Massachusetts Wildlife Climate Action Tool: Inspiring Local Adaptation on the Ground

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Photos by Carrie Banks & Bill Byrne

Outline

- Why did we build it? Motivation and development of the tool
- What does our target audience need? Initial user feedback
- How does it work? Tool functionality and tour
- Where can we go from here? Your feedback & discussion

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Massachusetts Wildlife Climate Action Tool:

Inspiring local action to protect the Commonwealth's natural resources in a changing climate

Project of the Mass Climate Adaptation Partnership involving:

- MA Division of Fisheries and Wildlife
- UMass Amherst Center for Agriculture, Food and the Environment
- MA Cooperative Fish and Wildlife Research Unit
- DOI Northeast Climate Science Center

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Diverse team of expert partners

Acknowledgments

This tool was developed by the Climate Action Tool Development Team:

- Scott Jackson, University of Massachusetts - Amherst
- John O'Leary, Massachusetts Division of Fisheries and Wildlife
- Michelle Staudinger, DOI Northeast Climate Science Center
- Stephen DeStefano, USGS Massachusetts Cooperative Fish and Wildlife Research Unit
- Melissa Ocana, University of Massachusetts – Amherst
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- Jonathan Brooks, Massachusetts Division of Fisheries and Wildlife
- Tom Cairns, University of Massachusetts - Amherst
- Marilyn Castriotta, Antioch University New England
- Paul Catanzaro, University of Massachusetts - Amherst
- Tony D'Amato, University of Vermont
- Nicole DeAngelis, Massachusetts Division of Fisheries and Wildlife
- Laura Hilberg, EcoAdapt
- Stephen Jane, University of Massachusetts - Amherst
- Toni Lyn Morelli, DOI Northeast Climate Science Center
- Emily Silver, University of Massachusetts - Amherst

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- Common Media, Inc. team
- Beth Armour and Andy Slocombe, UMass Amherst Center for Agriculture, Food, and the Environment
- Dan Koch and Kevin Robicheau, Massachusetts Division of Fisheries and Wildlife
- Alex Bryan, DOI Northeast Climate Science Center
- Hector Galbraith, EcoSolutions
- Ambarish Karmalkar, DOI Northeast Climate Science Center, University of Massachusetts - Amherst
- Mikaela Heming, University of Massachusetts - Amherst
- David Paulson, Massachusetts Division of Fisheries and Wildlife

Objective

Make science accessible for people active locally and regionally by providing -

- Dynamic website tool platform that can be expanded
- Information about climate change impacts
- Vulnerabilities of various fish, wildlife, and habitats
- Adaptation actions that can be taken in the face of climate change

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Photo Bill Byrne

Key Principles

- Research-based information vetted by scientists
- Promote adaptation actions that can be taken at a local level
- Acknowledge uncertainty
- A dynamic platform for information on climate change from diverse partners
- Use language suitable for target audiences

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Target Audiences

- Municipal government (conservation commissions, open space committees, departments of public works)
- Local conservation organizations (land trusts, watershed associations)
- Regional planning authorities (RPAs)
- Landowners and individual citizens looking to take action on climate change

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Phase 1 – what's currently included

- Initial focus on fish, wildlife, habitats
- Spatial data (map viewer)
- MA climate change projections and implications
- Climate and other stressors to be addressed for us to adapt to climate change
- Vulnerability assessments
- On-the-ground adaptation actions
- Expandable site design to accommodate additional content

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Massachussetts Wildlife
CLIMATE ACTION TOOL

Select your topic of interest to learn how climate change is affecting your community's fish, wildlife, and other natural resources. Use the tool to explore and plan climate change adaptation actions.

I'm interested in...

- LEARNING ABOUT CLIMATE CHANGE
- FISH & WILDLIFE
- FOREST RESOURCES
- WETLAND & AQUATIC RESOURCES
- PROTECTING LAND
- MANAGING MY LAND
- ROADS & OTHER INFRASTRUCTURE
- IMPROVING POLICY, LAWS & REGULATIONS
- LAND USE PLANNING
- STARTING WITH TOWN OR WATERSHED

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User Guide

Navigation | Tutorial Video | Important Terms | FAQ

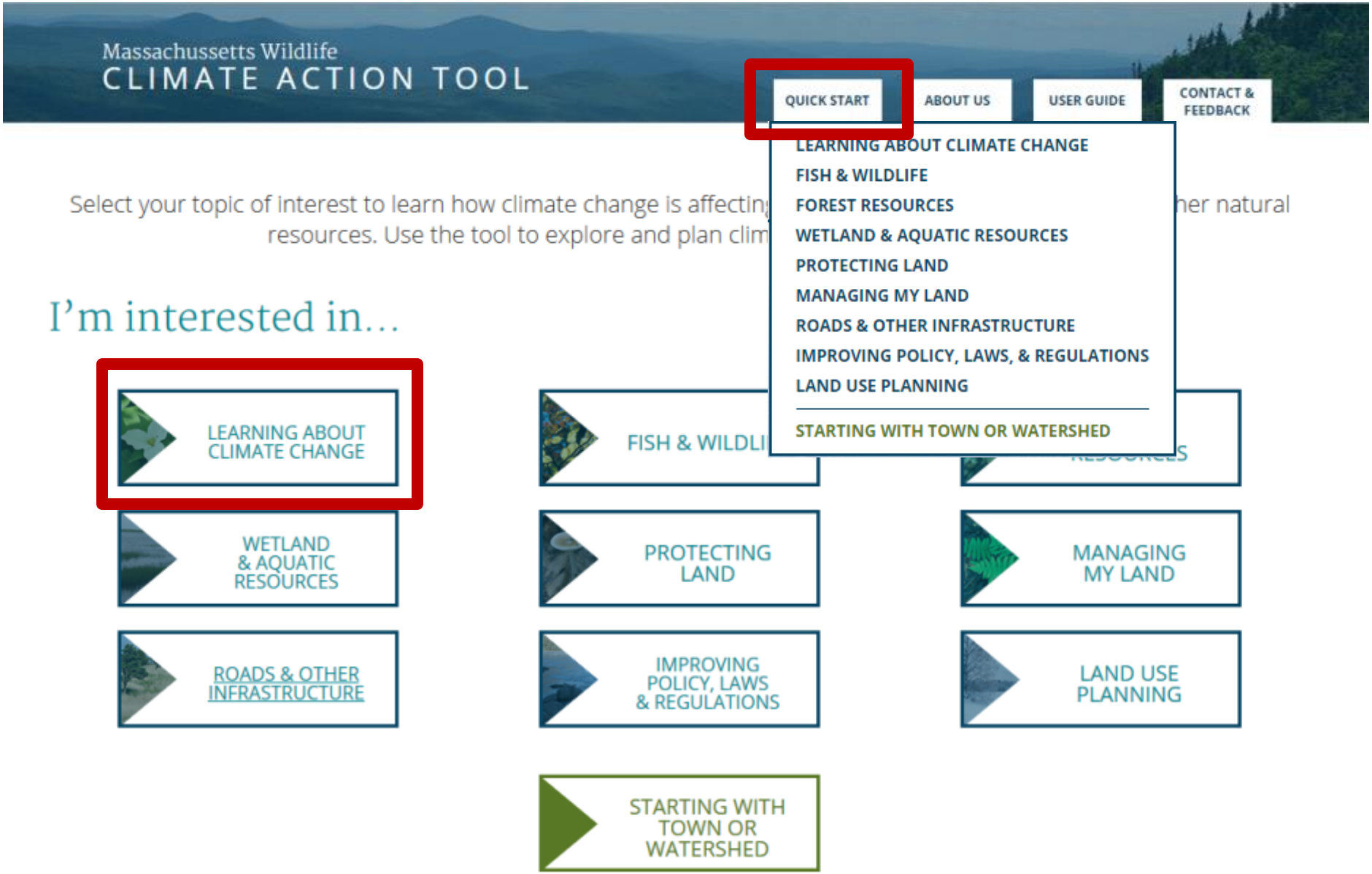
Welcome! The Massachusetts Wildlife Climate Action Tool is designed to inspire local action to protect the Commonwealth's natural resources in a changing climate. With this tool, you can:

1. access information on climate change impacts and vulnerability of species and habitats, as well as
2. explore adaptation strategies and actions based on your location and interests to help maintain healthy, resilient natural resources and communities.

Navigating through the Tool

See some helpful search instructions here.

Tutorial Videos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LEARNING ABOUT CLIMATE CHANGE
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FOREST RESOURCES
WETLAND & AQUATIC RESOURCES
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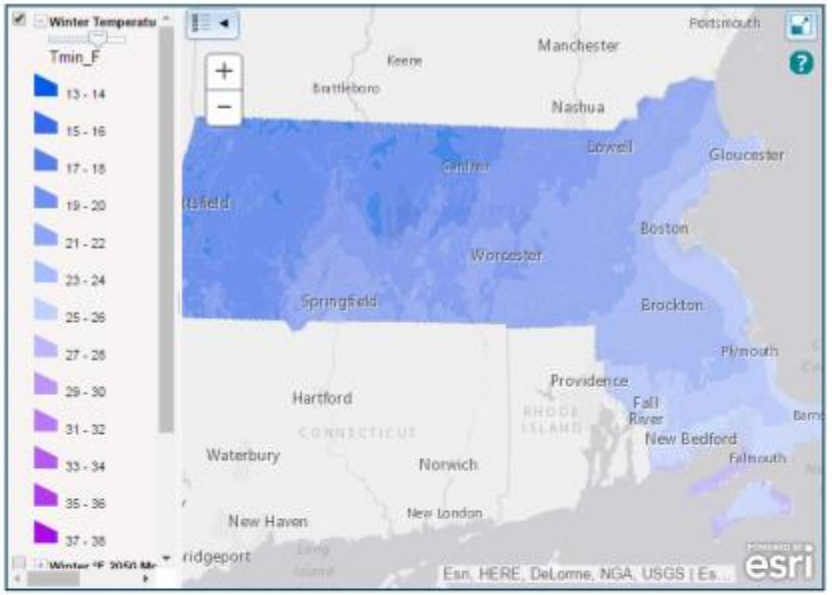
Climate Stressor Pages:

- Summary of historical and future trends
- Maps of current and projected conditions
- Additional graphics and resources
- Latest science synthesized by NECSC and partners

Stressors

Changes in winter

Recent research has shown that climate changes in winter, such as soil freezing and snow cover, are having strong and often surprising impacts on species and ecosystems in seasonally snow-covered areas such as high-elevation and alpine habitats. Changes in winter are impacting ecosystem structure and function with important consequences for carbon sequestration, decomposition, and export, which influence production in agricultural and forest habitats.



Climate projections displayed in this map represent the average of the minimum air temperature (degrees F) for December, January, and February. Colors change from blue to purple as air...
Read More

Winter Temperatures
Average air temperatures in New England have shown the greatest increases during the winter season; over the last half-century winter temperatures have risen by more than 3 °F. This trend is projected to continue with winter temperatures in Massachusetts potentially increasing as much as 6 °F under the highest emission scenario by the end-of-century. The winter season has also been getting shorter over past decades, as the timing of fall has shifted later, and spring earlier - each by about a week or more.

Extreme cold winter temperatures in Massachusetts and the Northeast region have been observed in recent years and are thought to be the result of rapid warming in the Arctic, which influences the strength and meandering of the jet stream. These atypical cold temperatures were the exception as the rest of the world experienced some of the highest temperatures on record. Studies of these extreme temperature events are an emerging area of climate science. Recent research suggests it is likely that North America will experience additional extreme winter temperatures though they are expected to vary in intensity and frequency over time. Increases in the amplitude of the jet stream in winter may also explain the observed increases in winter storms affecting the Northeast United States.

Winter Precipitation and Snowpack
Annual winter precipitation has been increasing; however, future projections of precipitation are generally less certain than temperature.

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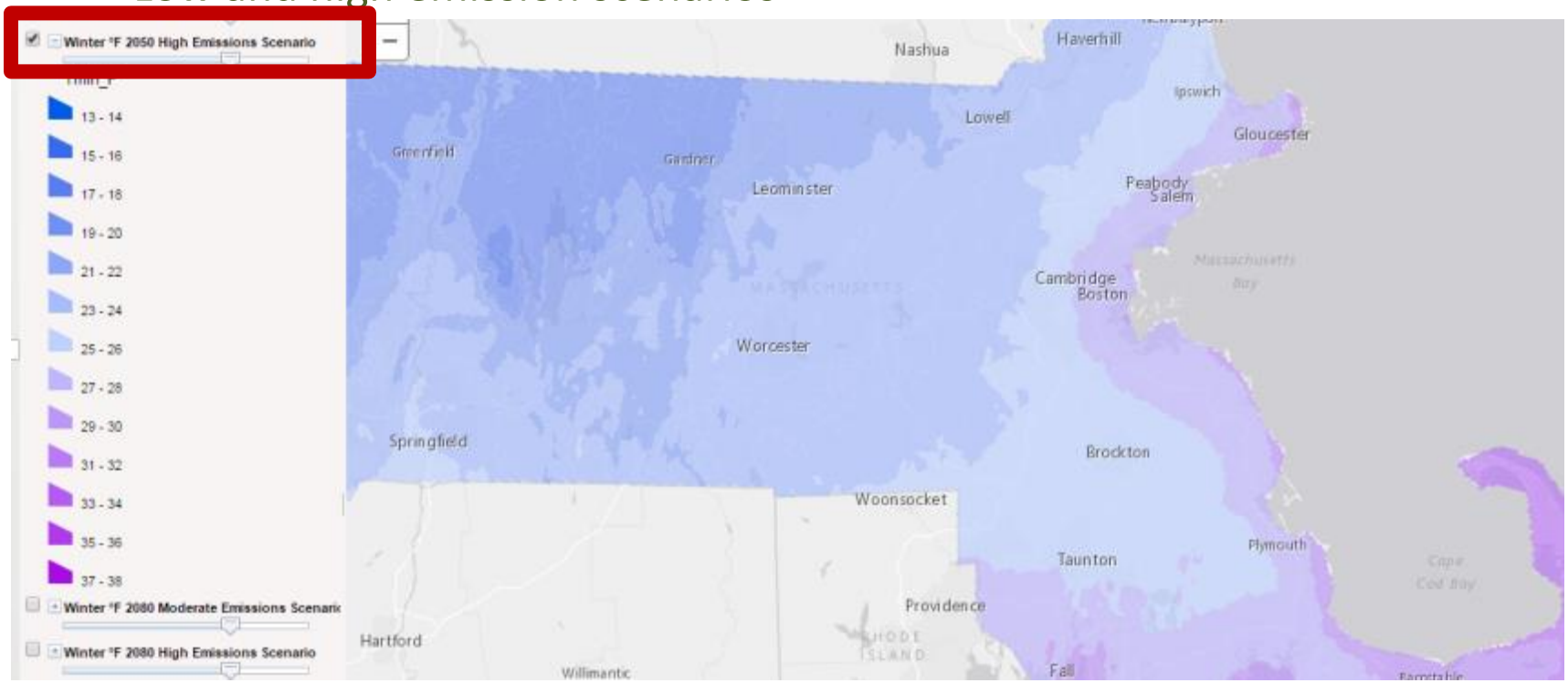
Climate Stressor Maps:

