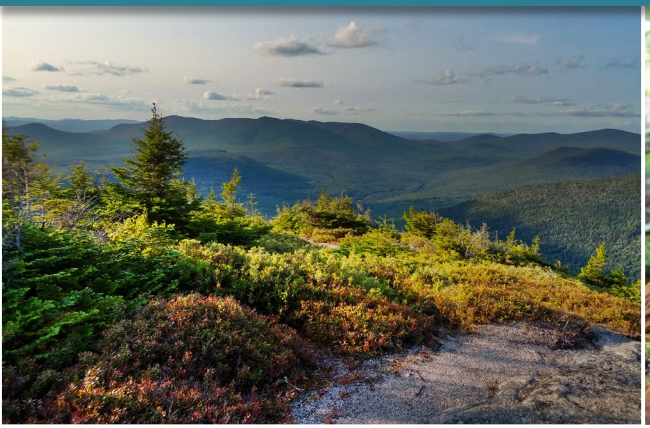
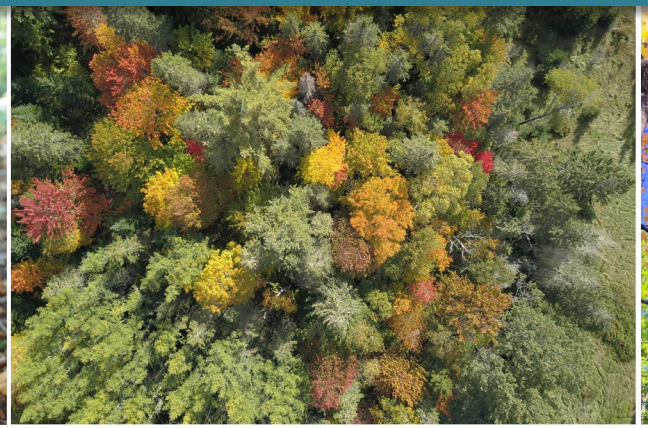
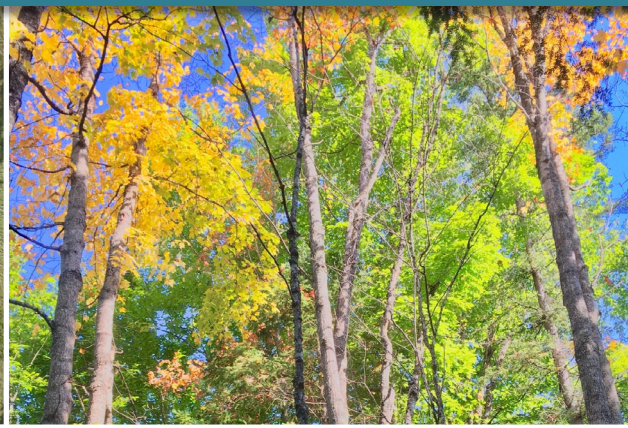
USDA United States Department of Agriculture
Northern Forests Climate Hub

Forest management for carbon sequestration and climate adaptation



Todd Ontl, PhD

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Northern Institute of Applied Climate Science
Michigan Technological University
Houghton, MI

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US forests:

- Absorb **15%** of total CO_2 emissions
- Contain **68%** of terrestrial carbon stocks
- Are **90%** of the land sector sequestration capacity

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- Absorb **15%** of total CO_2 emissions
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Proforestation: the practice of purposefully growing an existing forest intact toward its full ecological potential.

PROFORESTATION: NATURE'S CLIMATE SOLUTION

Search

Search

Search

Understanding the term and the importance of Proforestation

January 30, 2020

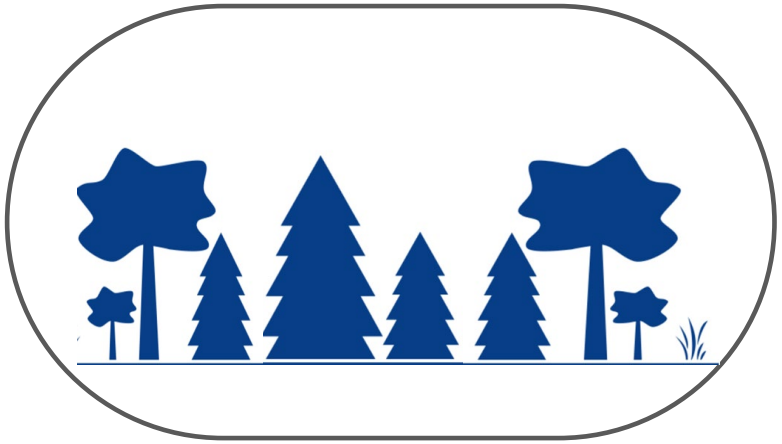
Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good, published June 11, 2019

Jan 19, 2021

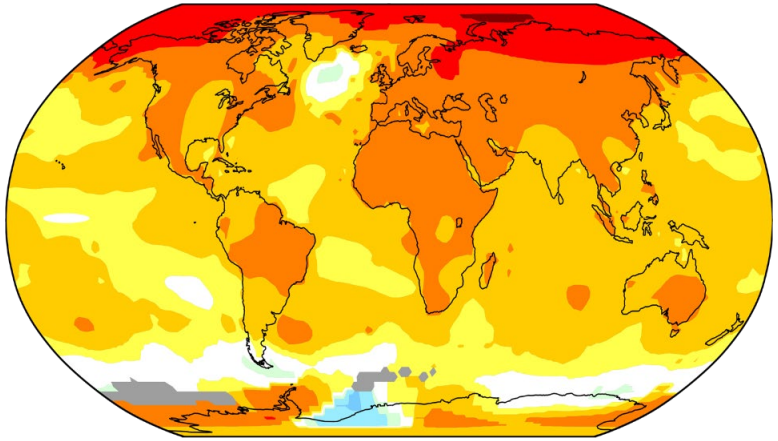
The push for standing forest protections in US climate policy

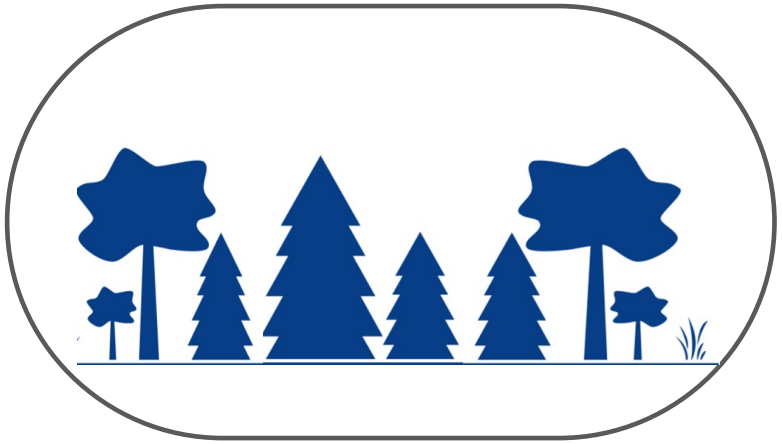
Researchers say "proforestation" policies are the fastest and most effective way to draw excess CO2 out of the atmosphere.

Kate S. Petersen



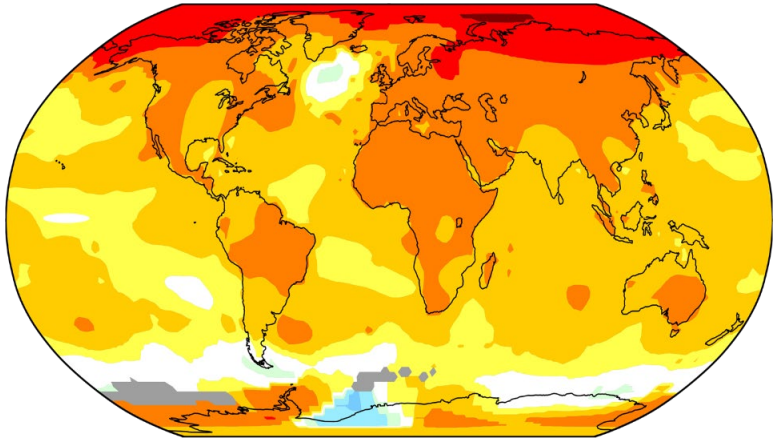
Climate mitigation





Climate mitigation

Climate impacts

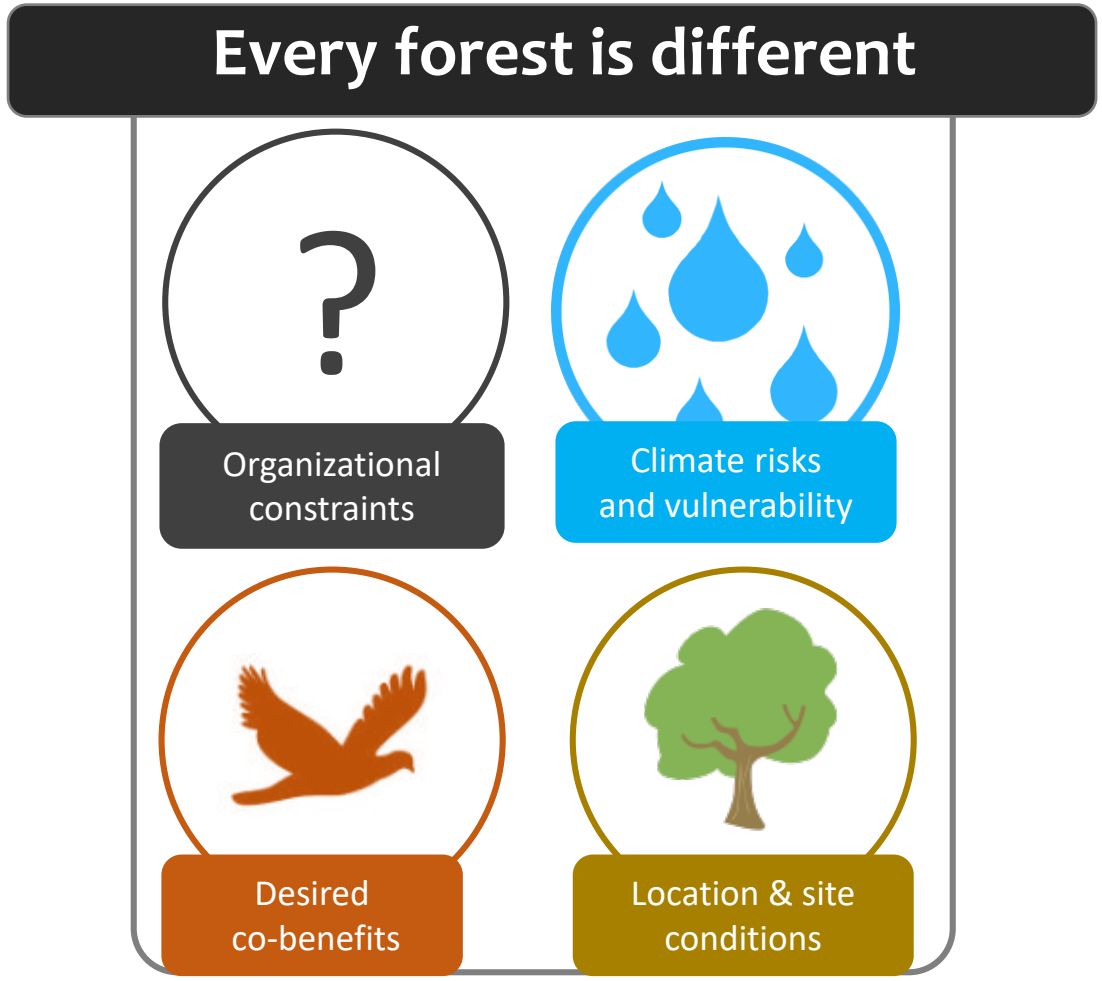


US forests:

- Absorb **15%** of total CO_2 emissions
- Contain **68%** of terrestrial carbon stocks
- Are **90%** of the land sector sequestration capacity

A changing climate puts those forests
and the carbon they sequester and store
at risk

Forest carbon: there is no single answer



Each decision is unique and will vary based upon:

People: Values, Culture, & Resources

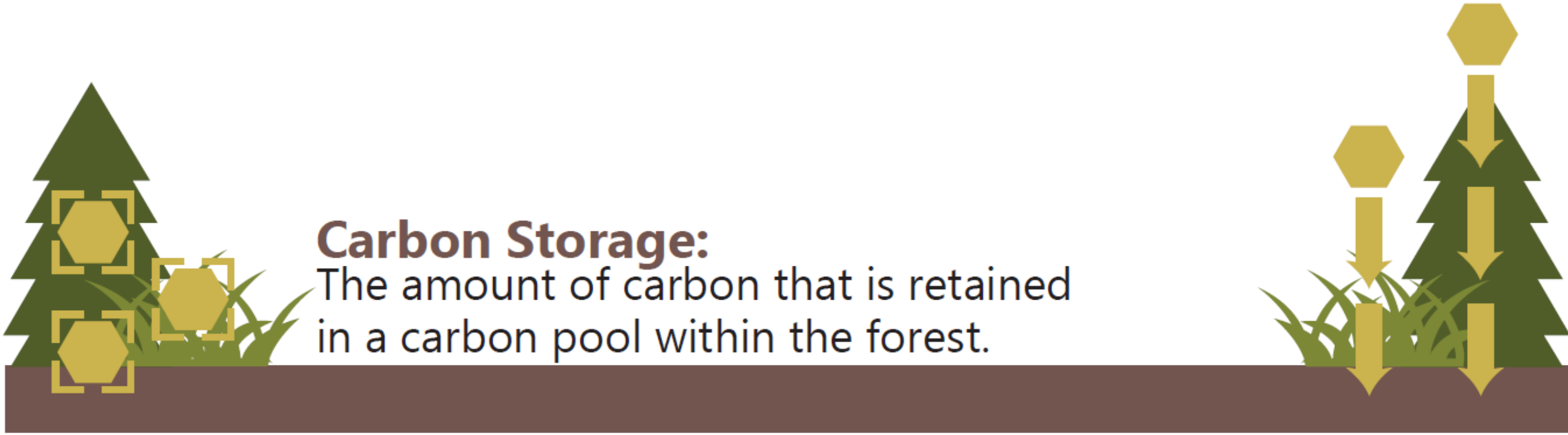
Place: Location & Site Conditions

Purpose: Goals & Objectives

Practices: Equipment, Procedures, & Methods

Don’t ignore climate risks and vulnerability!!!

Carbon benefits include both carbon *storage* and carbon *sequestration*



Carbon Storage:
The amount of carbon that is retained in a carbon pool within the forest.

Carbon Sequestration:
The process of removing carbon from the atmosphere for use in photosynthesis, resulting in the maintenance and growth of plants and trees.

Climate change Impacts to forest carbon

SHIFTING SEASONS | SHIFTING SPECIES | SHIFTING STRESSORS

Climate change Impacts to forest carbon

SHIFTING SEASONS | SHIFTING SPECIES | SHIFTING STRESSORS

THE GOOD:
Longer growing seasons.

Keenan *et al.* 2014; Singh *et al.* 2017; 4th National Climate Assessment 2018

THE BAD:
More competition from invasives.

Dukes *et al.* 2009; Hellman *et al.* 2008

THE UGLY:
Shorter, warmer winters.

Dale *et al.* 2001; Huntingon 2004; Parmesan 2006; Reinmann *et al.* 2019

Climate change Impacts to forest carbon

SHIFTING SEASONS | SHIFTING SPECIES | SHIFTING STRESSORS

THE UGLY:

Shorter, warmer winters.

- **Increases in freeze-thaw cycles** (*e.g.* cold nights followed by warmer, sunny days)
  - Frost cracking of bark (vertical cracks)
  - Opportunities for attack from decay fungi, boring insects
- **Deeper penetration of frost**
- **Frost heaving from lack of snowpack** to insulate the soil
  - Severing and death of fine roots
  - Increased root injury
  - Reduced nutrient uptake, less branch growth and decline in tree health

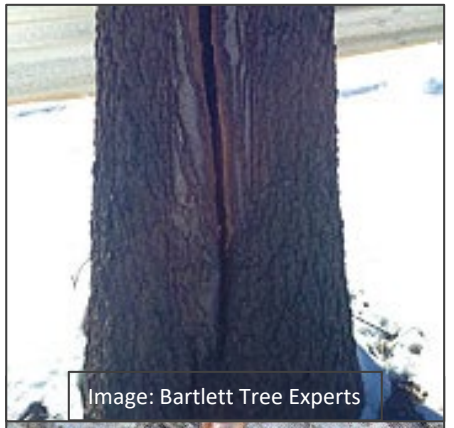


Image: Bartlett Tree Experts

Image: Northern Woodlands

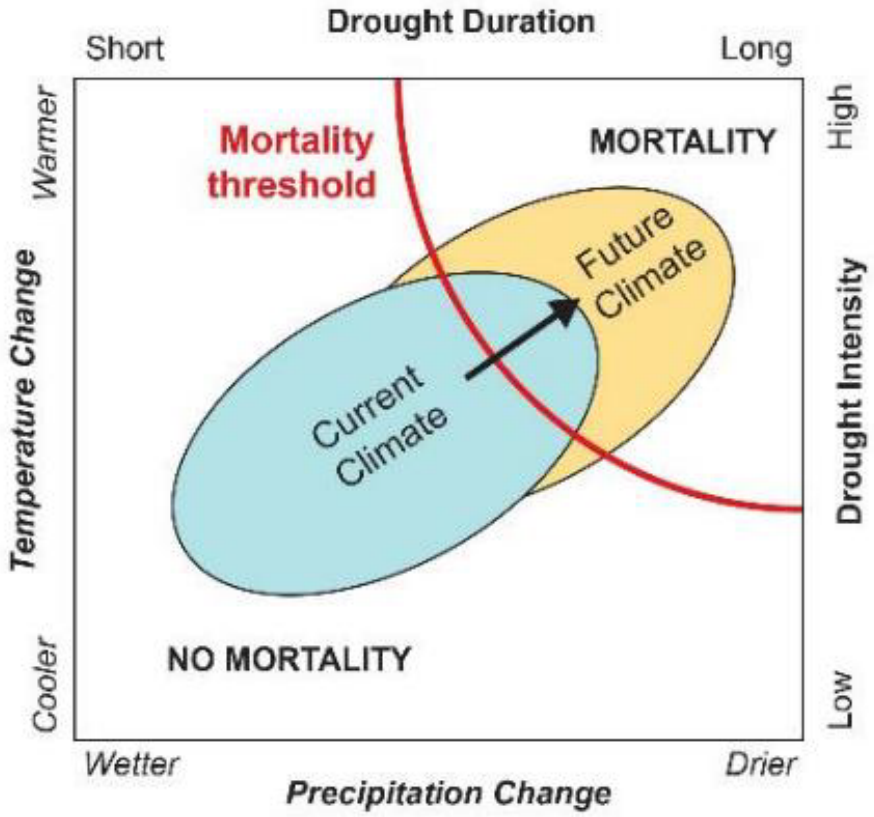
Climate change Impacts to forest carbon

SHIFTING SEASONS | SHIFTING SPECIES | SHIFTING STRESSORS

THE UGLY:

Shorter winters = altered hydrologic conditions.

- Longer period for evapotranspiration
- Warmer temperatures drive greater moisture deficits
- Greater frequency of soil moisture stress



Anticipated impacts on tree health, regeneration, productivity,... and increased mortality rates

Climate change Impacts to carbon

SHIFTING SEASONS | **SHIFTING SPECIES** | SHIFTING STRESSORS

Declining Habitat

- Balsam fir
- Black ash
- Striped maple
- Sycamore

Persisting Habitat

- American basswood
- Atlantic white cedar
- Bitternut hickory
- Black locust
- Eastern cottonwood
- Eastern redcedar
- Gray birch
- Northern red oak
- Pitch pine
- Sassafras
- Shagbark hickory
- Sugar maple
- Scarlett oak
- Yellow birch
- White oak

Increasing Habitat

- American beech
- Blackgum
- Black cherry
- Black oak
- Chestnut oak
- Pignut hickory
- Yellow-poplar

New habitat

- Bald cypress
- Black hickory
- Chinkapin oak
- Eastern redbud
- Loblolly pine
- Shortleaf pine
- Southern red oak
- Virginia pine

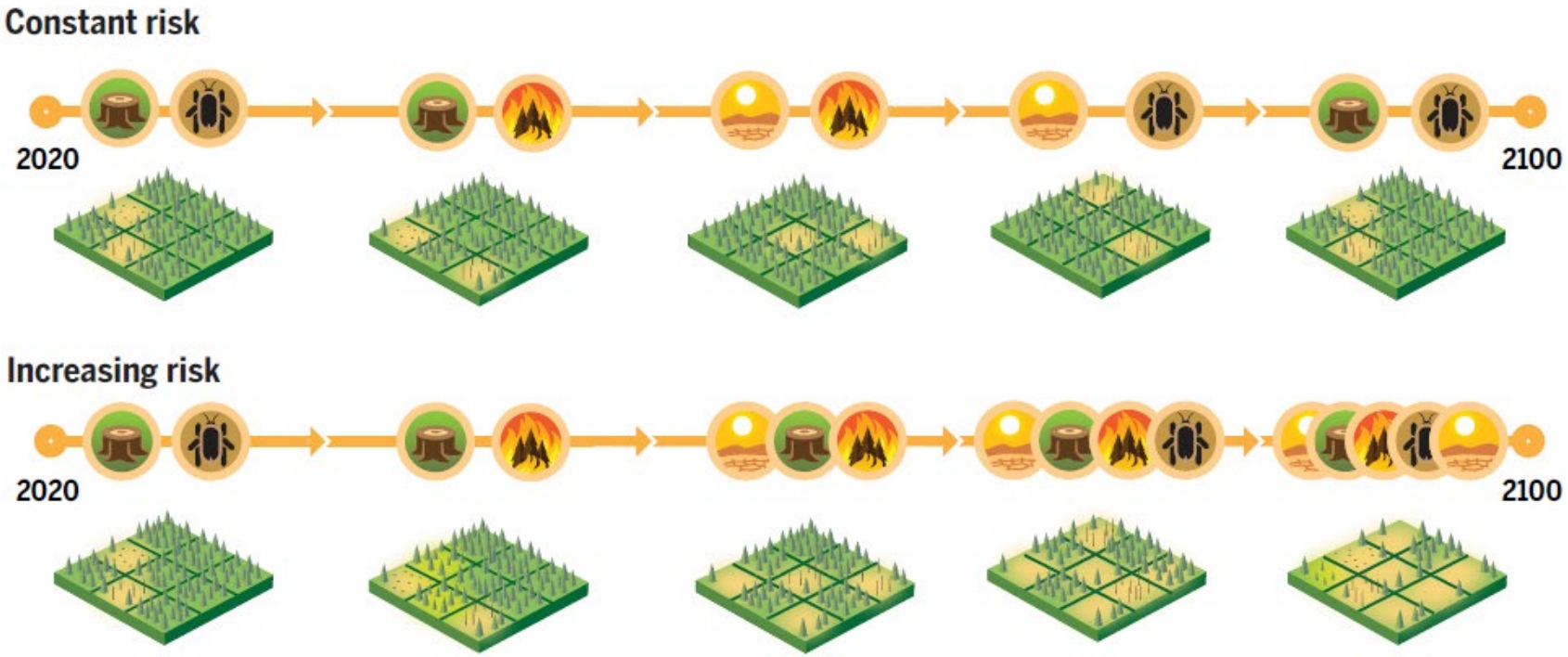
New DISTRIB-II data; www.fs.fed.us/nrs/atlas; www.forestadaptation.org/new-england

