End of Century Change



Change in Growing Season (days)



1: *Longer Growing Season*

Warmer temps result in longer growing seasons

- Evidence of phenological shifts
- Projected to increase 3-7+ weeks

Longer period for plant growth



1: *Longer Growing Season*

Warmer temps result in longer growing seasons

- Projected to increase 3-7+ weeks
- Evidence of phenological shifts

Longer period for plant growth

Potential risks:

- Early bud break/loss of cold hardening
- Frost damage during spring freezing

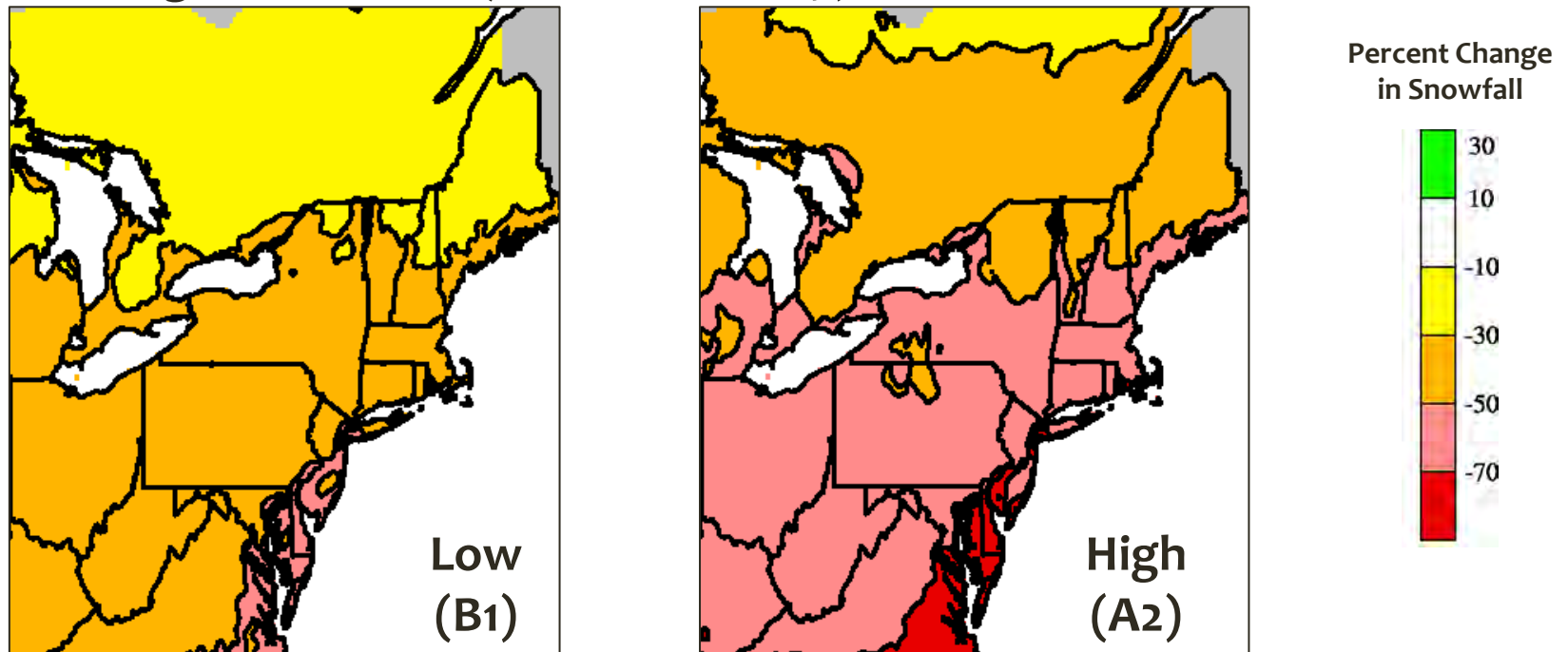


2: Shorter Winter (Less Snow)

Projected decreases in snow fall, cover, and depth

- 30-70% decreases in snowfall
- Greatest snowfall decreases in December or January

Percent change in snowfall (late 21st century)



2: Shorter Winter (Less Snow)

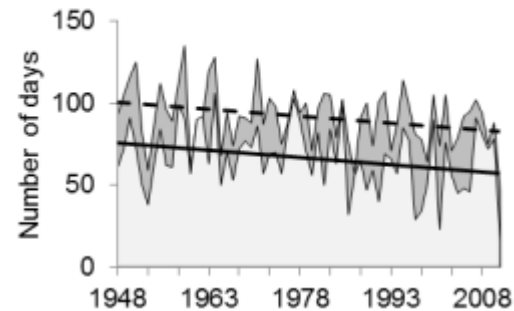
Decreased snowpack

- Increased soil frost and root damage in cold temps
- Warmer soil temperatures and altered processes

Wisconsin Frozen Ground



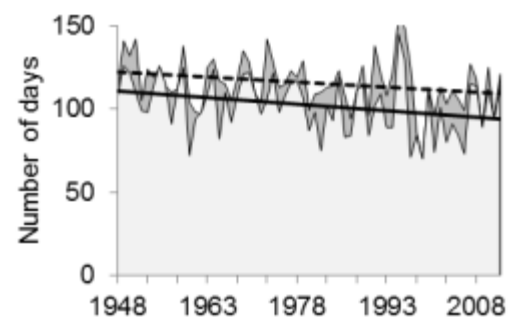
Dane County



Frozen Ground Season

— Annual data
- - - Trend

Onieda County

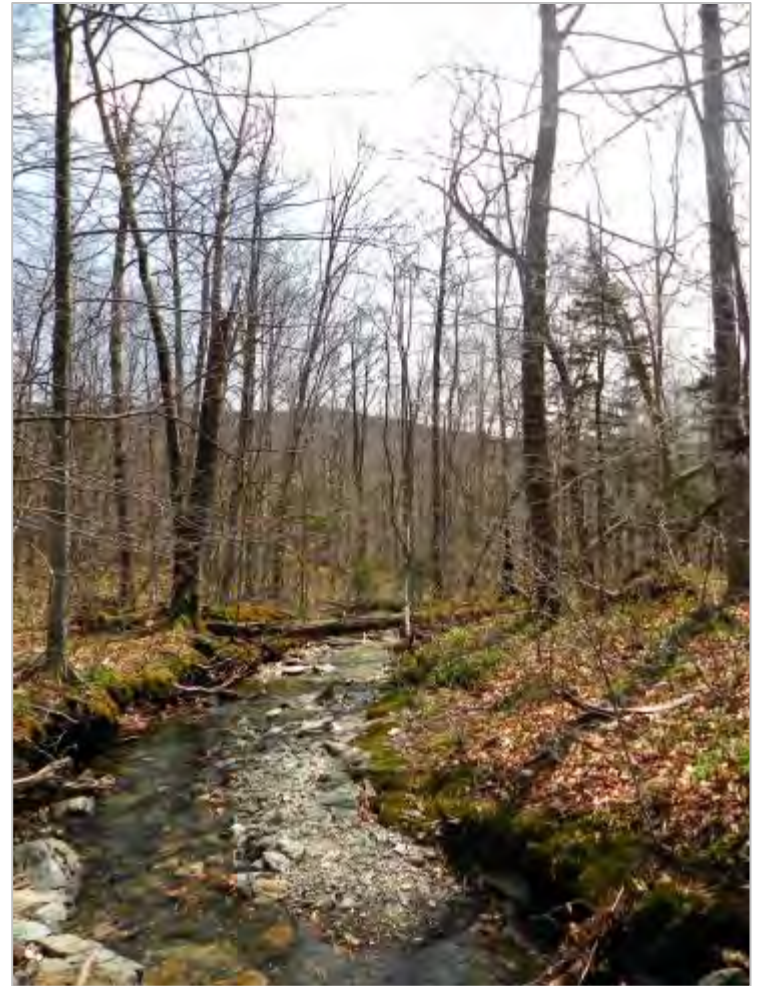


Frozen Ground Days

— Annual data
— Trend

2: *Shorter Winter (Less Snow, More Rain)*

Precipitation is projected to increase = more rain

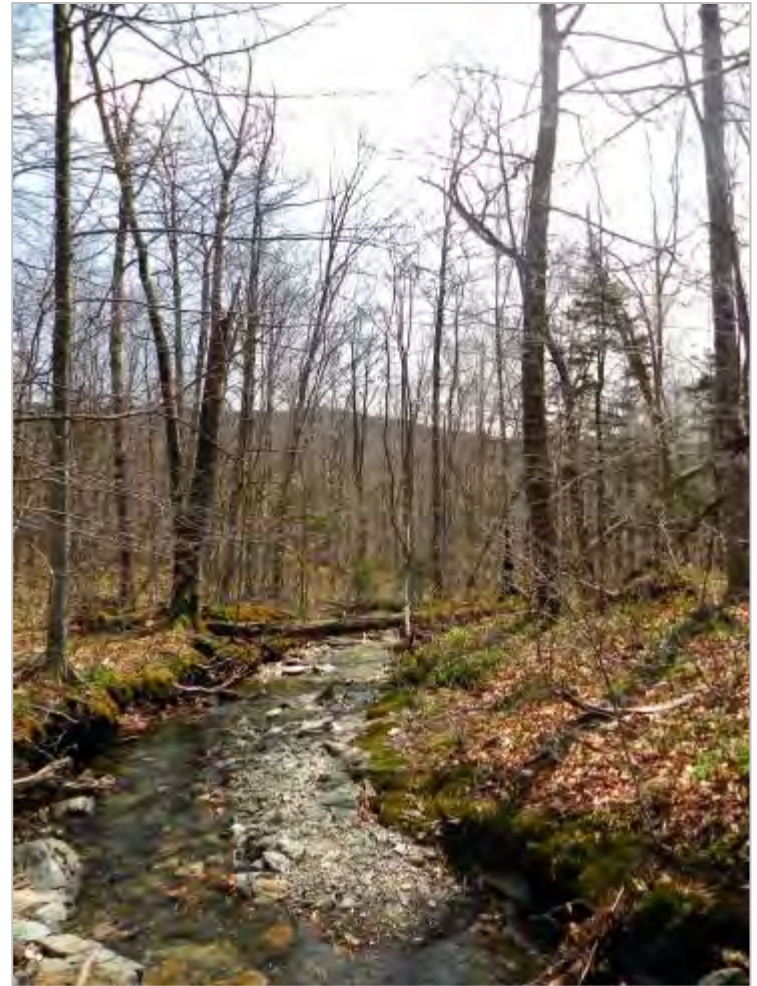


2: *Shorter Winter (Less Snow, More Rain)*

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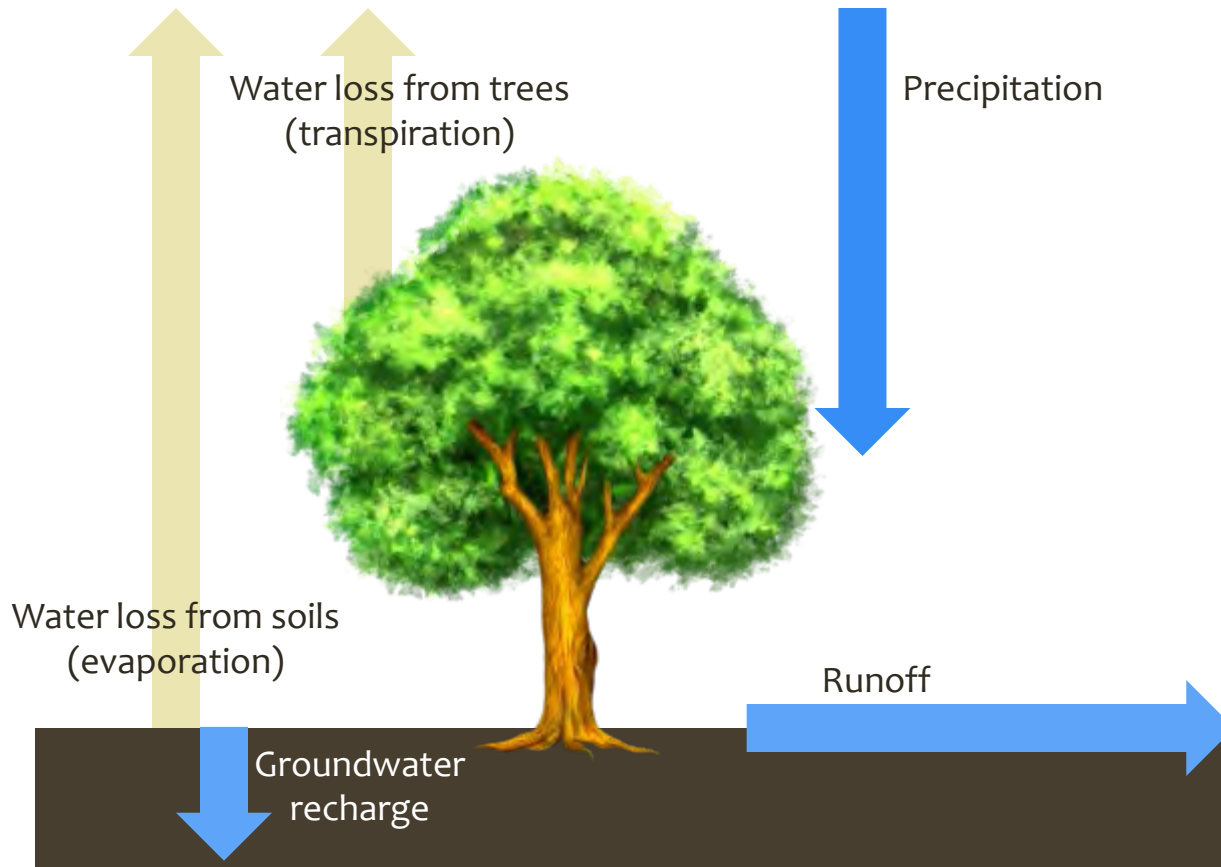
Altered streamflow timing and amount

- Earlier spring peak flows
- Potential increases in flashiness and episodic high flows
- Potential declines in summer seasonal stream flow



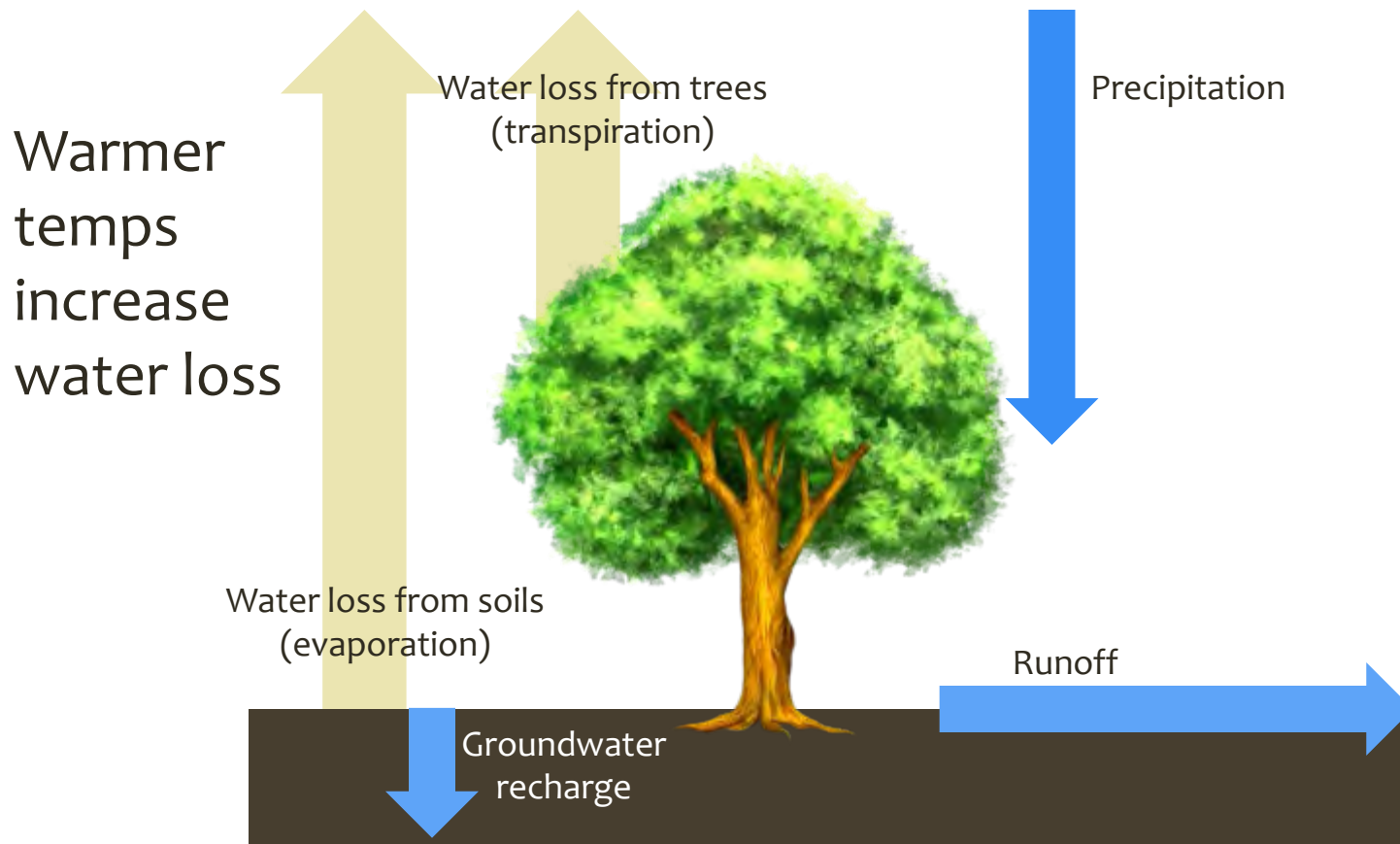
3: *Potential for Summer Drought*

Greater uncertainty about future precipitation, but increased risk of summer moisture stress



3: *Potential for Summer Drought*

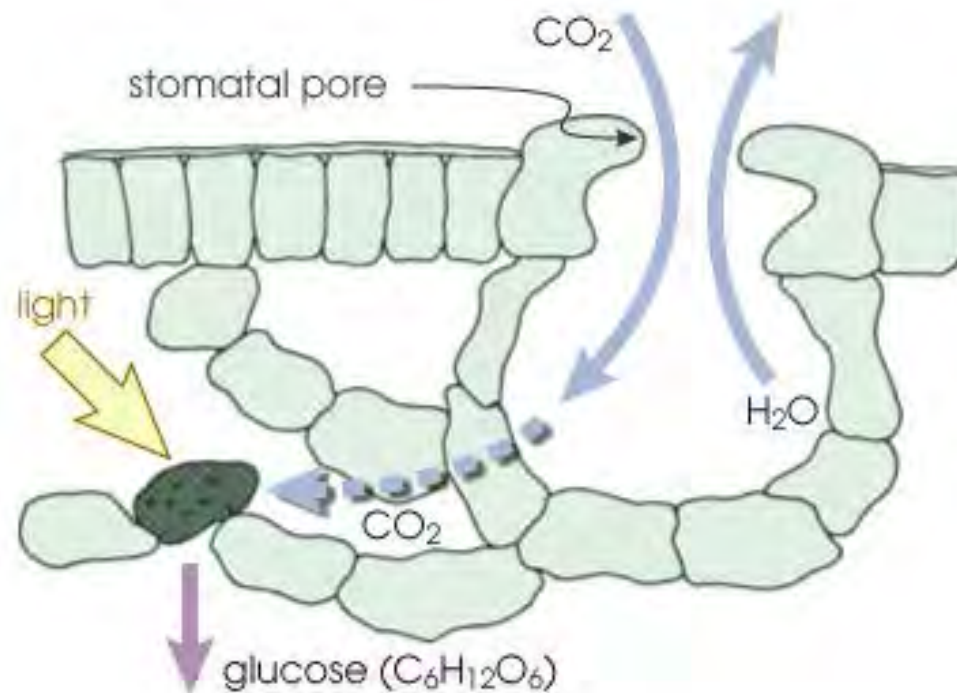
Greater uncertainty about future precipitation, but increased risk of summer moisture stress



4: CO₂ Fertilization

Benefits

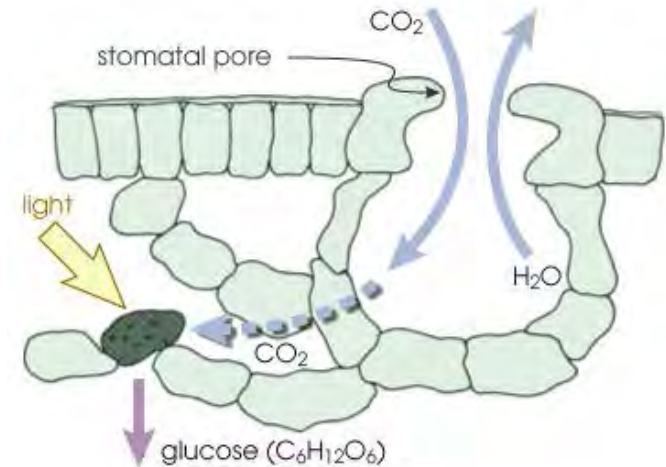
- Increased photosynthesis
- Increased water use efficiency



4: CO₂ Fertilization

Limits to CO₂ fertilization

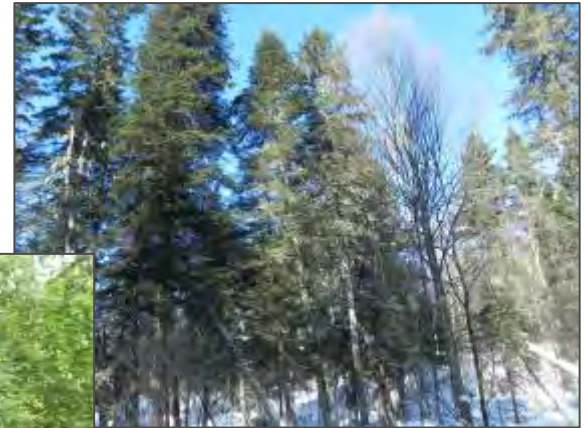
- Varies by species and site
- Nutrient deficiencies (especially N)
- Sensitive to ozone pollution
- Limited sink strength
- Limited evidence of long-term sequestration
- Any productivity increases may be offset by reductions from increased drought stress or disturbance



5: *Changes in Suitable Habitat*

Habitat based on:

- Temperature
- Precipitation
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management



5: *Changes in Suitable Habitat*

Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management

Climate Change Atlas:

What happens to tree and bird habitat when climate changes?