- Interactive layers
- Current conditions and future projections scaled to MA
- Low and high emission scenarios



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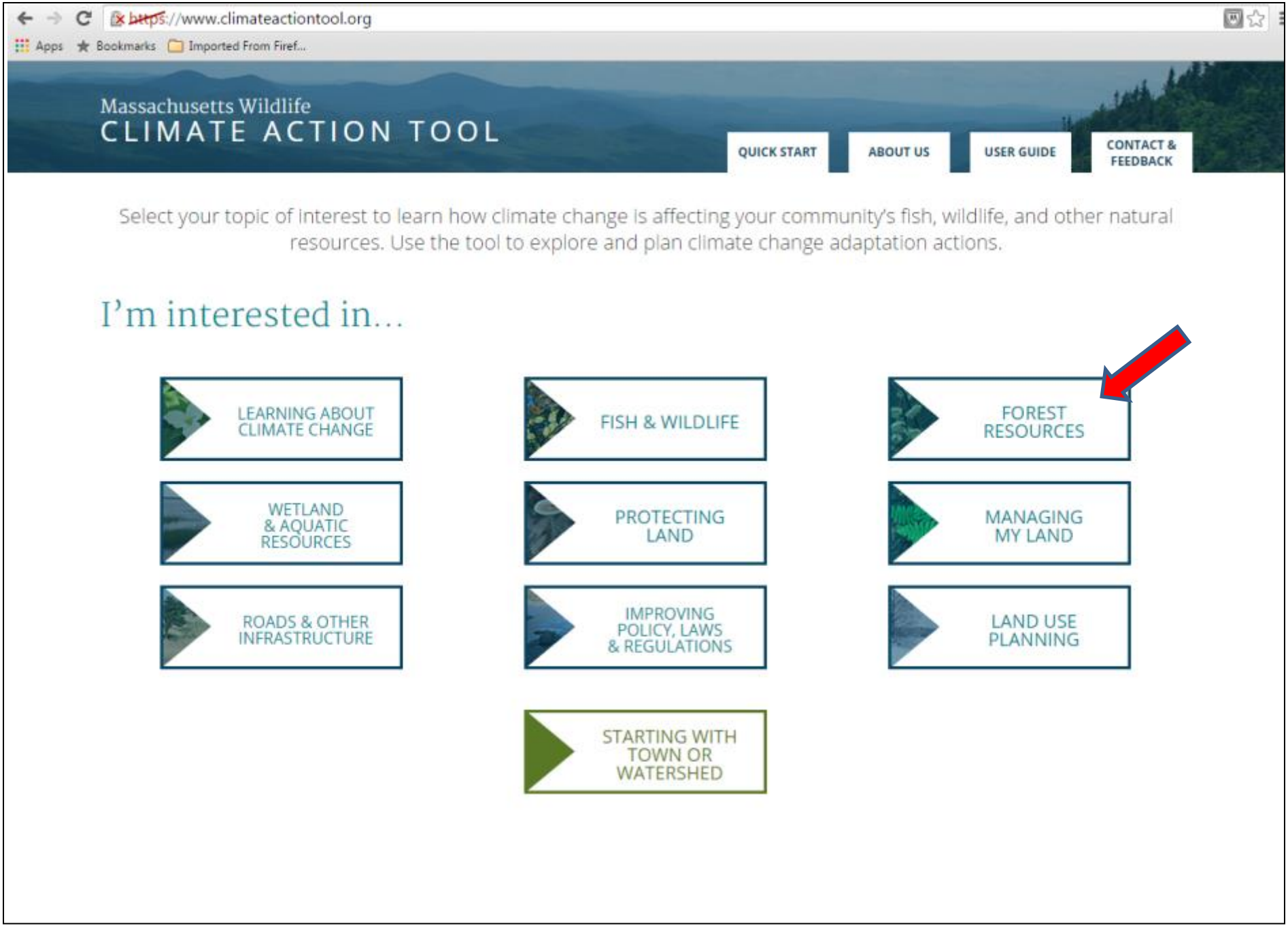
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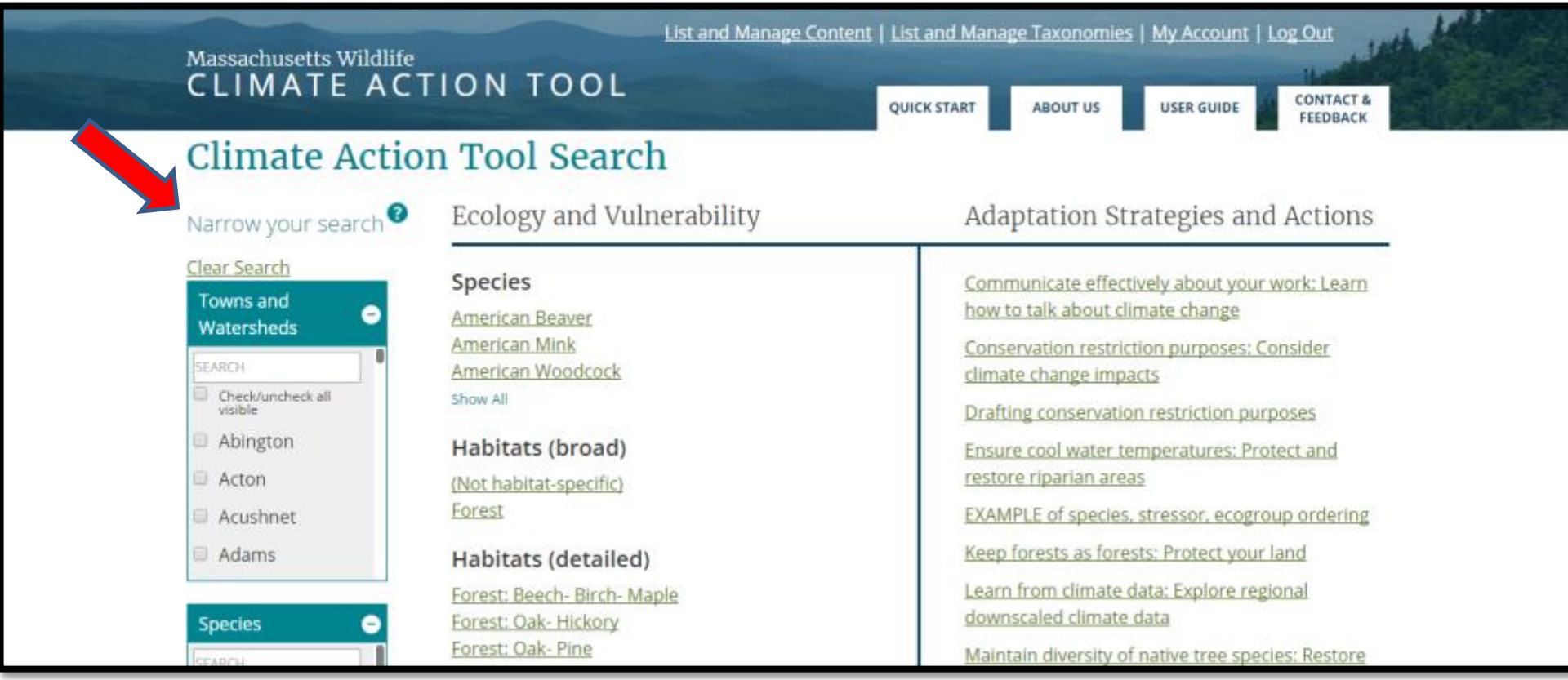

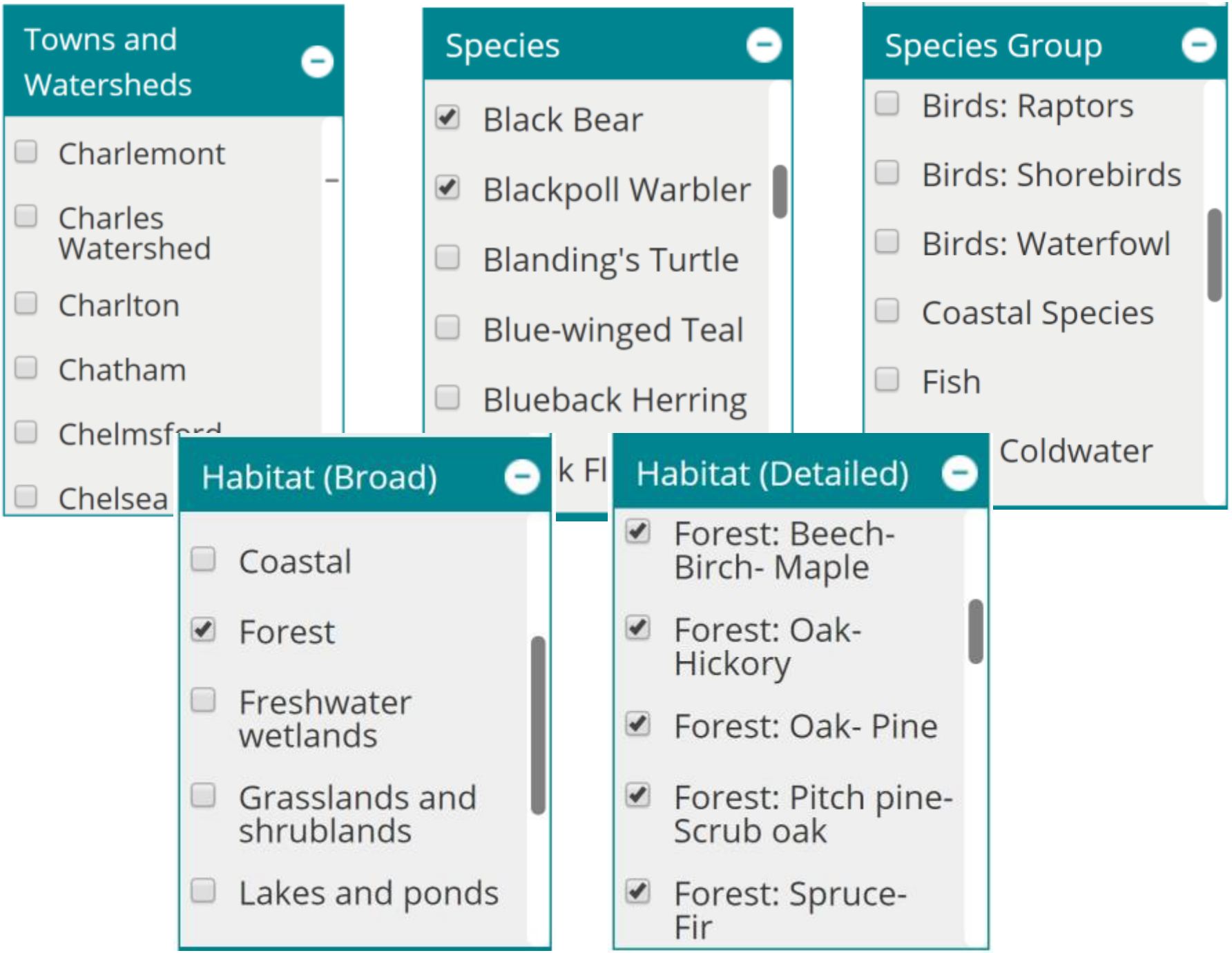
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Blanding's Turtle
Blue-winged Teal
Blueback Herring
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Birds: Raptors
Birds: Shorebirds
Birds: Waterfowl
Coastal Species
Fish
Coldwater
Habitat (Broad)
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Forest
Freshwater wetlands
Grasslands and shrublands
Lakes and ponds
Habitat (Detailed)
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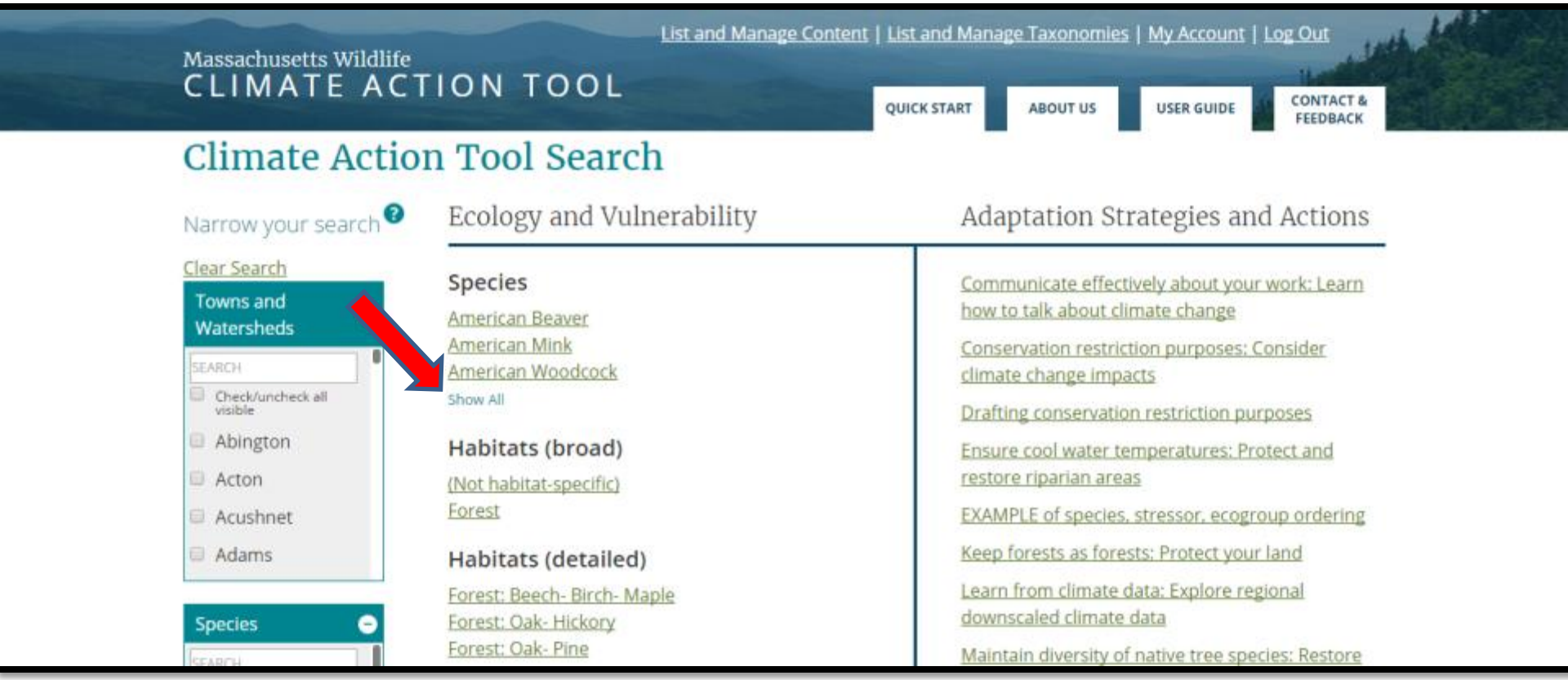
Forest: Oak-Hickory
Forest: Oak- Pine
Forest: Pitch pine-Scrub oak
Forest: Spruce-Fir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Species
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Species
American Beaver
American Mink
American Woodcock
Show All
Habitats (broad)
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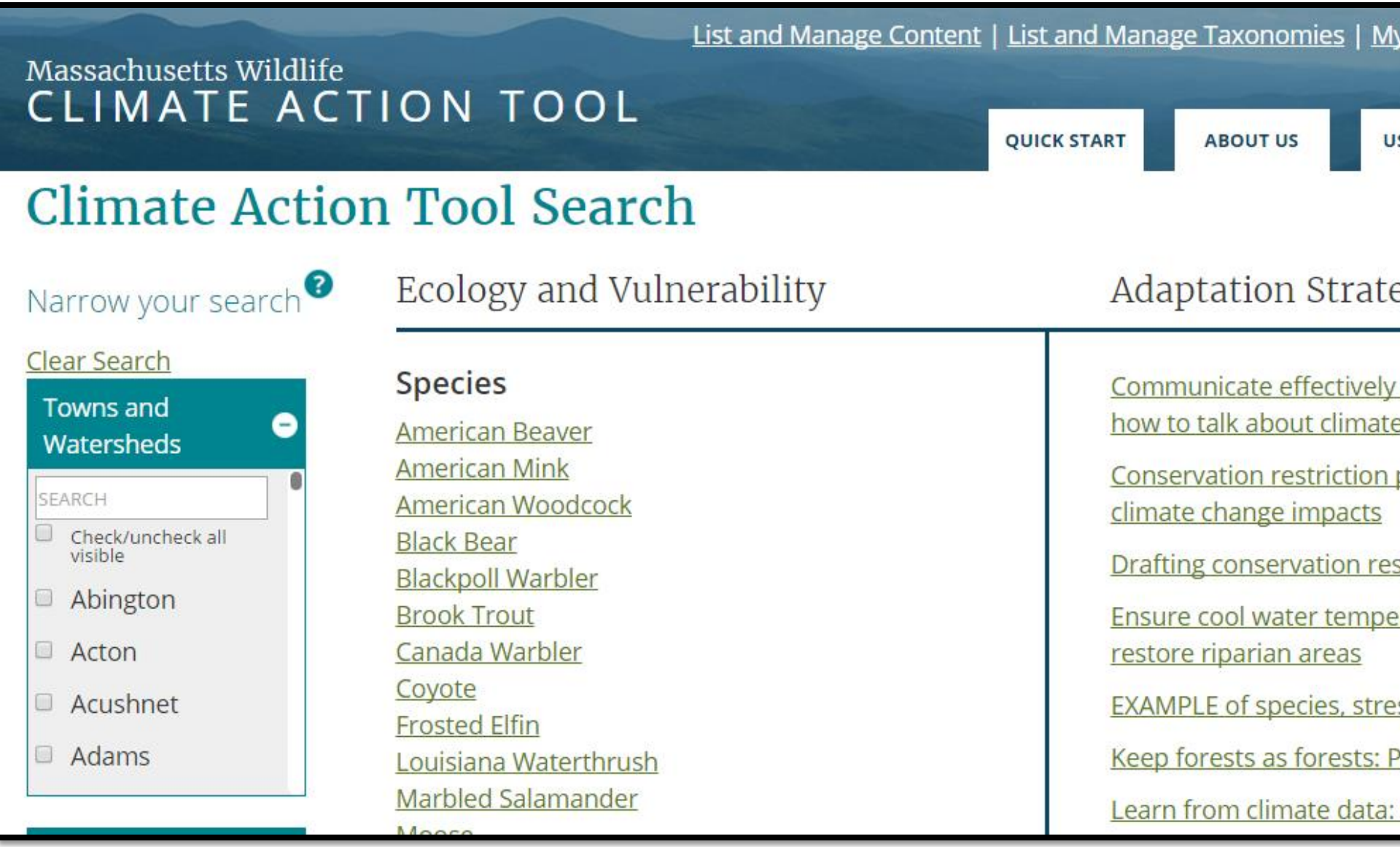
Habitats (detailed)
Forest: Beech- Birch- Maple
Forest: Oak- Hickory
Forest: Oak- Pine
Adaptation Strategies and Actions
Communicate effectively about your work: Learn how to talk about climate change
Conservation restriction purposes: Consider climate change impacts
Drafting conservation restriction purposes
Ensure cool water temperatures: Protect and restore riparian areas
EXAMPLE of species, stressor, ecogroup ordering
Keep forests as forests: Protect your land
Learn from climate data: Explore regional downscaled climate data
Maintain diversity of native tree species: Restore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Coyote
Frosted Elfin
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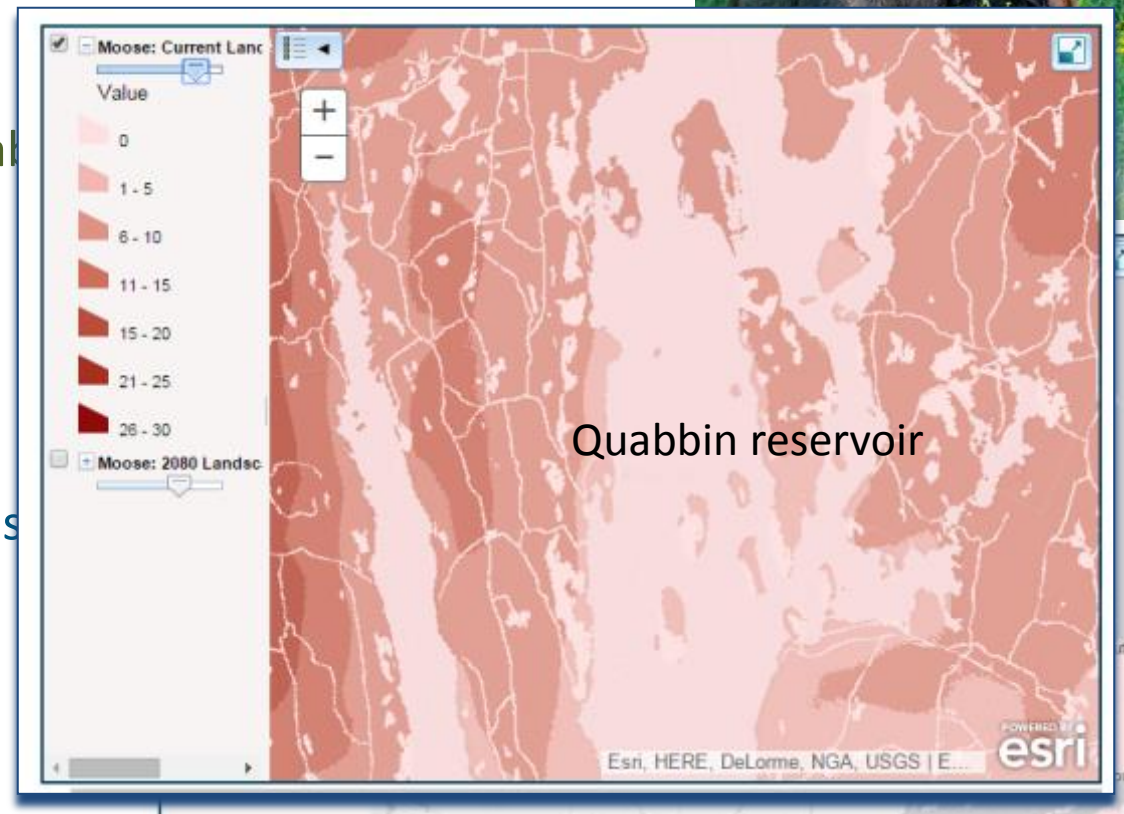
Learn from climate data:

Species Ecology and Vulnerability:

- Species-specific stressors
- Background
- Climate impacts
- Climate Change Vulnerab
  Assessment results
- Adaptation Strategies
- Related habitats
- Related species groups
  - Large mammals

Moose



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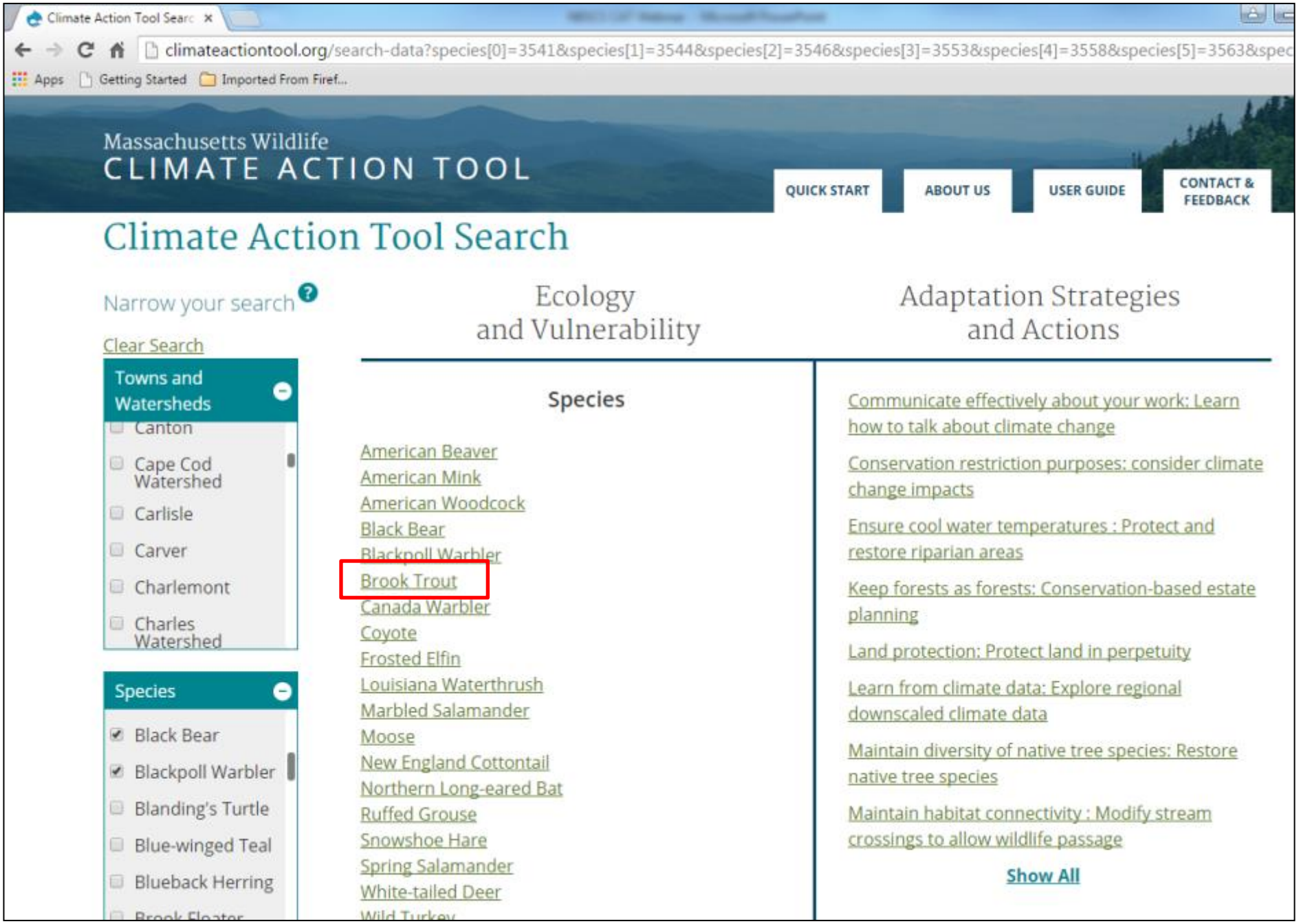
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Charles Watershed
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Canada Warbler
Coyote
Frosted Elfin
Louisiana Waterthrush
Marbled Salamander
Moose
New England Cottontail
Northern Long-eared Bat
Ruffed Grouse
Snowshoe Hare
Spring Salamander
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Land protection: Protect land in perpetuity
Learn from climate data: Explore regional downscaled climate data
Maintain diversity of native tree species: Restore native tree species
Maintain habitat connectivity : Modify stream crossings to allow wildlife passage
Show All

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Ecology and Vulnerability

Brook Trout

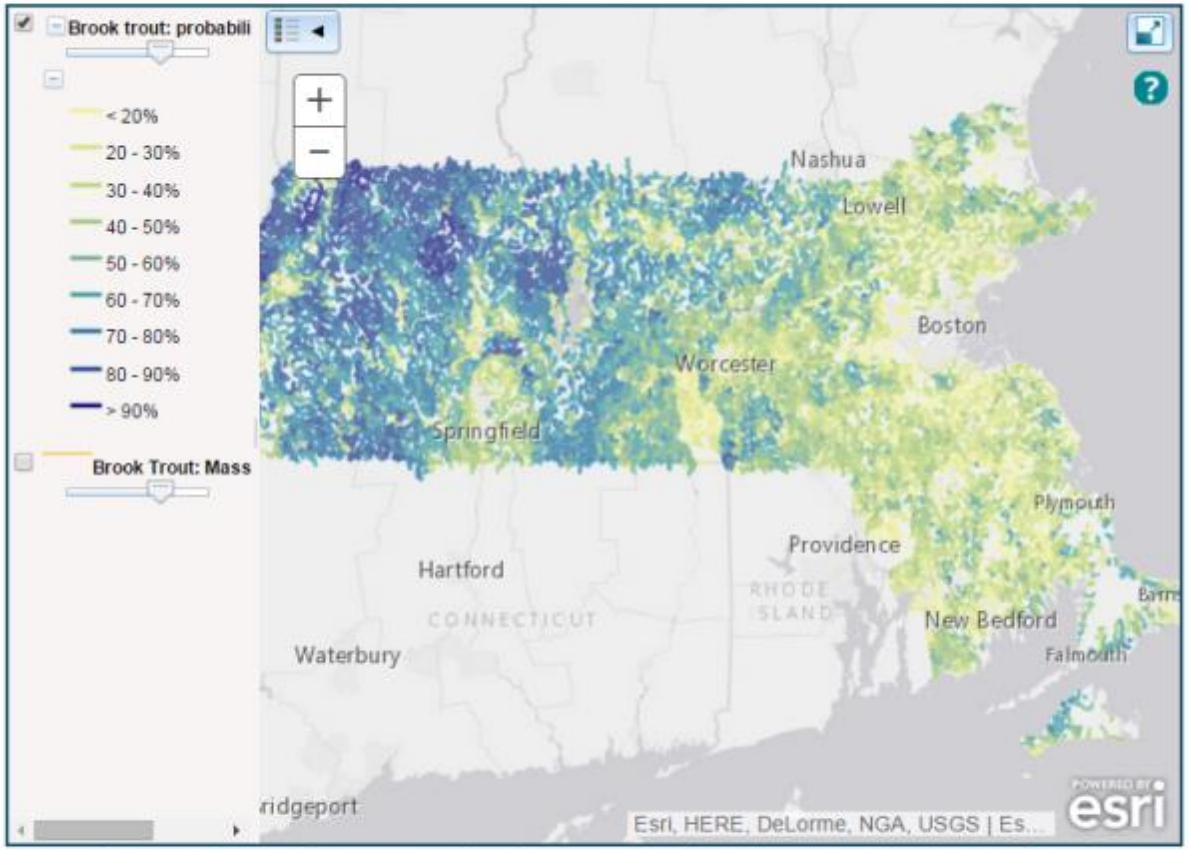
Photo credit: U.S. Forest Service

Scientific name:

Salvelinus fontinalis

Species stressors:

Aquatic connectivity loss (roads and dams)
Temperature changes
Changes in hydrology
Storms and floods
Change in timing of seasons
Invasive plants and animals
Pests and diseases



Brook trout probability of occurrence: The above map describes the current distribution of brook trout. Streams in blue are more likely to be inhabited by brook trout based on environmental...