Effects on Forest Carbon

SHIFTING SEASONS | SHIFTING SPECIES | **SHIFTING STRESSORS**

"Forests have always experienced disturbances and recover. Why is this any different?"

Increasing risk + interactions = greater impacts



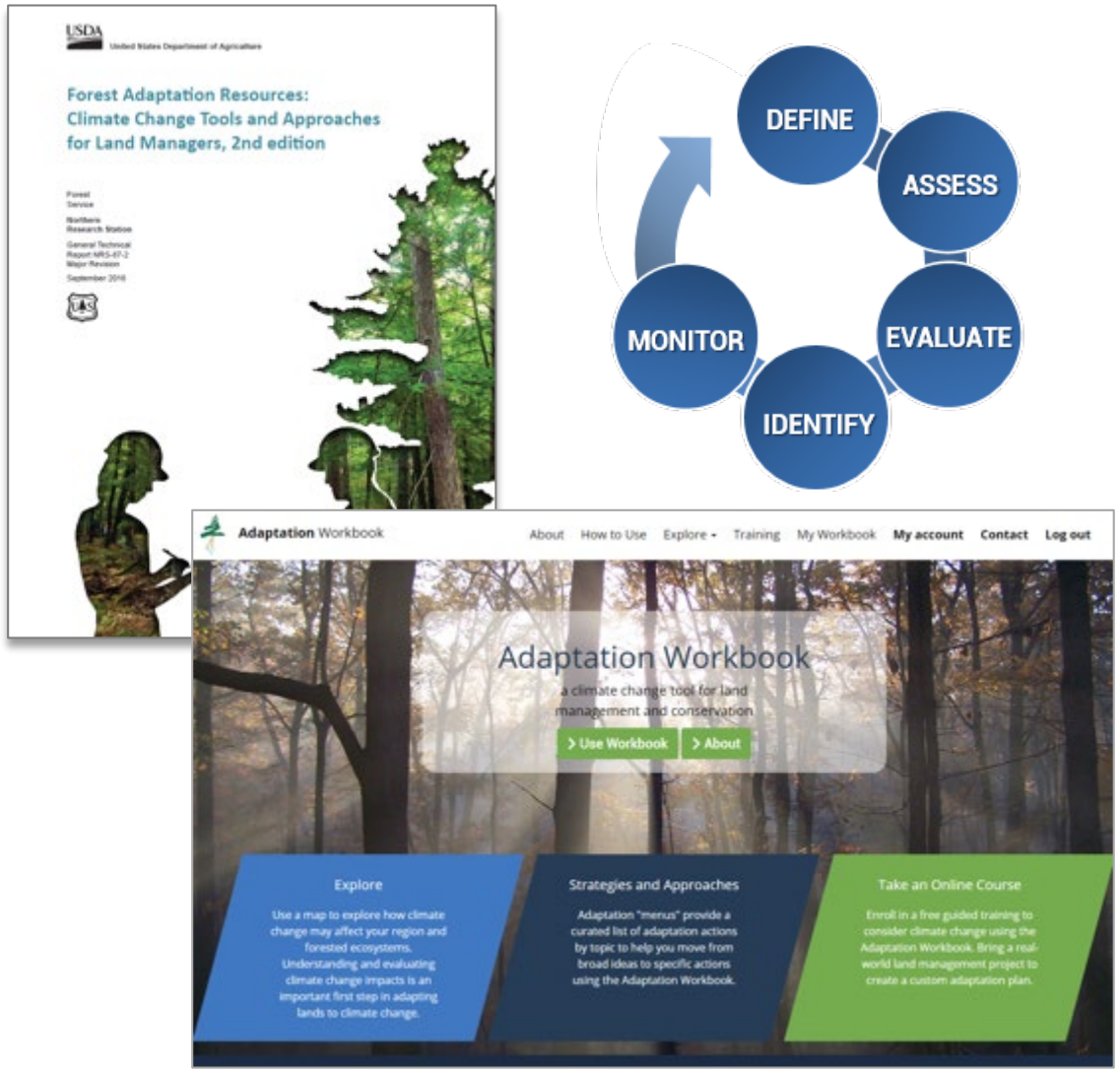
Anderegg *et al.*, *Science* **368**, eaaz7005 (2020)

Adaptation Resources

Adaptation actions intentionally address climate change risks to meet project goals and objectives

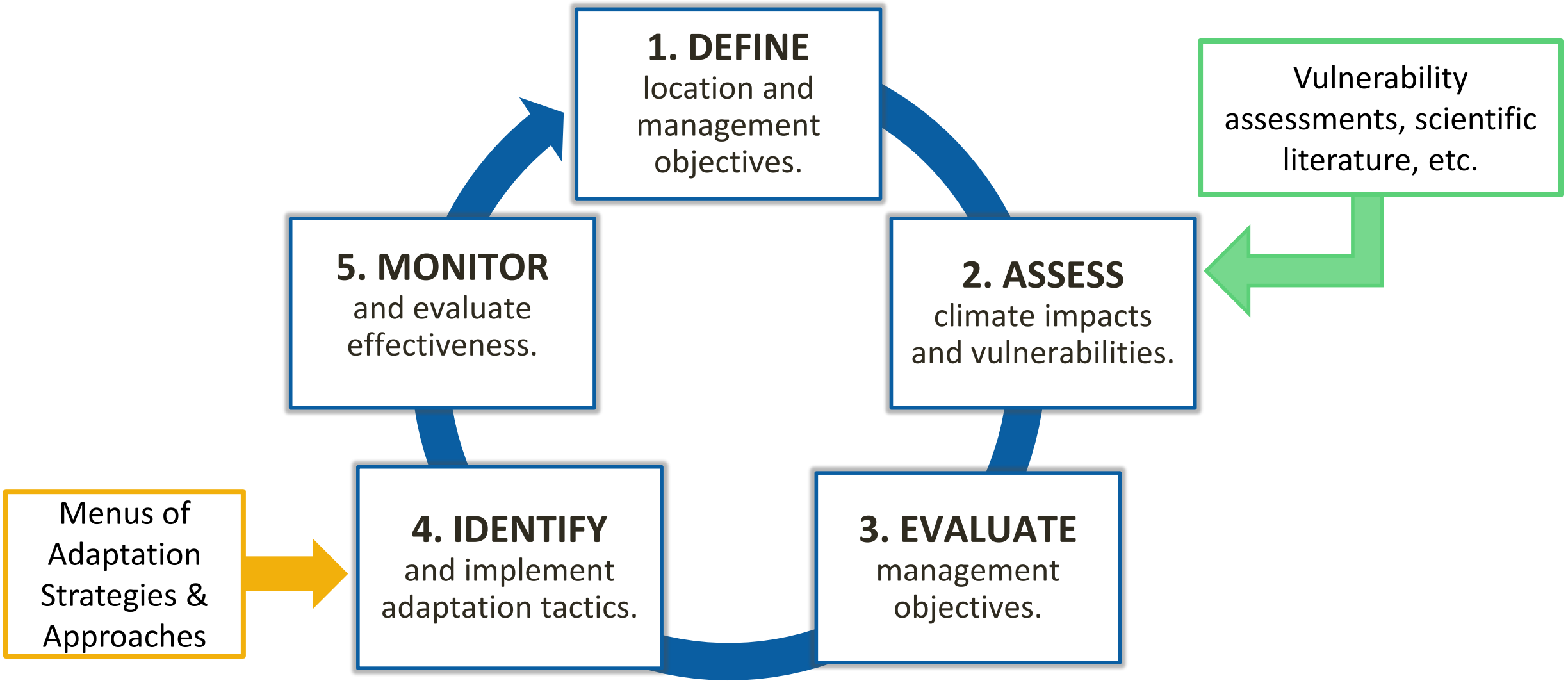
A flexible workbook and menu to address diverse needs of land managers

- Designed for a variety of land owners with diverse goals
- Does not make recommendations
- Includes:
  - Adaptation Workbook
  - Adaptation strategies for different resource areas (menus)



Swanston et al. 2016 (2nd edition); www.treesearch.fs.fed.us/pubs/52760; www.adaptationworkbook.org

