



Seeding ecosystems of the future

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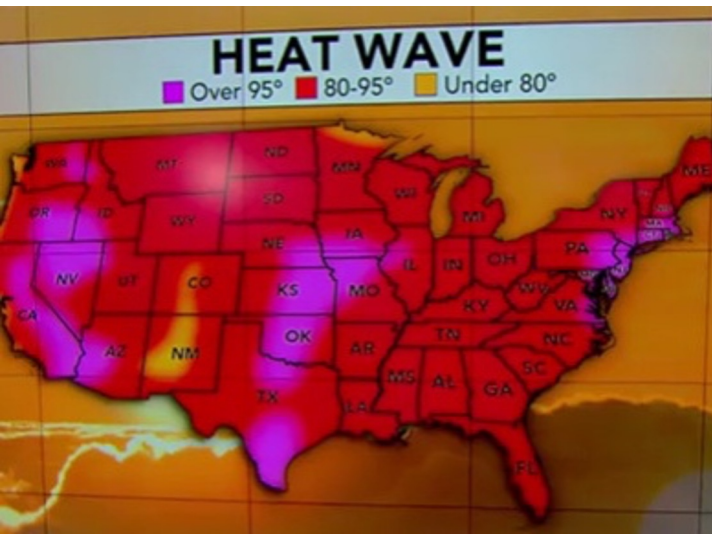
NECASc
Northeast Climate Adaptation Science Center



High Meadows
Environmental
Institute

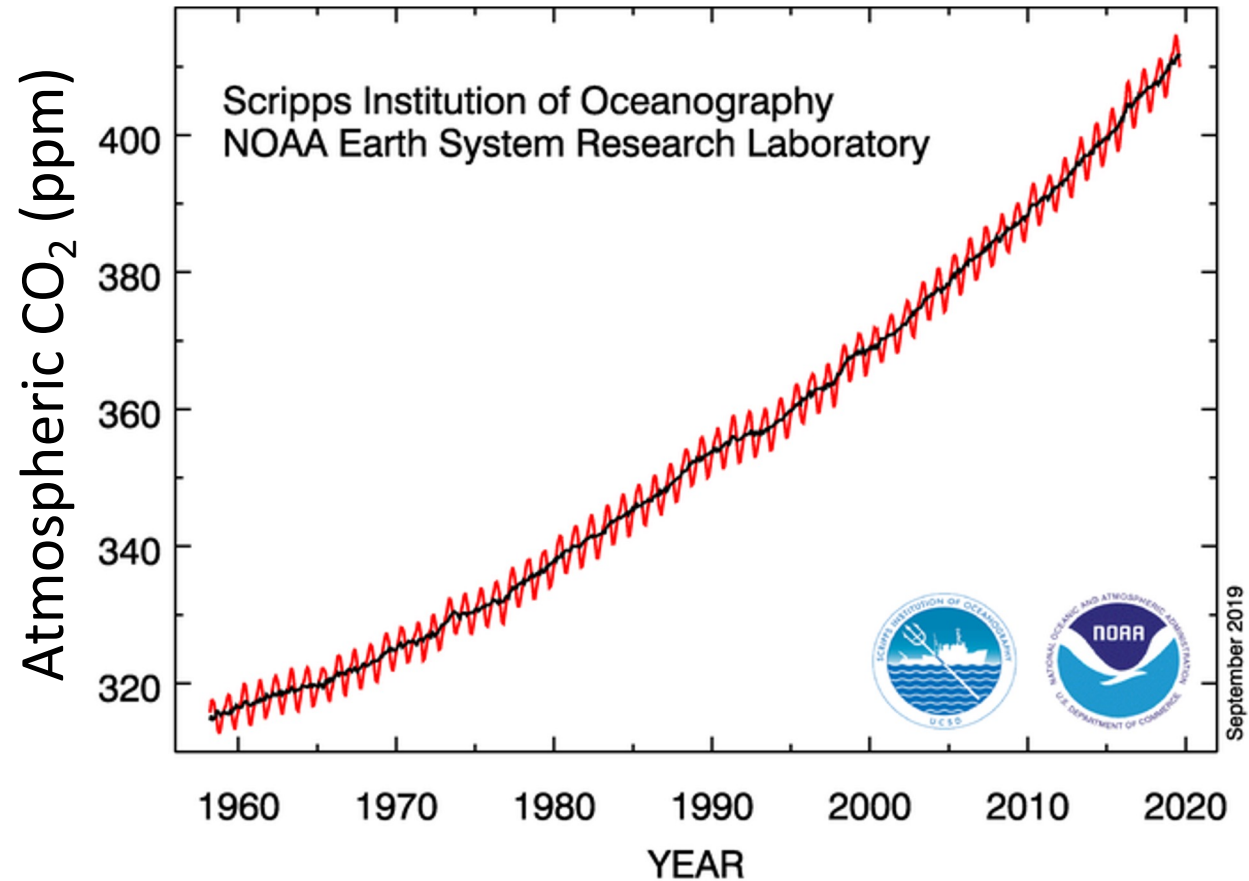
Outline

1. Brief overview of climate change
2. Impact on species
3. Gardens to support native biodiversity
4. Gardens as a pathway for invasion