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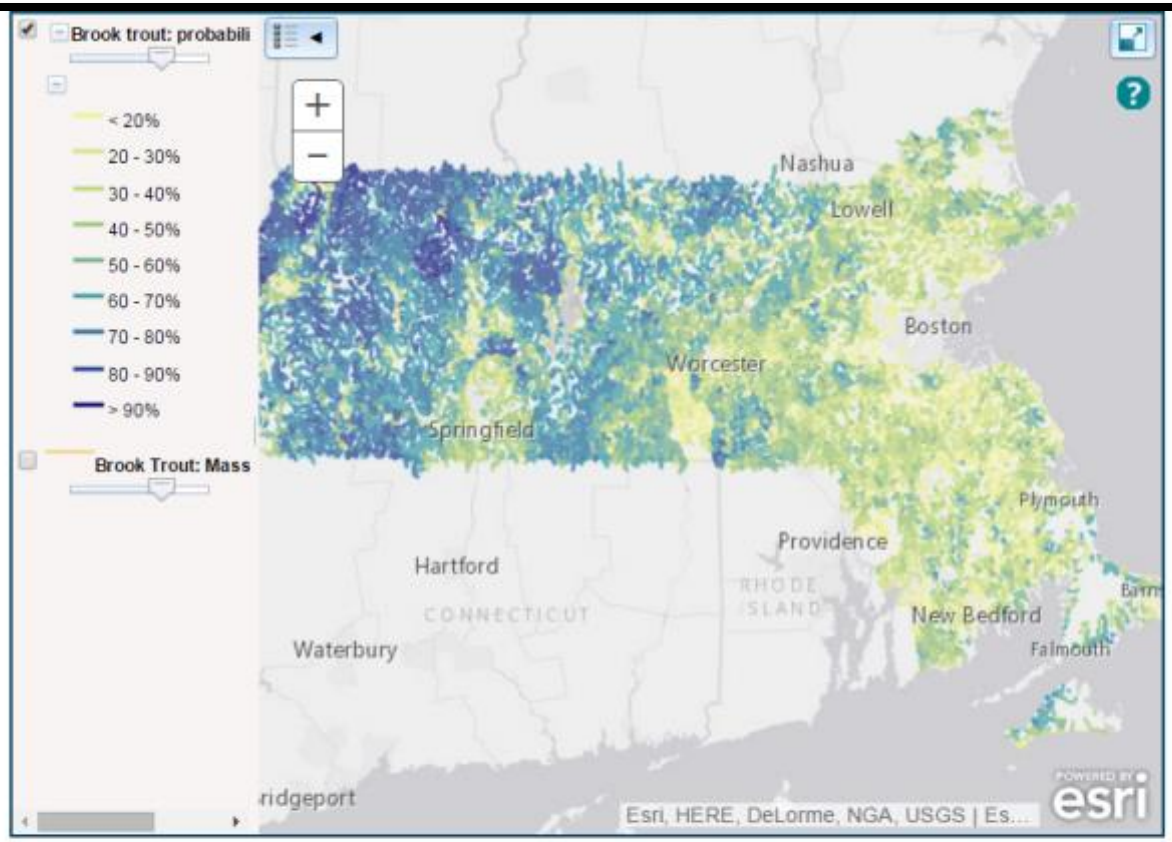

Brook trout probability of occurrence: The above map describes the current distribution of brook trout. Streams in blue are more likely to be inhabited by brook trout based on environmental conditions, while streams in yellow are less likely to have brook trout. Stream characteristics that help predict whether brook trout can be found in each stream include stream size, average air temperature, nearby forest cover, and soil characteristics. Estimates are from the USGS Conte Anadromous Fish Research Center, based on field surveys from Massachusetts DFW and agencies of nearby states CT, NH, VT, and NY.

Brook trout observations: Streams in orange indicate that brook trout have been observed by MassDFW field surveys.

Hide

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Ecology and Vulnerability

Brook Trout

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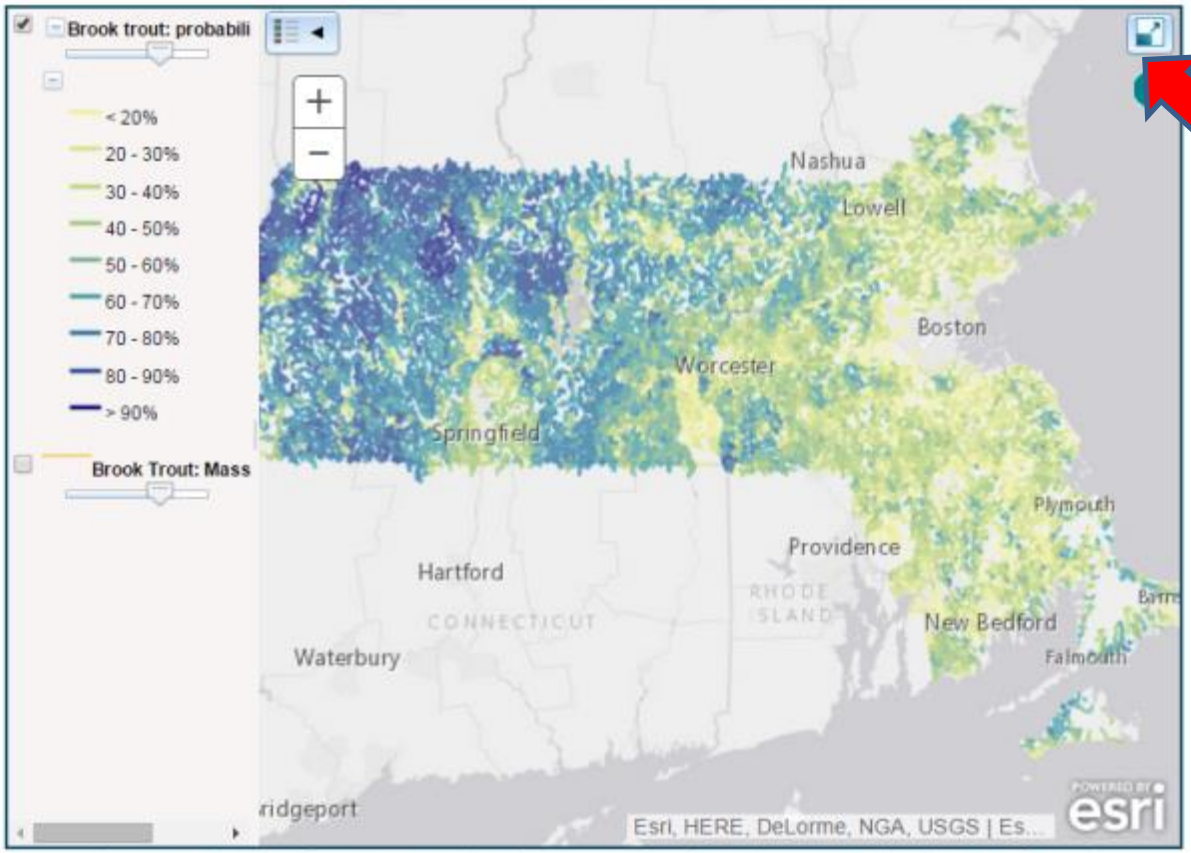

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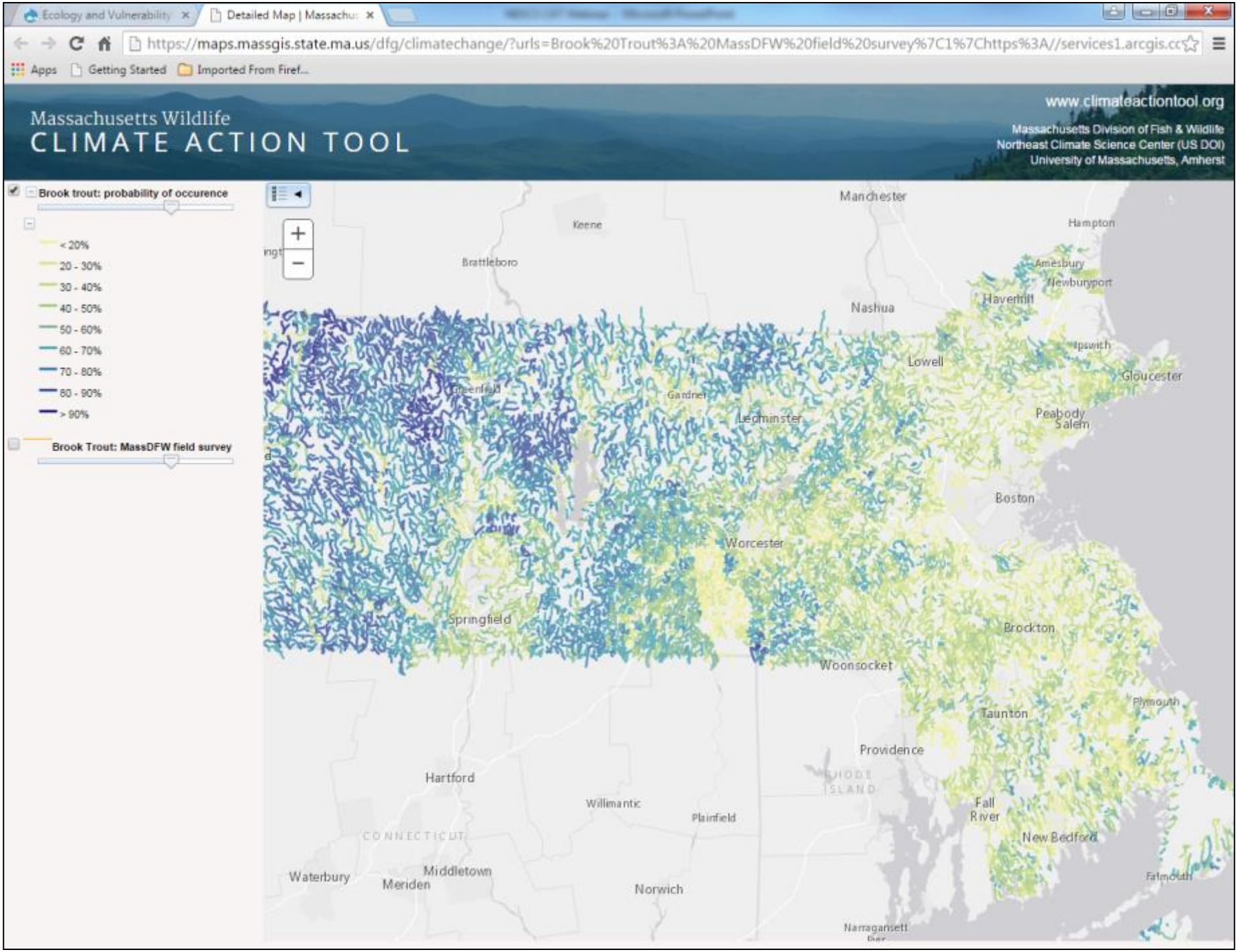
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Detailed Map | Massachu:
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Brook trout: probability of occurence
< 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
80 - 90%
> 90%
Brook Trout: MassDFW field survey
Manchester
Keene
Hampton
Brattleboro
Amesbury
Newburyport
Haverhill
Nashua
Ipswich
Lowell
Gloucester
Gardner
Peabody
Salem
Leominster
Boston
Worcester
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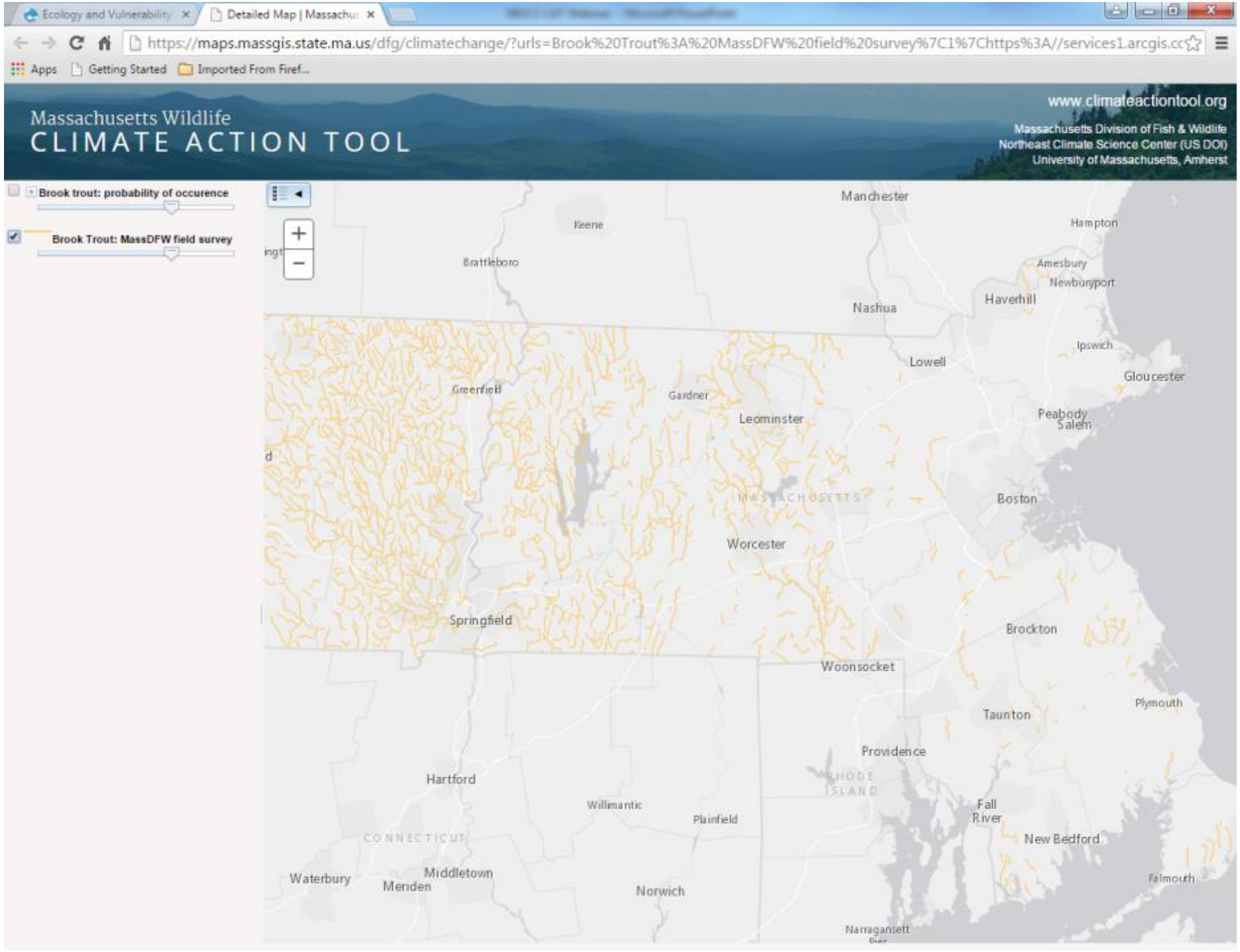
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Brook trout: probability of occurence
Brook Trout: MassDFW field survey
Manchester
Keene
Hampton
Brattleboro
Amesbury
Newburyport
Haverhill
Nashua
Ipswich
Lowell
Gloucester
Greenfield
Gardner
Leominster
Peabody
Salem
MASSACHUSETTS
Boston
Worcester
Springfield
Brockton
Woonsocket
Plymouth
Taunton
Providence
Hartford
RHODE ISLAND
Willimantic
Plainfield
Fall River
New Bedford
CONNECTICUT
Waterbury
Meriden
Middletown
Norwich
Falmouth
Narragansett

Profile: Brook Trout ▾

Background

Brook trout are an economically important game species throughout their native range, which extends south in the Appalachians to Georgia[1] and north to the Atlantic drainages of Newfoundland, Labrador, and Quebec[2]. Brook trout in Massachusetts are found primarily in streams that have cold, highly oxygenated water[3]. They generally do not tolerate extended periods of water temperatures above 20°C/68°F[3], and the ideal temperature for growth and activity is between 12-19°C (53.6-66.2°F)[4]. Because of their requirements for clean, cold water, brook trout have experienced extensive reductions in distribution and abundance because of habitat degradation[1]. In Massachusetts, wild, reproducing populations of brook trout have been greatly reduced and the majority that remain are restricted to isolated headwater streams[5].