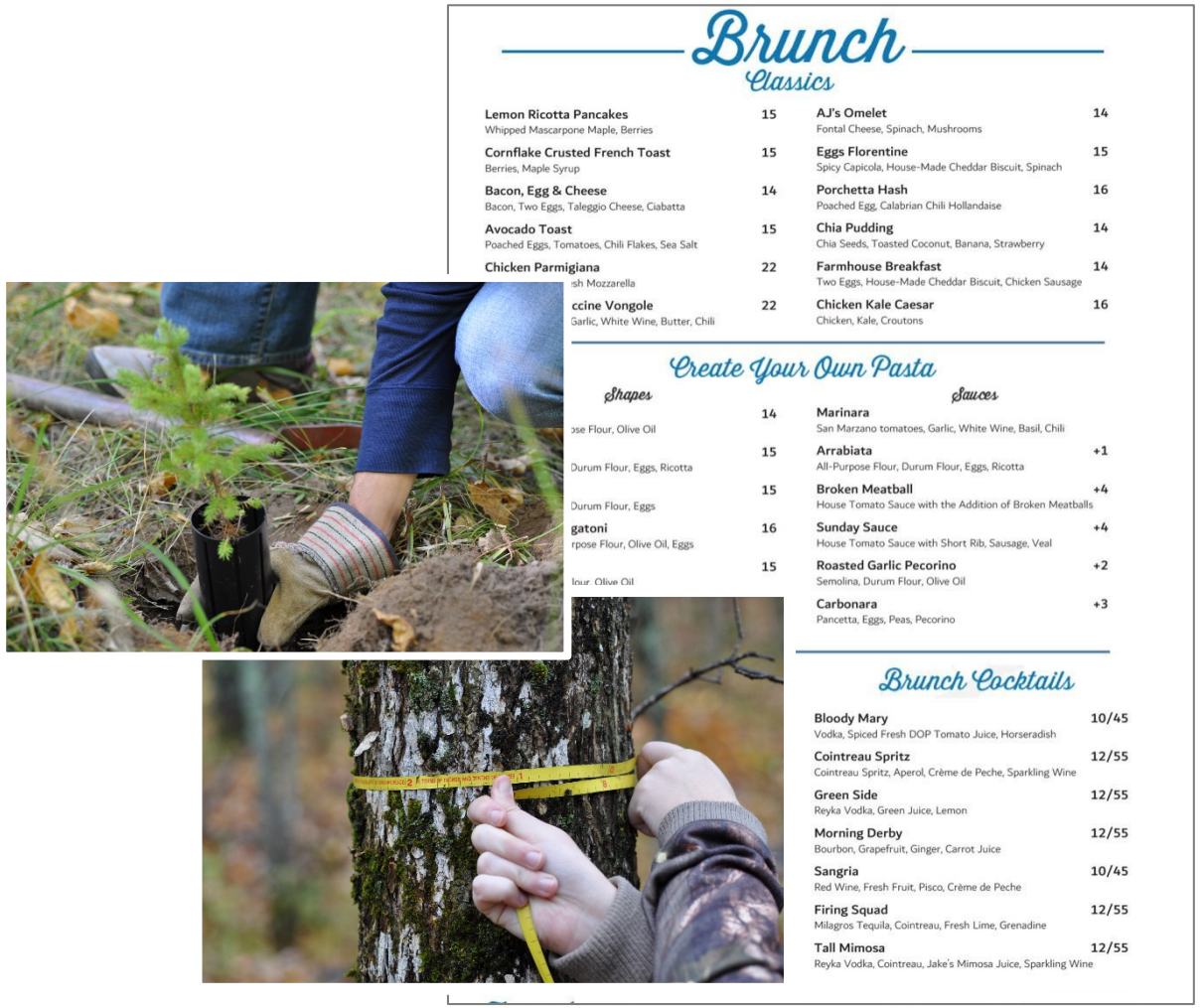
Adaptation Workbook



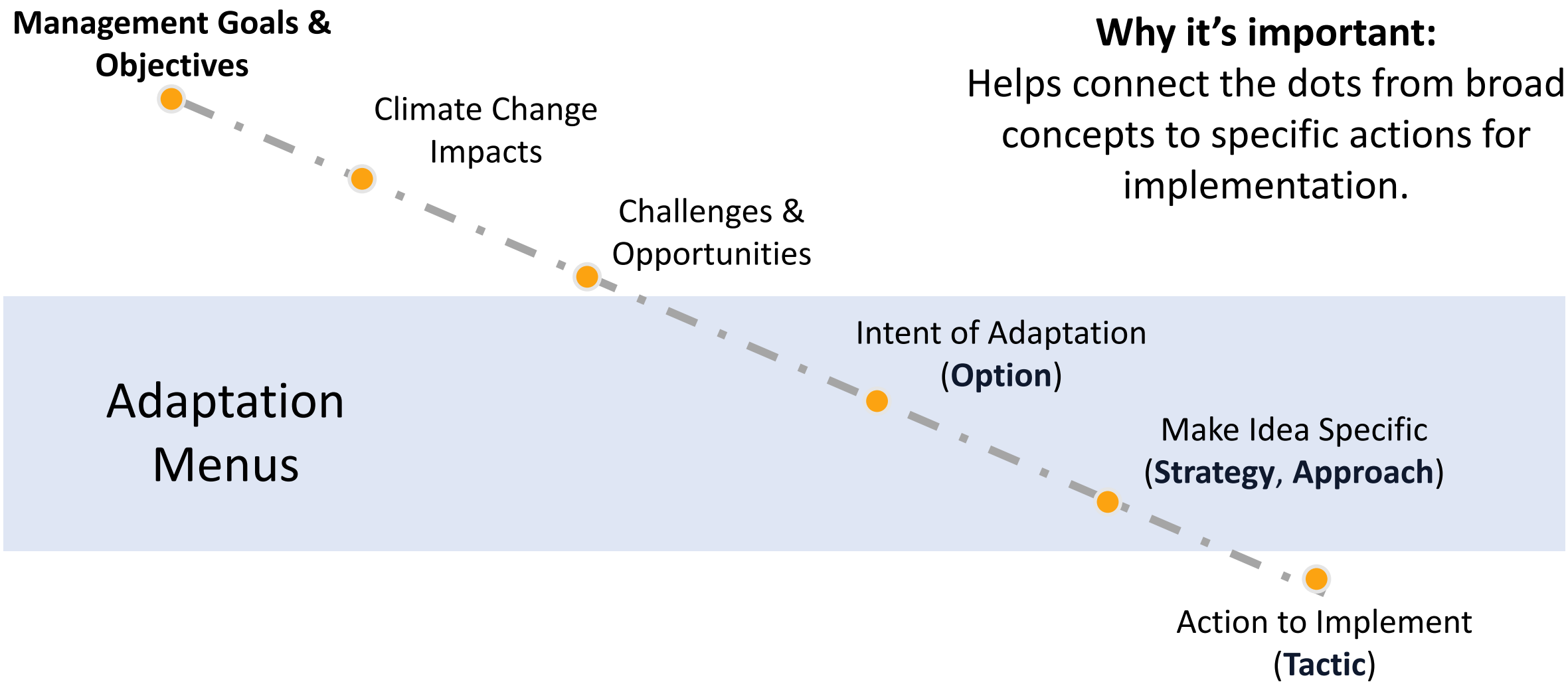
Swanston et al. 2016 (2nd edition) www.nrs.fs.fed.us/pubs/52760; **www.adaptationworkbook.org**

Menus of Adaptation Strategies and Approaches

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



Workbook + Menu



Why it's important:
Helps connect the dots from broad concepts to specific actions for implementation.

Adaptation Planning for Forest Carbon

What should I do here?

Forest carbon management

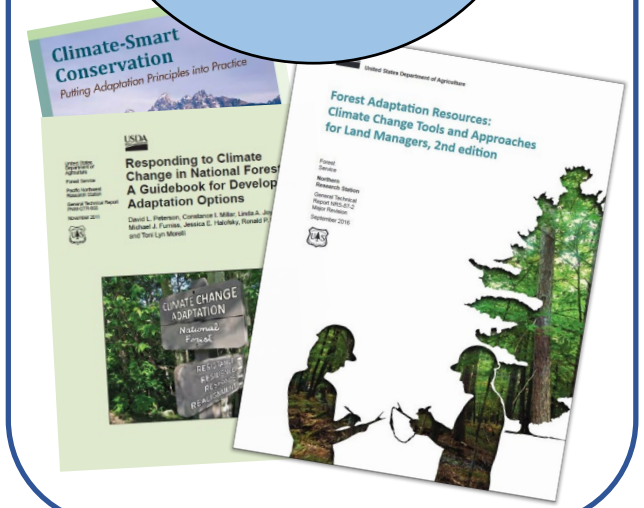
A synthesis of current knowledge on forests and carbon storage in the United States

Forest Carbon Management in the United States

Reforestation can sequester two petagrams of carbon in US topsoils in a century

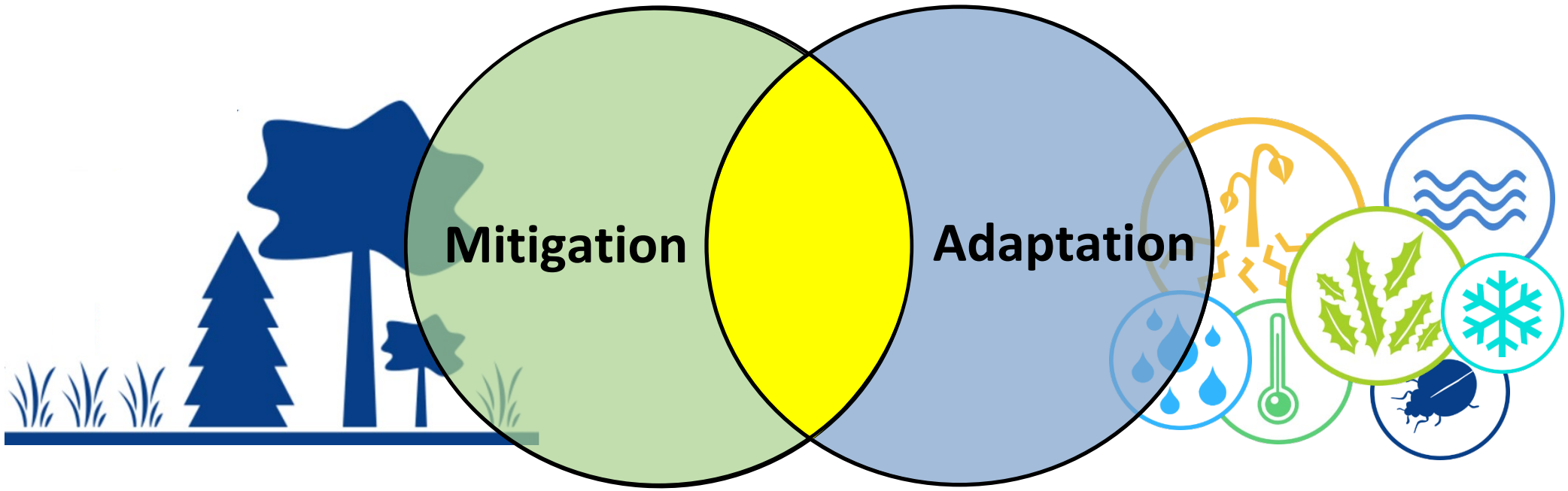
A Synthesis of the Science on Forests and Carbon for U.S. Forests

