Updated Projections of Species Response to Climate Change

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NIACS
Northern Institute of Applied Climate Science

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Climate Change and Forests

There is a great deal of interest among forest managers for integrating information about anticipated climate impacts and risks into management planning and activities. Models that project tree species responses to climate change provide valuable information to help managers understand potential changes in tree species habitat suitability so that they can proactively respond in a manner that minimizes negative impacts and facilitates ecosystem adaptation.

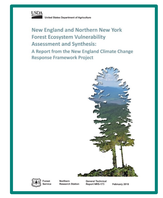
Multistage Modeling **Framework**

The Climate Change Tree Atlas provides a multistage decision support framework to guide management of tree species under climate change. Since its initial development, the species distribution model DISTRIB has been used to predict the habitat quality for individual tree species under a variety of climate scenarios. An updated version of the model, now called DISTRIB-II, incorporates updates to the underlying climate and environmental datasets and application of advanced processing techniques that increase overall model performance and allow for new data outputs. The merger of DISTRIB-II with SHIFT, a model projecting potential migration over 100 years into suitable habitat depicted by DISTRIB-II, allows a robust assessment of the most viable species for managing in the face of a changing climate.

Decision Support

Projected changes in habitat quality from the DISTRIB model have been an important component of the Climate Change Response Framework and a regional climate change vulnerability assessment for forest ecosystems. The new DISTRIB-II/SHIFT data provide an updated dataset that can be used to supplement the current resources, particularly at finer spatial scales.

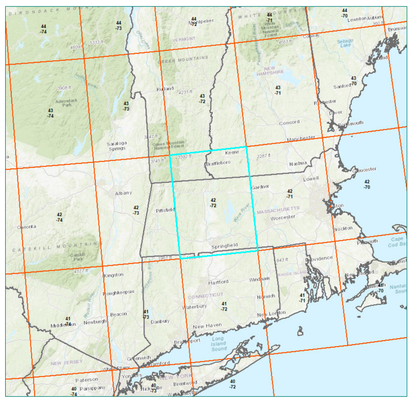
View the vulnerability assessment, interactive StoryMap, and more at
www.forestadaptation.org/new-england



Example **Data**

A primary product of the DISTRIB-II modeling effort is the compilation of higher-resolution data across a 1×1 degree grid.

These new data are presented in the table using the mapped area bounded by 42ºN on south and -72ºW on east near Amherst, MA.