Climate Impacts

This species' need for cold water implies that there is great potential for climate change to impact brook trout populations. Indeed, modeling studies conducted in various parts of its range, including parts of Canada[6], and in the southern Appalachians[7], suggest large reductions in future distributions for brook trout. Studies commonly have found that in streams where temperatures exceed 20°C/68°F for extended periods, brook trout are either at low abundance, or are absent altogether[8,9,10]. Brook trout begin to experience significant mortality as water temperatures approach 25°C/77°F[11]. However, studies have observed physiological indicators of heat stress in temperatures as low as 21°C/70/68°F[12]. These sublethal temperatures are accompanied by decreased feeding, growth, and reproduction[13,14]. In one Adirondack Lake with marginal temperatures for brook trout, warm temperatures in some years resulted in complete failure to reproduce[13].

Some studies have found that different strains of brook trout have different degrees of thermal tolerance, suggesting some limited capacity to adapt to higher temperatures[15]. Under such conditions, trout seek out thermal refuges such as inflows from cold tributaries or groundwater inputs, where they will aggregate until overall temperatures are more favorable[16]. However, on a broad geographic scale, distribution is largely defined by temperature constraints[16,17], suggesting that adaptive capacity is limited. Additionally, brook trout are able to persist in surprisingly small, isolated populations above barriers in headwater streams[18] so there is potential that these trout could continue to remain in isolated pockets in areas where larger populations decline[19]. While brook trout will likely not disappear from Massachusetts, reductions in suitable habitat are expected.

References:

[1]Hudy, M., T.M. Thieling, N. Gillespie, and E.P. Smith. 2008. Distribution, status, and land use characteristics of subwatersheds within the native range of brook trout in the eastern United States. North American Journal of Fisheries Management **28**:1069-1085.

[2]Ficke, A.D., D.P. Peterson, and W.A. Janowsky. 2009. Brook trout (*Salvelinus fontinalis*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available: <http://www.fs.fed.us/r2/projects/scp/assessments/brooktrout.pdf>. (Accessed on 20 May 2015).

[3]Hartel, K.E., D.B. Halliwell, and A.E. Launer. 2002. Inland Fishes of Massachusetts. Massachusetts Audubon Society, Lincoln, MA.

[4]Waco, K.E., and W.W. Taylor. 2010. The influence of groundwater withdrawal and land use changes on brook charr (*Salvelinus fontinalis*) thermal

Ecology and Vulnerability ×
climateactiontool.org/species/brook-trout?extents=
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Profile: Brook Trout ▸

Background
Brook trout are an economically important game species throughout their native range, which extends south in the Appalachians to Georgia[1] and north to... **Read More**

Climate Change Vulnerability Assessment: Brook Trout (North Atlantic Coast) ▸
Ranking: Moderately Vulnerable
Confidence: Moderate
Climate scenario: SRES A1B
Location: North Atlantic Coast
Time period: 2050

This species was identified as moderately vulnerable to climate change because of the following factors:

- Anthropogenic and natural barriers prevent dispersal or shifts in species'... **Read More**

Climate Change Vulnerability Assessment: Brook Trout (Connecticut) ▸
Ranking: Highly Vulnerable
Confidence: Not assessed
Climate scenario: SRES B1/A1B/A2
Location: Connecticut
Time period: 2080

This species was identified as highly vulnerable to climate change because of the following factors:

- Suitable habitat expected to decrease (coldwater streams)
  ... **Read More**

Climate Change Vulnerability Assessment: Brook Trout (North Atlantic Coast)
Ranking: Moderately Vulnerable
Confidence: Moderate
Climate scenario: SRES A1B (Mid-range emissions scenario)
Location: North Atlantic Coast
Time period: 2050

This species was identified as moderately vulnerable to climate change because of the following factors:

- Anthropogenic (human-made) and natural barriers prevent dispersal or shifts in species' range
- Sensitive to changes in temperature
- Sensitive to changes in precipitation
- Has already experienced slight variations in annual precipitation (over the last 50 years)
- Slightly impacted by changes due to human response to climate change

The factors below decrease this species' vulnerability to climate change:

- Ability to move across the landscape and/or disperse relatively long distances

What is a Climate Change Vulnerability Assessment?

References

Sneddon, L. A., and G. Hammerson. 2014. Climate Change Vulnerability Assessments of Selected Species in the North Atlantic LCC Region. NatureServe, Arlington, VA. Available from: http://northatlanticlcc.org/projects/completing-northeast-regional-vulne...

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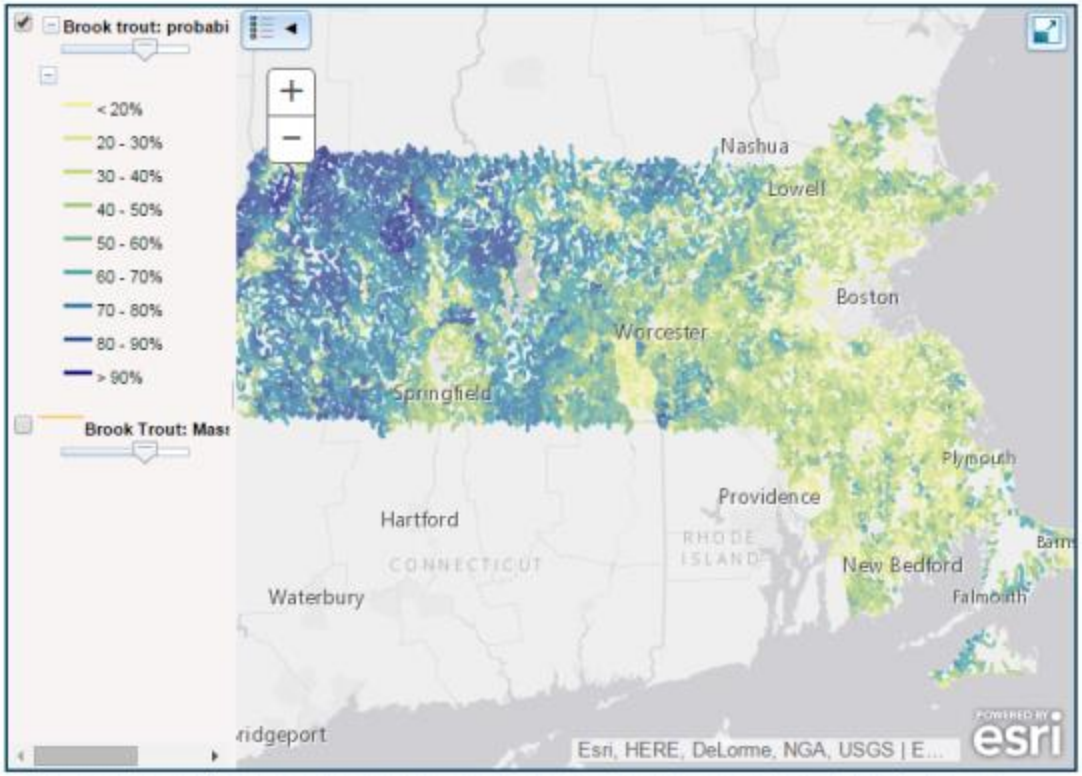
Ecology and Vulnerability
Brook Trout

Photo credit: U.S. Forest Service

Scientific name:
Salvelinus fontinalis

Species stressors:
Aquatic connectivity loss (roads and dams)
Temperature changes
Changes in hydrology
Storms and floods
Change in timing of seasons
Invasive plants and animals
Pests and diseases



Brook trout probability of occurrence: The above map describes the current distribution of brook trout in Massachusetts. Streams displayed in blue are more likely to be inhabited by brook...
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Profile: Brook Trout ▸

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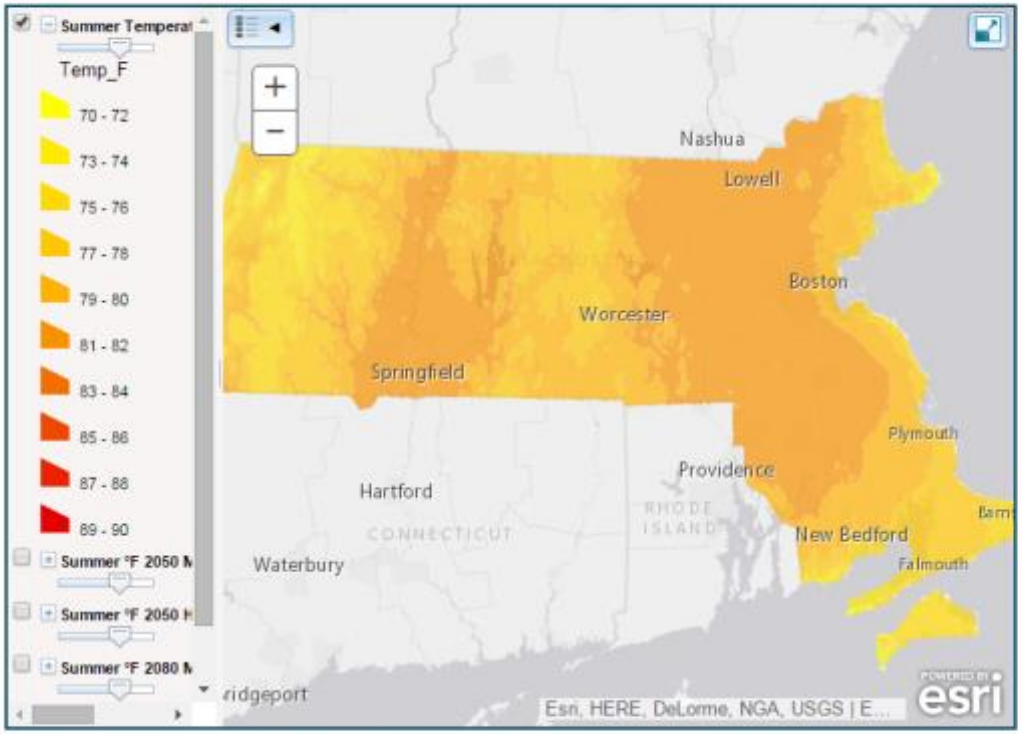
Stressors

Temperature changes

Annual and Seasonal Temperature Changes

The Earth's climate is warming. Global average annual temperatures have increased by 1.5° F since 1895, and the vast majority of this increase has occurred since 1980. The Northeast United States has experienced an increase in annual temperatures of 1.6°F over the last century. Warming has been occurring during all seasons, but has been greatest during winter (0.24°F/decade). Warming is also greatest at higher latitudes, elevations, and inland from the Atlantic coast.



Climate projections displayed in this map represent the average of the maximum air temperature (degrees F) for June, July, and August for the years 2010-2080...
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Future climate projections consistently show continued warming over the 21st century across Massachusetts and the entire New England region. All climate models agree that the warming trend will continue over the coming decades with high emission scenarios giving the greatest warming. However, for a given emissions scenario, the exact magnitude of warming varies slightly depending on the models used and their structure. Massachusetts is projected to see average temperature increases that exceed the global average, with potential warming of around 5°F annually by mid-century under a high emissions scenario. Model projections of future seasonal changes generally suggest winter will continue to show the greatest amounts of warming with increases up to 5°F by mid-century.

Extreme Temperature Events

Climate Change Vulnerability Assessment: Brook Trout (West Virginia) ▸
Ranking: Highly Vulnerable
Confidence: Very High
Climate scenario: SRES A1B
Location: West Virginia
Time period: 2050

This species was identified as highly vulnerable to climate change because of the following factors:

- Very sensitive to changes in temperature
- Natural and anthropogenic... **Read More**

Related Habitats (broad)

Rivers and streams

Related Habitats (detailed)

Rivers and streams: Rivers
Rivers and streams: Streams

Related Species Groups

Fish
Fish: Coldwater Fish
Game Species
Wetland and Aquatic Species

Related Adaptation Strategies and Actions

Ensure cool water temperatures : Protect and restore riparian areas
Land protection: Protect land in perpetuity
Maintain Habitat Connectivity: Assessment of Road-Stream Crossings
Maintain habitat connectivity: Retrofit or replace culverts

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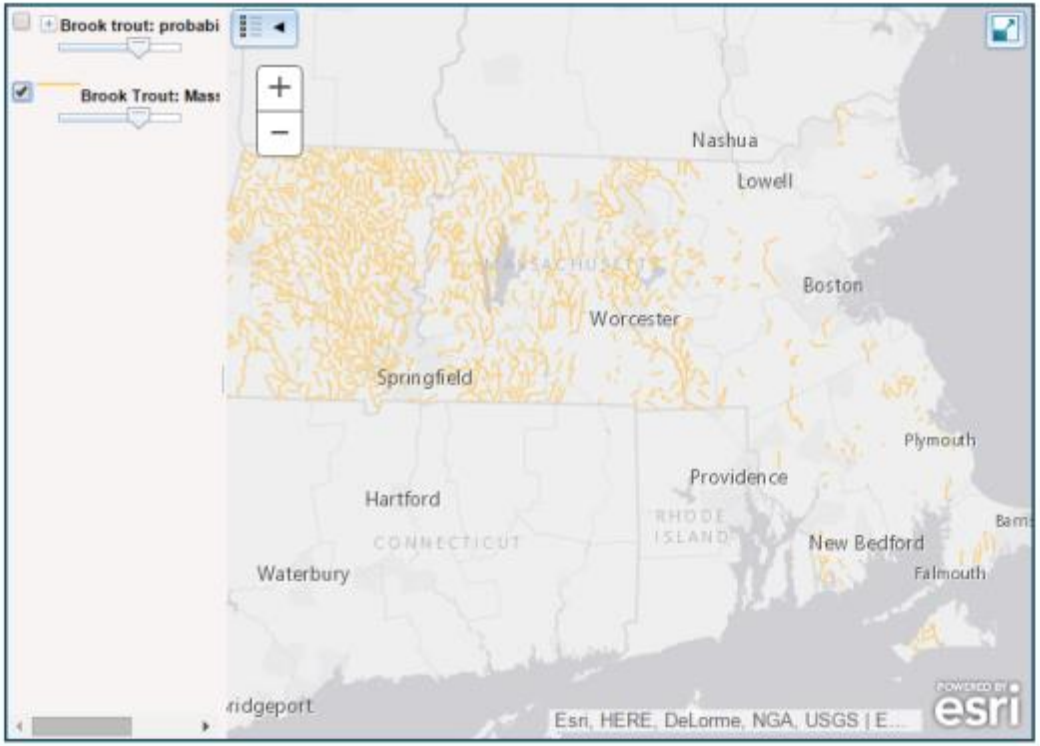
Adaptation Strategies and Actions

Ensure cool water temperatures: Protect and restore riparian areas

Adaptation type:
Land and forest stewardship or restoration
Species conservation and management

Strategy:
Maintain cool water temperatures in streams and ponds so that populations of species adapted to cool temperatures are able to survive.