Forest climate adaptation



Forest Management for carbon sequestration & climate adaptation

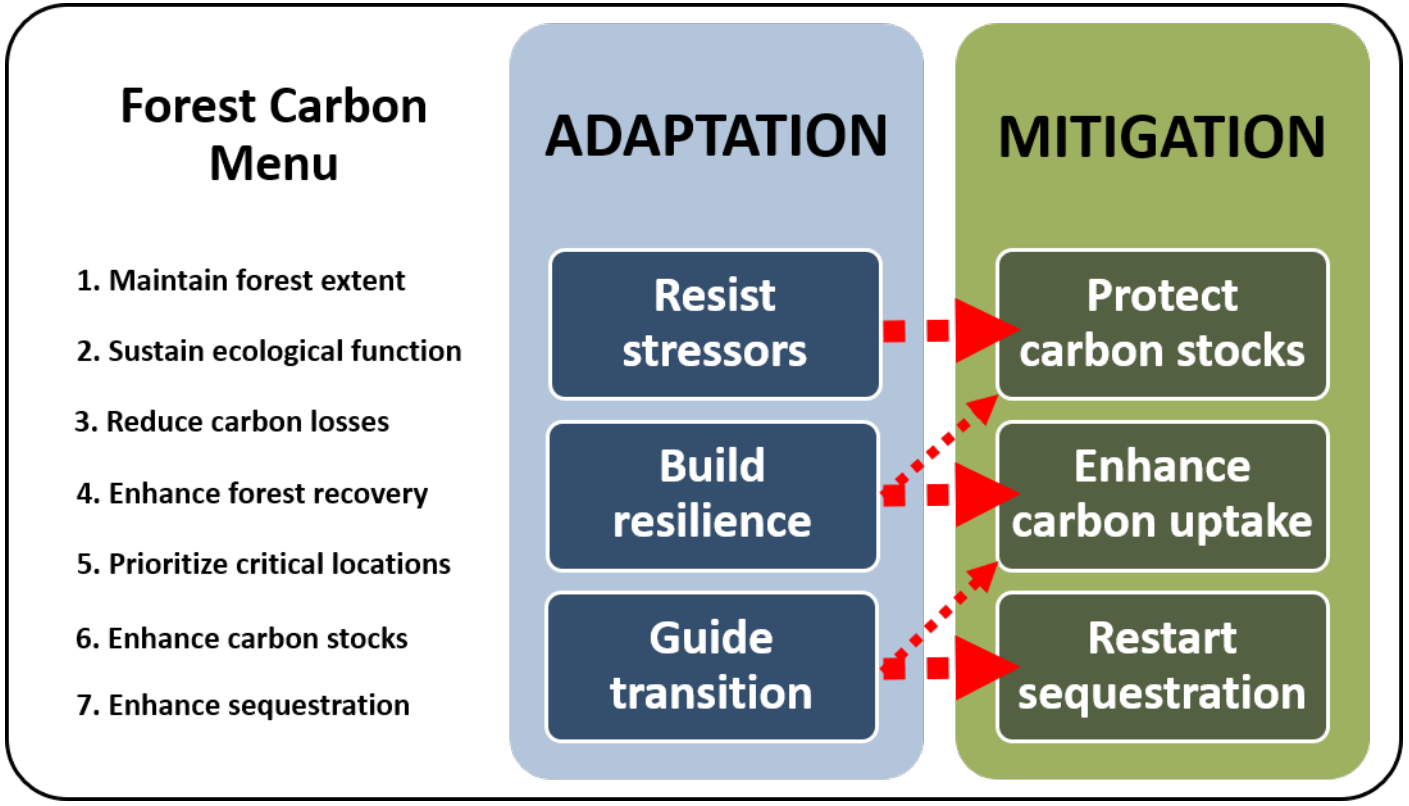
Integrate climate adaptation & mitigation practices for
robust & resilient carbon storage & sequestration



Practitioner's Menu of Strategies and Approaches for Forest Carbon Management

7 strategies, 31 approaches

Builds off of practices for sustainable forest management

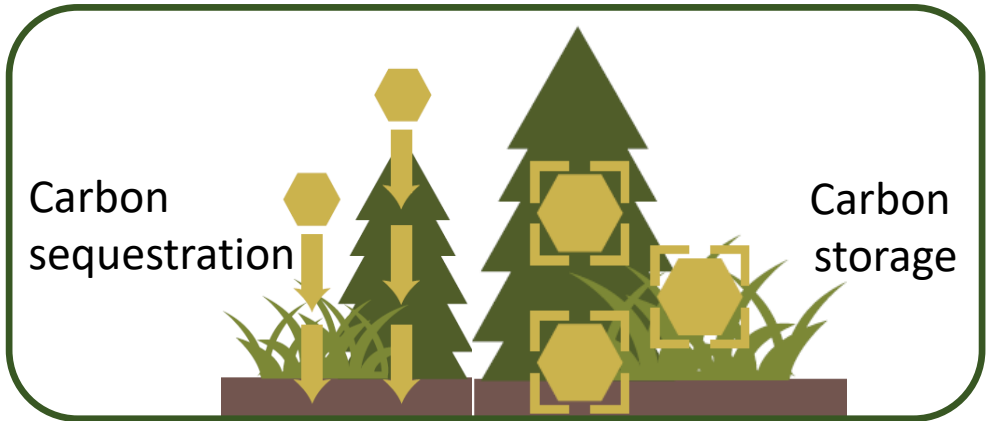


Ontl *et al.* 2020: fs.usda.gov/treesearch/pubs/59214; **ForestAdaptation.org/carbon**

Managing forests for Joint Mitigation and Adaptation (JMA)

Avoiding Forest carbon losses
(adaptation)

Increasing existing forest carbon
(mitigation)



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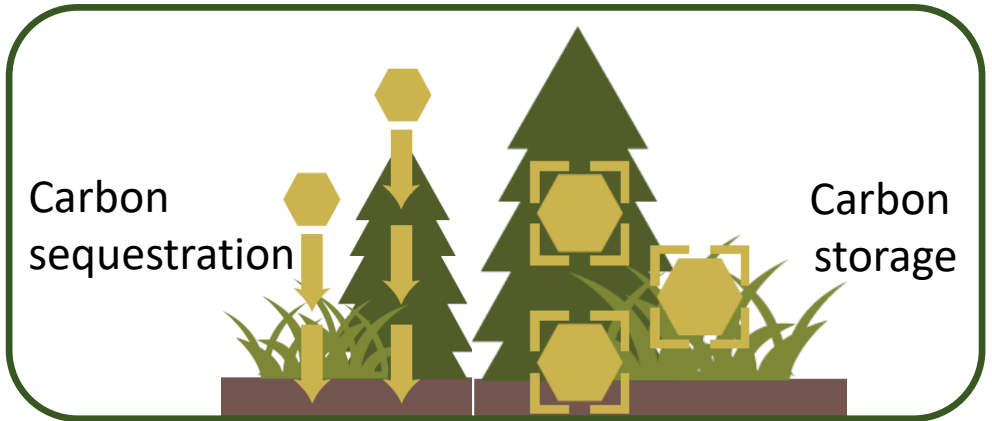
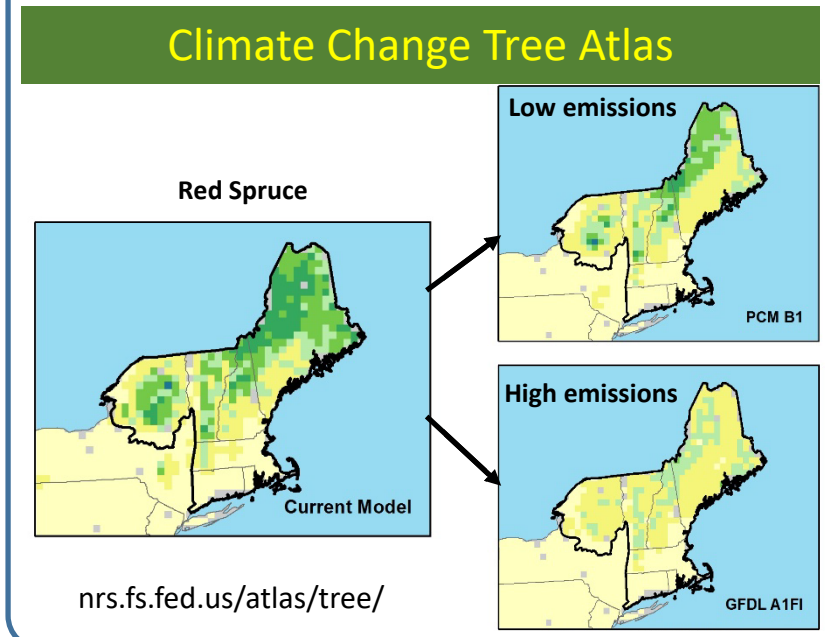


Forest Carbon Management menu

Considering vulnerability to climate and other stressors for effective management that enhances forest carbon benefits

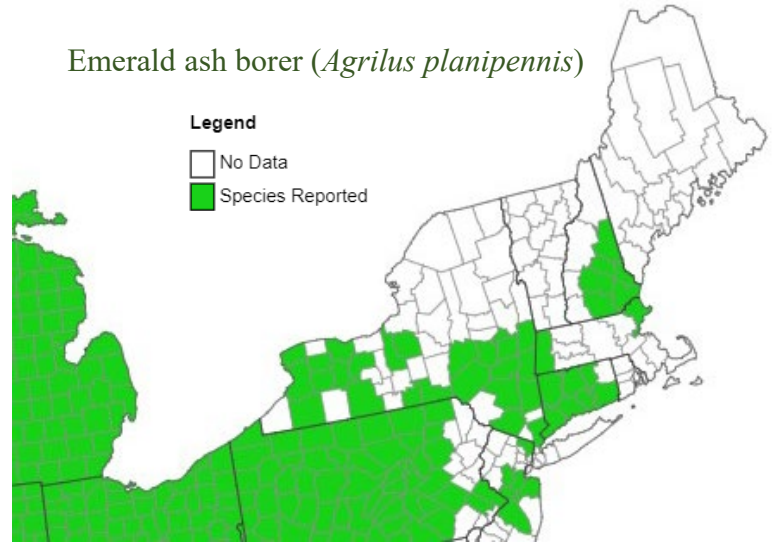
Vulnerability to large-scale forest disturbance events