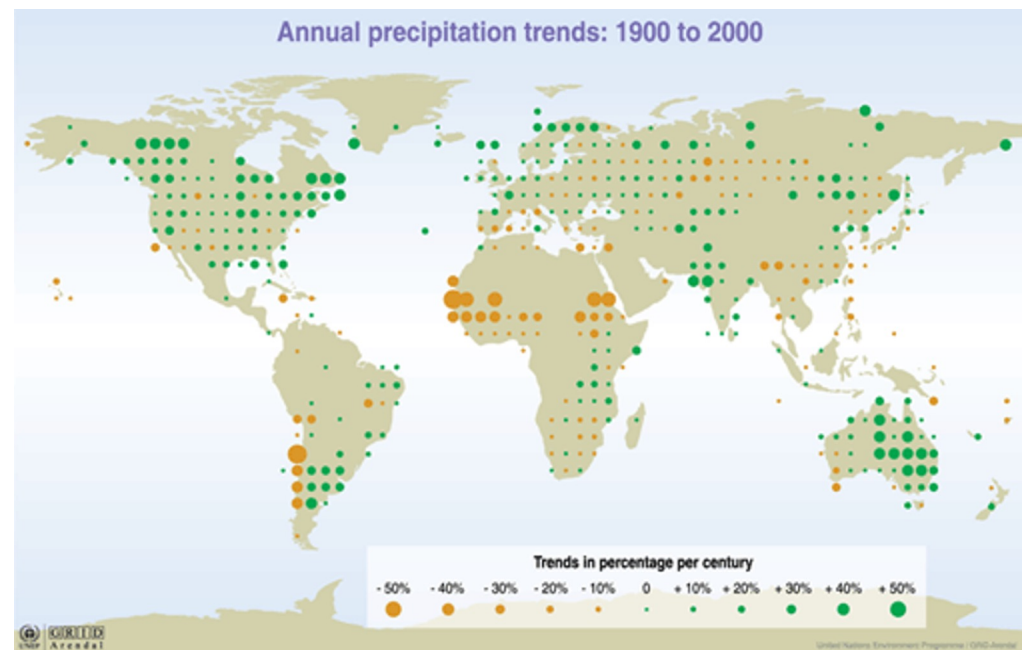
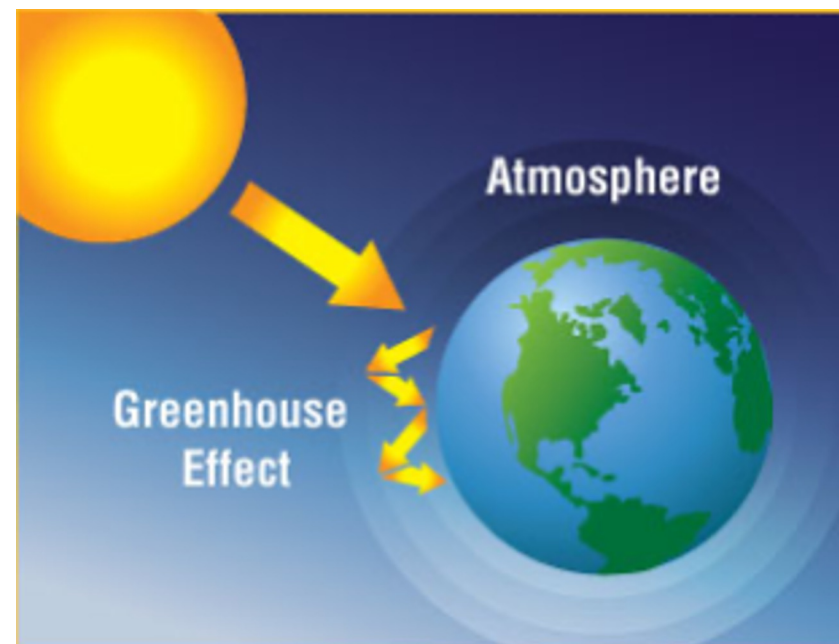
Rising CO₂: Not normal

- Risen from 280ppm pre-industrial
- Over 400ppm today



What does rising CO₂ mean for climate?

