Pathway: Transition

Transition actions intentionally accommodate ecosystem change, rather than resist it. These actions work to move forests toward conditions that are expected to be better adapted to future conditions. These alterations vary across a continuum from slight changes in species composition and structure in response to expected change (e.g., anticipatory adaptation) to full-fledged transformation to novel communities. Transition approaches are likely unnecessary in ecosystems that are not highly vulnerable, and it may take extreme effort to "push" these systems toward future conditions. Ecosystems that are highly vulnerable, especially those that have reduced adaptive capacity (e.g., degraded sites) or have undergone severe disturbance may be the most suitable locations to explore transition strategies. Because transition actions are often inherently experimental and outside "business as usual", monitoring and evaluation activities take on even greater importance.

You may also want to consider what capability you have to transition your forest, and whether a more gradual or more abrupt transition is most in line with your goals and capability. Compare this option with the **Resistance** and **Resilience** pathways to determine what option best meets your management goals and objectives

Actions for Forests Health and Productivity ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide wood products and other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Condition	Adaptation Approach	Example Action
High levels of invasive plants are affecting the natural or desired plant community	▪ 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species	▪ Remove existing invasive species with mechanical or chemical treatment to promote the current plant community
Site exposed to wind	▪ 3.3. Alter forest structure to reduce severity or extent of wind and ice damage.	▪ Use thinning or other silvicultural treatment to reduce tree density and increase the windfirmness of the residual trees and increase age and structural diversity
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.1. Maintain or improve the ability of forests to resist pests and pathogens. ▪ 1.4. Reduce competition for moisture, nutrients, and light.	▪ Use thinning or other silvicultural treatment to reduce tree density ▪ Use harvest and planting to alter forest composition toward species expected to be less vulnerable

Forest regeneration is desired; advance regeneration lacking or dominated by undesirable species	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 9.7 Introduce species that are expected to be adapted to future conditions	▪ Harvest using large patch cuts or clearcut with reserves and variable retention to eliminate mid-canopy shade ▪ Use mechanical or herbicide treatment to control competative plants ▪ Plant a novel mix of future-adapted species, such as southern red, bur, chestnut, or other oaks, shellbark hickory, hybrid chestnut, southern pines. ▪ Protect seedlings from browse, as needed.
Regeneration of future-adapted species desired	▪ 9.7. Introduce species that are expected to be adapted to future conditions. ▪ 10.3. Realign significantly disrupted ecosystems to meet expected future conditions	▪ Evaluate native and introduced species that may be suitable ▪ Avoid species known to have invasive or aggressive traits ▪ Plant future-adapted tree species that are also suited to current site (e.g., soils, light conditions) and management goals ▪ Plant larger seedlings to the extent possible ▪ Protect seedlings from browse, as needed
Forest condition is highly degraded as a result of pests or other disturbance	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 10.2. Allow for areas of natural regeneration to test for future-adapted species	▪ Reinitiate stand using clearcut (with reserves) where existing seedlings, stump sprouts, or nearby seed source can provide source of natural regeneration ▪ Remove all competing vegetation ▪ Retain trees of desired species as seed source
Disturbance has significantly impacted forest	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development.	▪ Reinitiate forest using clearcut (with reserves) where existing seedlings, stump sprouts, or nearby seed source can provide source of natural regeneration ▪ Remove all competing vegetation ▪ Retain trees of desired species as seed source

	▪ 9.7 Introduce species that are expected to be adapted to future conditions	▪ Plant a novel mix of future-adapted species, such as southern red, bur, chestnut, or other oaks, shellbark hickory, hybrid chestnut, southern pines.

Actions for Wildlife ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for wildlife habitat. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Wildlife (in review).

Condition	Adaptation Approach	Action
Forests lacks downed wood	▪ Create new sources of food, water, and cover in anticipation of future conditions	▪ Retain tree tops in woods or return tops to woods following harvest ▪ Fell trees for new source of dead wood ▪ Reserve standing live or dead trees, particularly of a large size, for future dead wood
Forest lacks tree and plant diversity	▪ 9.1. Use non-local, future-adapted genotypes in habitat management ▪ 9.2. Create new sources of food, water, and cover in anticipation of future conditions	▪ Plant seed sourced from southerly populations based on anticipated future climate conditions for trees and understory plants ▪ Introduce non-local hickory or oak species as a new source of hard mast
Rare or sensitive species are present (e.g., plants, turtles)	▪ 10.7. Protect climate refugia across the landscape ▪ 10.8. Protect sites that are expected to provide future suitable habitat	▪ Buffer cool spots on the landscape that may be slower to change
Raptors present	▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape	▪ Retain trees with multi-limbed tree crotches or “basket forks” in live hardwood crowns during harvest