Risk of decreasing tree species habitat suitability



nrs.fs.fed.us/atlas/tree/

Tree mortality risk from non-native insect pests



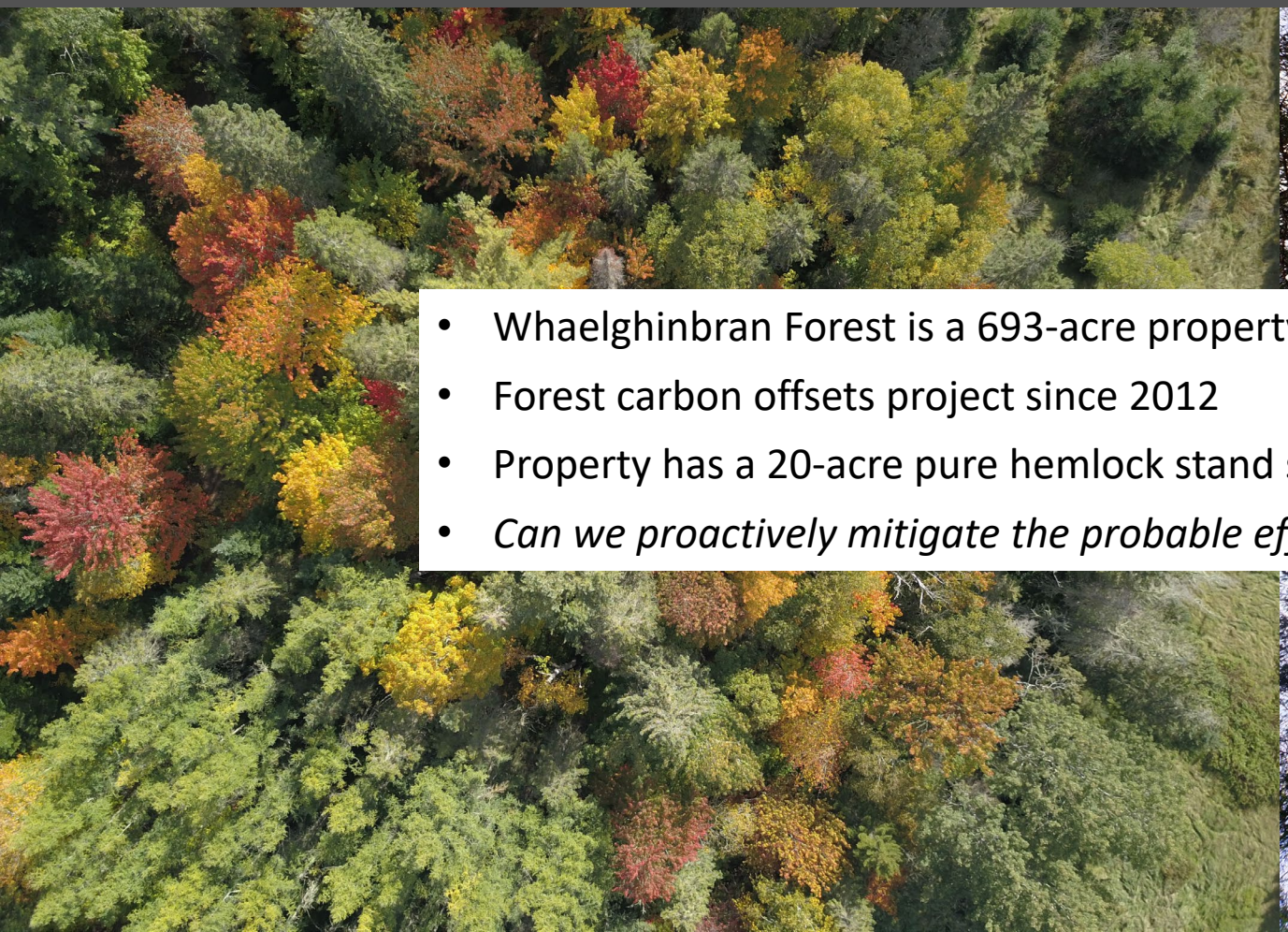
EDDMapS find · map · track eddmaps.org/distribution

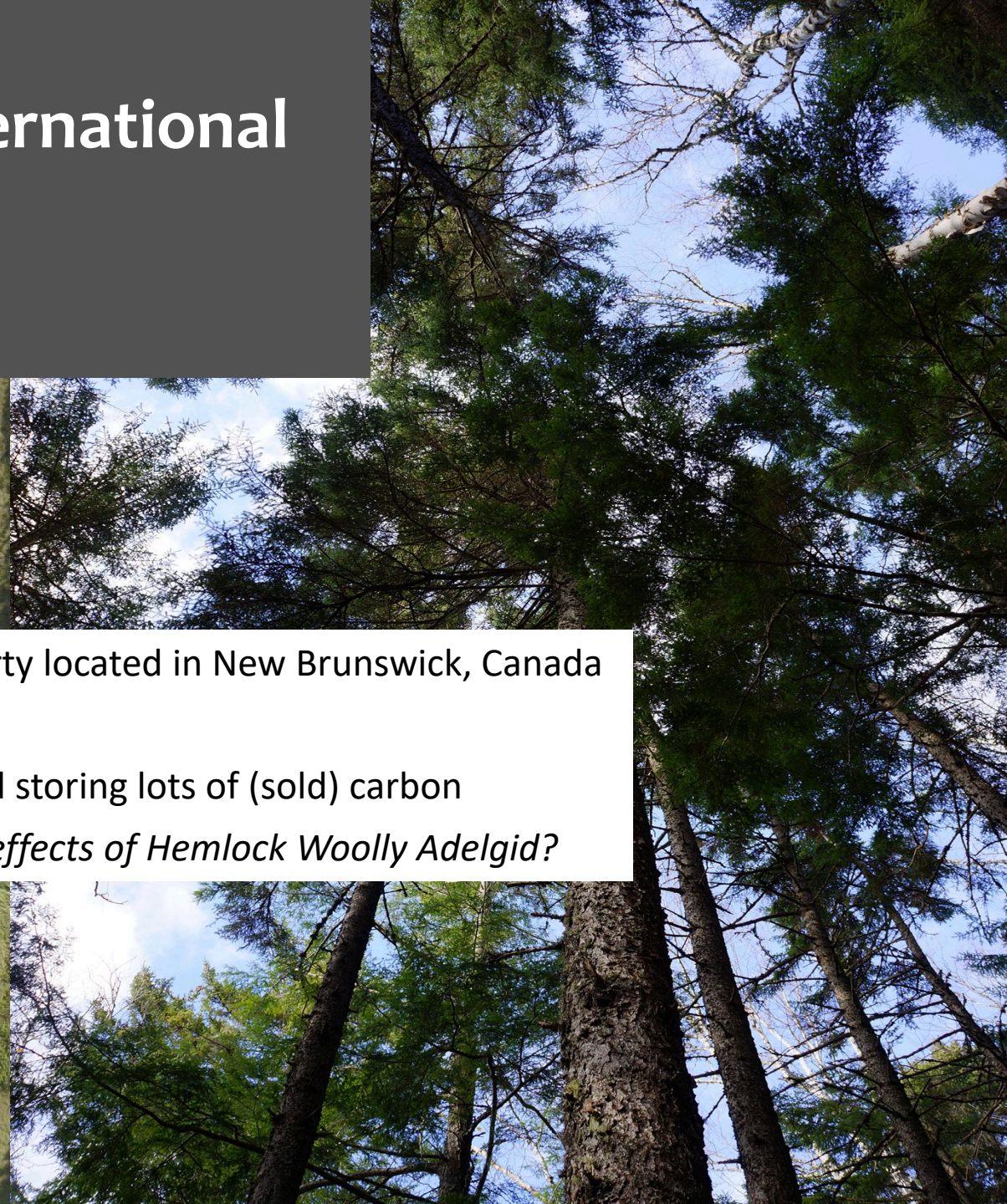
Case Study: Community Forests International

Whaelghinbran Hemlock stand

Case Study: Community Forests International

Whaelghinbran Hemlock stand





- Whaelghinbran Forest is a 693-acre property located in New Brunswick, Canada
- Forest carbon offsets project since 2012
- Property has a 20-acre pure hemlock stand storing lots of (sold) carbon
- *Can we proactively mitigate the probable effects of Hemlock Woolly Adelgid?*

Case Study: Whaelghinbran Hemlock stand

Management goals

- Improve the resistance of a portion of mature hemlock to HWA
- Increase species diversity within the stand
- Maintain carbon stocks

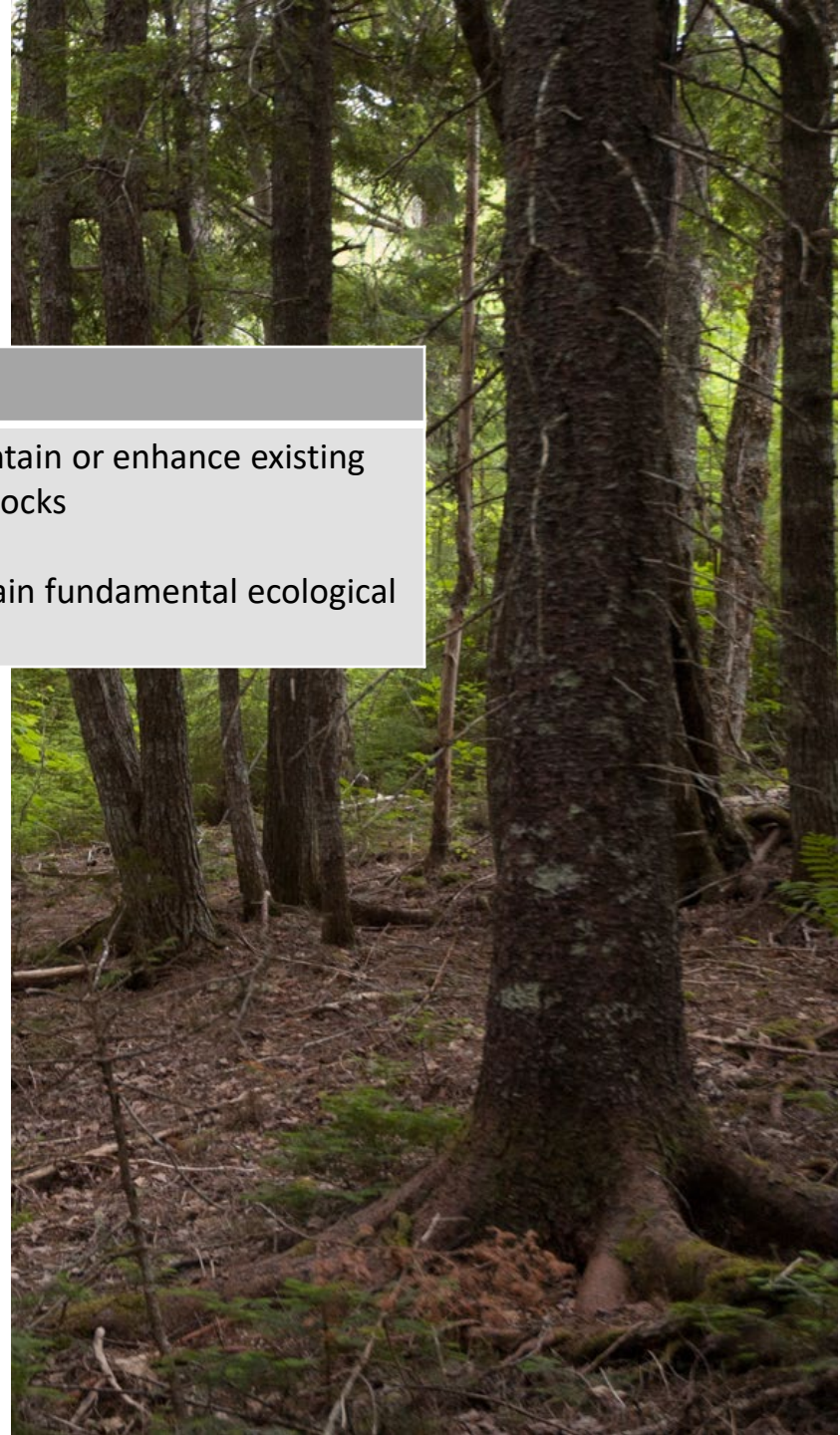
Climate impacts

Warming winters:

- Longer growing season
- Increased growing degree days
- Increased insect pests from northward expansion (HWA impacts anticipated in <10 years)

Case Study: Whaelghinbran Hemlock stand

Tactic	Approach	Strategy
Harvest ~30% of the overstory hemlock, uniformly distributed through the stand, to open the canopy	• [6.3] Increase harvest frequency or intensity because of greater risk of tree mortality • [2.4] Maintain or improve the ability of forests to resist pests and pathogens	• [S6] Maintain or enhance existing carbon stocks • [S2] Sustain fundamental ecological functions



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Forest Ecology and Management 385 (2017) 150–160