1. Rising temperatures (stronger greenhouse effect)
2. Altered precipitation (varies by region)

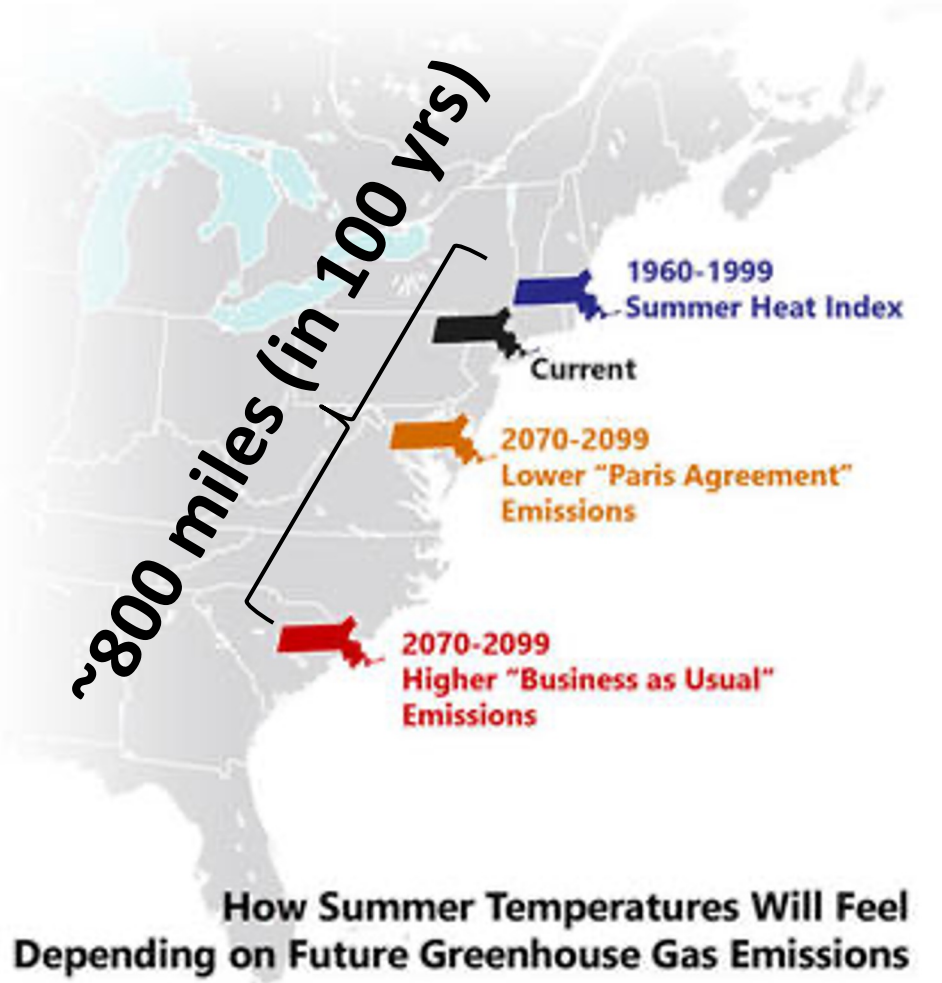


Temperatures are warming

Warming of 1°C (~2°F) has already occurred

Goal is to limit warming to 2°C (Paris Agreement)

Longer growing seasons are *'virtually certain'* (IPCC, 2013)



Temperatures are warming

FOURTH NATIONAL CLIMATE ASSESSMENT

CHAPTER 18: NORTHEAST

By 2035, and under both lower and higher scenarios (RCP4.5 and RCP8.5), the Northeast is projected to be more than 3.6°F (2°C) warmer on average than during the preindustrial era. This would be the largest increase in the contiguous United States and would occur as much as two decades before global average temperatures reach a similar milestone.³⁶



Also changing – more extreme extremes

WARMING

RUTGERS | NJ Climate Change Resource Center


Heat Wave: Is This Scorcher ‘the New Normal’ for NJ?