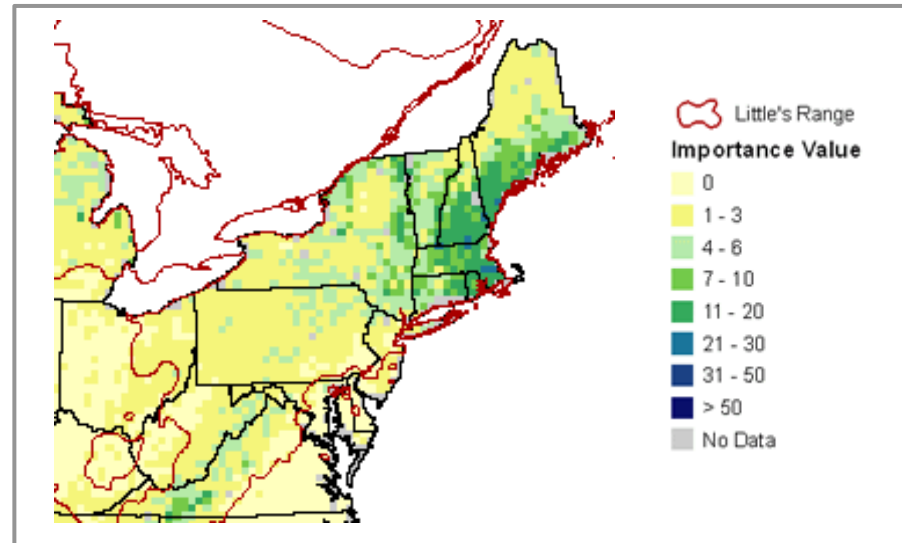
- 134 Trees
- 147 Birds

5: *Changes in Suitable Habitat*

Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

White Pine: Current Habitat (modeled)

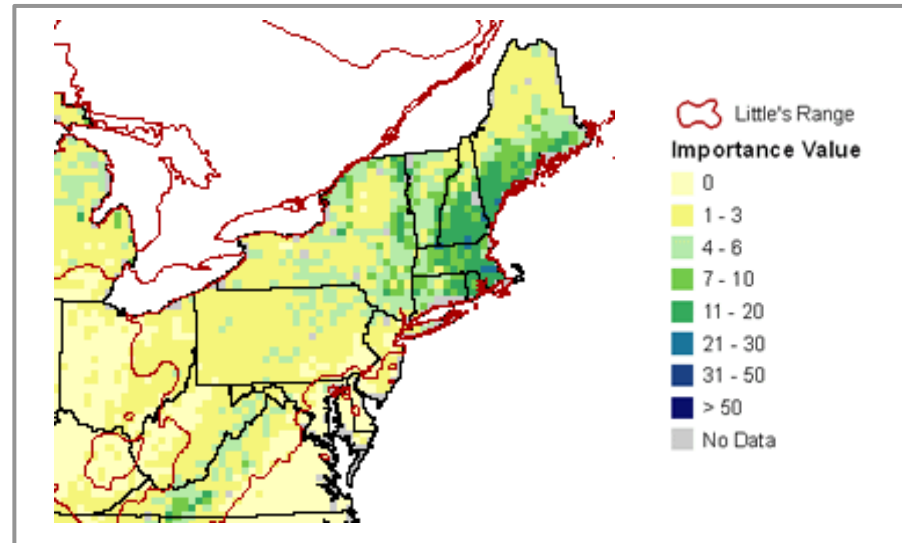


5: Changes in Suitable Habitat

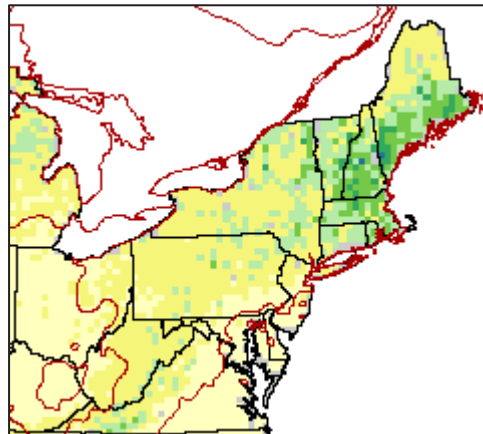
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

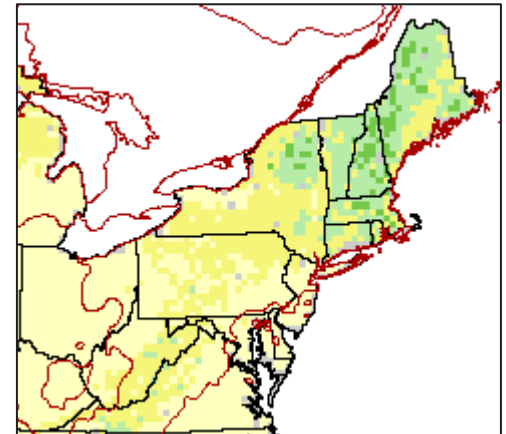
White Pine: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)

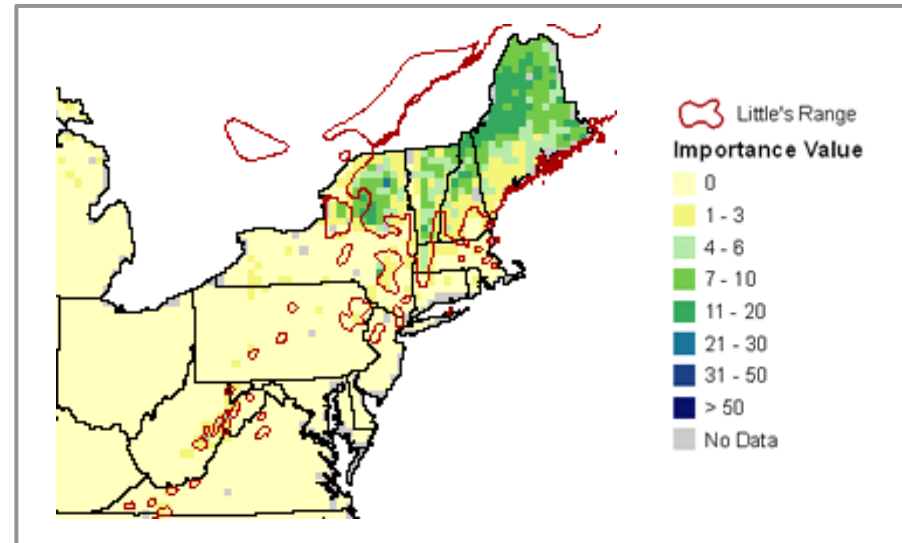


5: Changes in Suitable Habitat

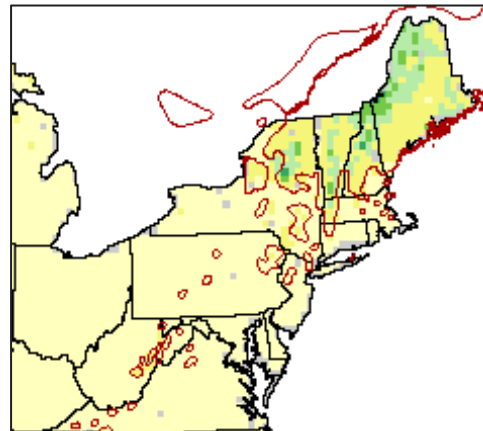
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

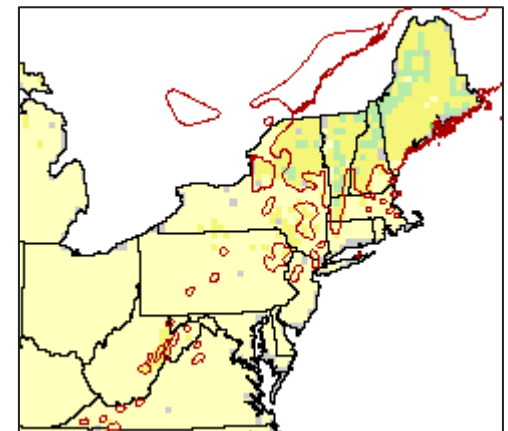
Red Spruce: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)

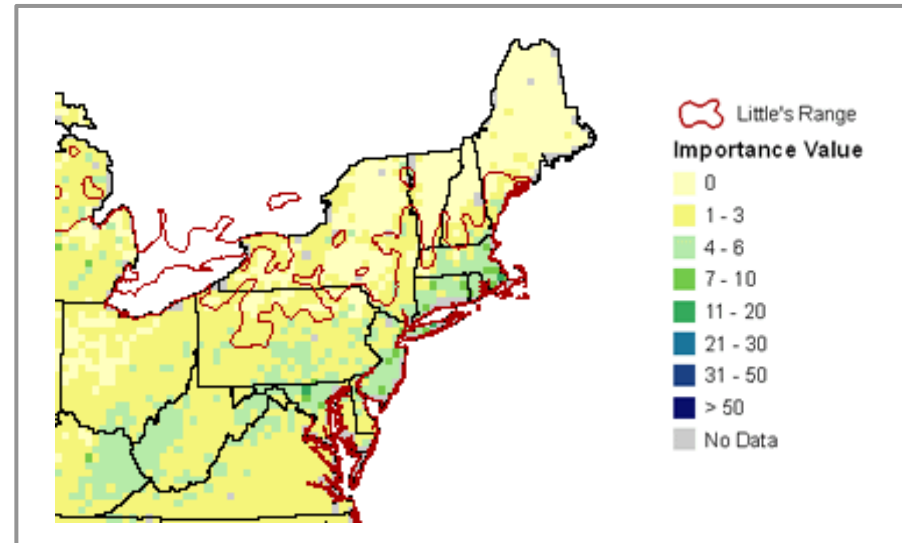


5: Changes in Suitable Habitat

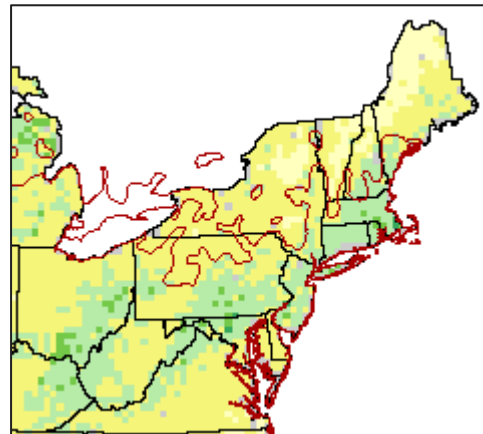
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

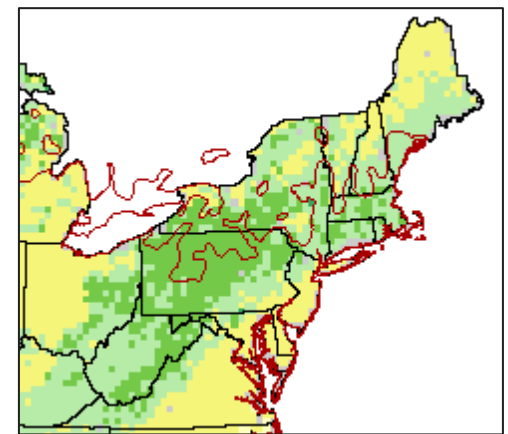
Black Oak: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)



5: *Changes in Suitable Habitat*

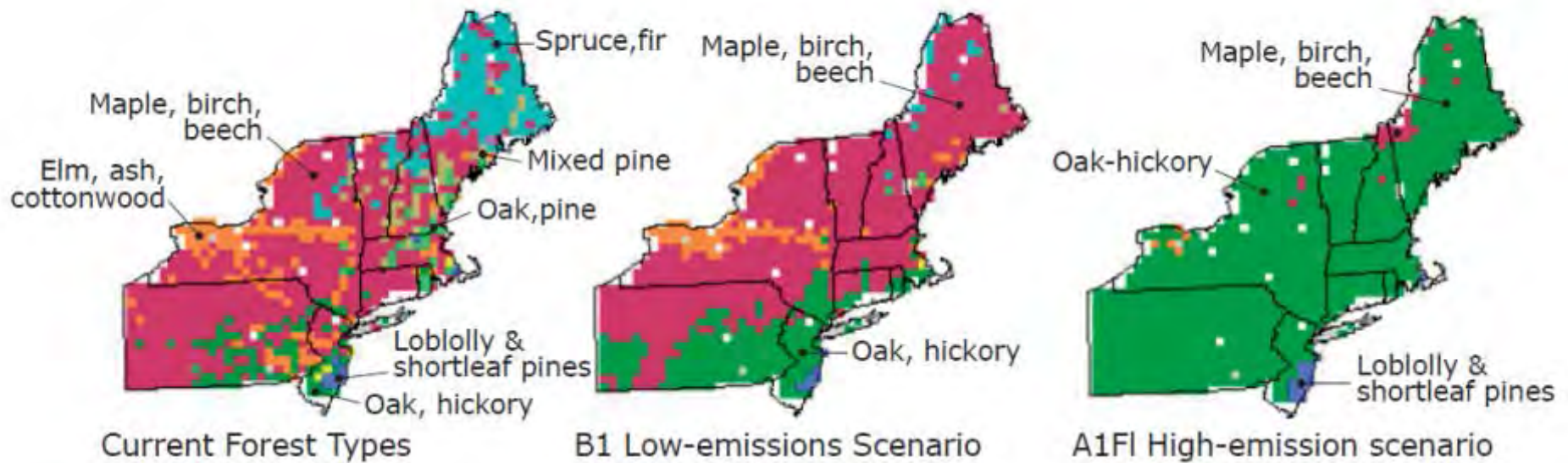
- Immense lag times
 - Range shifts \neq instant catastrophic dieback
- Factors causing change will increase over time
 - Temperature
 - Moisture
 - Competition
- Mature and established trees should fare better
 - Developed root system
 - Greater carbohydrate reserves
- Game changers: Disturbance, Land use, ...

5: *Changes in Suitable Habitat*

Use the Climate Change Atlas to:

- Evaluate how suitable habitat may change for species
 - Species more likely to decline or increase
 - Consider multiple scenarios
 - Consider local conditions and anticipated impacts
- Identify factors driving the modeled changes
- Generate ideas for potential future-adapted species

5: Changes in Suitable Habitat



6: *Extreme Events*

- Heavy precipitation
- Ice storms
- **“Events” are not well modeled**
- Heat waves/droughts
- Wind storms
- Hurricanes



Dan Turner, Cambridge Fire Dept.



NY DEC



VTRANS/VT ANR

7: *Wildfire Risk*

Fire may increase:

- Warmer/drier summers
- Increased stress or mortality from less suitable conditions
- Shift toward fire-associated species like oaks and pines



Prescribed fire – MASS DCR

Fire may not change:

- Spring/early summer moisture
- Current regeneration of more mesic species
- Spatial patterns of land use and fragmentation
- Fire suppression

8: *Forest Pests and Diseases*

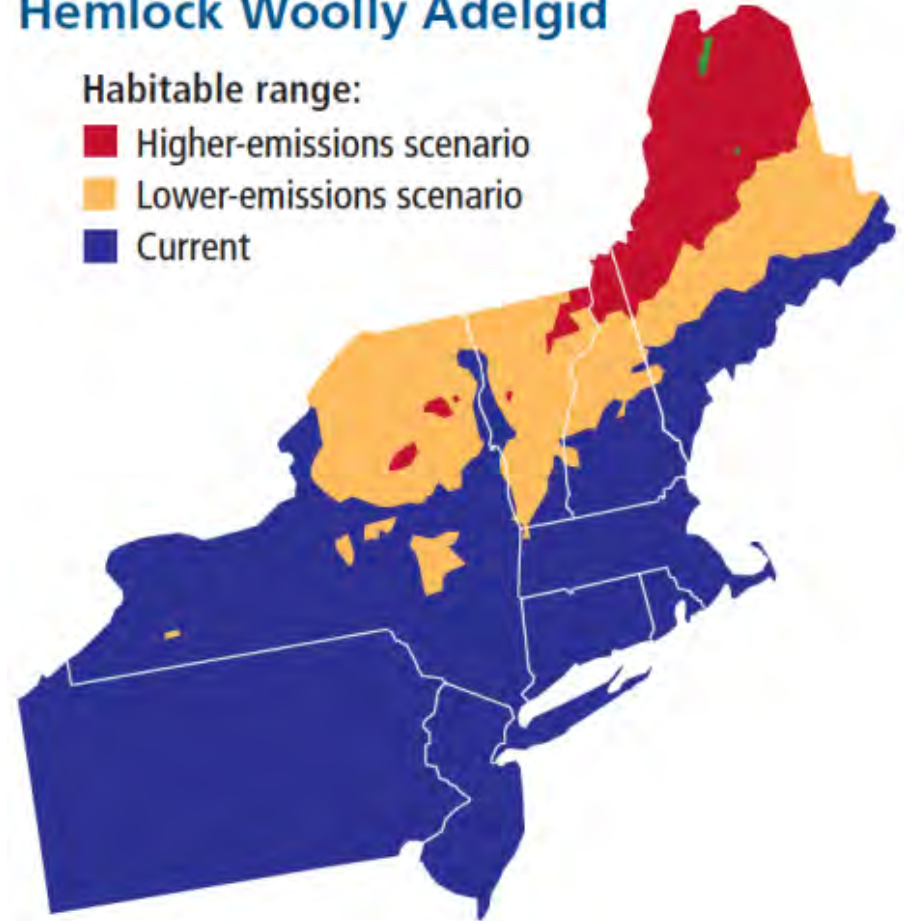
Indirect: Stress from other impacts increases susceptibility

Direct:

- Pests migrating northward
- Decreased probability of cold lethal temperatures
- Accelerated lifecycles

Hemlock Woolly Adelgid

Habitable range:
■ Higher-emissions scenario
■ Lower-emissions scenario
■ Current



HWA lethal temp: -20 to -30°F

9: *Invasive Plants*

Indirect: Stress or disturbance from other impacts can affect the potential for invasion or success

Direct:

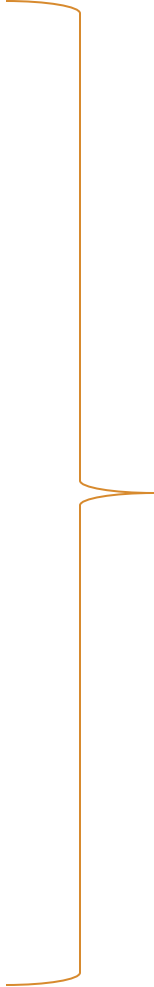
- Expanded ranges under warmer conditions
- Increased competitiveness from ability of some plants to take advantage of elevated CO₂



Invasives Plants Atlas of New England (www.eddmaps.org)

Climate Change Impacts

- 1) Longer Growing Season
- 2) Shorter Winters
- 3) Potential for Summer Drought
- 4) CO₂ Fertilization
- 5) Changes in Suitable Habitat
- 6) Extreme Events
- 7) Wildfire Risk
- 8) Forest Pests and Diseases
- 9) Invasive Plants



*What
conclusions
can we draw
from all this?*

Vulnerability: *Forest Communities*

Forest communities will be affected differently

May have greater risk:

- Low diversity
- Static
- Threatened, rare, or endangered
- Already in decline
- Fragmented

May have less risk:

- More diversity (species, genetics, ...)
- Adapted to disturbance
- Wider ecological range of tolerances
- Currently increasing
- Larger, contiguous blocks

Vulnerability: *Hardwood Forests*

Impacts:

- Extreme storms
- Several diseases, pests, invasives
- Several northern species projected to decline

Adaptive Capacity:

- Mixed species forests
- Several southern species projected to increase
- Extensive type, exists farther south



Vulnerability rated as low (central hardwoods) or moderate (northern hardwoods) based on species and location.