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Elevated light levels reduce hemlock woolly adelgid infestation and improve carbon balance of infested eastern hemlock seedlings

Steven T. Brantley [a,*], Albert E. Mayfield III [b], Robert M. Jetton [c], Chelcy F. Miniat [a], David R. Zietlow [a], Cindi L. Brown [a], James R. Rhea [d]

Case Study: Whaelghinbran Hemlock stand

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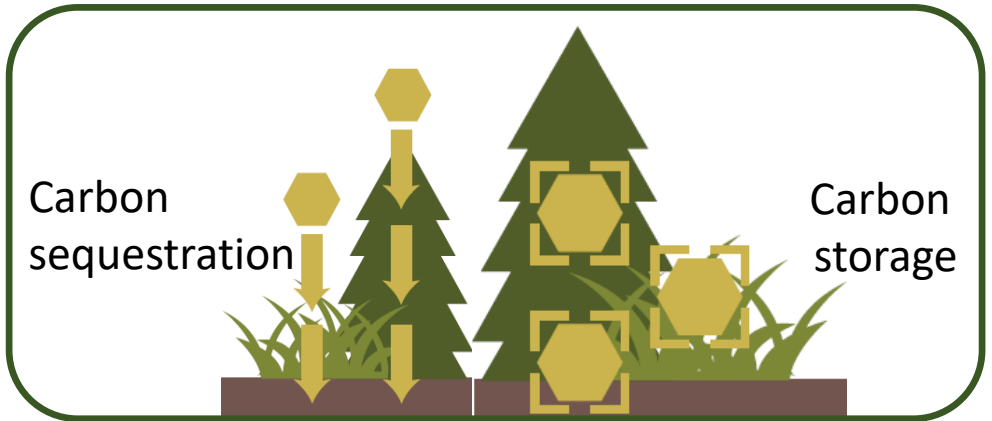
Encourage climate-adapted species by planting to augment natural regeneration.	• [7.1] Favor existing species that are better adapted to future conditions • [7.4] Introduce species that are expected to be better adapted to future conditions	• [S7] Enhance or maintain sequestration capacity through significant forest alterations

Opportunities for enhancing sequestration with future-adapted tree species

Managing forests for Joint Mitigation and Adaptation (JMA)

Avoiding Forest carbon losses
(adaptation)

Increasing existing forest carbon
(mitigation)



Forest Carbon Management menu

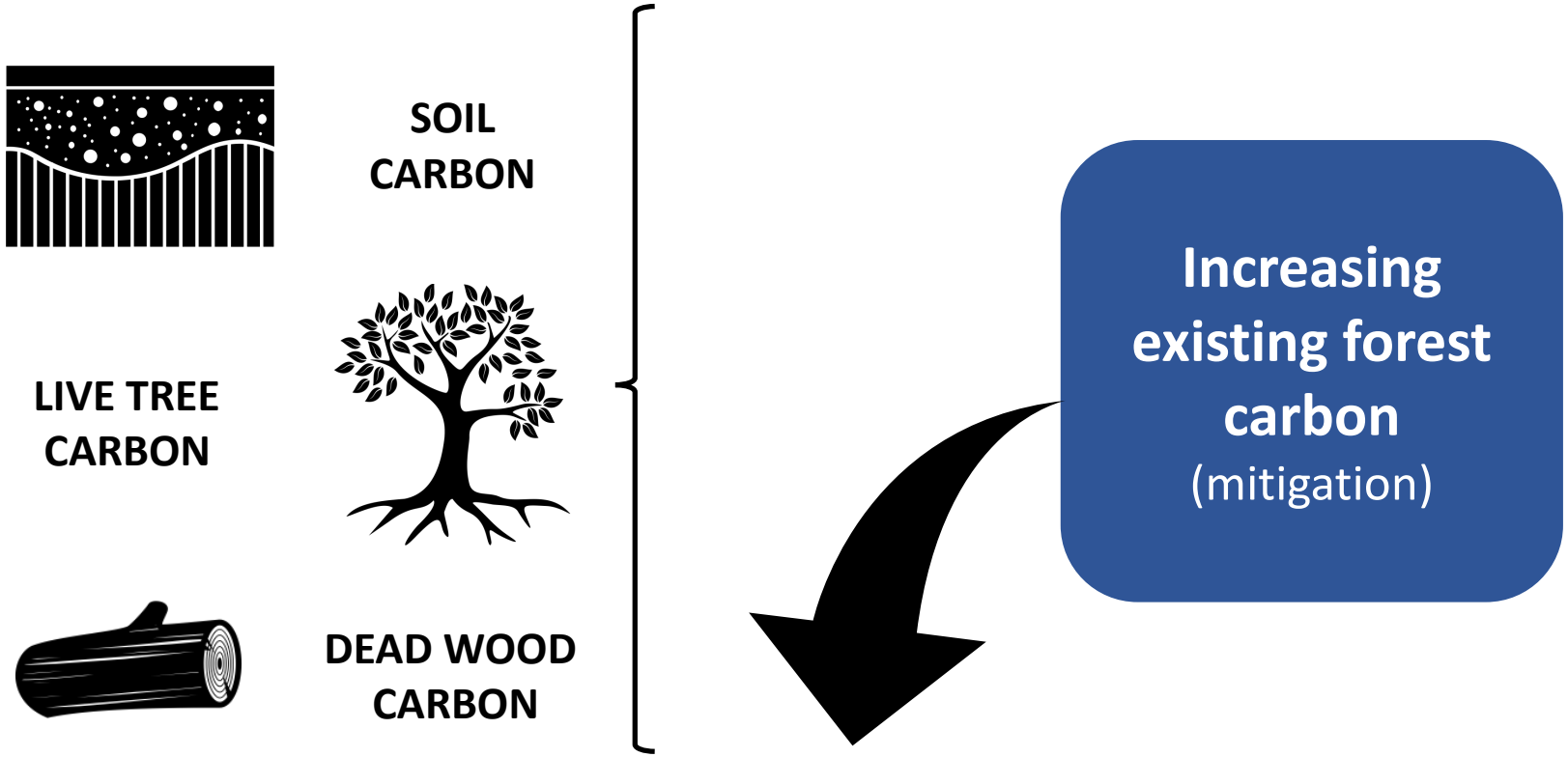
Considering an array of options helps managers identify unseen opportunities to maintain or enhance desired outcomes

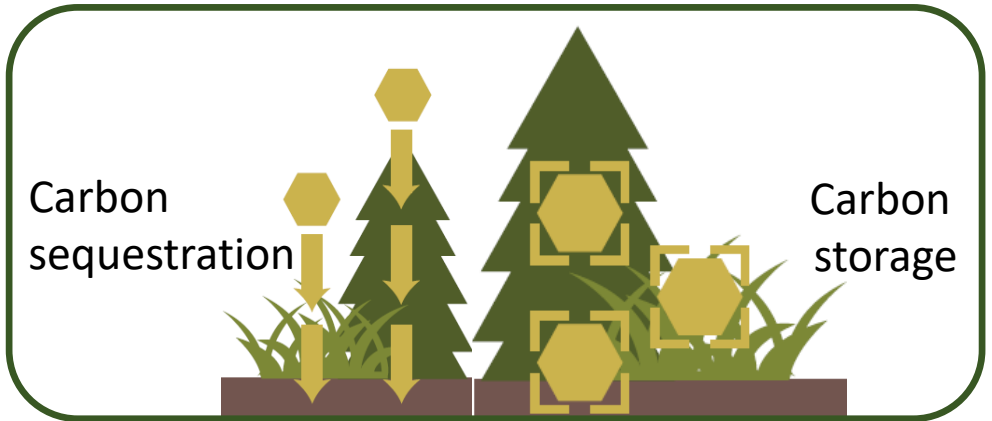
Existing carbon pools

Forest productivity & regeneration

Other desired co-benefits

Managing forests for Joint Mitigation and Adaptation (JMA)



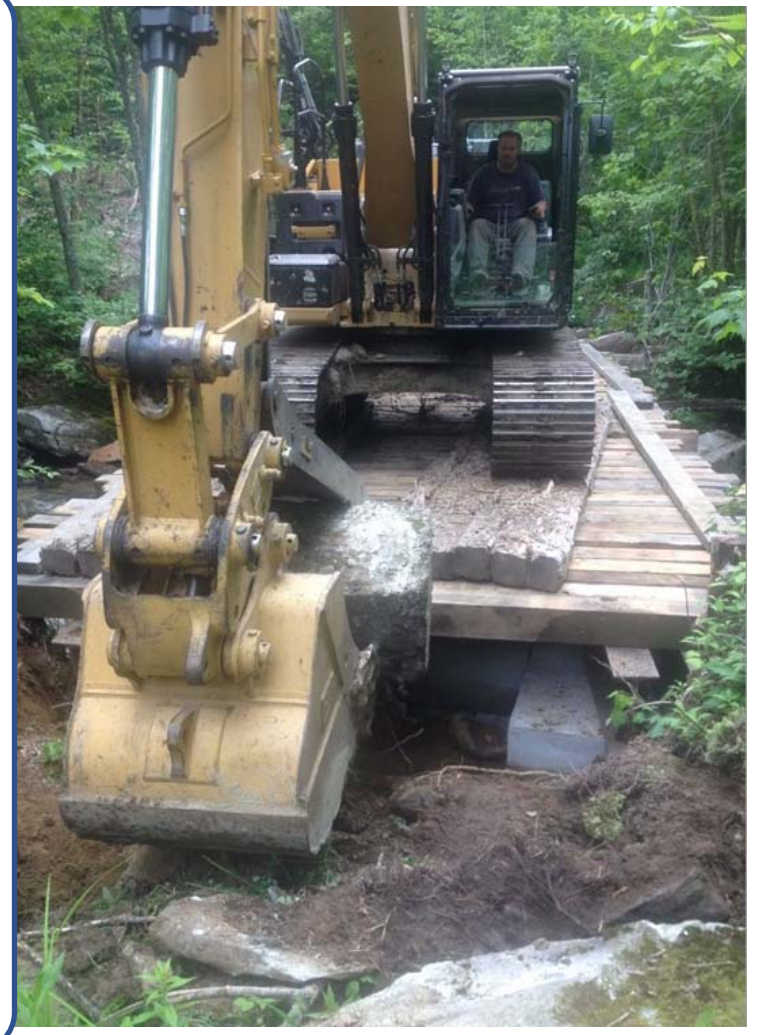


Joint Mitigation-Adaptation (JMA) actions in forest management

Actions that Maintain or Increase Existing Carbon Stocks

SOIL CARBON

Concern	JMA Action
Soil Damage Warming winters = smaller windows of frozen ground & greater risk of soil compaction/ rutting.	• Alter timing of harvest operations • Use temporary bridges at stream crossings or timber mats on sensitive soils
Flooding & erosion Extreme rainfall raises risk of soil carbon loss on floodplains and steep slopes.	• Widen buffers around riparian zones or wetlands, limit disturbance on slopes



Joint Mitigation-Adaptation (JMA) actions in forest management

Actions that maintain or increase existing carbon stocks & sequestration rates

LIVE TREES

Concern	JMA Action
Harvest Impacts Forest harvest reduces ecosystem carbon stocks	• Retain healthy large-diameter trees as legacy trees
Tree Health Damage from insects or pests.	• Promote greater tree diversity in regen through harvest
Species Suitability Low spp. diversity and stands dominated by spp. at southern extent of range.	• Plant a variety of future-adapted native species
Drought Overstocked stands compete for growing space/ water, may be more at-risk for drought.	• Thin from below around healthy crop trees

Joint Mitigation-Adaptation (JMA) actions in forest management

Actions that Maintain or Increase Existing Carbon Stocks

DEAD WOOD

Concern

Lack of Standing Dead Trees & Coarse Woody Debris (CWD)
Managed stands may have limited carbon stocks in snags and CWD.