Excessive heat warnings and heat advisories are in place across the state

Coastal flooding expected to worsen at the Jersey Shore

By [Trish Hartman](#) and Sharifa Jackson via 

Tuesday, October 4, 2022 4:30AM

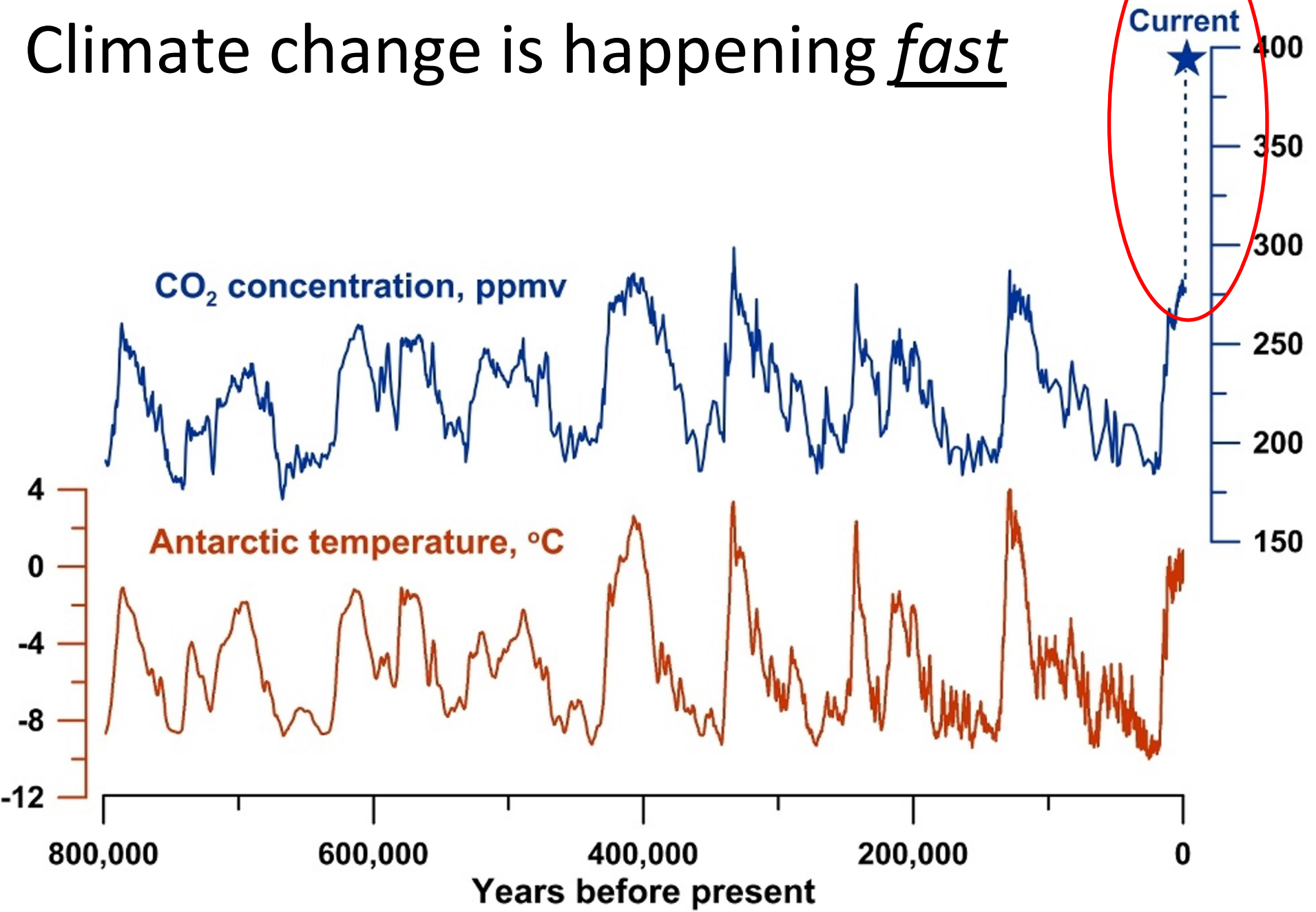
Ida’s Fierce Toll: 10 Dead, Massive Flooding, Thousands Forced from Homes

September 5, 2021

BRENDA FLANAGAN / NJ SPOTLIGHT NEWS

[Read More »](#)

Climate change is happening fast



Take home point:

- Temperatures are rising. Droughts, floods, and hurricanes are becoming more extreme.
- “The Northeast has seen a greater recent increase in extreme precipitation than any other region in the United States”.
- Things are changing fast