Tree Species outputs for 1x1º

Common Name	Scientific Name	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
red maple	Acer rubrum	High	98.5	2149.63	15.79	No change	Sm. dec.	High	Abundant	Very Good	Good			1	1
eastern hemlock	Tsuga canadensis	High	84.4	1665.56	14.71	Lg. dec.	Lg. dec.	Low	Abundant	Poor	Poor			0	2
eastern white pine	Pinus strobus	High	86.1	1608.26	13.77	Sm. dec.	Lg. dec.	Low	Abundant	Fair	Poor			0	3
northern red oak	Quercus rubra	Medium	80.4	1091.54	10.09	No change	No change	High	Abundant	Very Good	Very Good			1	4
sugar maple	Acer saccharum	High	65.7	716.91	7.1	Sm. inc.	Sm. inc.	High	Abundant	Very Good	Very Good			1	5
sweet birch	Betula lenta	High	75.7	622.38	6.15	No change	Sm. dec.	Low	Abundant	Fair	Fair			0	6
American beech	Fagus grandifolia	High	65.4	609.27	6.5	No change	No change	Medium	Abundant	Good	Good			1	7
yellow birch	Betula alleghaniensis	High	66.6	471.1	4.59	No change	Sm. dec.	Medium	Common	Fair	Poor			1	8
white ash	Fraxinus americana	Medium	67.4	369	4	Sm. inc.	Sm. inc.	Low	Common	Fair	Fair			1	9
black cherry	Prunus serotina	Medium	69.4	325.75	3.31	Sm. inc.	Sm. inc.	Low	Common	Fair	Fair			1	10
paper birch	Betula papyrifera	High	68.6	265.73	2.87	Lg. dec.	Lg. dec.	Medium	Common	Poor	Poor			0	11
white oak	Quercus alba	Medium	45.2	257.42	4.02	Lg. inc.	Lg. inc.	High	Common	Very Good	Very Good			1	12
black oak	Quercus velutina	High	39.6	226.22	4.8	Lg. inc.	Lg. inc.	Medium	Common	Very Good	Very Good			1	13
red spruce	Picea rubens	High	23.5	217.36	5.44	Lg. dec.	Lg. dec.	Low	Common	Very Poor	Very Poor			0	14
quaking aspen	Populus tremuloides	High	22.3	125.54	4.54	No change	No change	Medium	Common	Fair	Fair			1	15
scarlet oak	Quercus coccinea	Medium	17.8	121.1	5.38	Lg. inc.	Lg. inc.	Medium	Common	Very Good	Very Good			1	16
American elm	Ulmus americana	Medium	23.2	98.82	3.13	Sm. dec.	No change	Medium	Common	Poor	Fair			1	17
balsam fir	Abies balsamea	High	12.8	89.31	3.68	Lg. dec.	Lg. dec.	Low	Common	Very Poor	Very Poor			0	18
bigtooth aspen	Populus grandidentata	Medium	14	87.93	5.32	Sm. inc.	No change	Medium	Common	Good	Fair			1	19
pignut hickory	Carya glabra	Medium	20.9	82.75	3.22	Lg. inc.	Lg. inc.	Medium	Common	Very Good	Very Good			1	20
shagbark hickory	Carya ovata	Medium	13.7	52.03	2.66	Lg. inc.	Lg. inc.	Medium	Common	Very Good	Very Good			1	21
chestnut oak	Quercus prinus	High	10.6	51.3	4.54	Lg. inc.	Lg. inc.	High	Common	Very Good	Very Good	Infill ++	Infill ++	1	22
silver maple	Acer saccharinum	Low	1.8	49.65	16.63	Sm. dec.	No change	High	Rare	Poor	Fair		Infill +	2	23
gray birch	Betula populifolia	Low	15.4	37.17	2.05	Sm. dec.	No change	Medium	Rare	Very Poor	Poor			1	24
striped maple	Acer pensylvanicum	Medium	20.3	35.97	1.26	Sm. dec.	Lg. dec.	Medium	Rare	Very Poor	Very Poor			0	25
eastern hophornbeam; iro	Ostrya virginiana	Low	25.2	35.64	1.24	No change	Lg. inc.	High	Rare	Fair	Good			1	26
red pine	Pinus resinosa	Medium	6	23.27	2.74	Very Lg. dec	Very Lg. dec	Low	Rare	Lost	Lost			0	27
Norway spruce	Picea abies	FIA	2.3	22.85	6.73	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	28
pin cherry	Prunus pensylvanica	Low	7.9	17.19	1.48	Sm. dec.	Lg. dec.	Medium	Rare	Very Poor	Very Poor			0	29
American hornbeam; musc	Carpinus caroliniana	Low	11.8	13.72	1.1	Sm. dec.	Lg. inc.	Medium	Rare	Very Poor	Good			1	30
eastern redcedar	Juniperus virginiana	Medium	2.9	13.23	3.55	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	2	31
American chestnut	Castanea dentata	FIA	6.1	12.98	1.19	Unknown	Unknown	Medium	Rare	FIA Only	FIA Only			0	32
American basswood	Tilia americana	Medium	6.2	10.52	1.19	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	1	33
serviceberry	Amelanchier spp.	Low	4.5	10.23	0.73	No change	No change	Medium	Rare	Poor	Poor			1	34
black locust	Robinia pseudoacacia	Low	2.2	9.5	4.33	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	2	35
yellow-poplar	Liriodendron tulipifera	High	1.1	9.09	8.3	Lg. inc.	Lg. inc.	High	Rare	Good	Good			2	36
blackgum	Nyssa sylvatica	Medium	5.9	8.9	1.14	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	1	37
eastern cottonwood	Populus deltoides	Low	3.1	8.65	2.56	Sm. dec.	Sm. dec.	Medium	Rare	Very Poor	Very Poor			0	38
black walnut	Juglans nigra	Low	1.1	7.04	6.43	Sm. dec.	No change	Medium	Rare	Very Poor	Poor		Infill +	2	39