Vulnerability: *Pitch Pine-Scrub Oak*

Impacts:

- Less affected by warm temperatures, drought, or wildfire
- Pitch pine habitat suitability not projected to change much

Adaptive Capacity:

- Limited to sandy, nutrient-poor soils
- Affected by development, fragmentation, fire suppression

Generally rated as

low-moderate
vulnerability.



Eric Aldrich/The Nature Conservancy

Vulnerability: *Spruce-fir*

Impacts:

- Warm temperatures
- Declines in boreal tree species
- Extreme storms

Adaptive Capacity:

- Generally slow to adjust to change
- Constrained by elevation/latitude
- Isolated mountaintops

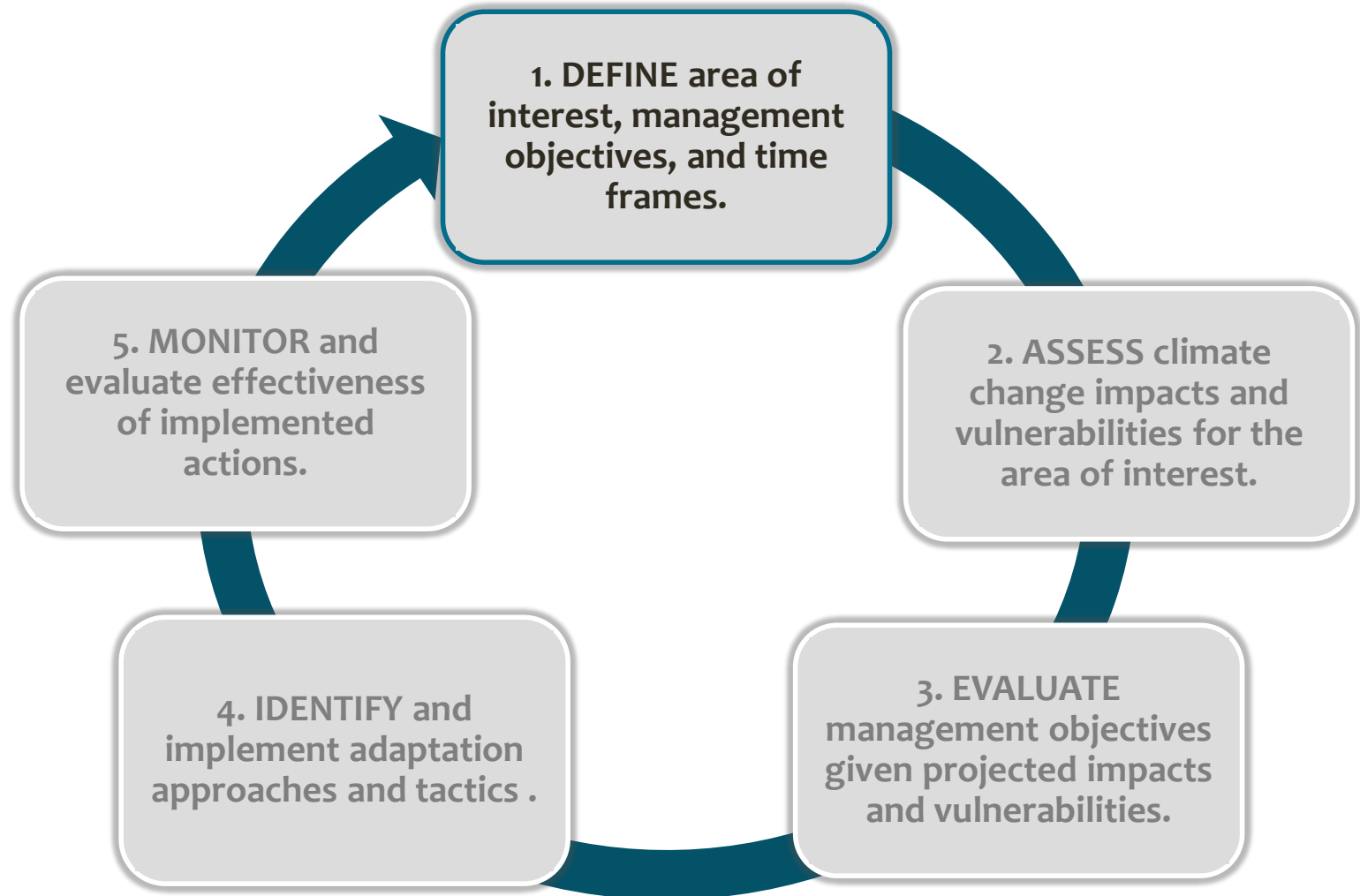


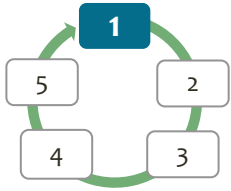
Generally rated as **most vulnerable forest community**, especially at southern extent of range.



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

Workbook Instructions





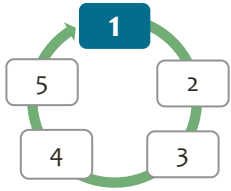
Step 1: DEFINE area of interest, management goals and objectives, and time frames.

Purpose:

- Define the scope of the project

Where are you working?

What are your current management goals and plans for this area?



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

Area of Interest

Location

Forest Type(s)

Management Goals

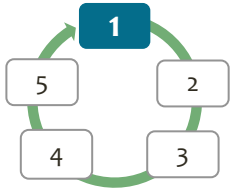
Management Objectives

Time Frames

Identifies the project area, including geographic location and topic area.

For example:

- *Property*
- *Unit, stand, compartment*
- *Program/issue (e.g., invasives, fire)*



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

Area of Interest

Location

Ecosystem Type(s)

Management Goals

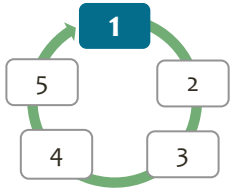
Management Objectives

Time Frames

Describes different ecosystems within the area of interest.

For example:

- *Spruce-fir forest*
- *Headwater streams*
- *Marshlands*



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

Area of Interest

Location

Forest Type(s)

Management Goals

Management Objectives

Time Frames

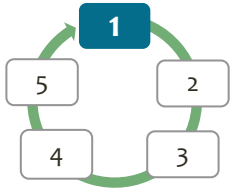
Describes intent.

Goals: *broad, generally not quantifiable*

- *Enhance wildlife habitat*
- *Restore wetland function*

Objectives: *specific, outline planned results*

- *Create 10 acres of early successional habitat by...*
- *Upgrade infrastructure to increase water flow...*



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

Area of Interest

Location

Forest Type(s)

Management Goals

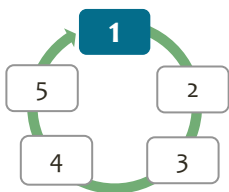
Management Objectives

Time Frames

Identifies approximate timing of activities and for achieving goals/objectives

For example:

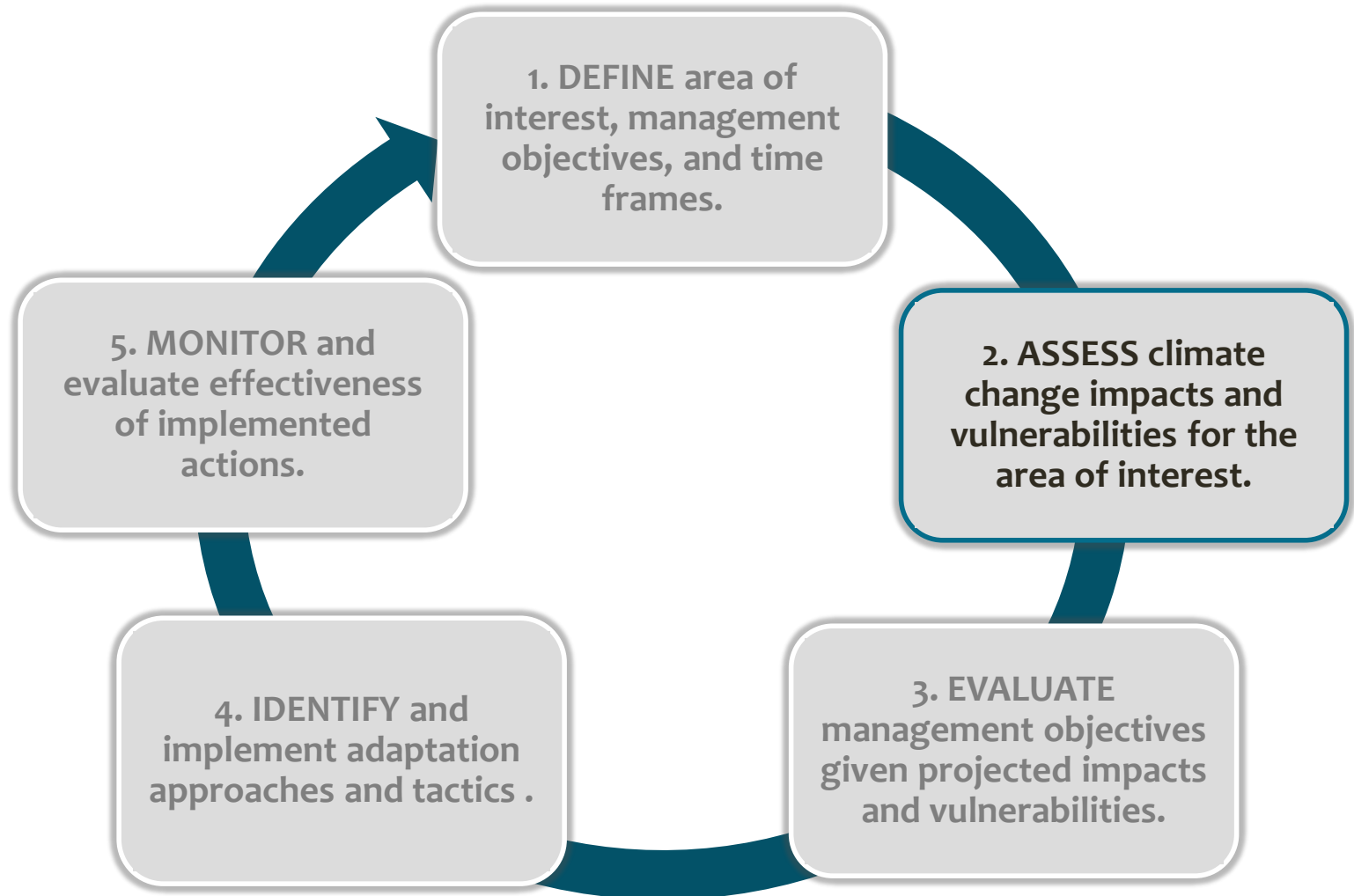
- *Harvest– within 3 years*
- *Regeneration– 10 years*
- *Improved habitat– long-term (30+ years)*

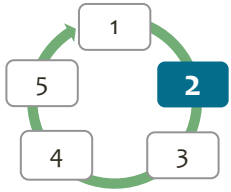


Step 1: DEFINE area of interest, management goals and objectives, and time frames.

Area of Interest	Location	Forest Type(s)	Management Goals	Management Objectives	Time Frames
SOUTH Camp Four Project Park Road Sale Stand 1089-025	East of Park Falls along FR1903, Newman Lake Road	<ul style="list-style-type: none"> – Mature aspen, mixed ages – Planted white spruce along road – Maple understory 	<ul style="list-style-type: none"> – Desired landscape conditions, MA 4A: even-aged management maintains early to mid-successional communities. Aspen is over-represented; transitions to conifer species are encouraged. – Maintain healthy forest and tree vigor – Appropriate age class distribution: redistribute toward younger aspen – Safe, efficient road infrastructure – Provide wood through environmentally responsible harvest 	<ul style="list-style-type: none"> – Maintain healthy white spruce along Newman Lake Road to achieve desired scenic conditions and diversity – Maintain healthy hardwoods to achieve desired landscape conditions and age class distribution – Protect against annosum root rot to maintain a healthy forest and tree vigor – Provide scenic integrity (moderate SIO) – Maintain consistency with Forest Plan Standards and Guidelines (e.g., reserve trees) 	<ul style="list-style-type: none"> – Marking is immediate (Oct.) – Harvest operations would occur in the short-term – Management goals would be achieved in the short- (white spruce) and medium- to long-term (hardwoods)

Workbook Instructions



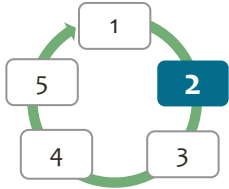


Step 2: ASSESS climate change impacts and vulnerabilities for the area of interest.

Purpose:

- Uses local expertise to determine how climate change may specifically affect the project area

How might the area be uniquely affected by climatic change and subsequent impacts?



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

General (Broad-scale) Impacts & Vulnerabilities

Climate Change Impacts
and Vulnerabilities for
the Area of Interest

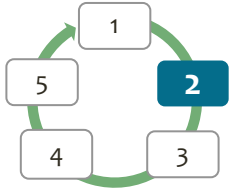
Vulnerability
Determination

Information on regionally-relevant climate change effects.

From vulnerability assessments, literature, etc.

For example:

- *Increased likelihood of extreme rain events*



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

General (Broad-scale)
Impacts & Vulnerabilities

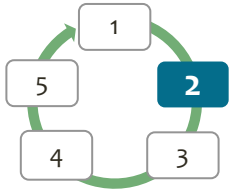
**Climate Change Impacts
and Vulnerabilities for
the Area of Interest**

Vulnerability
Determination

Site-based assessment of risk to regionally-relevant climate change impacts.

For example:

- *Steep stream banks and poorly-sized culverts are at increased risk; impacts already being observed during large rain events.*



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

General (Broad-scale)
Impacts & Vulnerabilities

Climate Change Impacts
and Vulnerabilities for
the Area of Interest

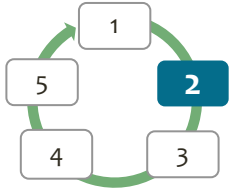
Vulnerability
Determination

How vulnerable is the site to the effects of climate change?

High: *Impacts exceed ability of ecosystem to cope; functions and services disrupted.*

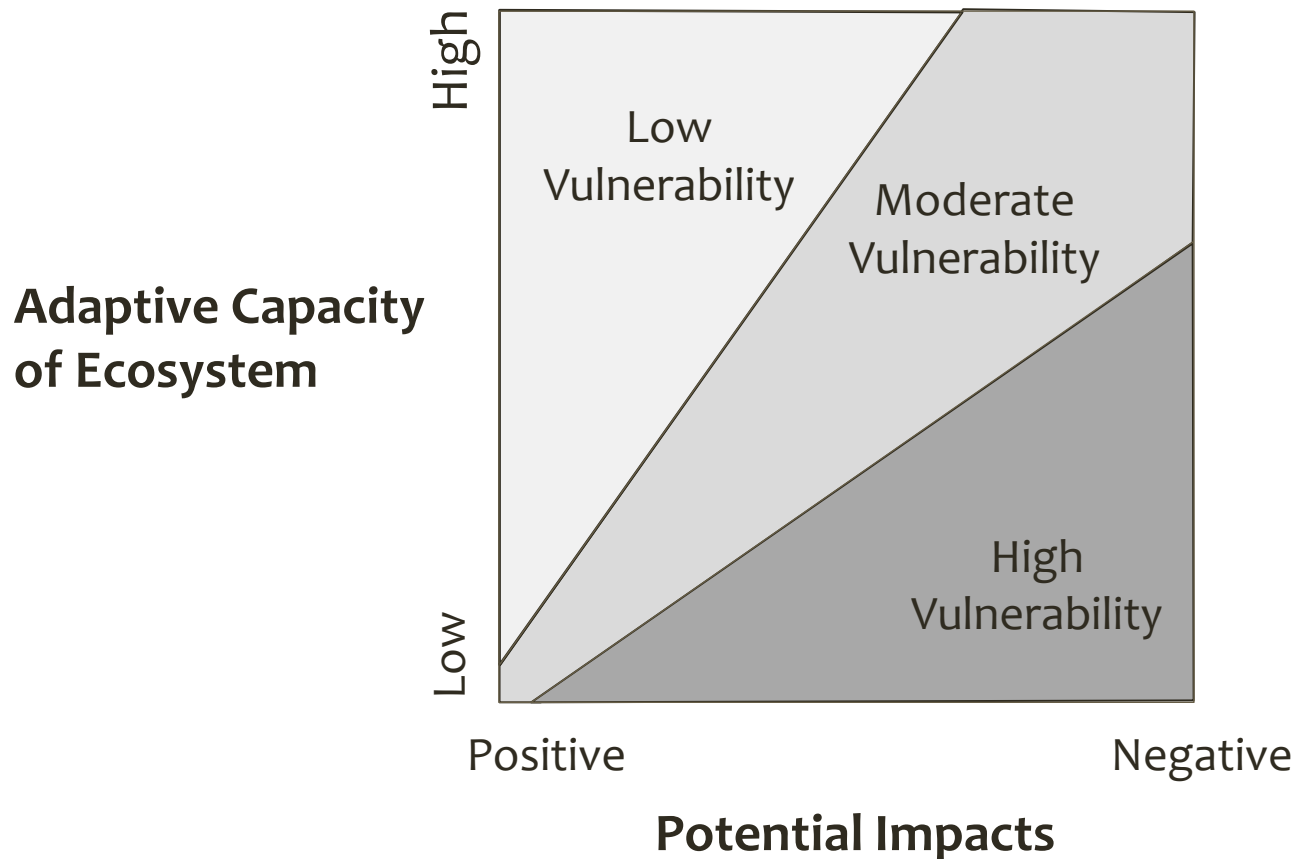
Moderate: *Impacts will cause changes, but systems can cope*

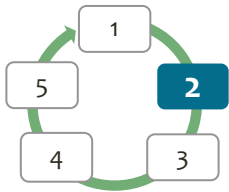
Low: *Ecosystems can readily cope with impacts; relatively few/minor negative impacts*



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

Vulnerability Determination





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

Broad-scale Impacts and Vulnerabilities	Climate Change Impacts and Vulnerabilities for the Area of Interest	Vulnerability Determination
Mean annual temperatures are projected to increase by about 6.5 °F to 10.5 °F over the next century	In NE Price County, winter temps projected to increase 12F from 1980 to 2090 (A2); summer temps projected to increase 9.75F	Low to Moderate
Growing seasons have become longer and this trend is expected to continue	Growing seasons have become longer and this trend is expected to continue	
Precipitation patterns may change, which may impact hydrologic regimes	Highly uncertain. Model average projects 0.75” increase in precip in the winter from 1980-2090; 0.25” decrease in the summer (A2); increase in extreme precipitation events	
Altered hydrologic regimes may contribute to drier soils during summer and increased potential for drought	Altered hydrologic regimes may contribute to drier soils during summer and increased potential for drought	
Increases in drought, rain and wind storms, wildfire, and other disturbances may contribute to successional changes or loss of forest cover	Increases in drought, rain and wind storms, wildfire, and other disturbances may contribute to successional changes or loss of forest cover	
Carbon dioxide and ozone pollution currently cause changes to forest productivity	Maria look up concentration maps and leaf symptoms	
Increases of invasive plant species, herbivores, and disease agents may contribute to reduced productivity or adult mortality		

Activity

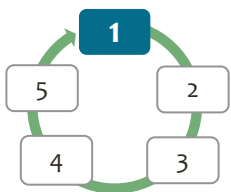
Step #2 (Activity): Assess climate change impacts and vulnerabilities for your project area.