2. Impact of climate change on our ecosystems



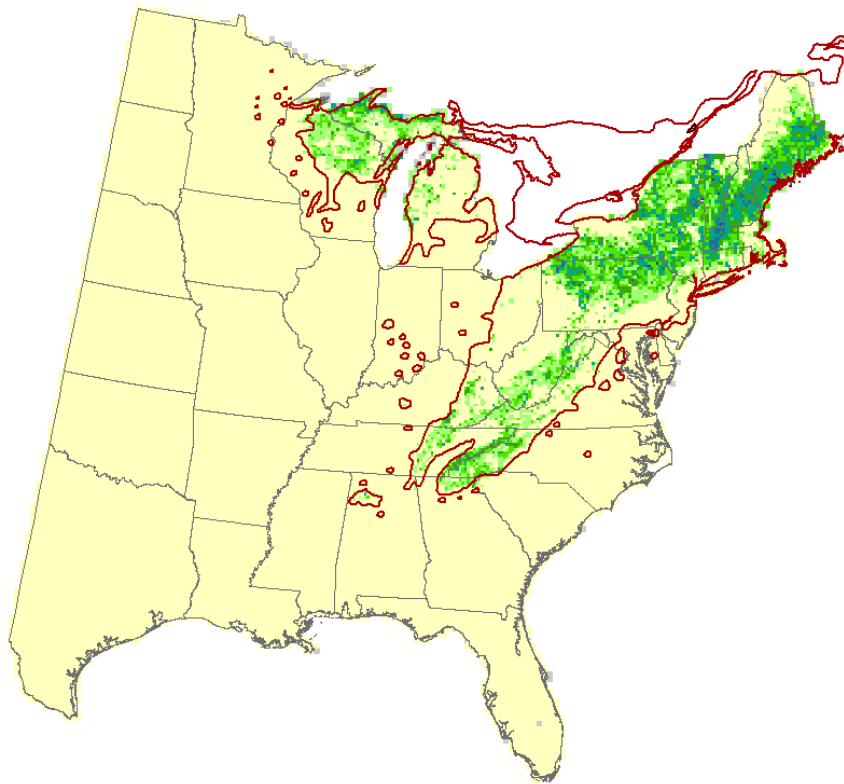
Species are shifting their ranges



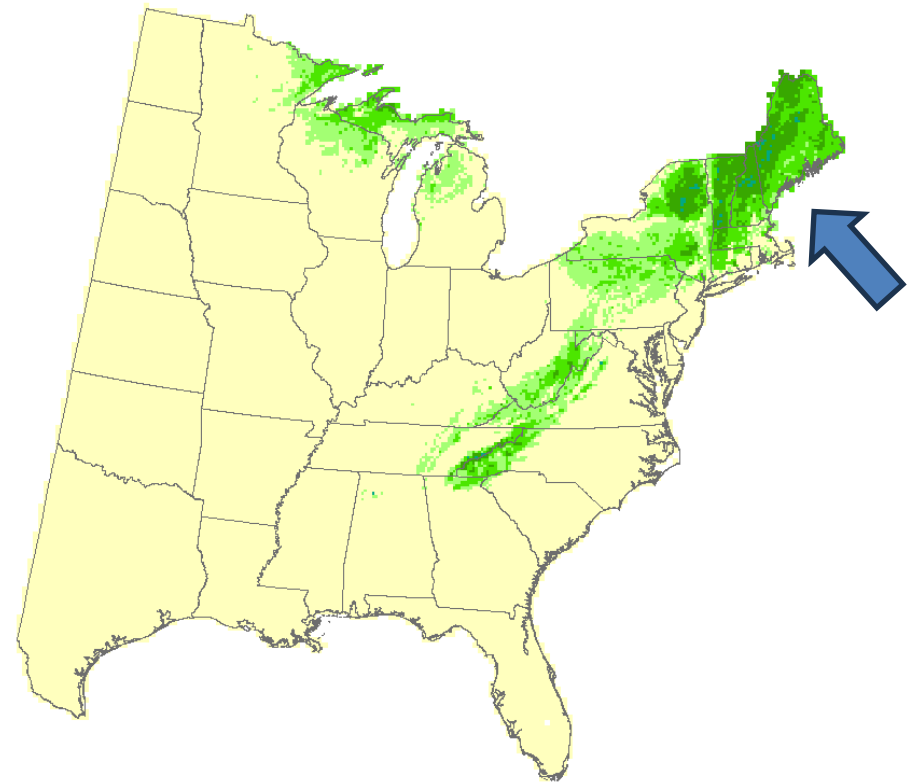
- White-tailed deer are expanding northward
- In southern part of range, moose experience greater parasitism
- Moose expanding northward replacing caribou