Brook trout probability of occurrence: The above map describes the current distribution of brook trout. Streams in blue are more likely to be inhabited by brook trout based on environmental...
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Action

Protect and restore riparian areas

As temperatures continue to rise, as expected due to climate change, it will be important keep seasonal temperatures within the tolerance limits of fish and wildlife that rely on cold-water habitat, such as brook trout. Landowners can help sustain important cold-water habitat by maintaining or restoring climate resilient shade along important stream reaches.

https://www.climateactiontool.org/content/ensure-cool-water-temperatures-protect-and-restore-riparian-areas
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Action

Protect and restore riparian areas

As temperatures continue to rise, as expected due to climate change, it will be important keep seasonal temperatures within the tolerance limits of fish and wildlife that rely on cold-water habitat, such as brook trout. Landowners can help sustain important cold-water habitat by maintaining or restoring climate resilient shade along important stream reaches.

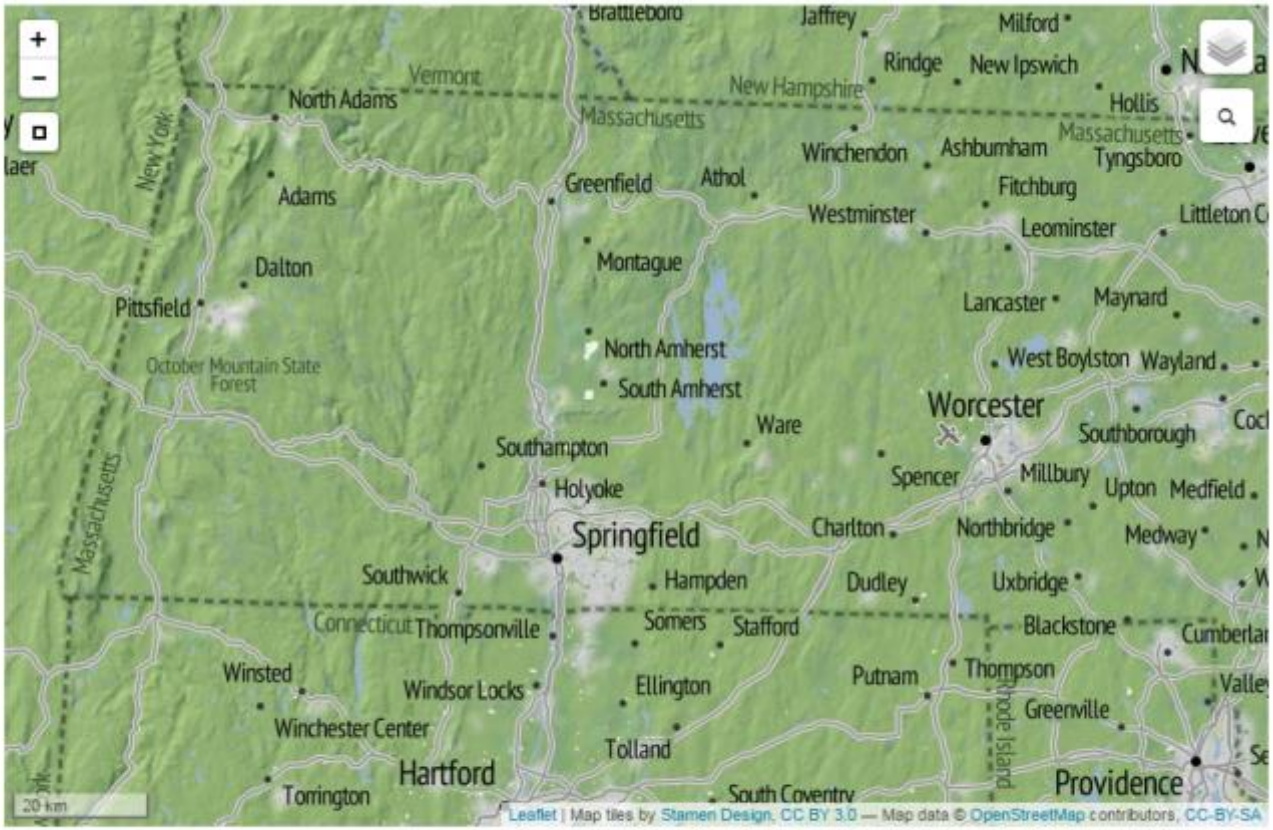
Tree cover in these areas is particularly important for regulating water temperatures. A forested buffer at least 100 feet wide along the stream is ideal. However, even a narrow strip of trees can provide vital shade and other benefits for cold-water streams. If a cold-water stream flows through your property, consider planting trees along open stream banks or allow areas that border the stream to return to forest.

What you can do:

- Stop mowing areas adjacent to cold-water streams and their tributaries and allow these areas to return to forest
- Plant appropriate, native, and resilient tree species along open stream banks
- Expand narrow riparian buffers
- In riparian areas where hemlock is threatened or was lost due to hemlock woolly adelgid, consult a professional forester to see if active management could be used to create a more resilient riparian forest

To help you decide where riparian buffers are most needed, see the Riparian Restoration Decision Support Tool below that identifies vulnerable stream and river banks lacking tree cover and shade in cold-water habitats.

The Riparian Prioritization for Climate Change Resilience



About RPCCR

The RPCCR tool enables users to dynamically locate areas (within the selected region) in the riparian zone that would benefit most from increased shading produced by planting of trees. The tool operates on a 200 meter stream buffer (100 on each side), and requires the user to specify values for maximum percent canopy cover and minimum solar gain percentile. The user can additionally choose to include minimum elevation (meters) and maximum percent impervious surface values in the analysis.

To use the tool, first select a layer from drop-down list and click Select Feature. The map will change. Zoom to select the polygon (or state) that you want to analyze. Enter the criteria that you want to include and click Make Request. You will see the request(s) in boxes on the right. This can take some time to complete, especially for large areas such as a state. You will see "working" noted next to the request(s). Once the request is complete, all the riparian zones in the selected area will be displayed in yellow, and the portions which correspond to the criteria

Make RPCCR Request

Layer

USA Hydrological Unit Code 1

Pick a layer to select a feature.

Canopy Cover

<= 70 %

Solar Gain Percentile

>= 70

Elevation

>= 600 meters

Use elevation?

Impervious Surface

<= 10 %

Use impervious surface?

Select Feature

fid 39302
Canopy Cover <= 70%
Solar Gain % >= 70

View Save

Ecology and Vulnerability

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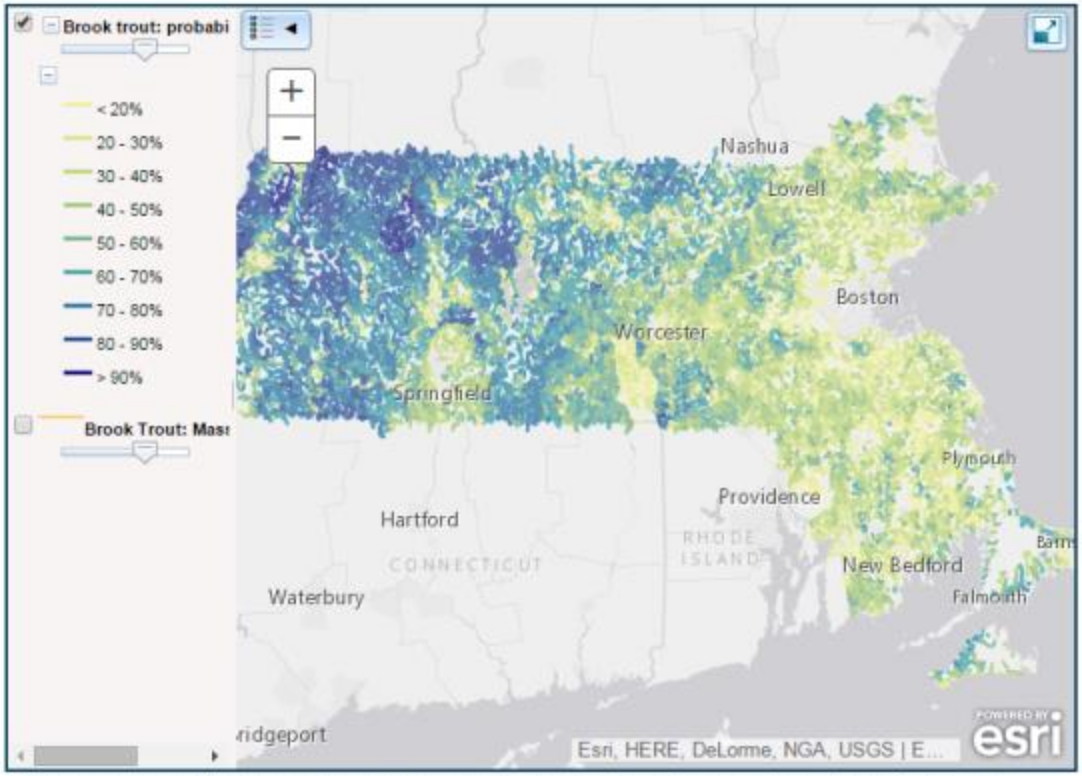
Ecology and Vulnerability
Brook Trout

Photo credit: U.S. Forest Service

Scientific name:
Salvelinus fontinalis

Species stressors:

- Aquatic connectivity loss (roads and dams)
- Temperature changes
- Changes in hydrology
- Storms and floods
- Change in timing of seasons
- Invasive plants and animals
- Pests and diseases



Brook trout probability of occurrence: The above map describes the current distribution of brook trout in Massachusetts. Streams displayed in blue are more likely to be inhabited by brook...
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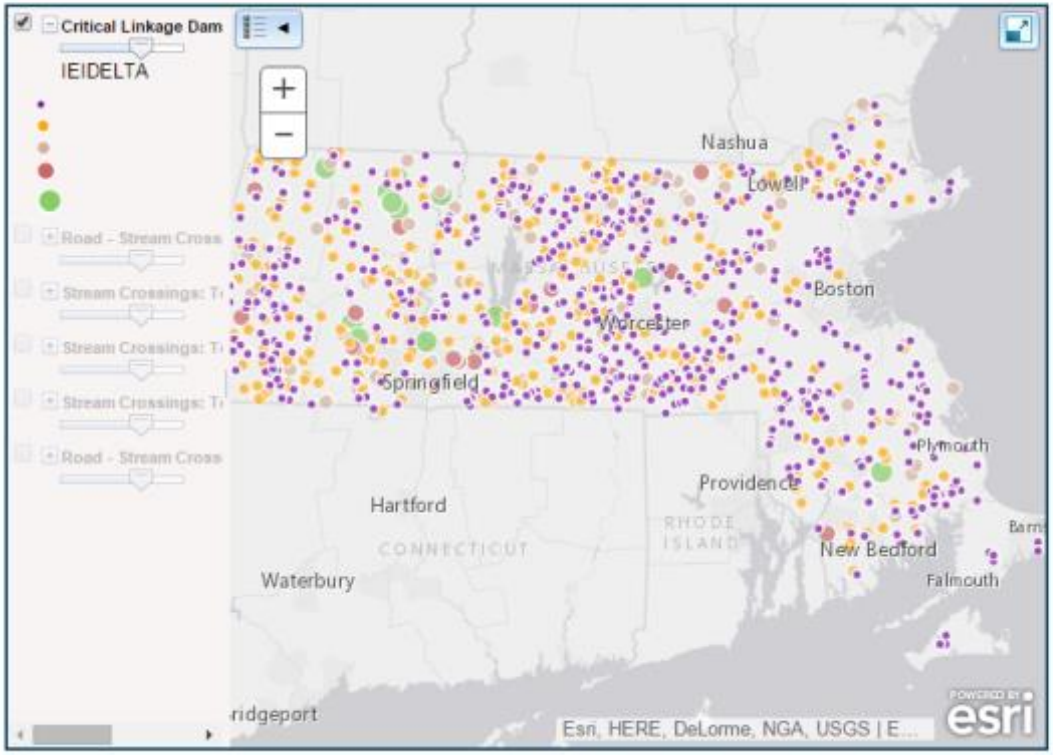
Profile: Brook Trout ▸

Stressors

Aquatic connectivity loss (roads and dams)



The first data layer is the results of a Critical Linkages analysis of dams based on the ecological restoration potential of dam removal; larger circles represent greater restoration potential....
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Fish and wildlife need to move in order to feed, reproduce, avoid predators, respond to changing habitat conditions and maintain health local and regional populations. Species that inhabit wetlands and aquatic ecosystems often rely on an interconnected network of streams and rivers as pathways for movement. Fully aquatic species (fish, mussels, crayfish) travel through the water while semi-aquatic wildlife (turtles, salamanders, beaver, mink, otter) move along streams utilizing both water and adjacent upland or wetland habitats.

Downstream movements are not generally difficult for these species, unless they have to pass over a dam or through a hydroelectric turbine. In fact, much downstream movement occurs involuntarily during flood events. Upstream movements are much more difficult as aquatic organisms must make headway against the current and contend with shallow riffles, natural waterfalls and cascades, and a variety of human created obstacles such as dams and road-stream crossings (bridges and culverts). Yet, without upstream movements that counter the inevitable downward shift in organisms headwater streams would be depopulated of fish and wildlife.

Rivers and streams are long, linear ecosystems that stretch out across the landscape. As such they are highly vulnerable to fragmentation due to barriers such as dams, channelized and buried stream segments, and the numerous intersections of roads and streams. Under normal conditions, this fragmentation is a serious conservation challenge. Given the stresses anticipated with climate change – increased water

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Most culverts under roads were designed to pass water, not fish or wildlife. Thus, many culverts represent significant barriers to the passage of aquatic organisms as well as some semi-aquatic wildlife, such as turtles. Photo credit: Scott Jackson.