In these stands, forest carbon stocks can be increased with additional dead wood.

JMA Action

- Identify legacy trees, such as trees in declining condition to retain as eventual snags.
- Retain low-quality timber on site for down dead wood (*e.g.* chop-and-drop).
- Retain slash, tree tops, and existing snags when present.

Forest Carbon Management menu

Considering an array of options helps managers identify unseen opportunities to maintain or enhance desired outcomes

Existing carbon pools

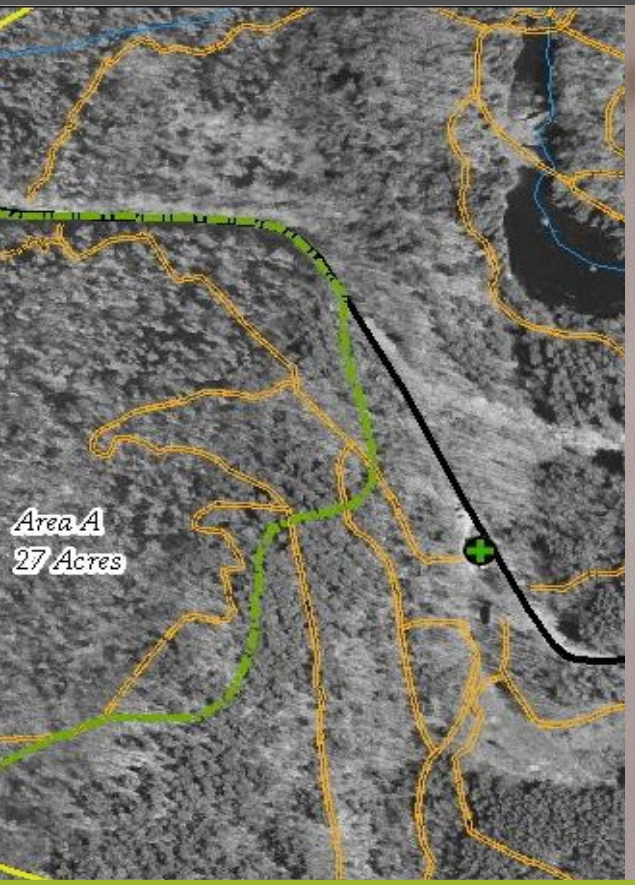
Forest productivity & regeneration

Other desired co-benefits

Identifying climate co-benefits case study:

Audubon Vermont

Green Mountain Audubon Center



https://forestadaptation.org/GMAC

Audubon Vermont/ Alberto Lopez

Identifying climate co-benefits case study:

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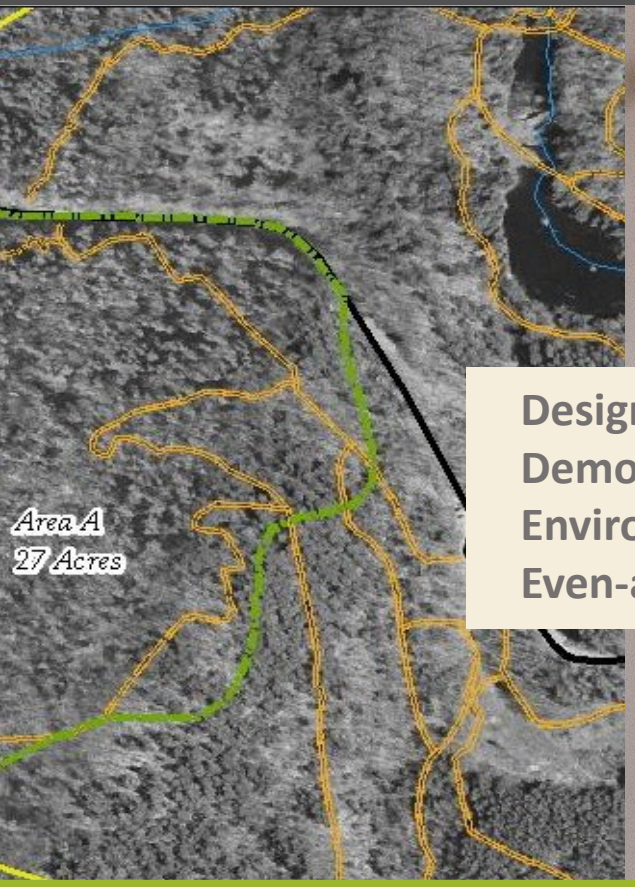


Designated Important Bird Area
Demonstration site for Foresters for the Birds
Environmental education, scientific research, and outdoor recreation
Even-aged, multi-strata northern hardwood stands

GREEN MOUNTAIN Audubon CENTER

https://forestadaptation.org/GMAC

Audubon Vermont/ Alberto Lopez

Integrating climate co-benefits case study: Green Mountain Audubon Center

Management goals

- Neotropical songbird breeding habitat
- Increase sawtimber quantity & quality
- Increase understory development
- Increase regeneration through controlling beech
- Control invasive plant species

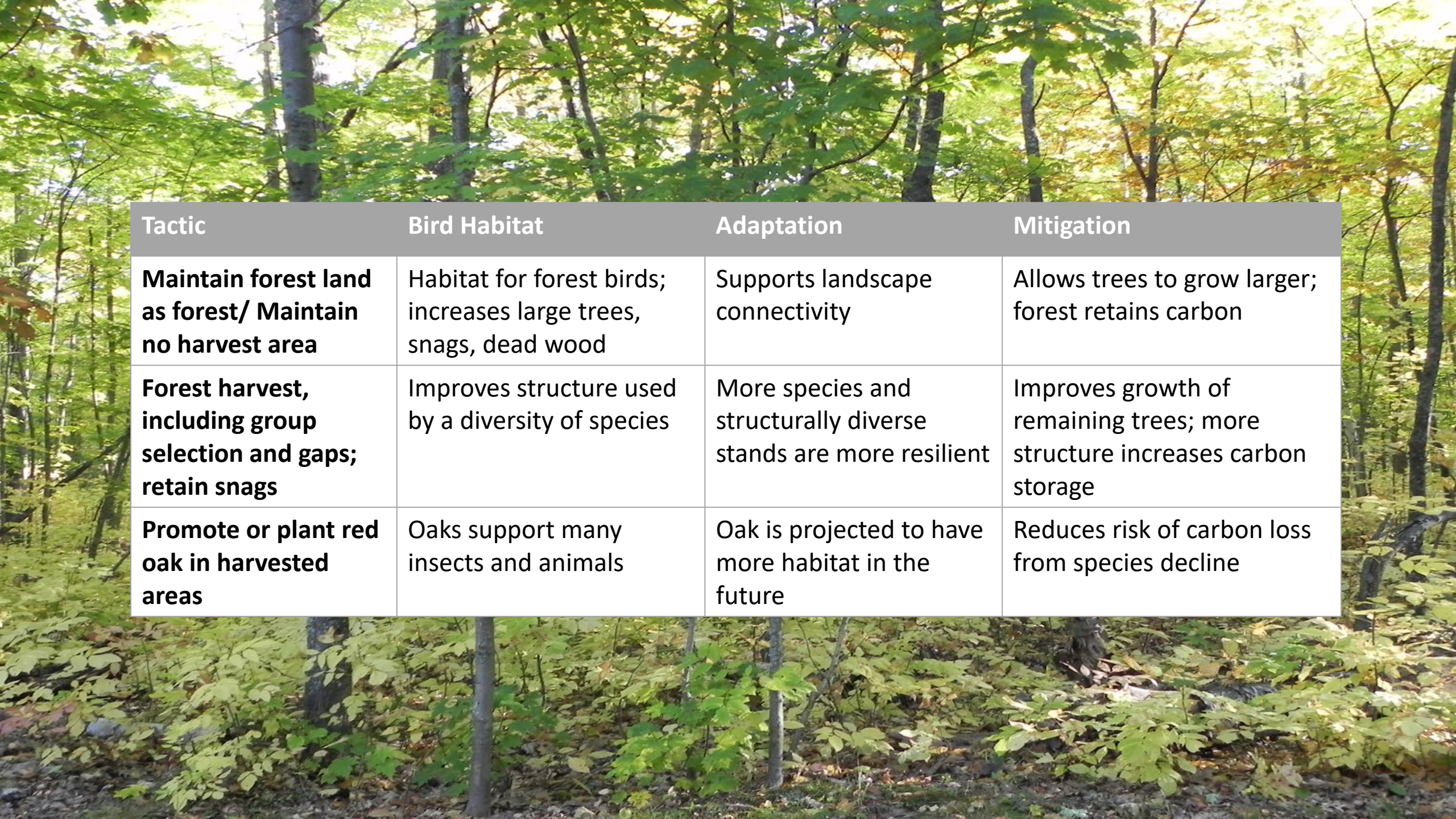
Climate impacts

Warming winters:

- reduce snowpack
- increase pests

Increased frequency and intensity of extreme weather:

- non-native invasive plant species
- soil erosion



Tactic	Bird Habitat	Adaptation	Mitigation
Maintain forest land as forest/ Maintain no harvest area	Habitat for forest birds; increases large trees, snags, dead wood	Supports landscape connectivity	Allows trees to grow larger; forest retains carbon
Forest harvest, including group selection and gaps; retain snags	Improves structure used by a diversity of species	More species and structurally diverse stands are more resilient	Improves growth of remaining trees; more structure increases carbon storage
Promote or plant red oak in harvested areas	Oaks support many insects and animals	Oak is projected to have more habitat in the future	Reduces risk of carbon loss from species decline

CLIMATE CHANGE
RESPONSE FRAMEWORK

Who we are | Assess | Adapt | Learn | Focus | Contact

There's no single answer for responding to climate change

Our team will work with you to find solutions that fit your individual needs.

> Learn More

Understanding risk

Climate change introduces uncertainty about future conditions and increases challenges for natural resource managers interested in sustaining

Adaptation in action

Responding to climate change requires an approach that tailors actions to the unique needs of a particular project.

forestadaptation.org/adapt/demonstration-projects
forestadaptation.org/focus/forest-carbon-management

CLIMATE CHANGE
RESPONSE FRAMEWORK

Who we are | Assess | Adapt | Learn | Focus | Contact

There's no single answer for responding to climate change (or managing for carbon benefits)

Our team will work with you to find solutions that fit your individual needs.

> Learn More

Understanding risk

Climate change introduces uncertainty about future conditions and increases challenges for natural resource managers interested in sustaining

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