Species are shifting their ranges

Hemlocks are moving north



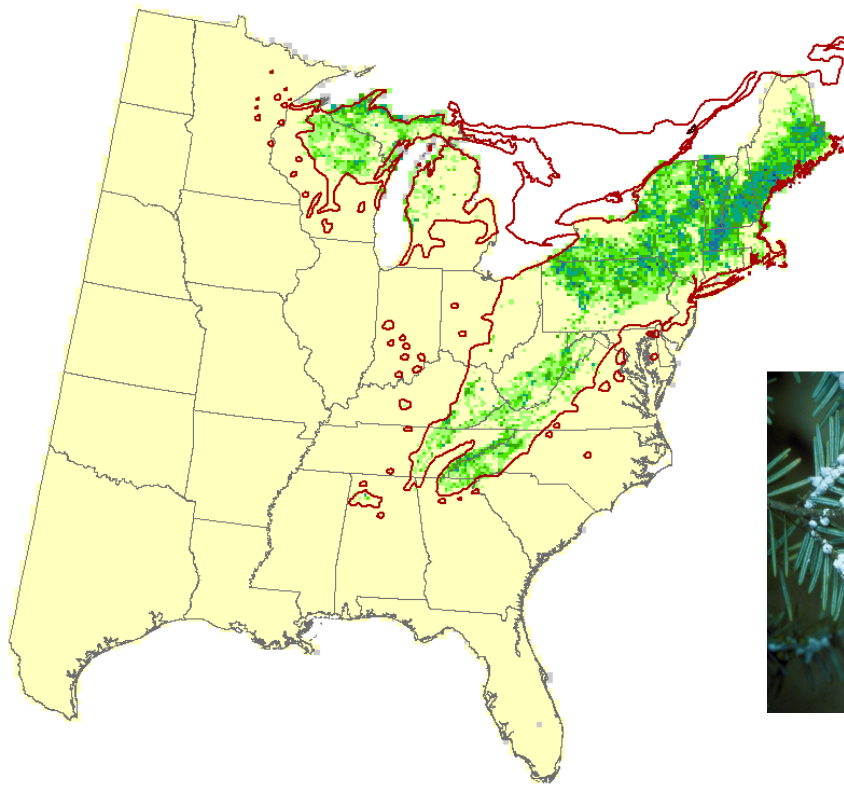
Current suitable habitat



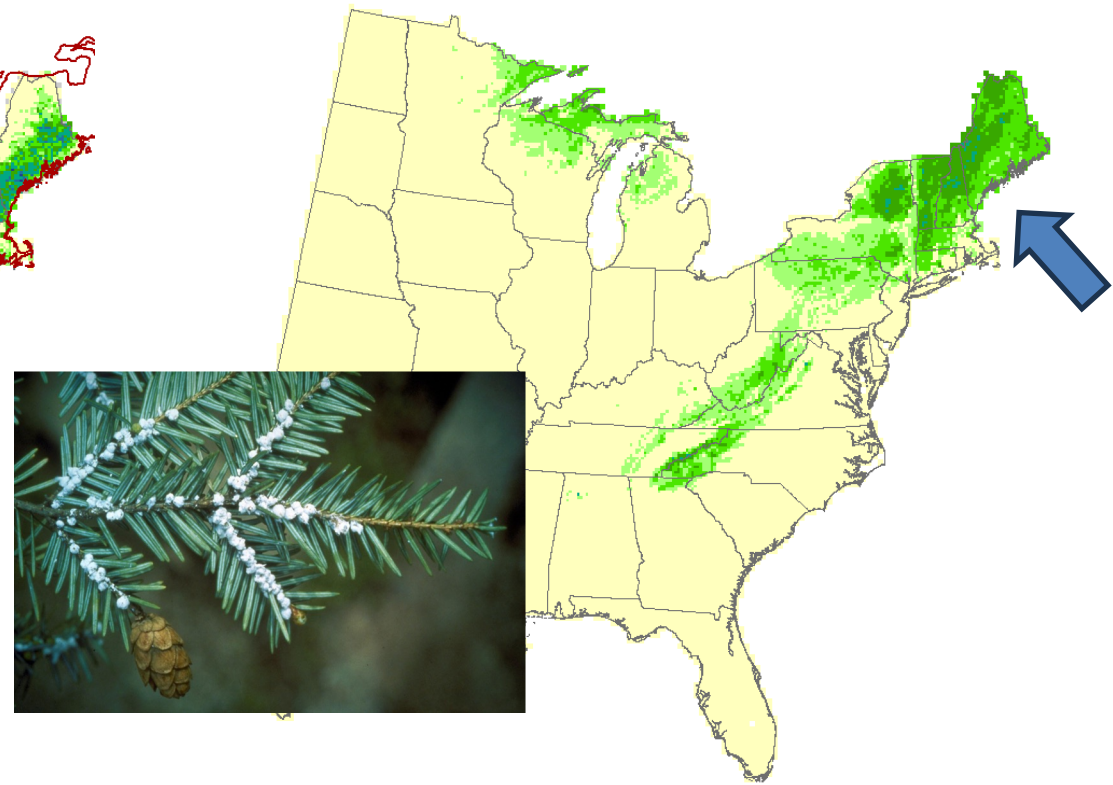
Future suitable habitat under a high emissions scenario

