CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES
VERMONT

Vermont's forests will be affected by a changing climate and other stressors during this century. A team of managers and researchers created an assessment that describes the vulnerability of forests in the New England and northern New York region (Janowiak et al. 2018). This report includes information on observed and future climate trends, and also summarizes key vulnerabilities for forested natural communities. The Landscape Change Research Group recently updated the Climate Change Tree Atlas, and this handout summarizes that information. Full Tree Atlas results are available online at www.fs.usda.gov/nrs/atlas/. Two climate scenarios are presented to "bracket" a range of possible futures. These future climate projections (2070 to 2099) provide information about how individual tree species may respond to a changing climate. Results for "low" and "high" emissions scenarios can be compared on the reverse side of this handout.

The updated Tree Atlas presents additional information helpful to interpret tree species changes:

- *Suitable habitat* - calculated based on 39 variables that explain where optimum conditions exist for a species, including soils, landforms, and climate variables.
- *Adaptability* - based on life-history traits that might increase or decrease tolerance of expected changes, such as the ability to withstand different forms of disturbance.
- *Capability* - a rating of the species' ability to cope or persist with climate change in this region based on suitable habitat change (statistical modeling), adaptability (literature review and expert opinion), and abundance (FIA data). The capability rating is modified by abundance information; ratings are downgraded for rare species and upgraded for abundant species.
- *Migration Potential Model* - when combined with habitat suitability, an estimate of a species' colonization likelihood for new habitats. This rating can be helpful for assisted migration or focused management (see the table section: "New Habitat with Migration Potential").

Remember that models are just tools, and they're not perfect. Model projections can't account for all factors that influence future species success. If a species is rare or confined to a small area, model results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions. Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change.

GOOD CAPABILITY	
American basswood	Ironwood
American elm	Mockernut hickory
Bigtooth aspen	Northern red oak
Bitternut hickory	Quaking aspen
Black cherry	Red maple
Black locust	Sugar maple
Black oak	Swamp white oak
Chestnut oak	Sweet birch
Eastern redcedar	White oak
FAIR CAPABILITY	
American beech	Green ash
Balsam fir	Serviceberry
Boxelder	Shagbark hickory
Bur oak	Silver maple
Eastern cottonwood	White ash
Eastern hemlock	White spruce
Eastern white pine	Yellow birch
POOR CAPABILITY	
American hornbeam	Northern white-cedar
American mountain-ash	Paper birch
Atlantic white-cedar	Pin cherry
Balsam poplar	Red pine
Black ash	Red spruce
Black spruce	Slippery elm
Gray birch	Striped maple
Mountain maple	Tamarack (native)
NEW HABITAT WITH MIGRATION POTENTIAL	
Bald cypress	Pecan
Black hickory	Pignut hickory
Blackgum	Pin oak
Blackjack oak	Pitch pine
Chinkapin oak	Post oak
Common persimmon	Sassafras
Eastern redbud	Scarlet oak
Flowering dogwood	Shingle oak
Hackberry	Shumard oak
Honeylocust	Sugarberry
Northern pin oak	Sweetgum
Osage-orange	Sycamore
Overcup oak	Virginia pine
Pawpaw	Water hickory

SOURCE: *This handout summarizes the full model results for the State of Vermont. Full results are available at https://www.fs.usda.gov/nrs/atlas/combined/resources/summaries/NCA/. More information on vulnerability and adaptation in the New England region can be found at www.forestadaptation.org/new-england. A full description of the models and variables are provided in Iverson et al. 2019 (www.nrs.fs.fed.us/pubs/57857 and www.nrs.fs.fed.us/pubs/59105) and Peters et al. 2019 (www.nrs.fs.fed.us/pubs/58353).*

NIACS
Northern Institute of Applied Climate Science
www.forestadaptation.org

ADAPTABILITY: Life-history factors, such as the ability to respond favorably to disturbance, that are not included in the Tree Atlas model and may make a species more or less able to adapt to future stressors.

- \+ **HIGH** *Species may perform better than modeled*
- • **MEDIUM**
- – **LOW** *Species may perform worse than modeled*

HABITAT CHANGE: Projected change in suitable habitat between current and potential future conditions.

- ▲ **INCREASE** *Projected increase of >20% by 2100*
- ● **NO CHANGE** *Projected change of <20% by 2100*
- ▼ **DECREASE** *Projected decrease of >20% by 2100*
- ★ **NEW HABITAT** *Tree Atlas projects new habitat for species not currently present*

ABUNDANCE: Based on Forest Inventory Analysis (FIA) summed Importance Value data, calibrated to a standard geographic area.

- \+ **ABUNDANT**
- • **COMMON**
- – **RARE**

CAPABILITY: An overall rating that describes a species' ability to cope or persist with climate change based on suitable habitat change class (statistical modeling), adaptability (literature review and expert opinion), and abundance within this region.