Points (20 Total)	General Climate Change Impacts and Vulnerabilities	Climate Change Impacts and Vulnerabilities for the Project Area
	<i>General climate change impacts across <u>the Northeast US and Eastern Canada:</u></i>	<i>How might broad-scale impacts and vulnerabilities be affected by conditions in the <u>project area</u>?</i>
	Warmer temperatures (annual and seasonal)	
	More days with extreme heat	
	Fewer days with extreme cold	
	Increased annual precipitation	
	Altered seasonal changes in precipitation	
	More frequent heavy precipitation events	
	Less snow/shorter winter season	
	Altered stream flows	

ADAPTATION EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN





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

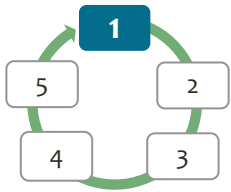
**Area of Interest
& Location**

Forested stand
near Park Falls, WI

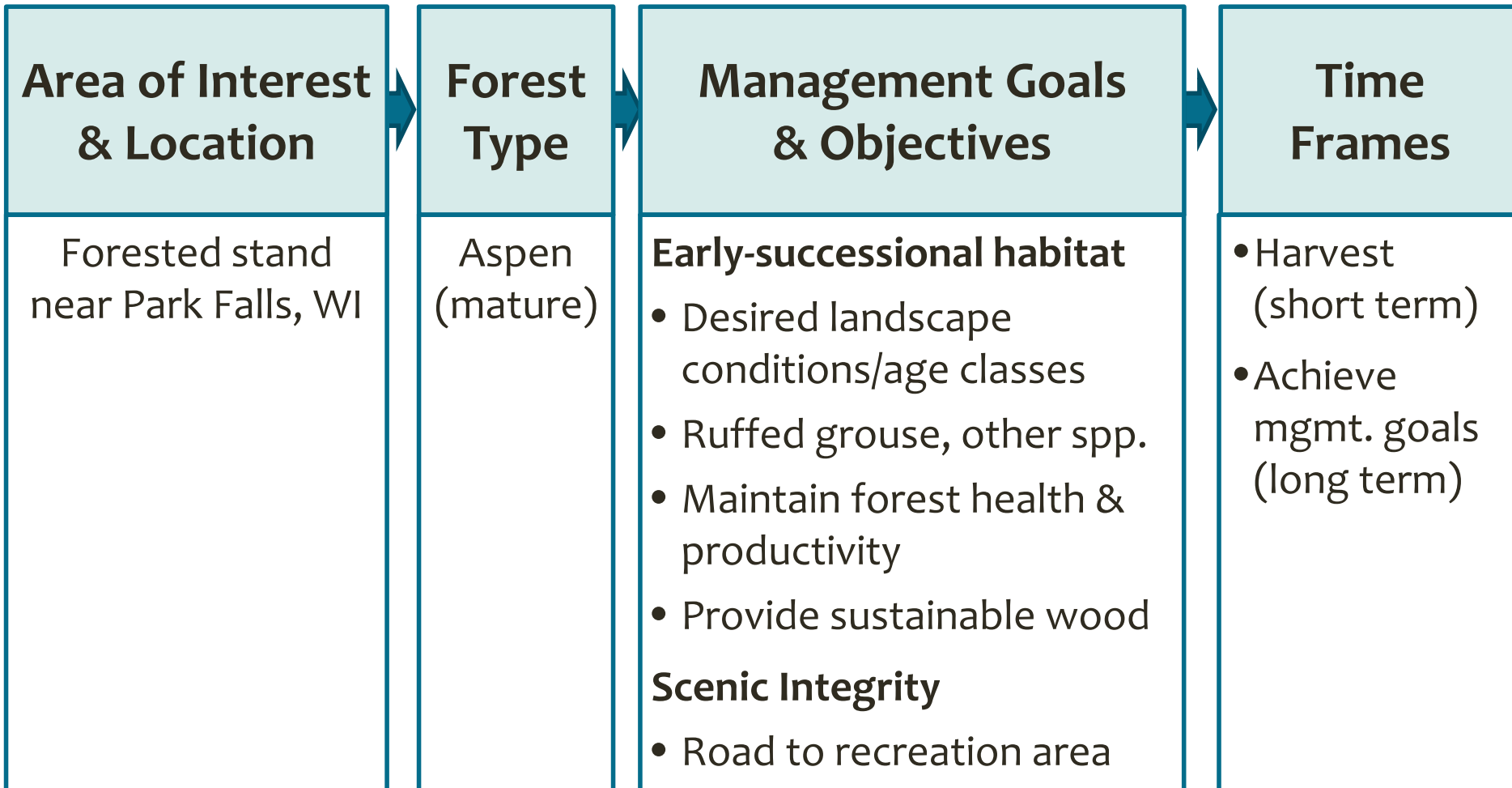
**Forest
Type**

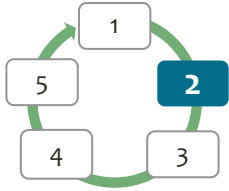
Aspen
(mature)





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

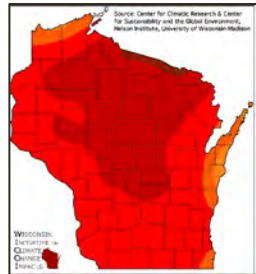
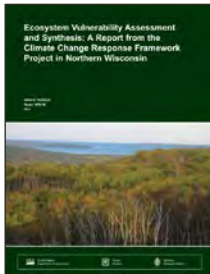
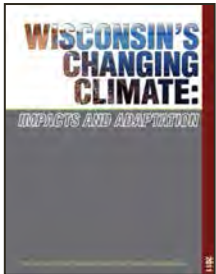




Step 2: ASSESS climate change impacts and vulnerabilities for the area of interest.

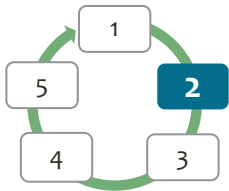
Broad-scale Impacts & Vulnerabilities

- Warmer temps, altered precip, drier summers
- Declines in many common northern species



How might broad impacts be different in the area of interest?

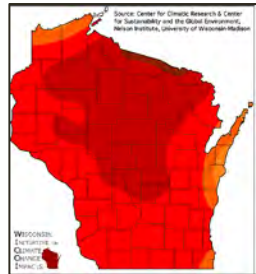
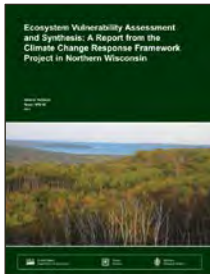
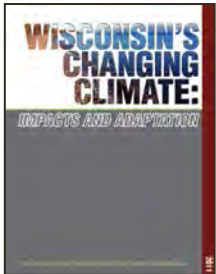




Step 2: ASSESS climate change impacts and vulnerabilities for the area of interest.

Broad-scale Impacts & Vulnerabilities

- Warmer temps, altered precip, drier summers
- Declines in many common northern species



Impacts & Vuln. for Area of Interest

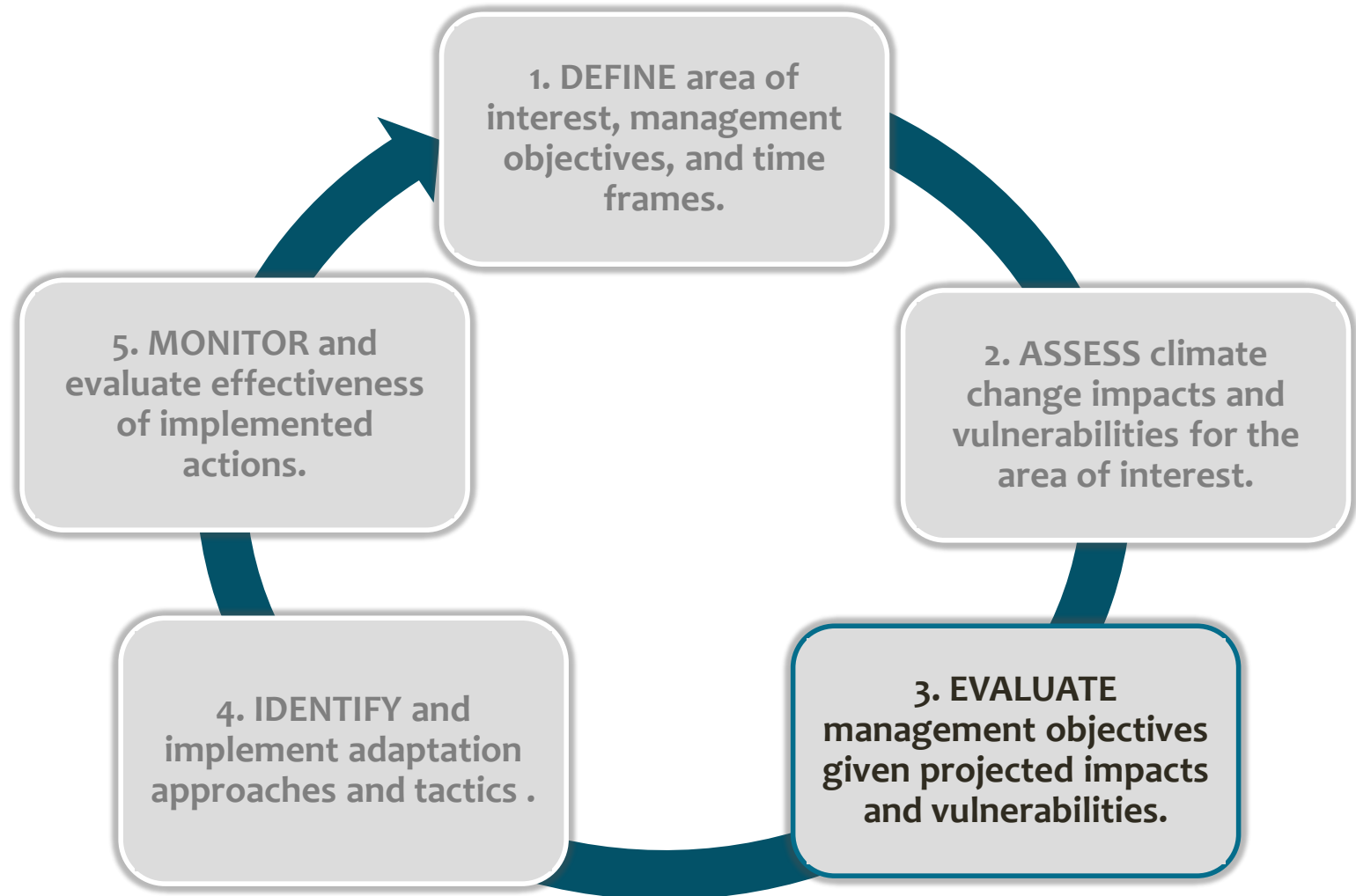
- Site is fairly dry now
- Mesic hardwoods are more susceptible
- Can regenerate aspen now, but maybe not in next rotation

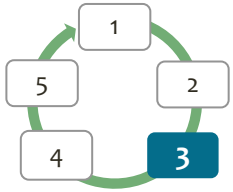
Overall vulnerability: Moderate -High



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Workbook Instructions



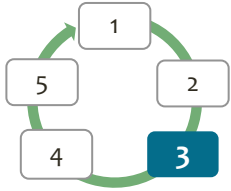


Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Purpose:

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

Can current management achieve goals?



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

**Management
(Conservation) Objective**

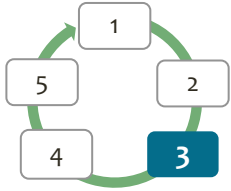
Challenges

Opportunities

Feasibility under
Current Management

Other Considerations

From Step 1



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Management Objective

Challenges

Opportunities

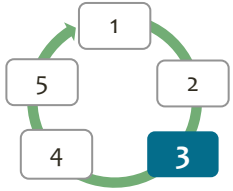
Feasibility under
Current Management

Other Considerations

How climate change impacts and vulnerabilities may make it more difficult to achieve the objective.

For example:

- *Reduced suitable habitat for target species*
- *Reduced winter access*



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Management Objective
Challenges

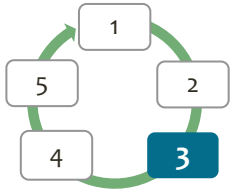
Opportunities

Feasibility under
Current Management
Other Considerations

How climate change impacts and vulnerabilities may make it easier to achieve the objective.

For example:

- *Reduced competition*
- *Increased growth*



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Management Objective

Challenges

Opportunities

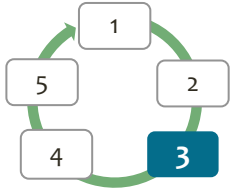
**Feasibility under
Current Management**

Other Considerations

Is current management adequate for meeting the objectives given climate change?

High: we can do it!
Opportunities > Challenges

Low: We'll need more resources or effort.
Challenges > Opportunities



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Management Objective

Challenges

Opportunities

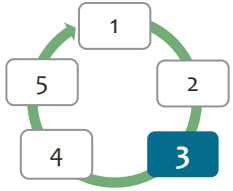
Feasibility under
Current Management

Other Considerations

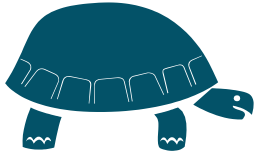
Social, administrative, financial, or other factors that also affect the ability to meet the objectives.

For example:

- *Rare species or high social value—we'll manage for it regardless*
- *Best chance of success—go for the long shot*



Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.



Slow down!

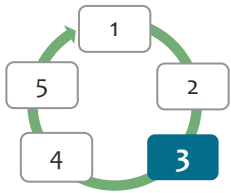
Are you going to continue with the management objectives that you have identified?

EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN

Management Objective (Step #1)	Challenges to Meeting Management Objective with Climate Change	Opportunities for Meeting Management Objective with Climate Change	Feasibility of Meeting Obj. under Current Management	Other Considerations
Achieve desired landscape conditions and age class distribution via aspen regeneration	<ul style="list-style-type: none"> ▪ Longer-term maintenance of stand may be more difficult under a changed climate (lower productivity, faster break-up) ▪ Observed productivity issues (worms?, drought?) may make site more vulnerable to climate change ▪ Low diversity. Few other species to fall back on ▪ Hazel present, and may become more competitive as site dries (?) ▪ Low diversity of stand increases the stand's vulnerability 	<ul style="list-style-type: none"> ▪ Future site conditions may be more conducive to pine (MA focus), if source was available 	Short term: High Long term: Moderate	Likelihood of follow-up on stand in first 20-30 years is low, so harder to do add'l needed treatments
Maintain a healthy forest and tree vigor via aspen regeneration			Short term: High Long term: Low	
Provide wood through environmentally responsible harvest via aspen regeneration			Short term: High Long term: Low (high uncertainty)	
Provide scenic integrity along Newman Lake Road	<ul style="list-style-type: none"> ▪ Reserve strips may be more vulnerable to wind throw if storms increase 	<ul style="list-style-type: none"> ▪ Mixed areas along the road might fare better and currently look good 	High	
Maintain consistency with Forest Plan Standards and Guidelines (e.g., reserve trees)	<ul style="list-style-type: none"> ▪ Current low diversity and productivity, which may be lower in future 	<ul style="list-style-type: none"> ▪ More snags and den trees? ▪ Non-aspen reserve trees will add diversity and may be better adapted to future conditions 	High	

ADAPTATION EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN





Step 3: EVALUATE management objectives given projected impacts and vulnerabilities.

Mgmt. Obj.	Challenges	Opportunities	Feasibility of Meeting Obj. (Current Mgmt)
<ul style="list-style-type: none"> • Regenerate aspen 	<ul style="list-style-type: none"> • Long-term maintenance • Few tree species • Productivity issues • Hazel competition 	<ul style="list-style-type: none"> • Future site may be suitable for pine 	<ul style="list-style-type: none"> • Short term: High • Long-term: Low
<ul style="list-style-type: none"> • Scenic integrity 	<ul style="list-style-type: none"> • Reserve strips more vulnerable to windthrow 	<ul style="list-style-type: none"> • Mixed areas along road look better 	<ul style="list-style-type: none"> • High



Identifying Adaptation Actions

What actions can be taken to enhance the ability of an ecosystem to cope with change while meeting conservation goals and objectives?

Uncertainty and Risk

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

Adaptation

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



Adaptation activities can build on sustainable management, conservation, and restoration of forests

Adaptation Actions



Manage for Change:

Ecosystems will fundamentally become something different

Manage for Persistence:

Ecosystems will still be recognizable as being the same system (character)

MANAGE FOR PERSISTENCE

RESISTANCE

Improve the defenses of the forest against effects of change.

- Short-term
- High-value



Photo: USFS



Millar et al. 2007

MANAGE FOR PERSISTENCE

RESILIENCE

Enhance the ability of an system to maintain or return to a particular ecological state following disturbance



Photo: USFS

MANAGE FOR CHANGE

TRANSITION

Intentionally encourage change, help ecosystems respond in a targeted fashion



Adaptation Options



When you might emphasize...