Actions for Water ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for water resources. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Condition	Adaptation Approach	Action
Riparian areas, vernal ponds, and other sensitive wetlands	▪ 5.3 Adjust systems to cope with increased water abundance, and high water levels ▪ 4.5 Move at-risk species to locations that are expected to provide habitat	▪ Manage riparian areas to include a diversity of species and genotypes, favoring future-adapted native species tolerant to saturated conditions or adapted to high water levels ▪ Plant cold-adapted species in areas likely to maintain persistently cooler temperatures areas (e.g. hemlock in shaded moist areas like ravines)
Areas of low vegetative cover or high tree mortality	▪ 4.4 Introduce species that are expected to be adapted to future conditions	▪ Plant flood-tolerant species, such as swamp white oak, on sites that are expected to become more prone to flooding and that are currently not occupied by flood-tolerant species. ▪ Plant drought-tolerant species on sites within the current range that are expected to become drier and that have not been historically occupied by those specie

Actions for Recreation and Forest Roads and Trails ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives related to forest roads and trails used for recreation and other purposes. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Recreation.

Condition	Adaptation Approach	Action
Forest roads and trails significantly impacted by extreme rain, flooding, or other changes	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Reroute roads and trails when current road/trail is not consistently passable or improvement is not feasible
Water crossings missing or undersized on woods roads	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation	▪ Replace and redesign stream crossings, including changes such as the replacement of culverts with bridges.

		▪ Create water crossings, such as rock fords, that are designed to be overtopped
Buildings or other infrastructure are in at-risk locations	▪ 6.2 Relocate existing infrastructure and opportunities to areas with less risk of climate-induced damage ▪ 6.5 Remove or decommission vulnerable infrastructure	▪ Relocate or remove outbuildings or other infrastructure

Actions for Forest Carbon

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide carbon sequestration and storage, along with other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forest Carbon.

Condition	Adaptation Approach	Action
Potential for land use change	▪ 1.1 Avoid forest conversion to nonforest land uses	▪ Use conservation easements or other land use restrictions to prevent land use change or development.
Mix of agriculture and forest lands on property	▪ 1.2 Reforest lands that have been deforested and afforest suitable lands	▪ Plant desirable or future-adapted tree species on suitable sites, particularly areas marginal for agriculture
Stand is overstocked and/or susceptible to drought or forest pests	▪ 6.3 Increase harvest frequency or intensity because of greater risk of tree mortality	▪ Create gaps and thin areas between gaps (matrix) to reduce tree density and encourage regeneration of drought-tolerant species
Forest harvest	▪ 2.1: Reduce impacts to soils and nutrient cycling ▪ 2.2: Maintain or restore hydrology	▪ Minimize the area (footprint) of forest roads and trails ▪ Alter the timing of forest operations to reduce potential impacts on water, soils, and residual trees, especially in areas that rely on particular conditions for operations that may be affected by a changing climate ▪ Retain coarse woody debris (e.g., tree tops, harvest residue) to maintain soil moisture, nutrients, and enhance soil organic matter pools

	▪ Use soil amendments to restore or improve soil quality ▪ Restore native herbaceous groundcover following management activities in order to retain soil moisture and reduce erosion

On-the-Ground Examples

- Adaptive Silviculture – Southern New England Oak Forests
  - The Adaptive Silviculture for Climate Change (ASCC) study sites in southern New England include resistance, resilience, transition, and no action treatments in oak forests that are representative of forests across much of the region. The treatments were developed by a team of scientists and managers working to identify options relevant to smaller parcel sizes and varied ownership.
- Providence Water: Planting Future Adapted Forests
  - The forests surrounding Providence's Scituate Reservoir provide clean water to over 600,000 people, or two-thirds of all Rhode Islanders. Challenges to northern hardwood regeneration ultimately threaten water quality. Managers are experimenting with actions that promote a variety of oaks and other species that are expected to be better adapted to future conditions.
- South Central Connecticut Regional Water Authority: Maltby Lakes Southern Pine Beetle Response
  - Managers conducted a clearcut in this forested watershed in response to a southern pine beetle infestation that threatened to expand northward into other forests. Silvicultural techniques and supplemental planting were used to support the establishment of future-adapted tree species.