Common Name	Scientific Name	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
sassafras	Sassafras albidum	Low	1.7	6.68	2.6	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	2	40
ailanthus	Ailanthus altissima	FIA	1.1	6.52	5.95	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	41
green ash	Fraxinus pennsylvanica	Low	2.2	6.3	2.88	No change	Lg. inc.	Medium	Rare	Poor	Good	Infill +	Infill ++	2	42
pitch pine	Pinus rigida	High	3.3	5.53	1.68	No change	Sm. inc.	Medium	Rare	Poor	Fair	Infill +	Infill +	1	43
bitternut hickory	Carya cordiformis	Low	2.8	5.11	1.36	No change	Lg. inc.	High	Rare	Fair	Good	Infill +	Infill ++	2	44
slippery elm	Ulmus rubra	Low	2.2	4.71	2.15	Sm. dec.	Sm. dec.	Medium	Rare	Very Poor	Very Poor			0	45
mockernut hickory	Carya alba	Medium	2.2	3.03	1.39	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	46
mountain maple	Acer spicatum	Low	2.3	2.32	0.65	Lg. dec.	Lg. dec.	High	Rare	Poor	Poor			1	47
swamp chestnut oak	Quercus michauxii	Low	1.1	2.27	2.07	Sm. dec.	Sm. dec.	Medium	Rare	Very Poor	Very Poor			2	48
black ash	Fraxinus nigra	Medium	1.1	2.11	1.93	Sm. dec.	Very Lg. dec	Low	Rare	Very Poor	Lost			2	49
white spruce	Picea glauca	Medium	1.1	1.13	1.03	Very Lg. dec	Very Lg. dec	Medium	Rare	Lost	Lost			0	50
Norway maple	Acer platanoides	FIA	0.9	0.99	0.77	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	51
swamp white oak	Quercus bicolor	Low	1.1	0.99	0.9	Sm. inc.	Lg. inc.	Medium	Rare	Fair	Good	Infill +		2	52
boxelder	Acer negundo	Low	1.1	0.82	0.75	Very Lg. dec	No change	High	Rare	Lost	Fair		Infill +	2	53
black spruce	Picea mariana	High	1.1	0.8	0.73	Very Lg. dec	Very Lg. dec	Medium	Rare	Lost	Lost			0	54
tamarack (native)	Larix laricina	High	0.2	0.38	0.07	Lg. dec.	Lg. dec.	Low	Rare	Very Poor	Very Poor			0	55
American mountain-ash	Sorbus americana	Low	0.2	0.31	0.06	Lg. dec.	Sm. dec.	Low	Rare	Very Poor	Very Poor			0	56
shortleaf pine	Pinus echinata	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate ++	3	57
loblolly pine	Pinus taeda	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate ++	3	58
Virginia pine	Pinus virginiana	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate ++	3	59
cittamwood/gum bumelia	Sideroxylon lanuginosum	Low	0	0	0	Unknown	Unknown	High	Absent	Unknown	Unknown			0	60
pecan	Carya illinoinensis	Low	0	0	0	Unknown	New Habitat	Low	Absent	Unknown	New Habitat			0	61
black hickory	Carya texana	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	62
sugarberry	Celtis laevigata	Medium	0	0	0	Unknown	New Habitat	Medium	Absent	Unknown	New Habitat			0	63
eastern redbud	Cercis canadensis	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	64
flowering dogwood	Cornus florida	Medium	0	0	0	Unknown	New Habitat	Medium	Absent	Unknown	New Habitat		Likely +	3	65
common persimmon	Diospyros virginiana	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate +	3	66
American holly	Ilex opaca	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	67
sweetgum	Liquidambar styraciflua	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate ++	3	68
bigleaf magnolia	Magnolia macrophylla	Low	0	0	0	Unknown	Unknown	Medium	Absent	Unknown	Unknown			0	69
sourwood	Oxydendrum arboreum	High	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	70
sycamore	Platanus occidentalis	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	71
southern red oak	Quercus falcata	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate +	3	72
cherrybark oak; swamp re	Quercus pagoda	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	73
blackjack oak	Quercus marilandica	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	74
chinkapin oak	Quercus muehlenbergii	Medium	0	0	0	Unknown	New Habitat	Medium	Absent	Unknown	New Habitat		Migrate +	3	75
water oak	Quercus nigra	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	76
post oak	Quercus stellata	High	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate ++	3	77
winged elm	Ulmus alata	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	78

Citations

Iverson, LR, AM Prasad, MP Peters & SN Matthews. 2019. Facilitating adaptive forest management under climate change: A spatially specific synthesis of 125 species for habitat changes and assisted migration over the eastern United States. *Forests* 10, 989.

Iverson, LR, MP Peters, AM Prasad, & SN Matthews. 2019. Analysis of climate change impacts on tree species of the eastern US: Results of DISTRIB-II modeling. *Forests*, 10, 302.

Peters, MP, LR Iverson, AM Prasad, & SN Matthews. 2019. Utilizing the density of inventory samples to define a hybrid lattice for a macro-level species distribution model. *Ecology and Evolution*, 9, 8876-8899.

Interpretation of table

The table is sorted from most to least abundant species in the 1×1º area, represented by FIAsum and led by red maple, eastern hemlock, eastern white pine, and northern red oak. The columns represent the reliability to the model for each species (MR), the approximate percent area of current suitable habitat for each species (%Cell), the overall abundance across the 1×1º (FIAsum), the average abundance of the species where it is present (FIAiv), the potential change in suitable habitat according to low (ChngCl45) or high (ChngCl85) emissions, the adaptability of the species to the changing climate (Adap), the abundance class (Abund), the capability of the species to cope with a changing climate (Capabil45 or Capabil85), the potential of the species to infill inside the 1×1º or migrate into the 1×1º (SHIFT45 or SHIFT85), the species selection option for planting (SSO:1=good to plant, here already and should be good in future; SSO:2=good to plant, rare now but could expand; SSO:3=good candidate to plant but not here now), and the number of species being evaluated (N=78 for this 1×1º). As such, up to 16 species could be considered as potential candidates for planting proactively via assisted migration if aligned with management goals.