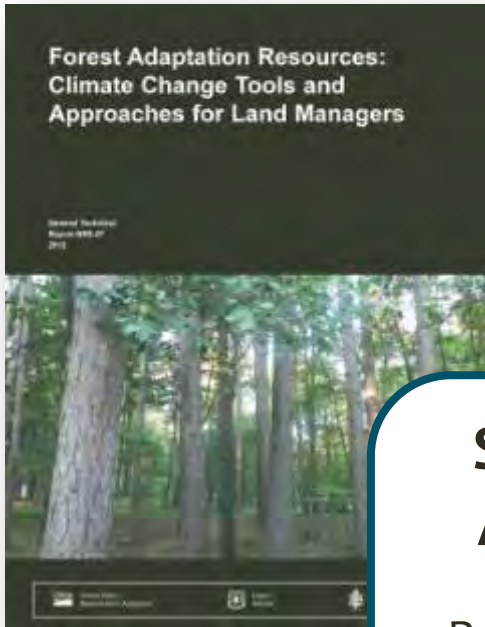
Persistence (Same/Similar)

- High ecological value or unique/rare condition
- High social value associated with current condition
- Inherent ability to buffer changes
- Highly vulnerable, but place represents best chance of success

Change (Future-adapted)

- High likelihood that current conditions will fail, making change is necessary
- Changes are already occurring, and can be enhanced
- Good opportunity to try something new

Forest Adaptation Resources



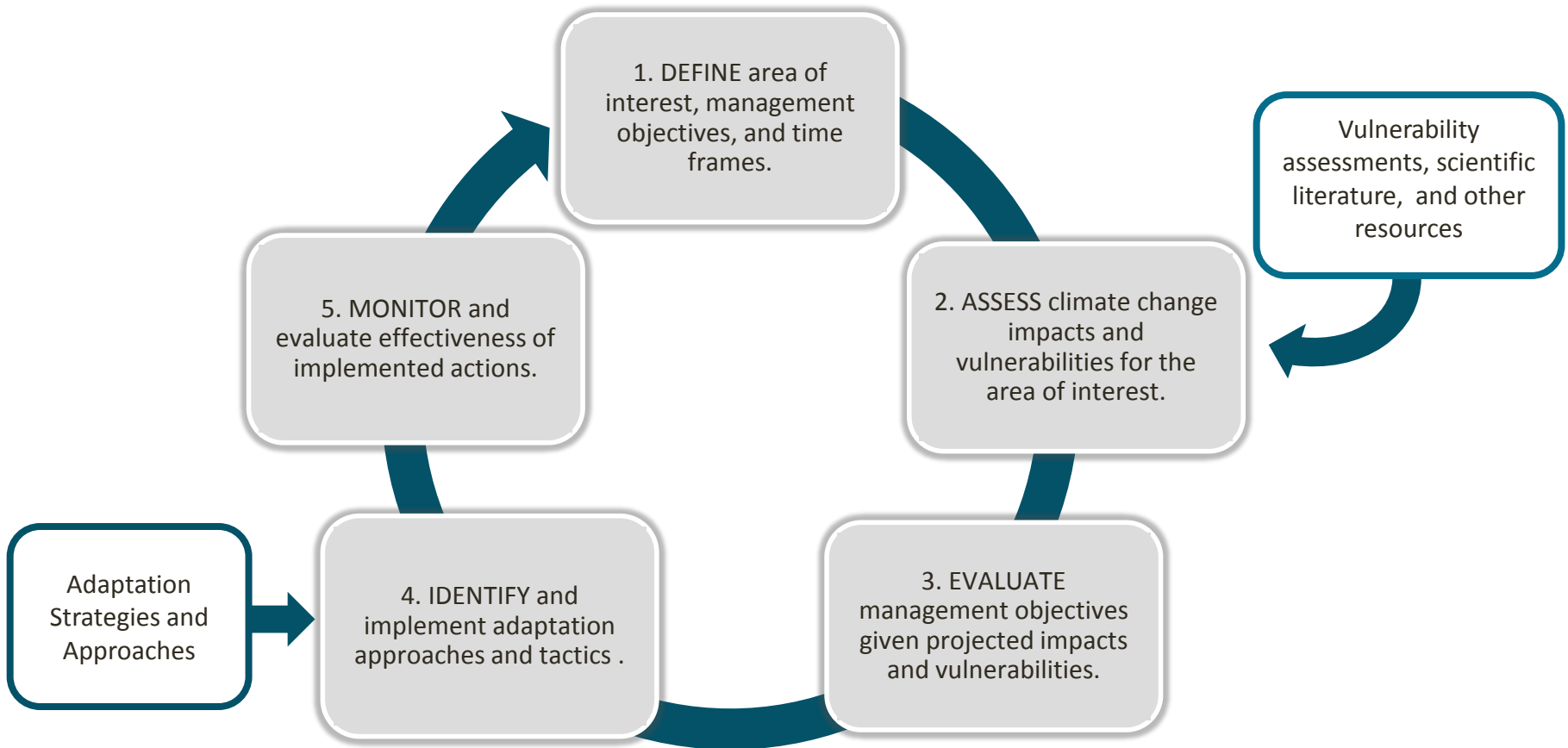
Strategies & Approaches

Provides a menu of adaptation actions

Adaptation Workbook

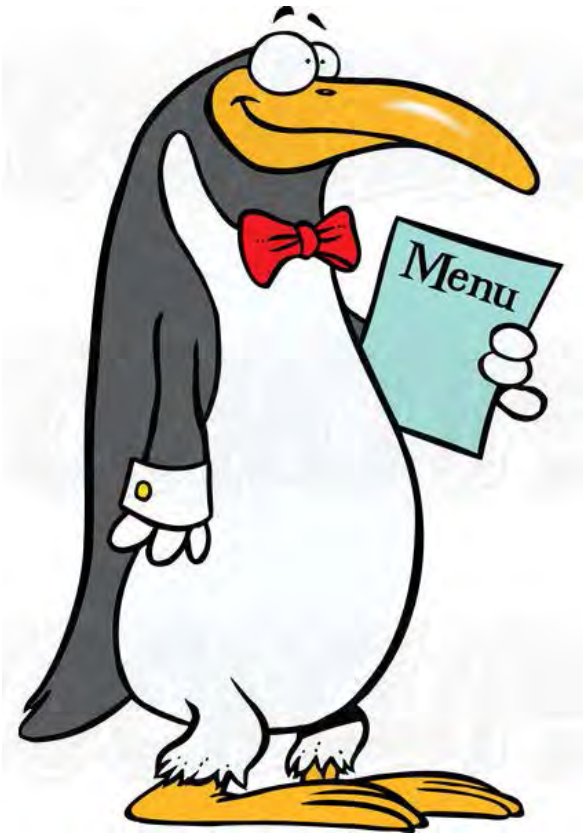
Provides a structure for considering climate change in management

Adaptation Workbook



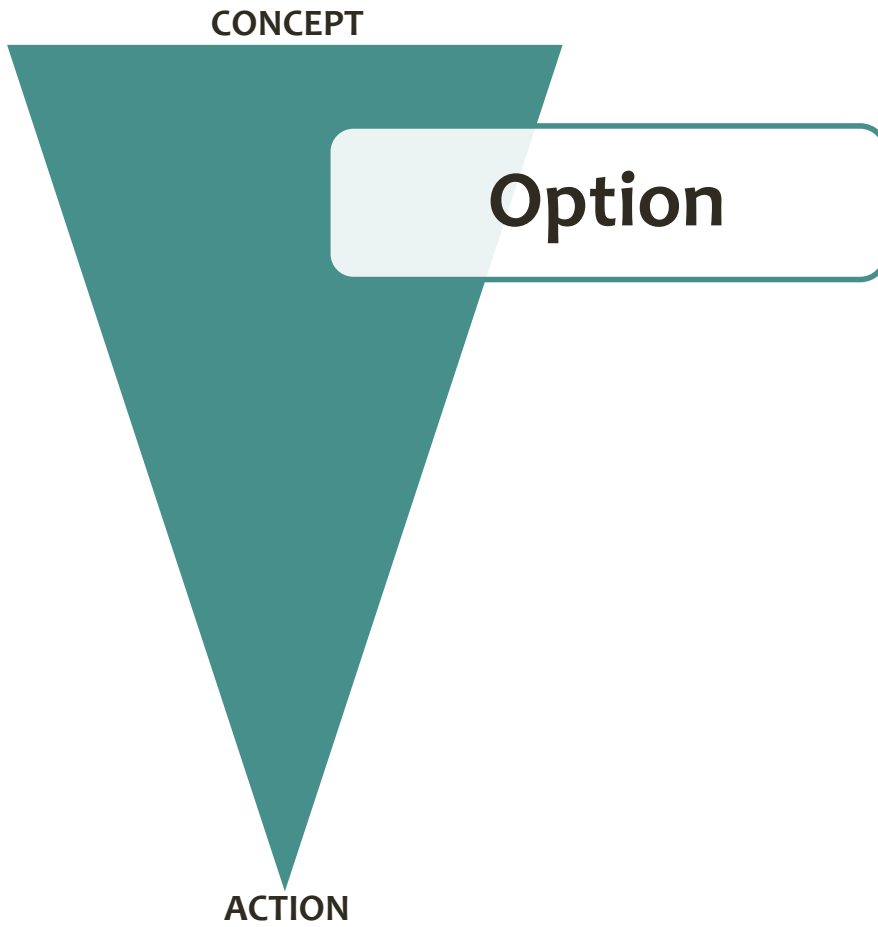
Can we use this approach for other resource areas?

Adaptation Strategies & Approaches



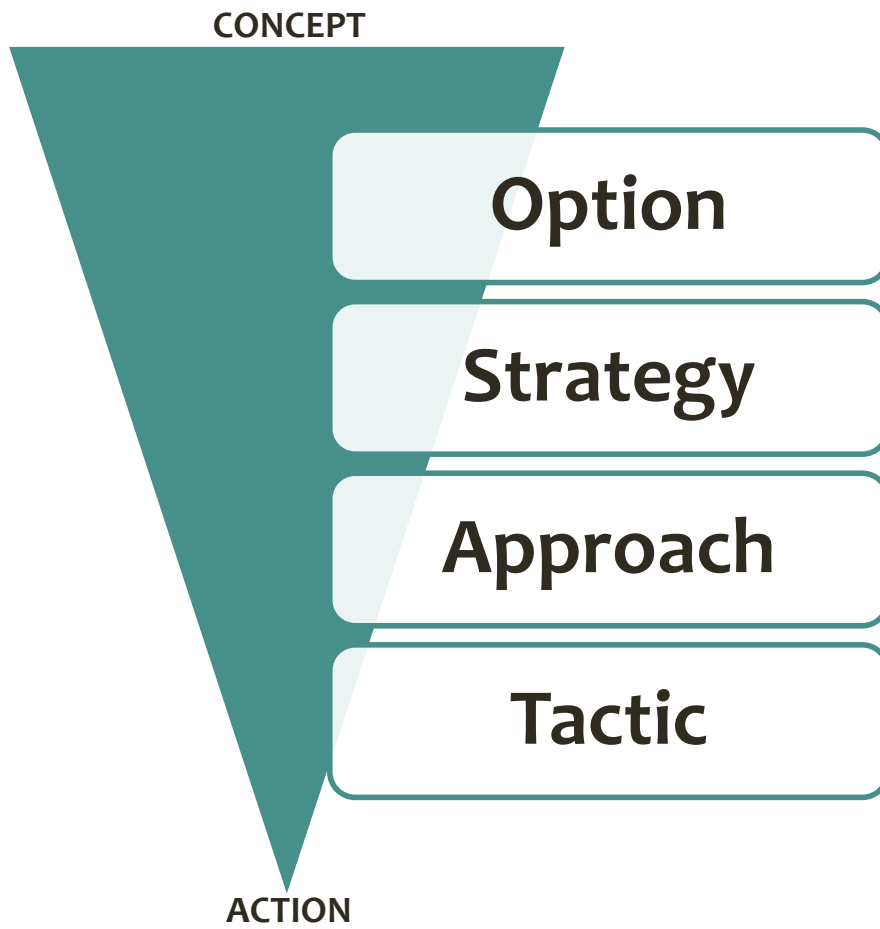
A “menu” of possible actions that allows you to decide what is most relevant for a particular location and set of conditions.

Adaptation Strategies and Approaches



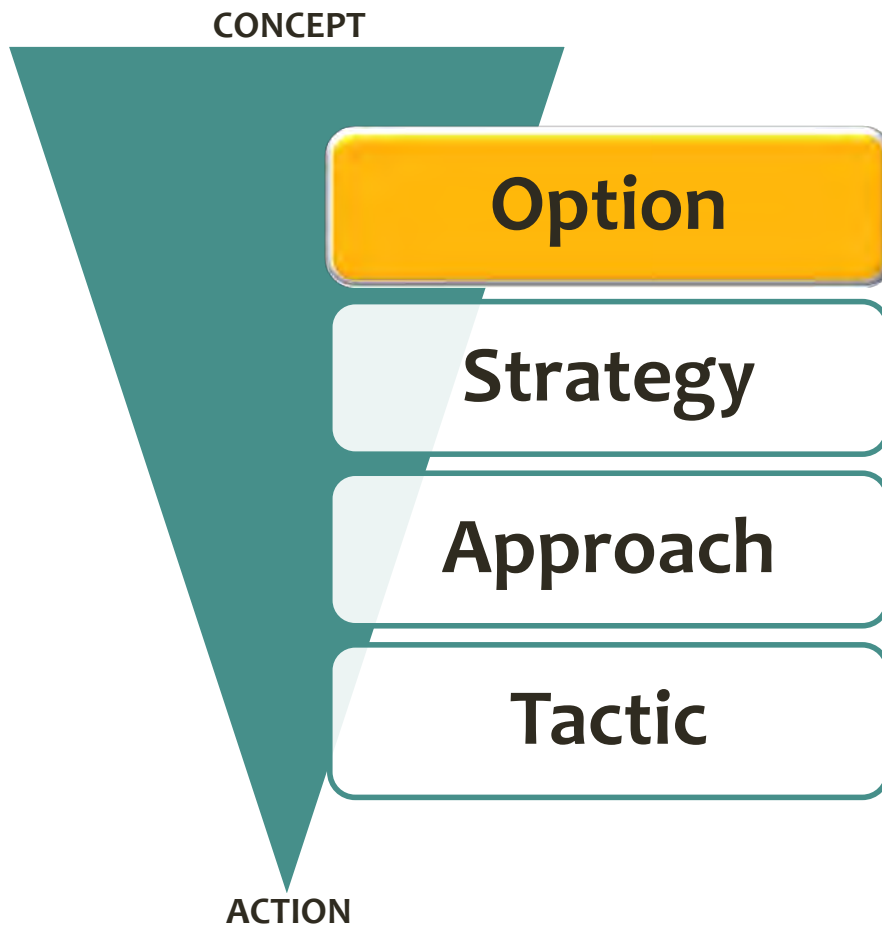
- Resistance
- Resilience
- Transition

Adaptation Strategies and Approaches



A menu of **Strategies** and **Approaches** provides a way to translate broad **Options** into locally-relevant **Tactics**

Adaptation Strategies and Approaches



Start with an Option

Resistance:

Forestall change

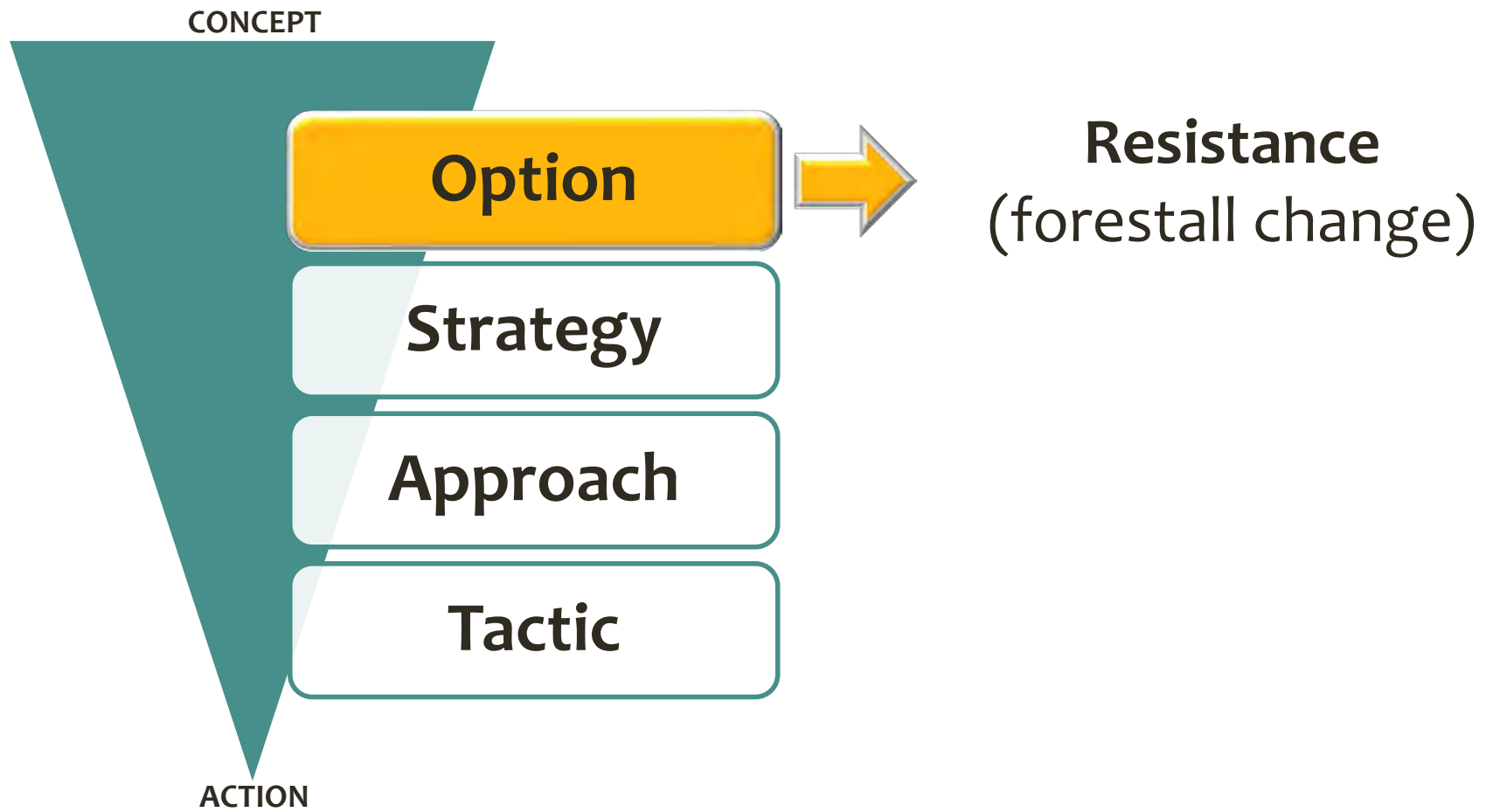
Resilience:

Rebound from change

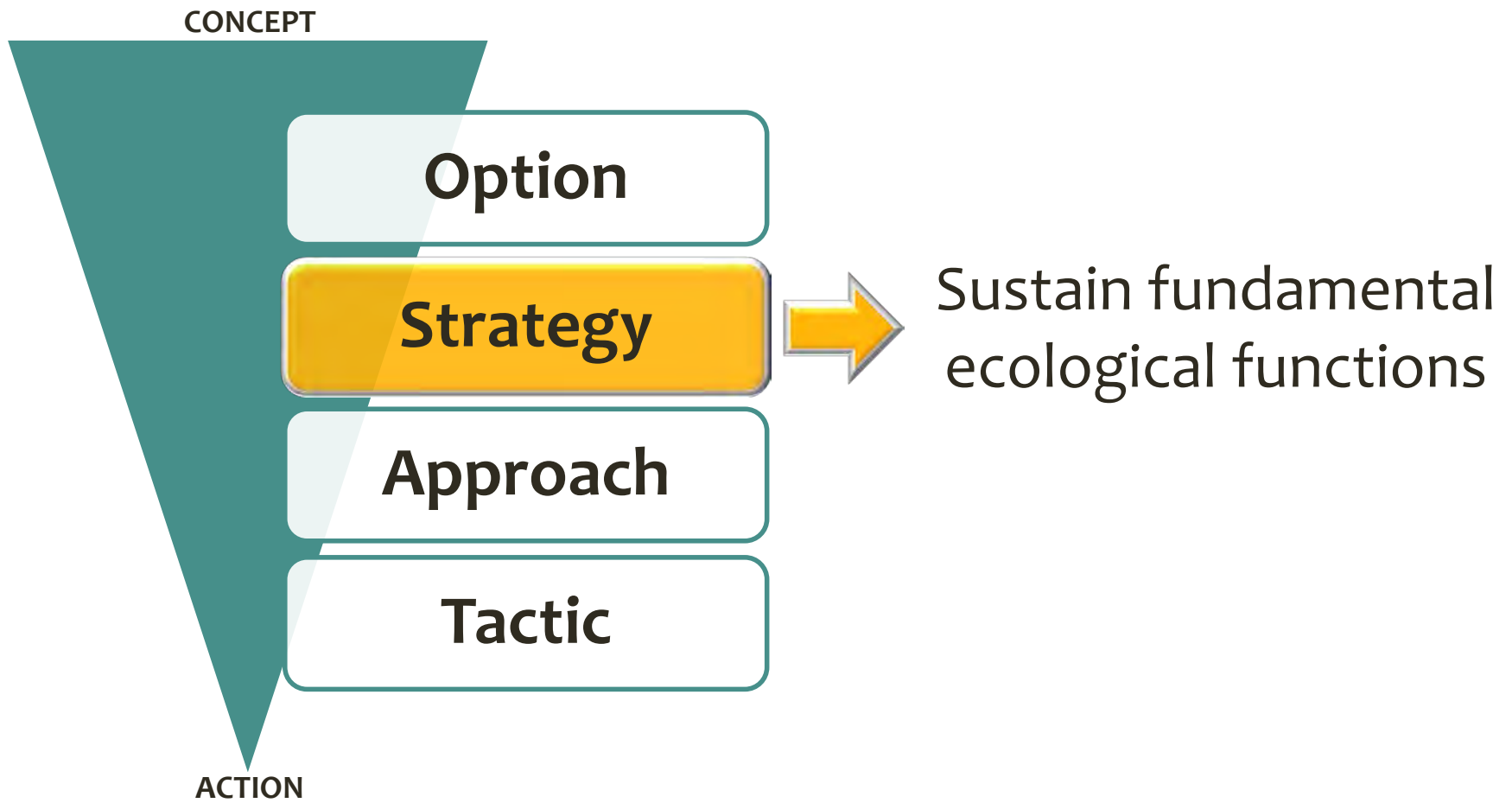
Transition:

Facilitate change

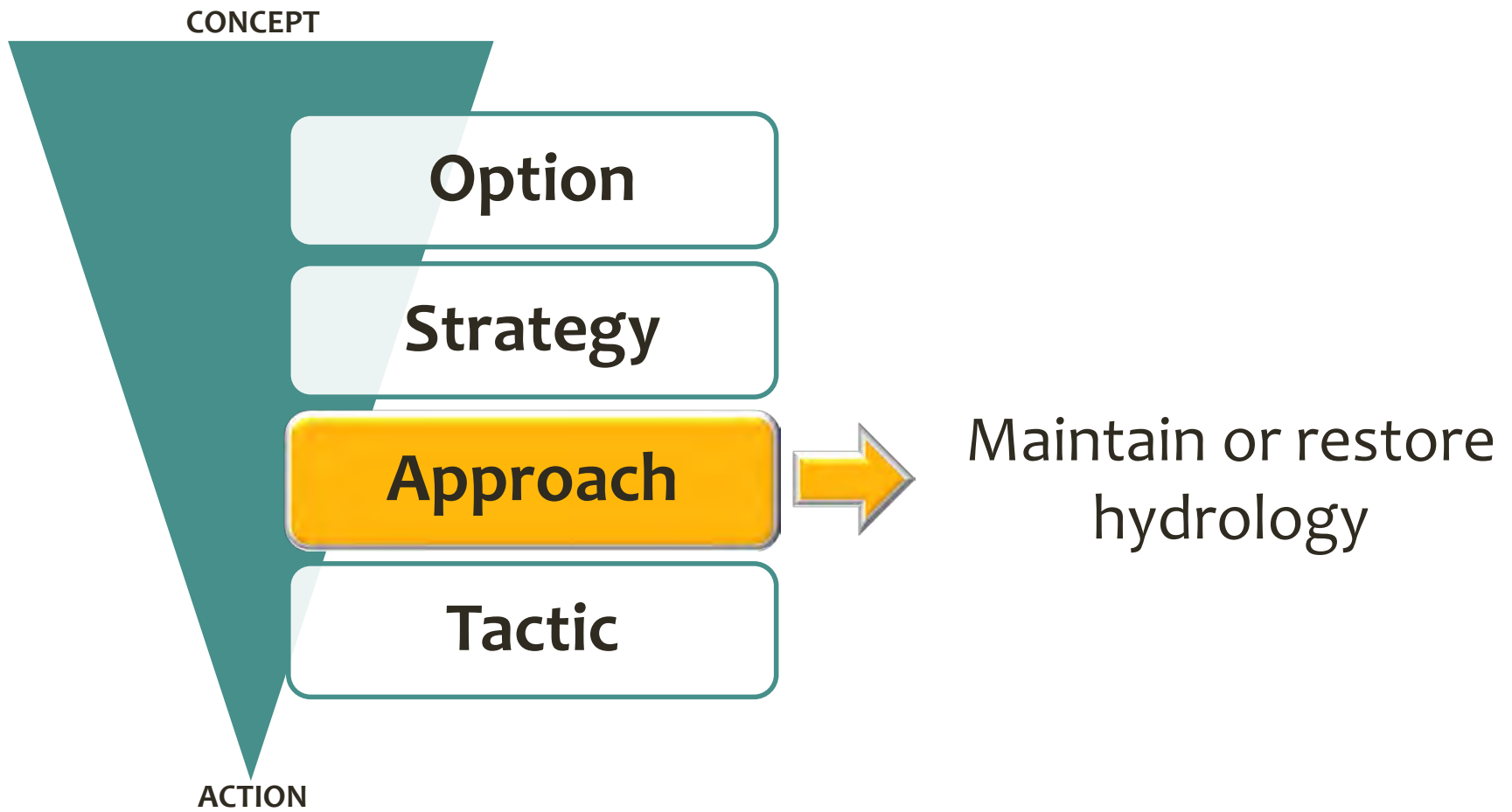
Adaptation Strategies and Approaches



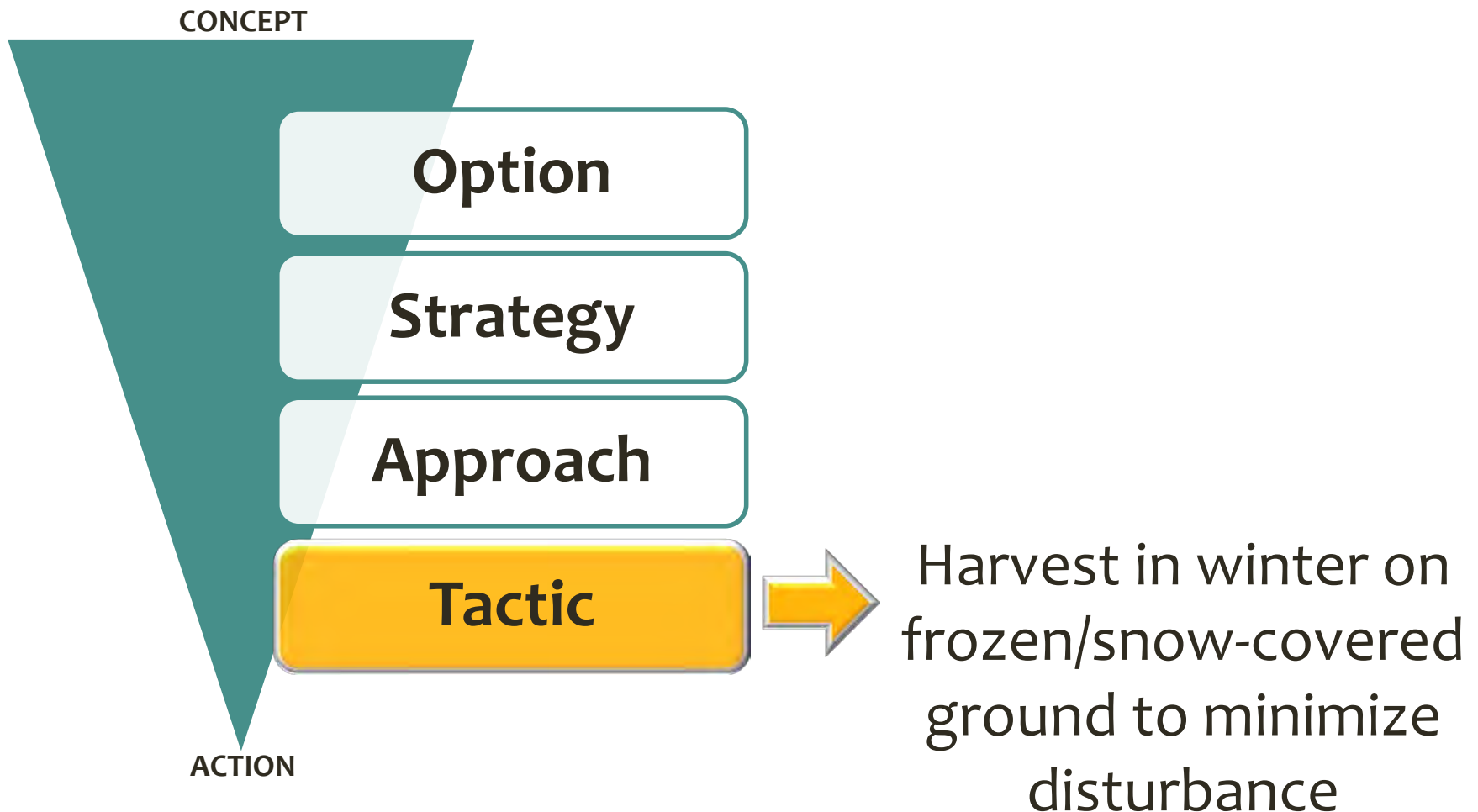
Adaptation Strategies and Approaches



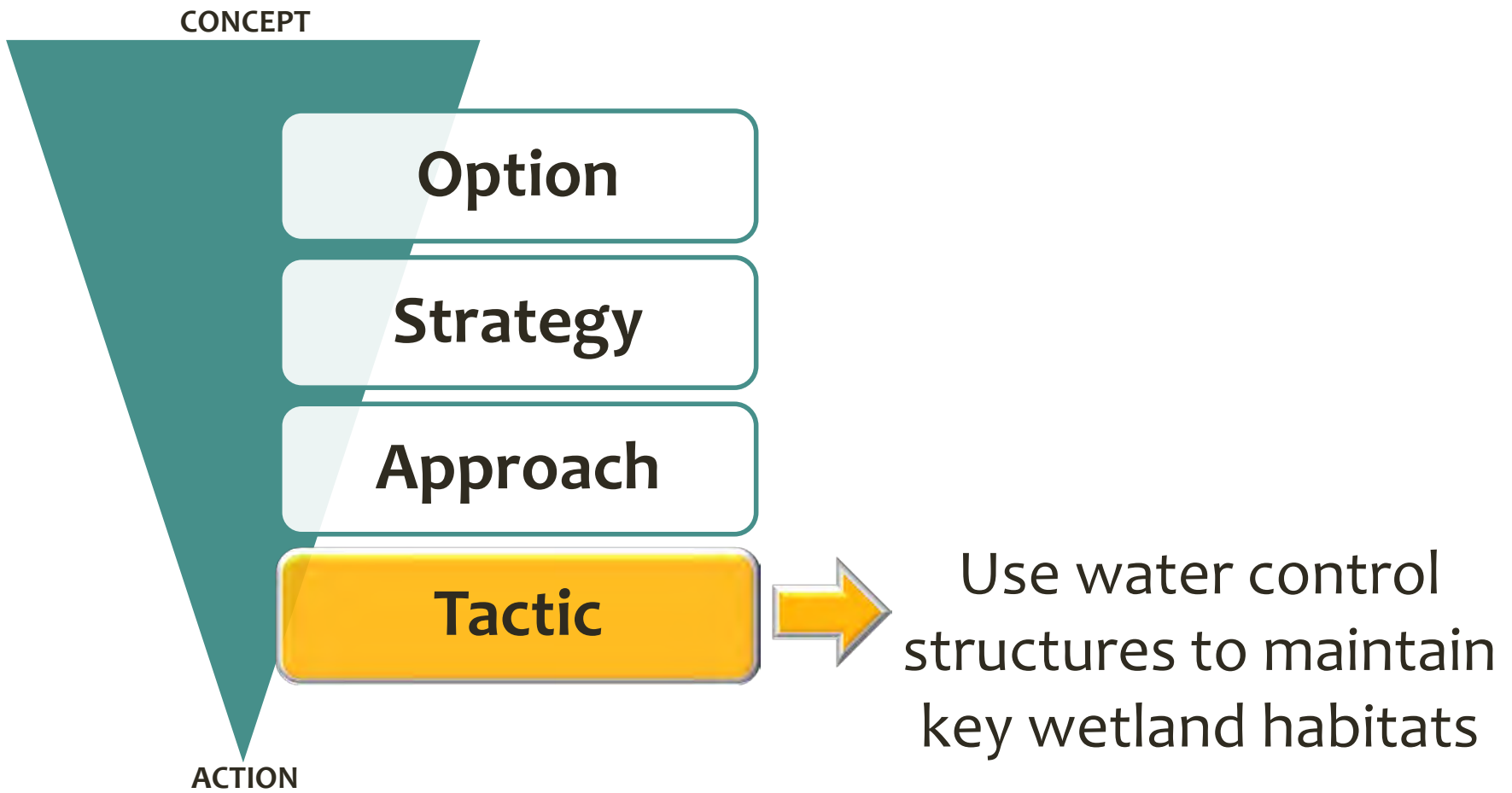
Adaptation Strategies and Approaches



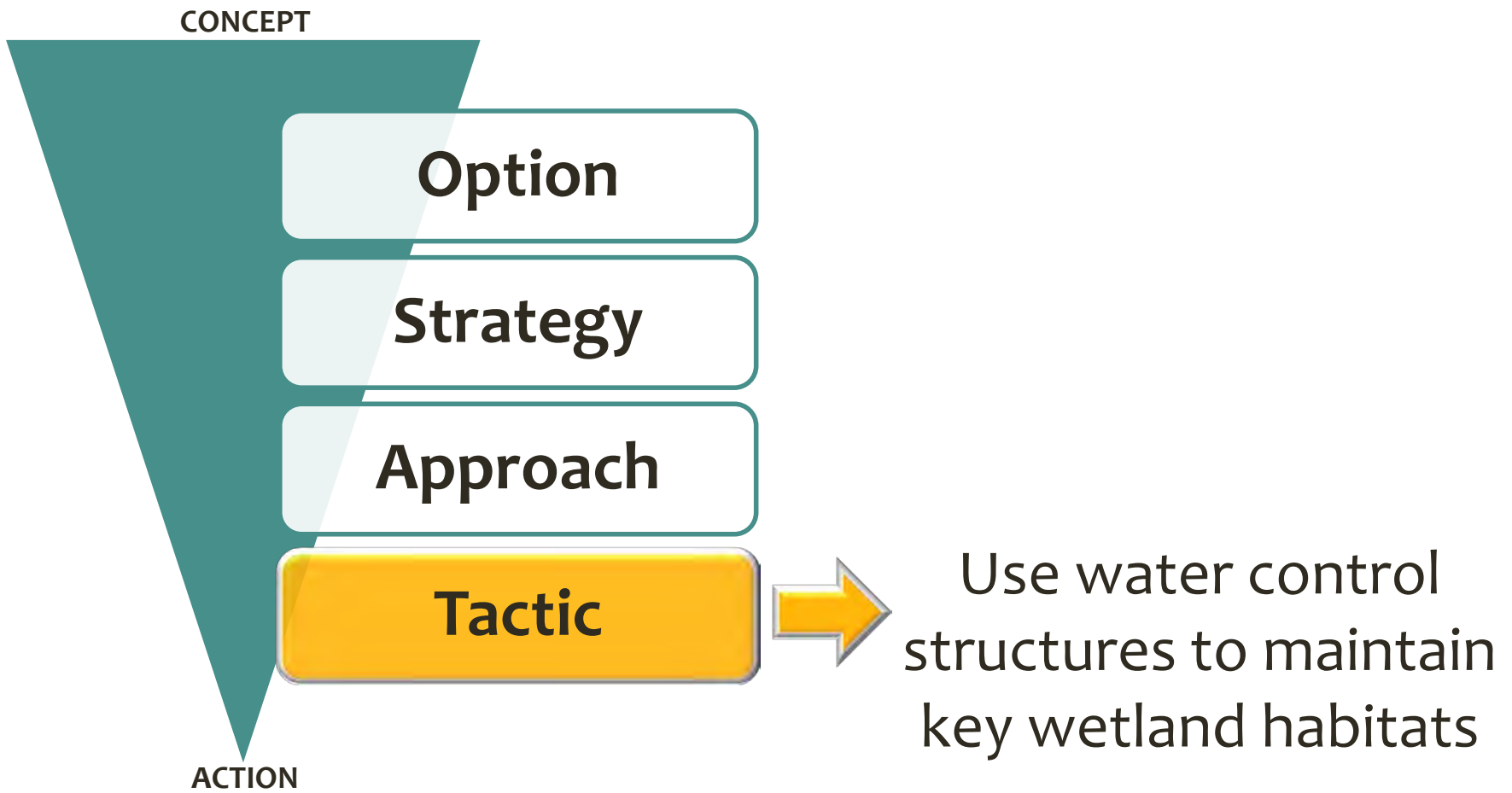
Adaptation Strategies and Approaches



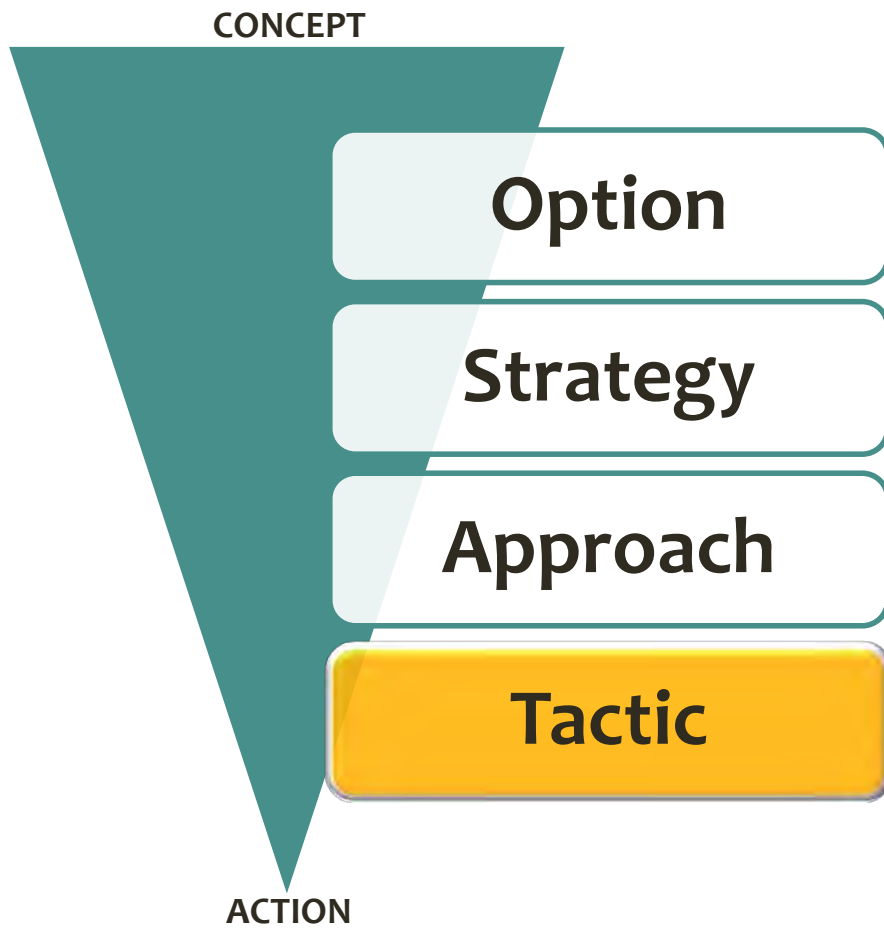
Adaptation Strategies and Approaches



Adaptation Strategies and Approaches



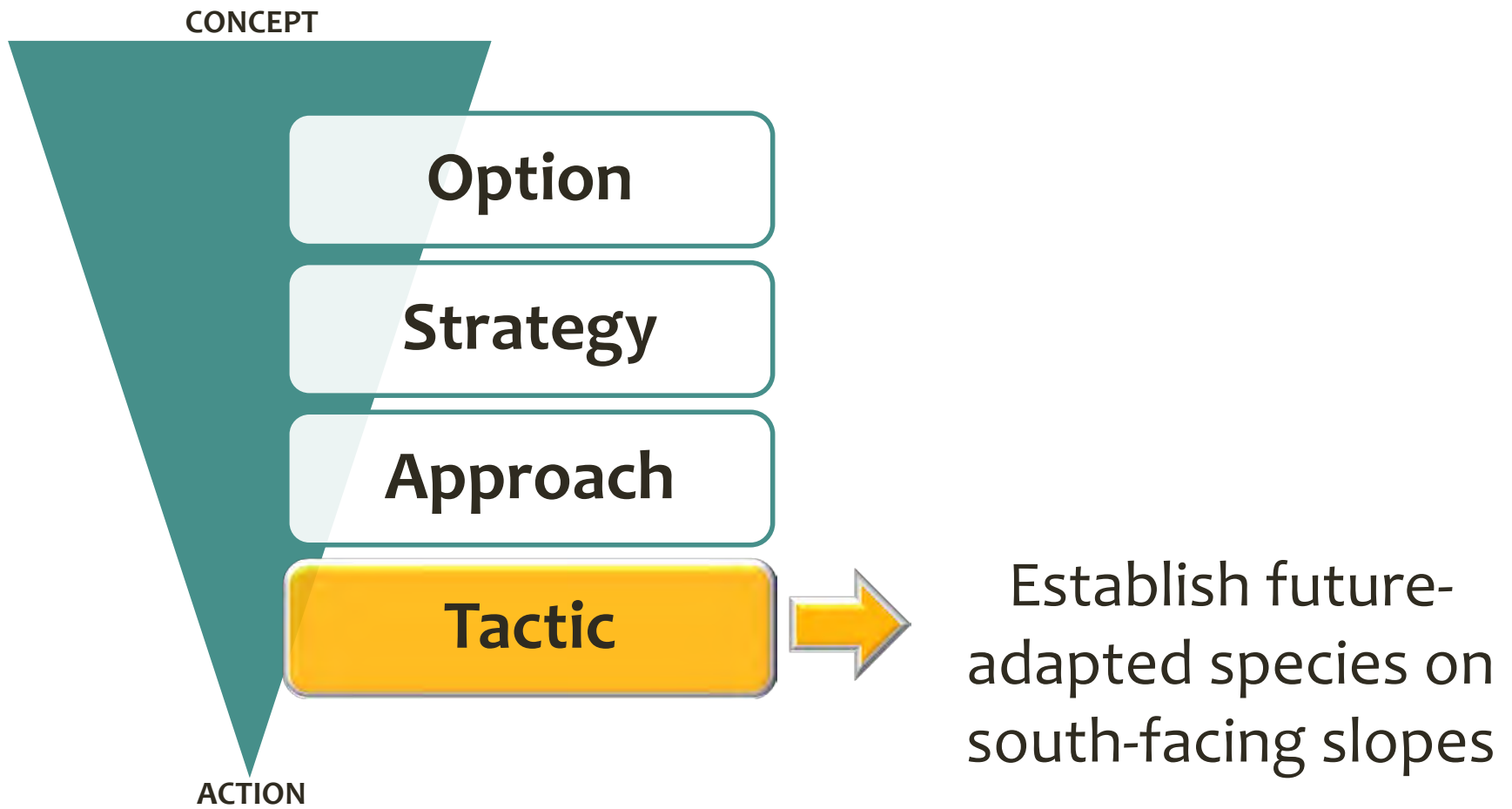
Adaptation Strategies and Approaches



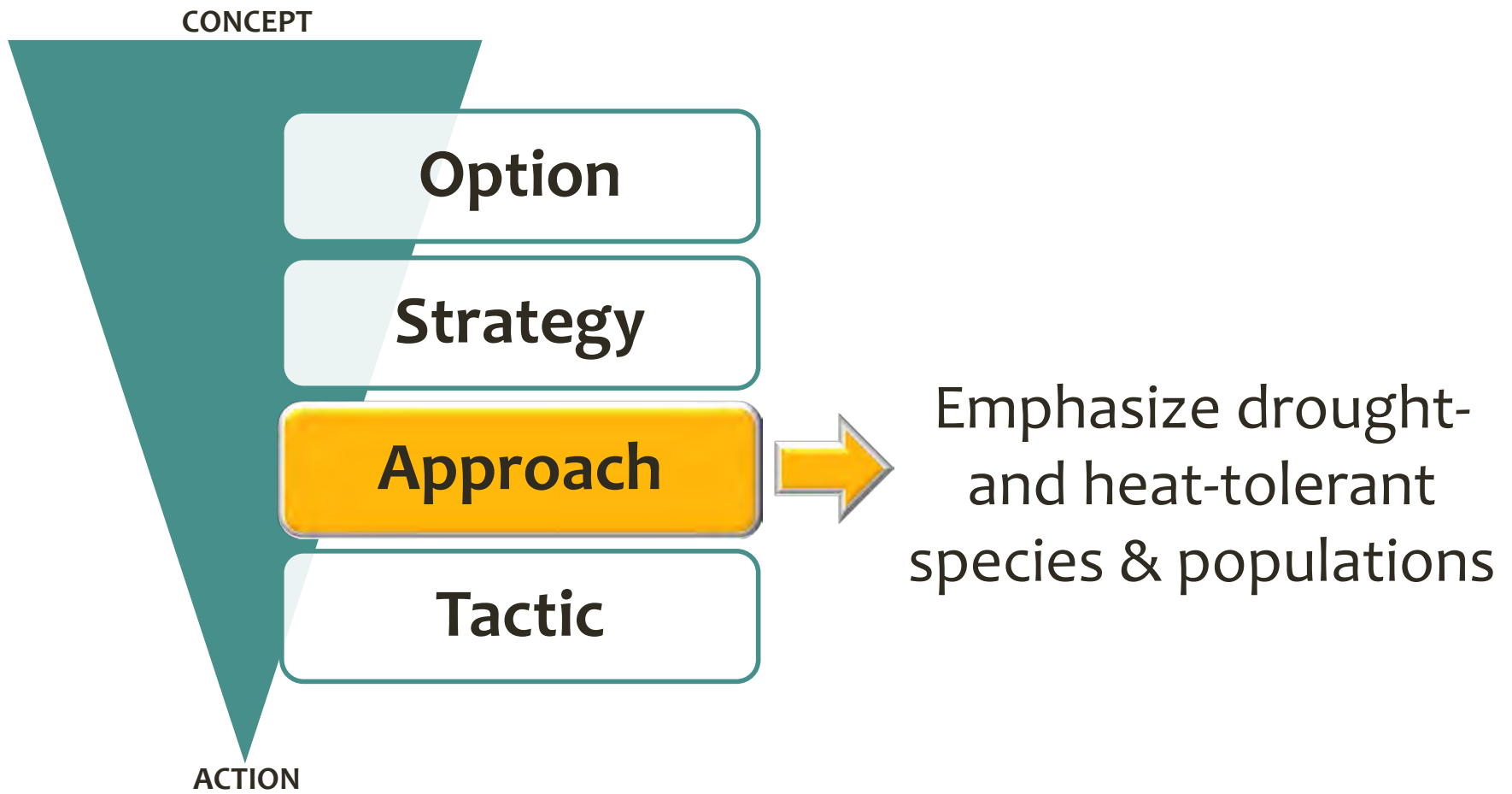
Start with a Tactic

Work backwards to
show intentionality

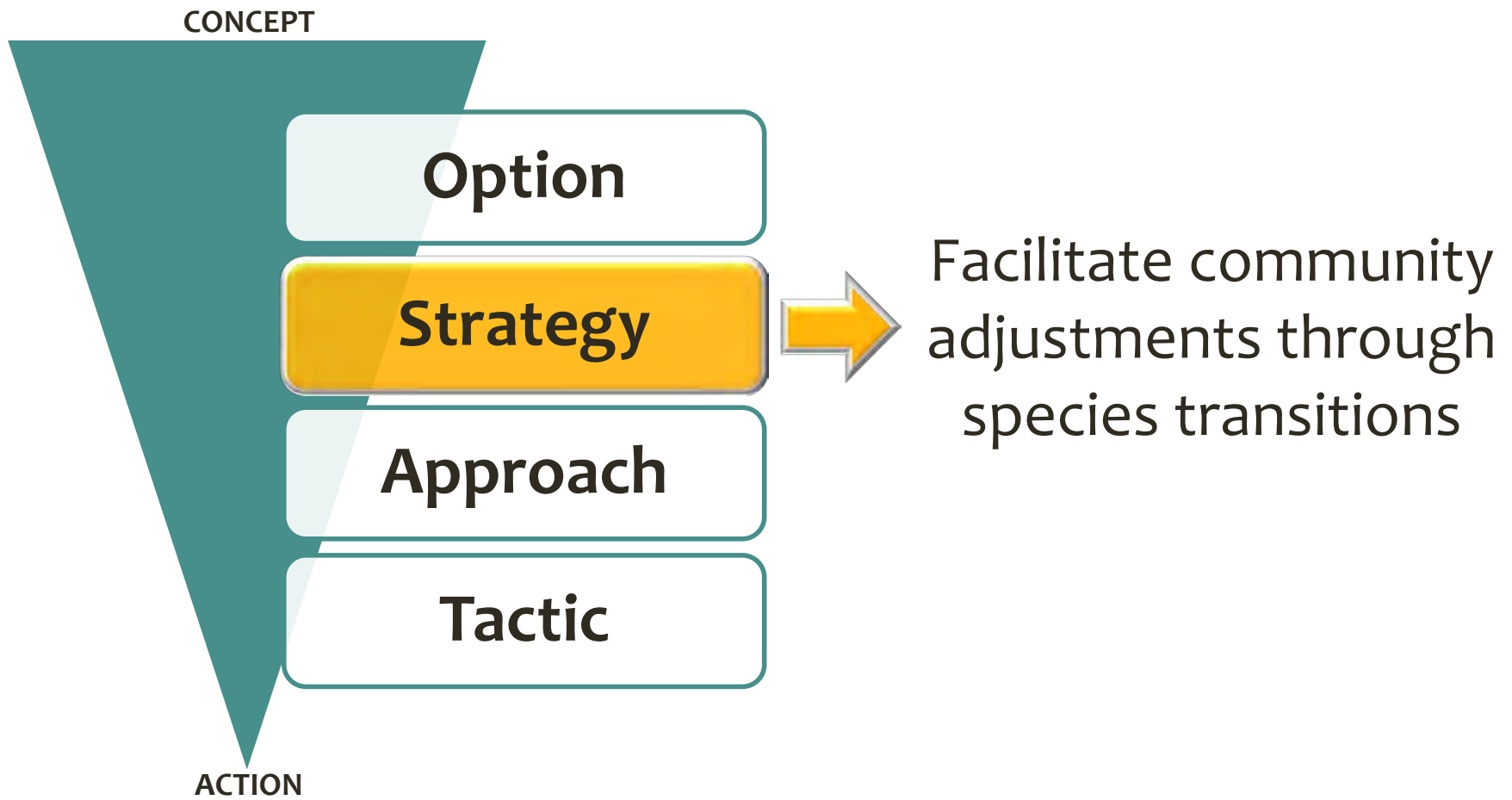
Adaptation Strategies and Approaches



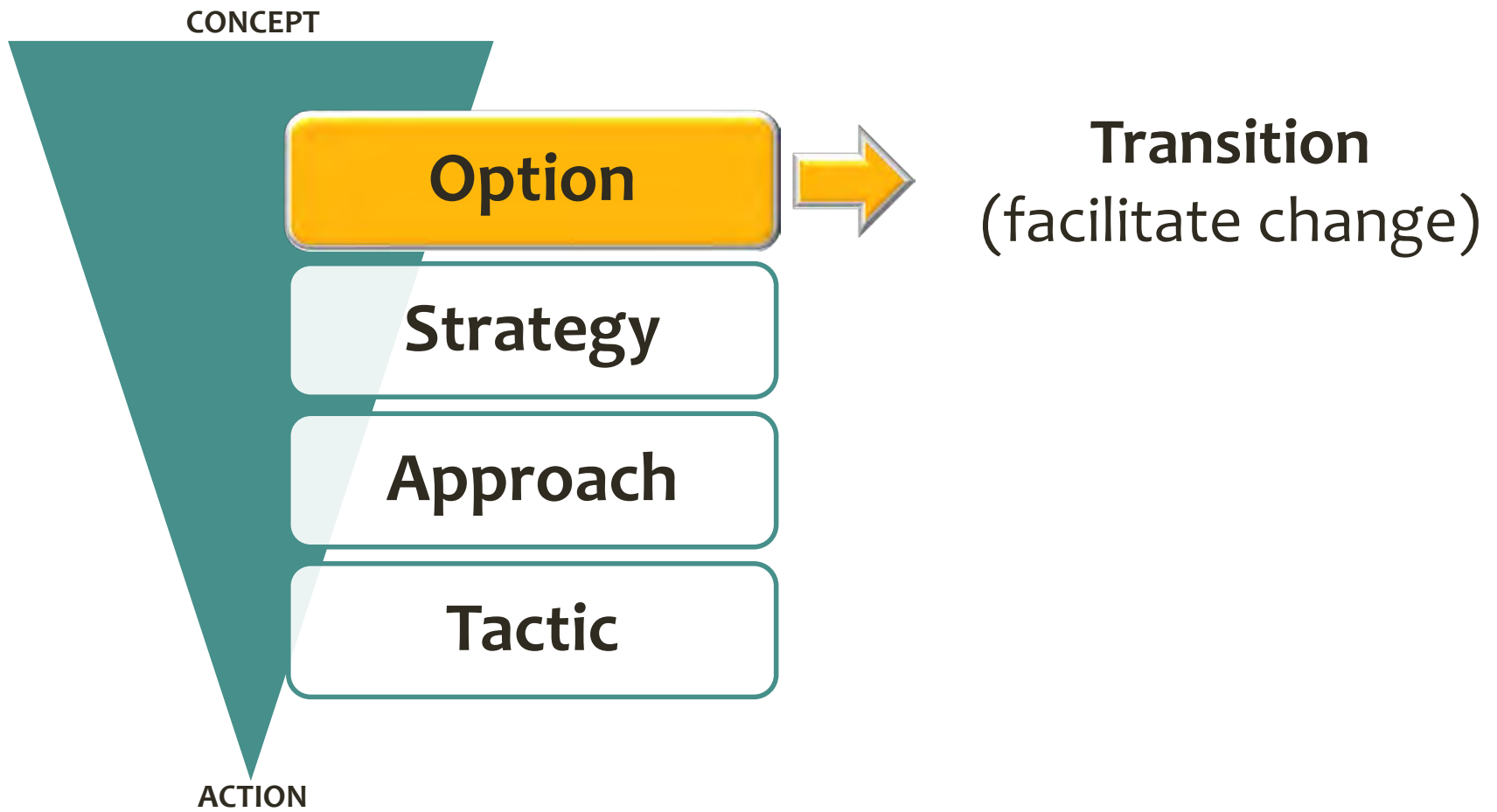
Adaptation Strategies and Approaches



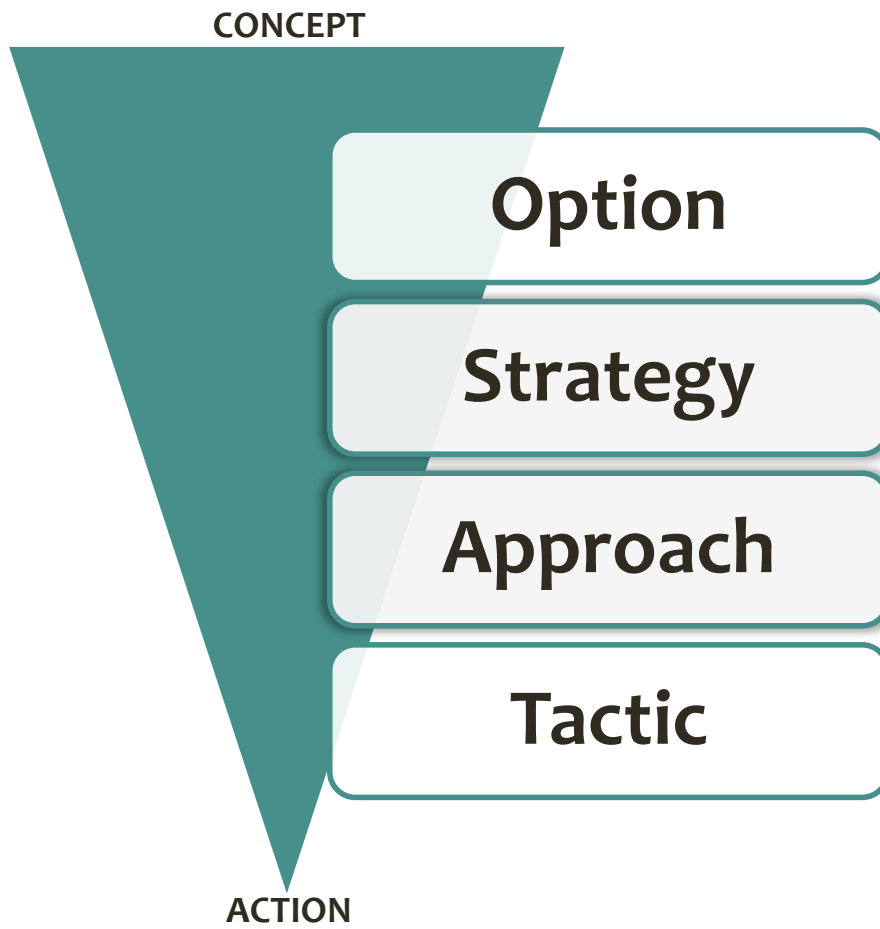