Resources

North Atlantic Aquatic Connectivity Collaborative (NAACC)
Critical Linkages Phase I
MA Division of Ecological Restoration - Aquatic Ecosystem Restoration

Related Adaptation Strategies and Actions

Land protection: Strategic land protection
Maintain habitat connectivity: Assessment of road-stream crossings
Maintain habitat connectivity: Modify stream crossings to allow wildlife passage
Maintain habitat connectivity: Retrofit or replace culverts
Restore habitat connectivity: Remove obsolete dams

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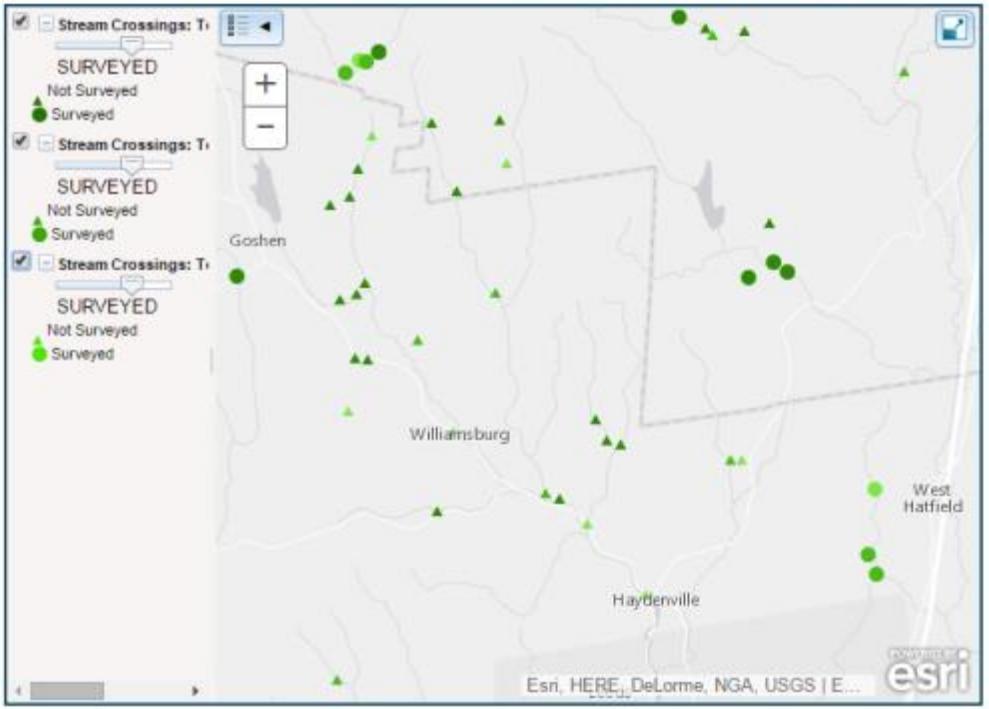
Adaptation Strategies and Actions

Maintain habitat connectivity: Retrofit or replace culverts

Adaptation type:
Removal of dams and other barriers to aquatic connectivity
Roadway infrastructure, crossings, and dams

Strategy:
Restore and maintain terrestrial and aquatic connectivity sufficient to maintain healthy ecosystems and wildlife populations



Priority crossings for possible culvert replacement or retrofit are represented by green dots and triangles. If these are not visible, use the plus sign to zoom in. You can layer in locations for...
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Animal movements (of individuals or their offspring) across the landscape are important for maintaining health wildlife populations. Climate change is likely to result in changes to habitat conditions (temperature, rainfall, vegetation) that will require adjustments in the areas occupied by many species. Restoring and maintaining landscape connectivity sufficient to allow wildlife populations to adjust their distribution over time is a critically important strategy for adapting to climate change.

Action

Replace or retrofit deficient culverts at strategic locations

It has been recognized that dams are significant barriers to upstream movement of fish and other aquatic organisms. Road-stream crossings, especially culverts, can also constitute barriers to aquatic organism passage. Although the impacts of dams may be more severe, road-stream

Action

Replace or retrofit deficient culverts at strategic locations

It has been recognized that dams are significant barriers to upstream movement of fish and other aquatic organisms. Road-stream crossings, especially culverts, can also constitute barriers to aquatic organism passage. Although the impacts of dams may be more severe, road-stream crossings are more numerous. Some culverts are severe barriers to upstream movement; others represent little or no barrier at all. And there are many in between.

Tools are now available to assess the passability of road-stream crossings and model their effects on aquatic connectivity. Volunteers and technicians working with state agencies and environmental organizations are using protocols from the North Atlantic Aquatic Connectivity Collaborative (NAACC) to assess the passability of bridges and culverts in the field. The University of Massachusetts Amherst uses Critical Linkages software to model crossings where upgrades would result in the largest benefits in terms of aquatic connectivity.

Field assessments and passability scores along with Critical Linkages analyses can be used to target specific culverts for replacement or retrofit. Culvert replacement involves the complete replacement of a sub-standard crossing with another, usually larger, structure. Retrofits are halfway measures such as the use of rock weirs to back up water just below the structure and eliminate outlet drops. In some cases, retrofits can improve aquatic passability at a road-stream crossing until such time that a full replacement is possible.

Culvert replacements are tricky business and replacement structures must be carefully designed, permitted and constructed. Attention must be paid to the potential for downstream flooding (larger structures will pass water more quickly) as well as the potential for stream adjustments such as erosion and head cutting (progressive erosion up the stream channel above the culvert). The stream channel and bed characteristics either need to be retained (bridged) or created within the crossing structure. Appropriate expertise and experience is required to design a stream bed that both simulates characteristics of the natural stream and is able to withstand velocities that are often higher in the structure than in the natural stream during periods of high flow.

Older crossing structures are often single or multiple culvert crossings designed with the sole objective of getting water from one side of the road to the other. Replacement structures that meet the Massachusetts River and Stream Crossing Standards are generally bridges, open bottom arches or large culverts designed according to the principles of Stream Simulation. Stream Simulation design seeks to create crossings that simulate the channel and bottom characteristics and replicate the water depth and velocity conditions found in the natural stream. The U.S. Forest Service has an in-depth manual on Stream Simulation Design that is the best current resource available for culvert replacements.

The Massachusetts Division of Ecological Restoration has a program that assists municipalities with culvert replacement projects. For more information contact Tim Chorey at timothy.chorey@state.ma.us or (617) 626-1541.

https://www.climateactiontool.org/content/maintain-habitat-connectivity-retrofit-or-replace-culverts
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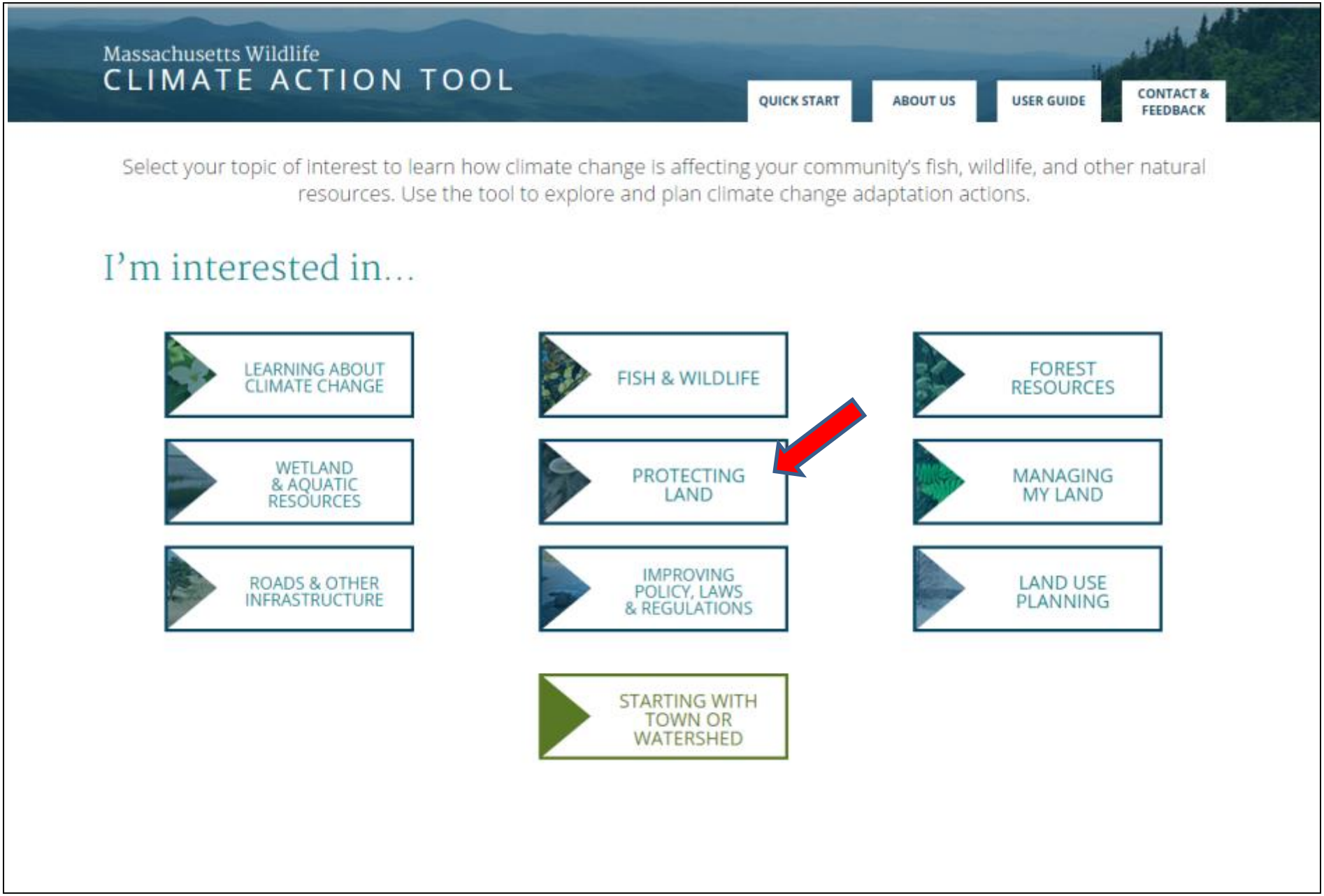
projects. Tim Chorey has extensive experience with culvert replacement, Stream Simulation design, and construction. He is available to provide technical assistance and can be reached at: email: timothy.chorey at state.ma.us or phone: (617) 626-1541.

Mitchell Brook in Whately, MA, before and after culvert replacement. The PVC piping in the photos are antennae to monitor the passage of fish through the crossing. Researchers report that not only are more brook trout moving from the West Brook up into Mitchell Brook but dace are now being found in the stream for the first time. Photo credits: Scott Jackson.

Resources

USFS Stream Simulation Manual
Design of Bridges and Culverts for Wildlife Passage at Freshwater Streams
Massachusetts Stream Crossings Handbook
Massachusetts Stream Crossings Poster
Massachusetts River and Stream Crossing Standards
Culvert Replacement Examples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Select your topic of interest to learn how climate change is affecting your community's fish, wildlife, and other natural resources. Use the tool to explore and plan climate change adaptation actions.
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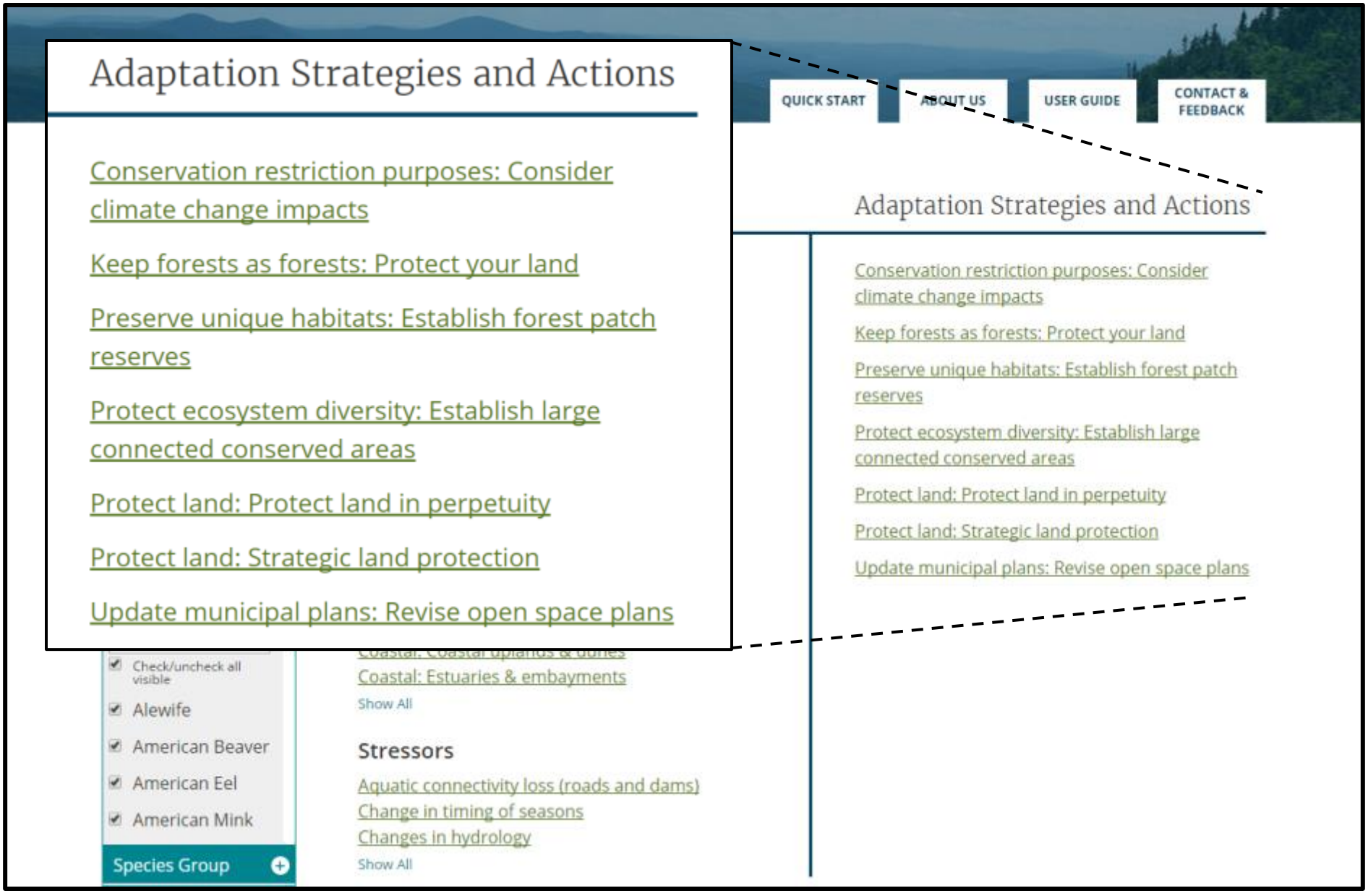
FISH & WILDLIFE
FOREST RESOURCES
WETLAND & AQUATIC RESOURCES
PROTECTING LAND
MANAGING MY LAND
ROADS & OTHER INFRASTRUCTURE
IMPROVING POLICY, LAWS & REGULATIONS
LAND USE PLANNING
STARTING WITH TOWN OR WATERSHED