- △ **GOOD** *Increasing suitable habitat, medium or high adaptability, and common or abundant*
- ○ **FAIR** *Mixed combinations, such as a rare species with increasing suitable habitat and medium adaptability*
- ▽ **POOR** *Decreasing suitable habitat, medium or low adaptability, and uncommon or rare*

SPECIES	ADAPT	ABUN	LOW CLIMATE CHANGE (RCP 4.5) HABITAT CHANGE	LOW CLIMATE CHANGE (RCP 4.5) CAPABILITY	HIGH CLIMATE CHANGE (RCP 8.5) HABITAT CHANGE	HIGH CLIMATE CHANGE (RCP 8.5) CAPABILITY
American basswood	•	–	▲	△	▲	△
American beech	•	+	▼	○	▼	○
American elm	•	•	▲	△	▲	△
American hornbeam*	•	–	●	▽	●	▽
American mountain-ash*	–	–	▼	▽	▼	▽
Atlantic white-cedar*	–	–	▼	▽	▼	▽
Bald cypress	•		★		★	
Balsam fir	–	+	▼	○	▼	○
Balsam poplar	•	–	▼	▽	▼	▽
Bigtooth aspen	•	–	▲	△	▲	△
Bitternut hickory*	+	–	▲	△	▲	△
Black ash	–	•	▼	▽	▼	▽
Black cherry	–	•	▲	△	▲	△
Black hickory	•		★		★	
Black locust*	•	–	▲	△	▲	△
Black oak	•	–	▲	△	▲	△
Black spruce	•	–	▼	▽	▼	▽
Black walnut*	•	–	▲	○	▲	△
Black willow*	–		★		★	
Blackgum	+		★		★	
Blackjack oak	+		★		★	
Boxelder*	+	–	●	○	●	○
Bur oak	+	–	●	○	●	○
Chestnut oak	+	–	▲	△	▲	△
Chinkapin oak	•		★		★	
Cittamwood*	+		★		★	
Common persimmon*	+		★		★	
Eastern cottonwood*	•	–	●	▽	▲	○
Eastern hemlock	–	+	●	○	▼	○
Eastern redbud*	•		★		★	
Eastern redcedar	•	–	▲	△	▲	△
Eastern white pine	–	+	▲	△	●	○
Flowering dogwood	•		★		★	
Gray birch*	•	–	▼	▽	●	▽
Green ash*	•	–	●	▽	▲	○
Hackberry	+		★		★	
Honeylocust*	+		★		★	
Ironwood*	+	•	●	△	●	△
Mockernut hickory	+	–	▲	△	▲	△
Mountain maple*	+	–	▼	▽	▼	▽
Mountain magnolia*			★		★	
Northern pin oak	+		★		★	
Northern red oak	+	•	▲	△	▲	△
Northern white-cedar	•	•	▼	▽	▼	▽
Osage-orange	+		★		★	
Overcup oak	–		★		★	
Paper birch	•	•	●	○	▼	▽
Pawpaw*	•		★		★	
Pecan*	–		★		★	
Pignut hickory	•		★		★	
Pin cherry*	•	•	▼	▽	▼	▽
Pin oak*	–		★		★	
Pitch pine	•		★		★	
Post oak	+		★		★	
Quaking aspen	•	•	▲	△	▲	△
Red maple	+	+	▲	△	▲	△
Red pine	–	–	●	▽	●	▽
Red spruce	–	•	▼	▽	▼	▽
Sassafras*	•		★		★	
Scarlet oak	•		★		★	
Serviceberry*	•	–	▲	○	▲	○
Shagbark hickory	•	–	▲	○	▲	△
Shingle oak	•		★		★	
Shumard oak*	+		★		★	
Silver maple*	+	–	●	○	●	○
Slippery elm*	•	–	●	▽	●	▽
Striped maple	•	–	▼	▽	▼	▽
Sugar maple	+	+	▼	△	▼	△
Sugarberry	•		★		★	
Swamp white oak*	•	–	▲	△	▲	△
Sweet birch	–	•	▲	△	▲	△
Sweetgum	•		★		★	
Sycamore*	•		★		★	
Tamarack (native)	–	–	▼	▽	▼	▽
Virginia pine	•		★		★	
Water hickory	•		★		★	
White ash	•	–	▲	○	▲	○
White oak	+	–	▲	△	▲	△
White spruce	•	•	▼	▽	●	○
Willow oak*	•		★		★	
Winged elm	•		★		★	
Yellow birch	•	+	▼	○	▼	○
Yellow-poplar	+		★		★	

**Species with low model reliability based on five statistical metrics of the habitat models that affect change class.*