Species are shifting their ranges

Hemlocks are moving north



Current suitable habitat



Future suitable habitat under a high emissions scenario

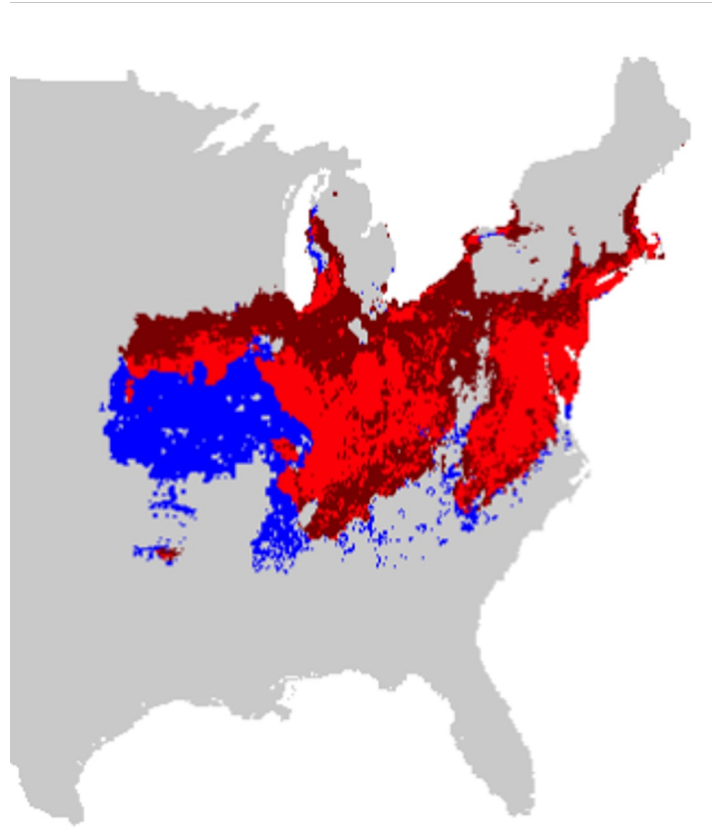


Species are shifting their ranges

Invasive species are also on the move

Suitability for invasion under climate change:

- Decreasing
- Unchanged
- Increasing



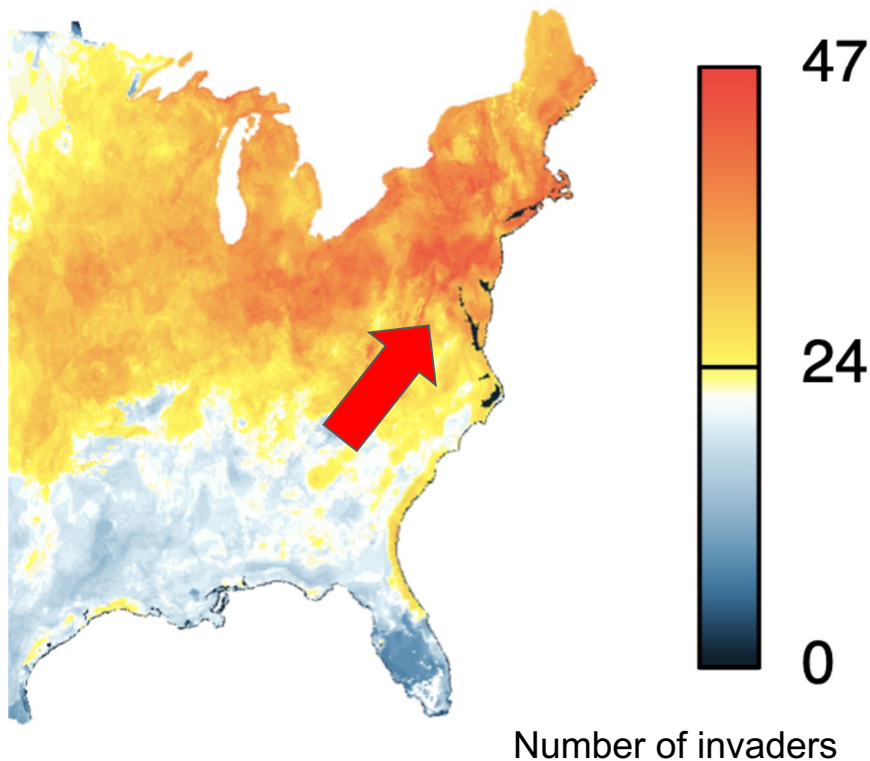
Rubus phoenicolasius, invasive wineberry