Adaptation Strategies and Actions
Conservation restriction purposes: Consider climate change impacts
Keep forests as forests: Protect your land
Preserve unique habitats: Establish forest patch reserves
Protect ecosystem diversity: Establish large connected conserved areas
Protect land: Protect land in perpetuity
Protect land: Strategic land protection
Update municipal plans: Revise open space plans
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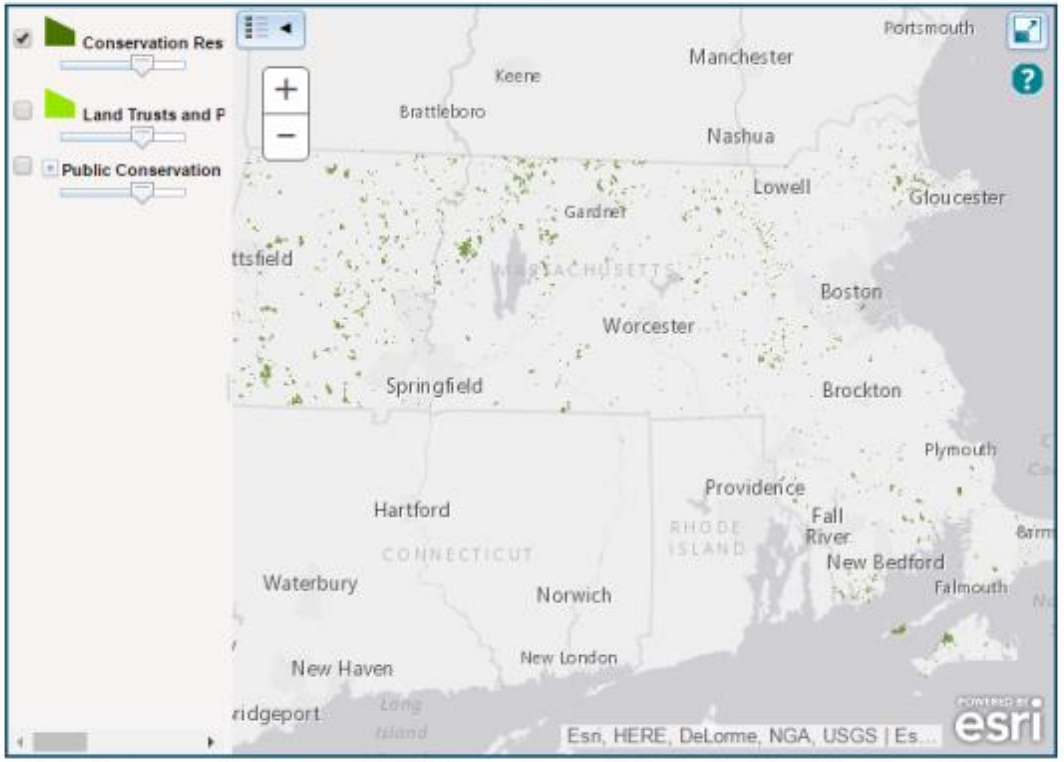
Update municipal plans: Revise open space plans
Check/uncheck all visible
Alewife
American Beaver
American Eel
American Mink
Species Group
Coastal: Estuaries & embayments
Show All
Stressors
Aquatic connectivity loss (roads and dams)
Change in timing of seasons
Changes in hydrology
Show All

Adaptation Strategies and Actions

Keep forests as forests: Protect your land

Adaptation type:
Land protection

Strategy:
Keep forests as forests by protecting your land for future generations



Protected conservation lands are depicted in three layers: 1) Conservation Restrictions Areas (private lands currently protected from development through the use of conservation restrictions). 2)...
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Action

Protect your land through conservation-based estate planning

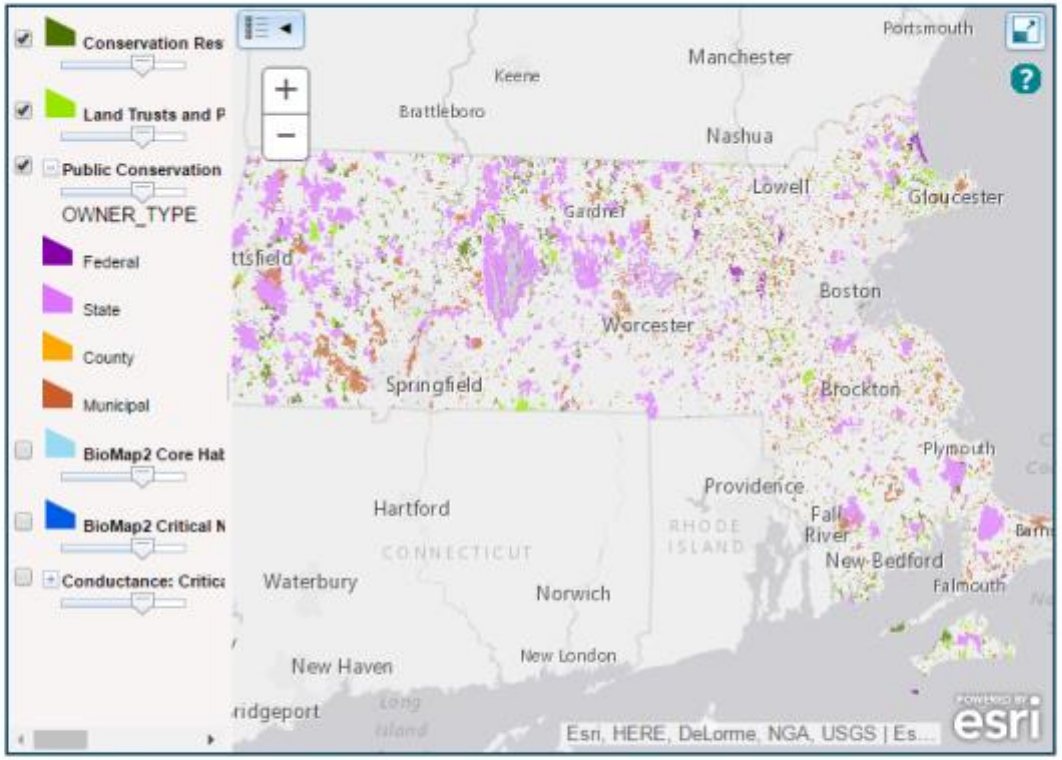
Why keep forests as forest?
Forests provide a natural buffer against the negative effects of climate change by storing and sequestering carbon, absorbing and filtering water, and providing shade for wildlife, streams and understory vegetation. Keeping forests as forest is critical to maintaining resilient forested ecosystems and ensuring their ability to provide these important services. One of the ways forests end up being developed is when land is

Adaptation Strategies and Actions

Protect land: Protect land in perpetuity

Adaptation type:
Land protection
Species conservation and management

Strategy:
Permanently protect enough undeveloped land to ensure healthy, self-sustaining ecosystems and maintain the Commonwealth's fish, wildlife and biodiversity resources



Protected conservation lands are depicted in three layers: 1) Conservation Restrictions Areas (private lands currently protected from development through the use of conservation restrictions), 2)...
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Unlike western states, where public lands make up a large proportion of the landscape, the vast majority of Massachusetts is private land. Given the large number of landowners in MA, it is an ongoing challenge to protect interconnected areas of sufficient size to support wildlife, biodiversity, and ecosystem services for future generations. Large, interconnected conservation lands are particularly important as a strategy for adapting to climate change because the distributions of plants and animals are likely to shift and keep shifting as temperatures, precipitation, storms, sea level rise and the timing of seasons continue to change over the next several decades.

Action

Protect your land and encourage others to protect their land
The concept of land ownership means little to forests, wildlife, water and soil. Yet to ensure that the wild lands of Massachusetts retain their

Options for protecting your land[1]:

Donating or Selling Conservation Restrictions. Your land includes several different types of rights, including the right to develop your land, farm, hunt, and manage your woods. A conservation restriction (known as a conservation easement in states other than Massachusetts) is a legal agreement that extinguishes some or all of the development rights of the land forever, but allows your other rights, such as farming, forestry, and recreation to continue, all while maintaining your ownership of the land.

A conservation restriction (CR) is a flexible tool that can be placed on all or only designated parts of your land, allowing you to reserve house lots to provide financial value or housing options for your family. Some CRs allow public access, others do not—it usually depends on which organization you work with and whether you are receiving funds for your CR.

A CR can be donated, which often provides the landowner with a tax deduction for a charitable gift. A CR can be sold for income if the land has exceptional natural resources. A CR can also be sold below market value for both income and tax benefits (see "Bargain Sale" below).

Donating or Selling Land. Land can be permanently protected by donating it or selling it to a qualified conservation organization, such as a land trust or state conservation organization. Donations of land may provide significant tax advantages as a charitable gift.

Bargain Sale. Landowners can sell their land or conservation restrictions at a price below its fair market value. The difference between the appraised market value and the sale price to a qualified conservation organization, such as a land trust or a state conservation organization, is considered a tax-deductible charitable contribution, providing some income and potentially some tax benefits.

Bequest. A donation of land or a conservation restriction through your will is another way to ensure your land's permanent protection and potentially to reduce your estate tax burden. You can change your will at any time, and a bequest does not become effective until your death. This is a good approach if you need to keep the financial value of your property in reserve in case of unexpected medical bills or other needs, but want to be sure the land will be conserved if you do not need to sell it during your lifetime.

Reserved Life Estate. Landowners sometimes negotiate a gift or sale of the property while reserving the right to occupy and use the property for life. Upon the death of the landowner, control of the property automatically transfers to a conservation organization. The gift of a property with a reserved life estate can qualify the donor for a charitable deduction based on the value of the property donated and the reserved life estate, which is all based on the donor's age.

Limited Development. Limited development protects the majority of the land while a small portion is sold or maintained by the landowner for future development. In a limited development scenario, the areas with the greatest conservation value are protected through one of the tools described above, while other less sensitive areas of the land are set aside for future development.

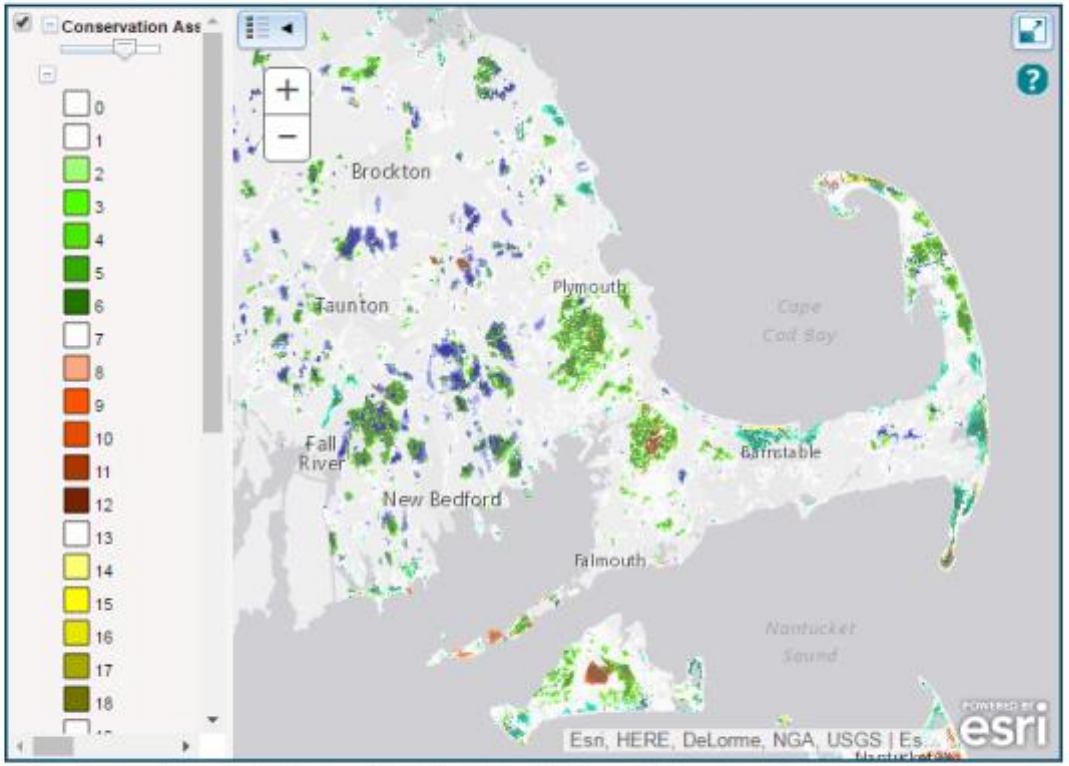
For more information about each of these options, visit: www.masswoods.net. The site includes a feature you can use to find land trusts and other professionals in your area that you can work with to protect your land. For parcel level information about the habitat value of undeveloped land, use Massachusetts Audubon's Mapping & Prioritizing Parcels for Resilience Project tool.

Adaptation Strategies and Actions

Protect ecosystem diversity: Establish large connected conserved areas

Adaptation type:
Land protection

Strategy:
Protect ecosystem diversity



The first two layers depict Index of Ecological Integrity Scores (IEI-I) produced by the Conservation Assessment and Prioritization System (CAPS) at UMass Amherst for those areas identified as...
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Action

Establish large connected conservation areas
It is likely that trees and wildlife within large natural areas of thousands of acres will be most resilient to the impacts of climate change. Large areas of conserved land typically provide enough site and species diversity to sustain the impacts we expect from a changing climate. Though your land is not thousands of acres in size, it plays a very important part within the larger landscape. Combined with other properties, it is a part of a landscape that is thousands of acres in size.

Determine if your land is part of an important group of conserved land that acts as a core wildlife habitat area. Conserving connections between

Adaptation Strategies and Actions

Conservation restriction purposes: Consider climate change impacts

Adaptation type:
Land protection
Planning and prioritization
Policy, laws, and regulations

Strategy:
Ensure that conservation restrictions remain viable as the climate changes

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Action

Define multiple, clearly articulated purposes for a conservation restriction that will stay relevant as the landscape changes.

Conservation restrictions and purposes
A conservation restriction (or conservation easement) is one of several methods for protecting land. Conservation restrictions may be permanent or temporary and are legally binding agreements between a landowner and land trust or other agency designed to protect certain conservation values of a piece of land. These agreements restrict allowed uses of the land, including future development or subdivision. Conservation restrictions contain purposes that specify the reasons for protecting a site and are used to help manage that property.

The purpose clause is arguably the most important in a conservation restriction as it outlines the conservation values the landowner and easement holder wish to protect and provides the logic for the restricted uses on the land. Purposes can be very specific (to protect a certain species), or they can be more general (to protect open space within the landscape). These goals are often negotiated by the conservation restriction holder and the landowner when the easement is being finalized.

Applicants seeking to receive federal tax deductions for conservation easements must include one of the following purposes:

Future Phases

Next Steps – Phase 2:

- Develop new content and showcase expertise of partners
- Expand
  - Coastal resources
  - Municipal land use planning
  - Vulnerable habitats and species
- Enhance website functionality
  - Provide outputs/favorites to help users plan
  - Share case studies and success stories contributed by practitioners
  - Incorporate more images and graphics

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Phase 3:

- Expand content to address transportation, emergency services & critical infrastructure and provide communities with climate change vulnerability information

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THANKS!

QUESTIONS?

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