Adaptation Strategies and Approaches



Adaptation Strategies and Approaches



Adaptation Strategies and Approaches



Helps connect the dots from broad concepts to specific actions for implementation.

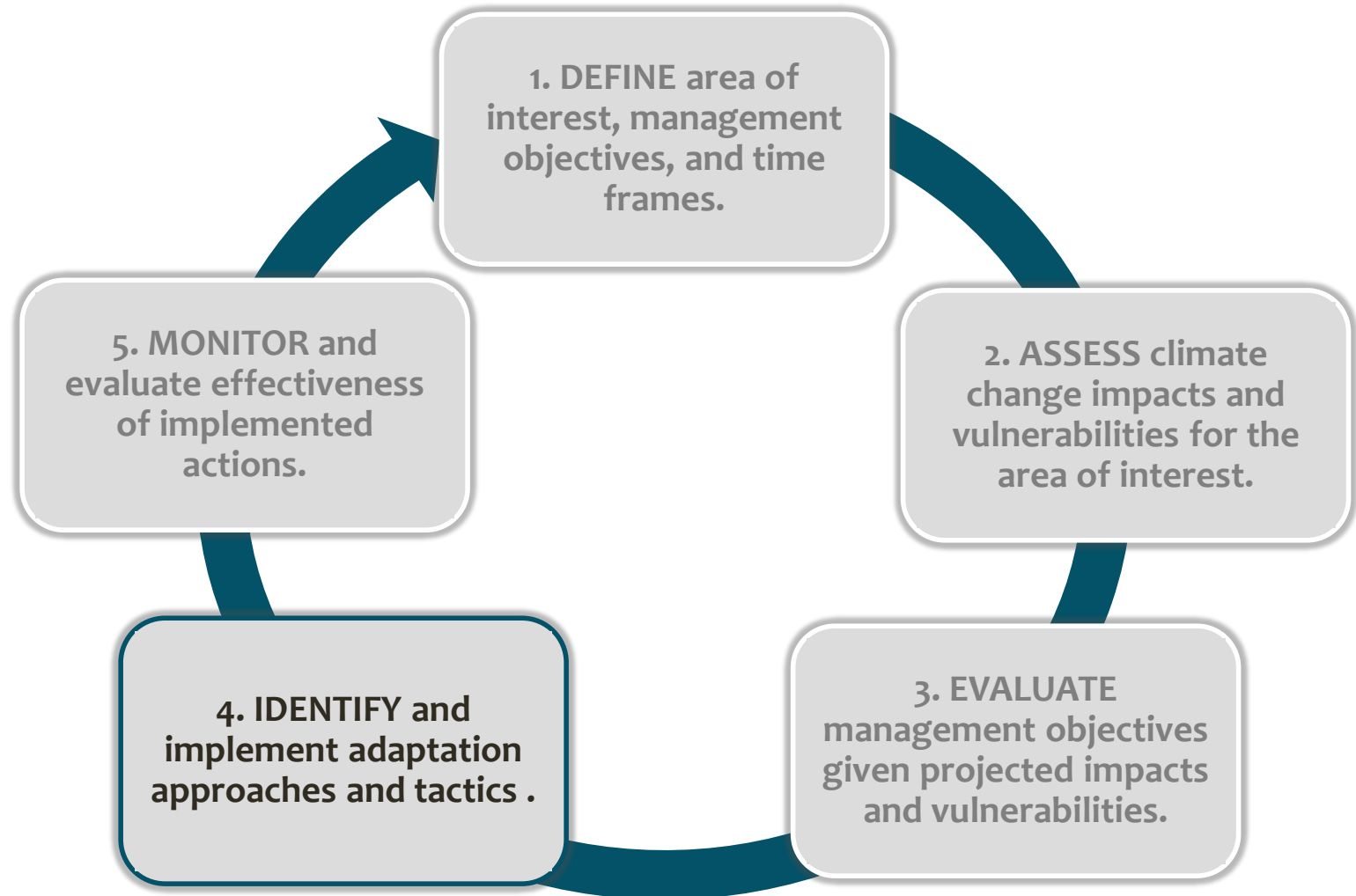
- It doesn't matter whether you start with approaches or tactics.
- It is important to connect the two: shows how your action is related to climate change

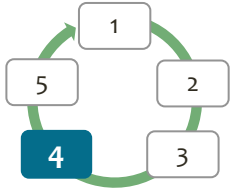




Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Workbook Instructions





Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

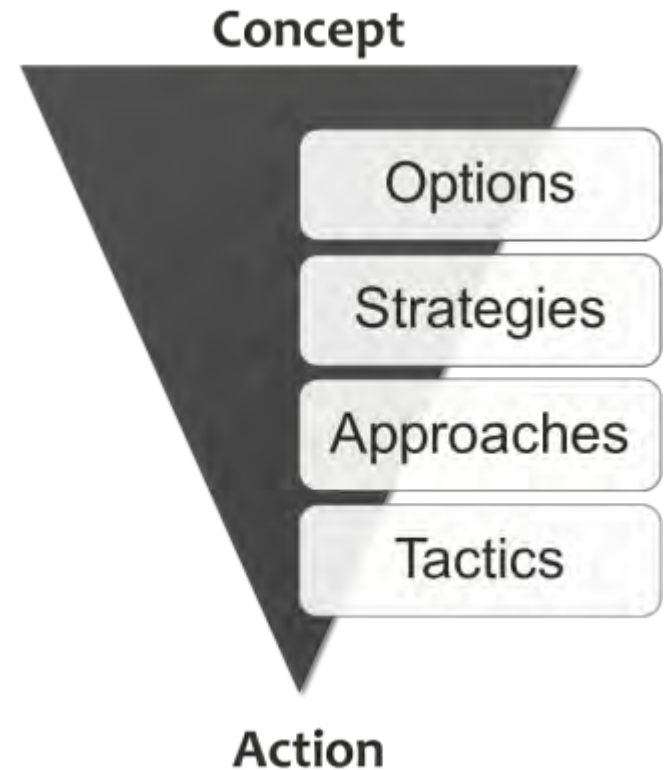
Purpose:

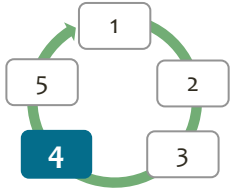
- Select potential adaptation actions

What actions can be taken to enhance the ability of the area to cope with change and meet management goals/objectives?

Two Questions

1. What actions can help achieve my management objectives and address the potential climate change impacts?
2. Will future managers know what we were trying to do?





Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

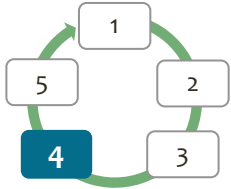
Drawbacks and Barriers

Practicability

Recommend Tactic?

Select from the menu of adaptation strategies and approaches.

Pick any that seem to make sense and help address the challenges.



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

Practicability

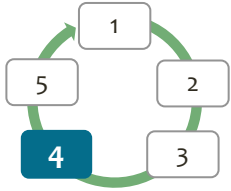
Recommend Tactic?

How the adaptation approach will be implemented.

For example:

- *Restore fire through prescribed burn*
- *Increase genetic diversity by acquiring seed from IL*

Note: There may be multiple approaches for a single tactic, or vice versa.



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

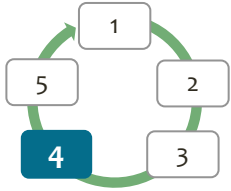
Practicability

Recommend Tactic?

Timing for the tactics

For example:

- *Summer 2014*
- *Winter 2013-2016*
- *Within 3 years of...*
- *After...*



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

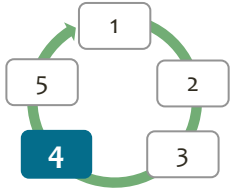
Practicability

Recommend Tactic?

Why it's good

For example:

- *Addresses biggest or multiple challenges*
- *Cheap, easy*
- *Co-benefits*
- *Likely to succeed*



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

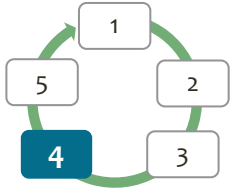
Practicability

Recommend Tactic?

Why it's not so good

For example:

- *Negative side effects*
- *High cost or effort*
- *Social, financial, or other barriers*
- *Uncertainty of success*



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

Practicability

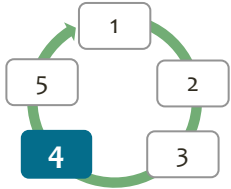
Recommend Tactic?

Is it both effective and feasible?

High: Yes to both!

Moderate: Yeah, but it will take some additional effort or planning...

Low: No, the barriers/drawbacks seem too big or the benefits too small.



Step 4: IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach

Tactic

Time Frame

Benefits

Drawbacks and Barriers

Practicability

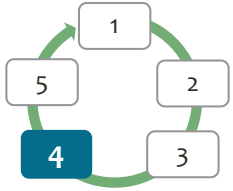
Recommend Tactic?

Given all this, is this tactic likely to be helpful?

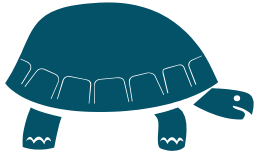
Also consider: trade-offs, urgency, likelihood of success, cost, and effort...

Yes: look to integrate into plan, prescription, or other activities

No: not useful at this time



Step 4: IDENTIFY adaptation approaches and tactics for implementation.



Slow down!

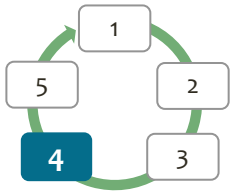
Are you going to continue with the adaptation tactics that have been selected?

EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks & Barriers	Practicability of Tactic	Recommend Tactic?
5.2 — Maintain or improve the ability of forests to resist pests and pathogens.	Clearcut aspen in winter to promote vigorous regrowth	Short term (harvest)	<ul style="list-style-type: none"> Young aspen is generally less susceptible to pests and diseases than mature aspen May help reduce patchiness of aspen in stand 	<ul style="list-style-type: none"> 	Extremely High	Yes
9.2 — Favor or restore native species that are expected to be better adapted to future conditions. 9.4 — Emphasize drought- and heat-tolerant species and populations.	Plant red oak in select areas to introduce a small component to stand and add species diversity, especially in reserve areas near road. Consider deer protection for oak.	Short-term (harvest)	<ul style="list-style-type: none"> Species seems like it would be well-adapted to site Add diversity and a future adapted species 	<ul style="list-style-type: none"> Not sure whether competition could be controlled sufficiently Not good place to put oak where it can get the right amount of light at the right time Emphasis is aspen, so sinking lots of effort into oak doesn't make sense Not specified in NEPA 	Low (effectiveness and feasibility are both low) Additional steps would be needed to prep for oak planting	Yes
9.4 — Emphasize drought- and heat-tolerant species and populations. 8.2 — Favor existing genotypes that are better adapted to future conditions	For any planted red oak, consider selecting acorns from trees that have survived drought and other stressors (e.g., Twin Ghost areas of oak mortality)	Short term	<ul style="list-style-type: none"> Stock might be better adapted to future conditions. Stock would be within the same seed zone. 	<ul style="list-style-type: none"> Overall suitability for this stand is unknown. Haven't done this before. Low probability of success? 	Getting acorns: high Successfully raising oak: low (see #10)	No

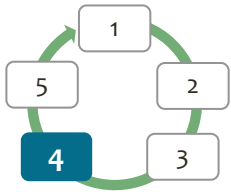
ADAPTATION EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN





Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

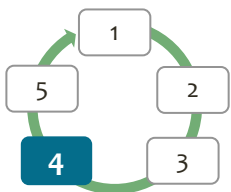
What actions can be taken to enhance the ability of the area to cope with change and meet management goals?



Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

Overall Approach: Enhance future options within existing management trajectory

- Aspen will regenerate now, but is likely to fare poorly over the long term.
- Maintain plans for clearcut, with additional actions to promote diversity and provide future options
- Pro-active on invasives and disturbance planning



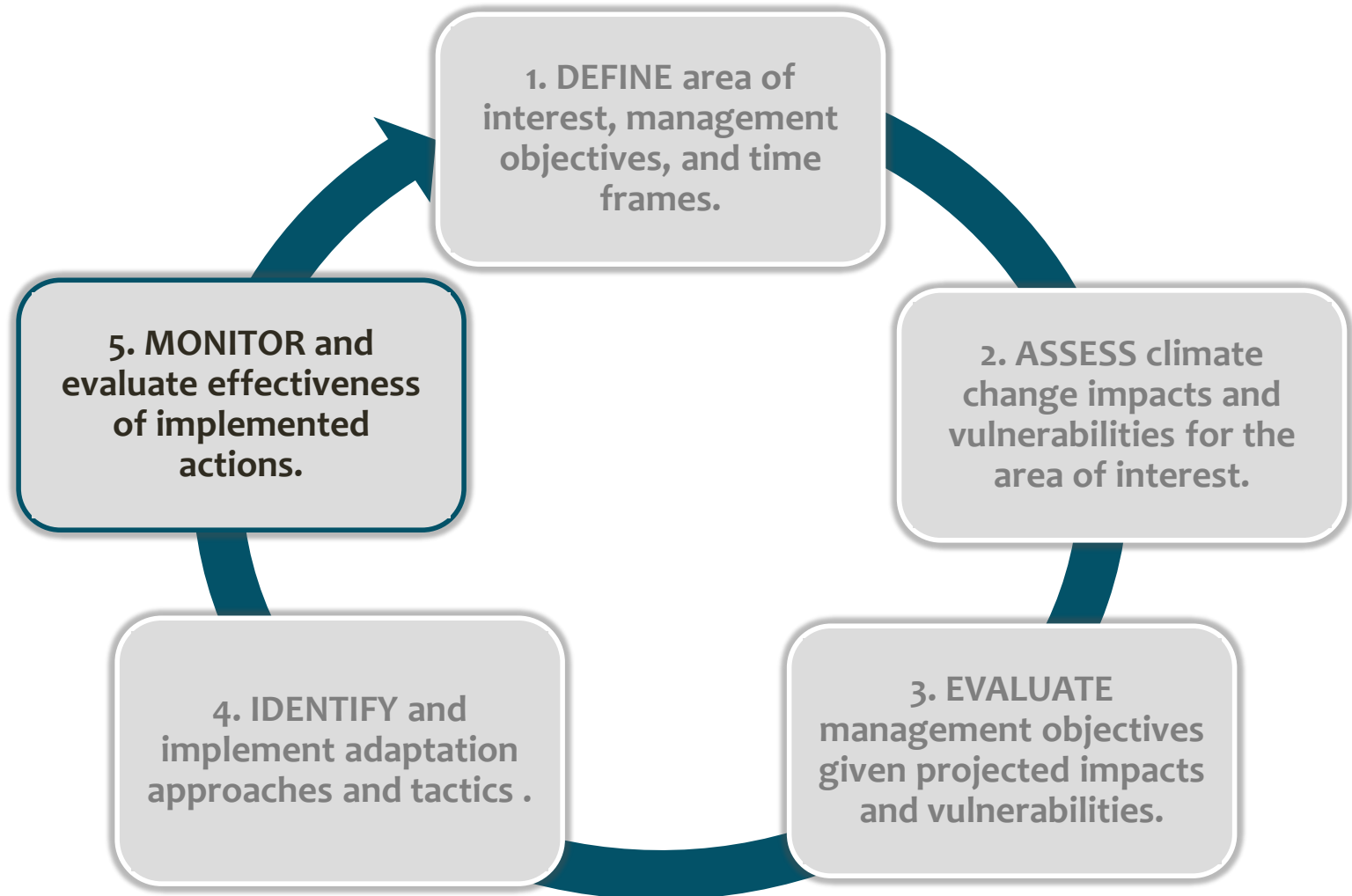
Step 4: IDENTIFY and adaptation approaches and tactics for implementation.

Adaptation Approach	Tactic	Consider:	Recommend Tactics?
<ul style="list-style-type: none"> • Maintain or improve the ability of forests to resist pests and pathogens. 	<ul style="list-style-type: none"> • Clearcut aspen • Thin roadside aspen 	<ul style="list-style-type: none"> • Benefits • Drawbacks • Barriers • Practicability 	<p>Yes</p>
<ul style="list-style-type: none"> • Favor or restore native species that are expected to be better adapted to future conditions. 	<ul style="list-style-type: none"> • Plant white pine and red oak (to become minor component) • Favor future-adapted species on site 		<p>Yes</p>



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Workbook Instructions

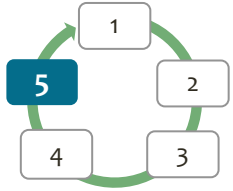


A Few Thoughts About Monitoring...

- Be VERY CLEAR about your information needs and the kind of monitoring that might help you get that information:
 - Implementation monitoring = Did we do the action?
 - Surveillance/impact monitoring = What change is occurring over time?
 - Effectiveness/adaptation monitoring = Did our action actually have the desired effect?
 - Scientific research = Is this outcome statistically significant compared to a control? Could we expect similar results elsewhere?

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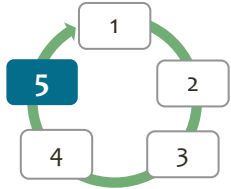
Step 5: MONITOR and evaluate effectiveness of implemented actions.

Purpose:

- Practice adaptive management

How do we know if the selected actions were effective?

What can we learn from these actions to inform future management?



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Monitoring Item

Monitoring Metric

Criteria for Evaluation

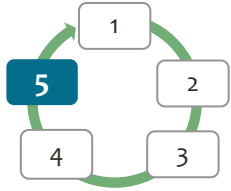
Monitoring
Implementation

Item that can tell you whether you have achieved your management goals or objectives.

If possible, use an item that also helps evaluate the effectiveness of the tactics.

For example:

- *Planted seedling survival*



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Monitoring Item

Monitoring Metric

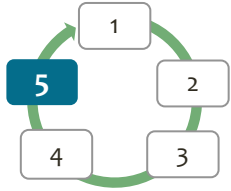
Criteria for Evaluation

Monitoring
Implementation

What you're monitoring or measuring.

For example:

- *Percentage success at 1, 2, 5, and 10 years after planting.*



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Monitoring Item

Monitoring Metric

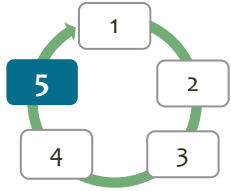
Criteria for Evaluation

Monitoring
Implementation

Evaluation of success

For example:

- *60% survival of non-local genotypes*



Step 5: MONITOR and evaluate effectiveness of implemented actions.

Monitoring Item

Monitoring Metric

Criteria for Evaluation

Monitoring
Implementation

How the monitoring will actually get done.

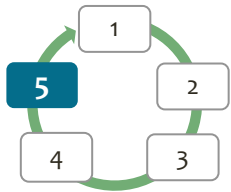
Note: use existing monitoring when possible

For example:

- *Regular post-planting stocking surveys.*
- *Supplemental surveys at 10 years.*

ADAPTATION EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN





Step 5: MONITOR and evaluate effectiveness of implemented actions.

Monitoring Item	Monitoring Metric	Criteria for Evaluation	Implement
Post clearcut stocking*	Stems/acre	Established criteria	Stocking surveys
Survival of planted trees*	Seedling survival	Established criteria	Survival surveys
Spp. composition for trees >1" diameter*	n/a	n/a	Regular stand exam
Intensified inventory before harvest to establish baseline (?)	n/a	n/a	Before harvest, then revisit

*Standard monitoring item

How can we better use inventory data?

- Evaluate success of management in achieving goals
- Evaluate effectiveness of adaptation actions
- Integrate monitoring and evaluation into forest management plan



Forest Inventory: Climate Change Filter

Common Measures

- Species
- Diameter
- Merchantable height

Key Ecological Attributes

- Stocking/Density
- Structure
- Large live trees
- **Species richness/evenness**

Can also tell you...

- **Proportion of forest at risk of decline from climate change**
- **Stocking of desirable or future-adapted trees**



Forest Inventory: Climate Change Filter

Extra Measures

- Tree condition class
- Tree crown ratio
- Regen
- Snags
- Browse severity
- Woody/vegetative competition

Can also tell you...

- **Tree health/vigor (sort of)**
- **Established seedlings of desirable or future-adapted species**



Forest Inventory: Climate Change Filter

Stand 25 – Trees at risk of declining from climate change

TREES Species	BA/Ac	TPA	IV	<u>At Risk?</u>		<u>At Risk BA</u>		<u>At Risk TPA</u>		<u>At Risk IV</u>	
				PCM	GFDL	PCM	GFDL	PCM	GFDL	PCM	GFDL
Balsam Fir	2.3	11.8	7.1	yes	yes	2.3	2.3	11.8	11.8	7.1	7.1
Basswood	5.1	9.3	7.2			0.0	0.0	0.0	0.0	0.0	0.0
Black Ash	0.6	0.4	0.5		yes	0.0	0.6	0.0	0.4	0.0	0.5
Black Spruce	0.6	0.4	0.5	yes	yes	0.6	0.6	0.4	0.4	0.5	0.5
Hemlock	4.0	5.7	4.8			0.0	0.0	0.0	0.0	0.0	0.0
Ironwood	0.6	2.1	1.3			0.0	0.0	0.0	0.0	0.0	0.0
Paper Birch	0.6	0.8	0.7	yes	yes	0.6	0.6	0.8	0.8	0.7	0.7
Quaking Aspen	4.6	8.5	6.5	yes	yes	4.6	4.6	8.5	8.5	6.5	6.5
Red Maple	22.2	59.9	41.1			0.0	0.0	0.0	0.0	0.0	0.0
Red Oak	1.1	0.5	0.8			0.0	0.0	0.0	0.0	0.0	0.0
Sugar Maple	38.2	76.9	57.6		yes	0.0	38.2	0.0	76.9	0.0	57.6
White Cedar	5.7	8.3	7.0		yes	0.0	5.7	0.0	8.3	0.0	7.0
Yellow Birch	14.8	23.4	19.1		yes	0.0	14.8	0.0	23.4	0.0	19.1
Grand Total	100.4	207.9	154.1	<u>At-Risk Value:</u>		8.0	67.3	21.5	130.6	14.8	98.9
				Proportion at Risk:		8%	67%	10%	63%	10%	64%

EXAMPLE: CHEQUAMEGON-NICOLET NATIONAL FOREST—ASPEN

Monitoring Items	Monitoring Metric(s)	Criteria for Evaluation	Monitoring Implementation
Effectiveness of clearcut to see whether site is adequately stocked (STANDARD)	Stems per acre	Established criteria	<ul style="list-style-type: none"> - First-year stocking survey (Post-harvest survey to assess condition of midstory and see if follow-up actions are needed) - Additional stocking surveys at 3 and possibly 5 years - FACTS database tracks activity
Survival of planted species (STANDARD)	Seedling survival	Established criteria	<ul style="list-style-type: none"> - Survival survey at 1 and 3 years - FACTS database tracks activity
Post-sale and post disturbance monitoring of invasives - See tactics #2,10 (IN ADDITION TO STANDARD)	Presence/absence	Plant ecologist evaluation	<ul style="list-style-type: none"> - Two years after close of sale - Two years after any large disturbances - TESP Invasives would record invasives if present - FACTS database tracks activity
Stand exam – relative amounts of major stand components. Trees greater than 1". Seedlings optional. (STANDARD)	n/a	n/a	<ul style="list-style-type: none"> - Every 10 years. - Recorded in FSVEG
Certification of release for planted trees following TSI (STANDARD)	Survival/condition	Forester/silviculturist evaluation	<ul style="list-style-type: none"> - Concurrent with final (2nd or 3rd) release - FACTS database tracks activity
Breeding birds (STANDARD)			<ul style="list-style-type: none"> - Breeding bird plots nearby
OPTIONAL: Intensified stand exam or veg survey before harvest to identify baseline conditions (ADDITIONAL)	n/a	n/a	<ul style="list-style-type: none"> - Before harvest: additional “intensified stand exam” in this stand and possibly 1-2 control stands within sale area. Measure marked stand before harvest to collect “pre/post” harvest data. Preferably by plant ecologist in summer to collect other veg data. - Use intensified stand exams in future to collect data over long-term. - Recorded in FSVEG

Monitoring Items

- Proportion of young forest habitat
- Effectiveness of invasives control
- Desired tree species composition
- Desirable seedling species (and abundance)
- Planted seedling survival (by species or genotype)
- Condition/health of white pine
- Understory herbaceous species diversity
- Experience interactions/contact hours for education
- Herbivory
- Wildlife (?)