N = 144 east coast invaders

97% of invaders will have suitable habitat for invasion in new areas

Species are shifting their ranges

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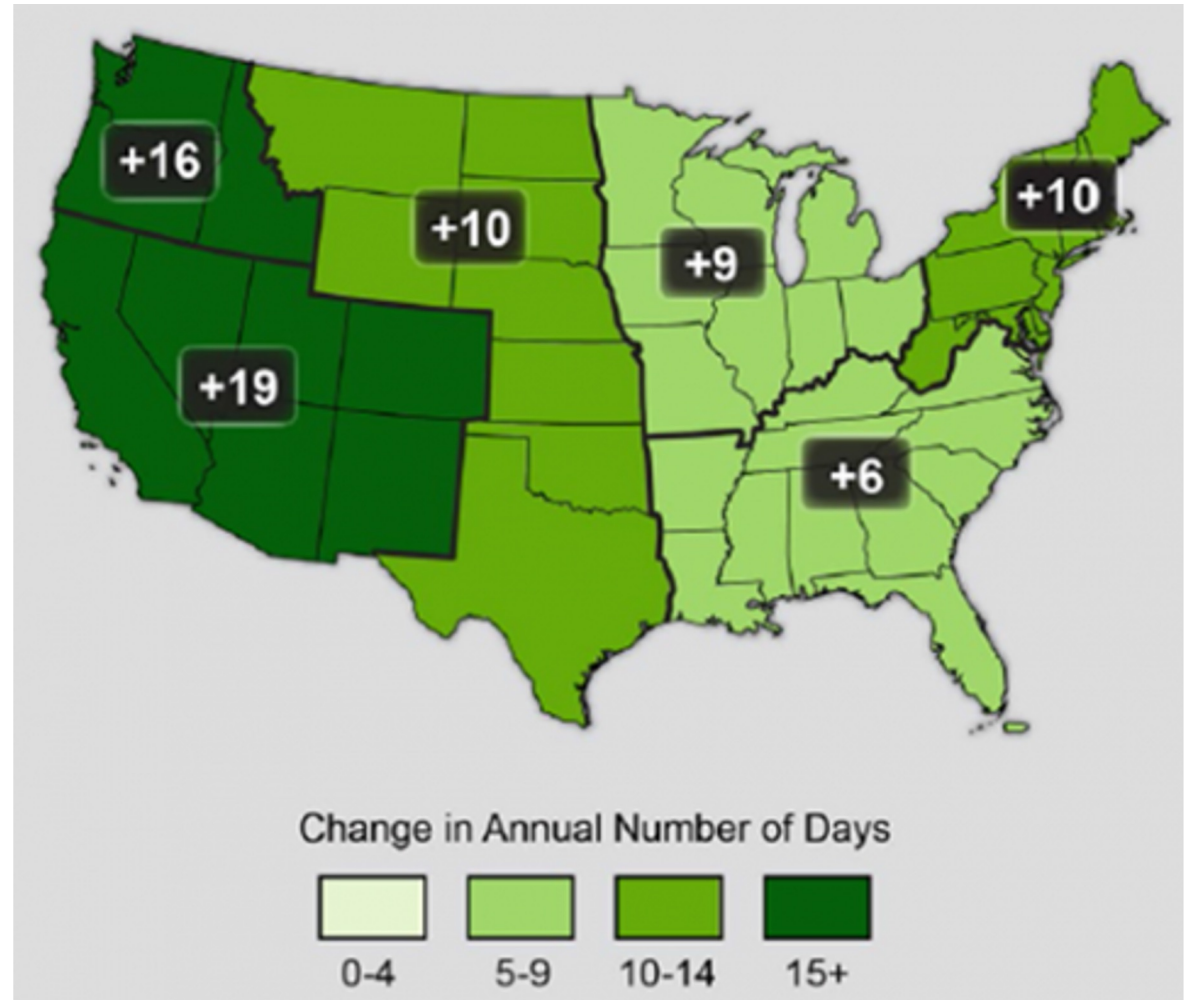


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Also seeing shifts in time – longer growing season

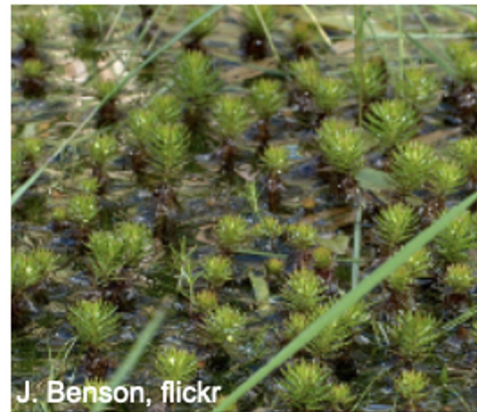
- Increase in growing degree days relative to mid-1900s
- Shorter winters, longer summers



Also seeing shifts in time – longer growing season

Shifting seasons promote invasions

- Milder winters increase pest survival.
- Invasive plants are more likely to shift the timing of green-up and brown-down in response to longer growing seasons, giving them a competitive advantage.



J. Benson, flickr

Eurasian millfoil

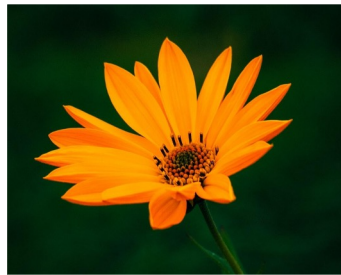


CT Ag Exp Station, Wikimedia

hemlock woolly adelgid

- Increase in growing degree days relative to mid-1900s
- Shorter winters, longer summers

Also seeing shifts in time – mismatched life history



Plant species 1

Plant species 2

Plant species 3

Phenological shifts



Pollinator



Time of year

Take home point:

- Climate change driving changes across space (range shifts) and over time (life history)
- Changes may advantage invasive species
- Not all species will keep pace with change



3. Gardening as an ecological tool



Facilitate native species persistence in response to change

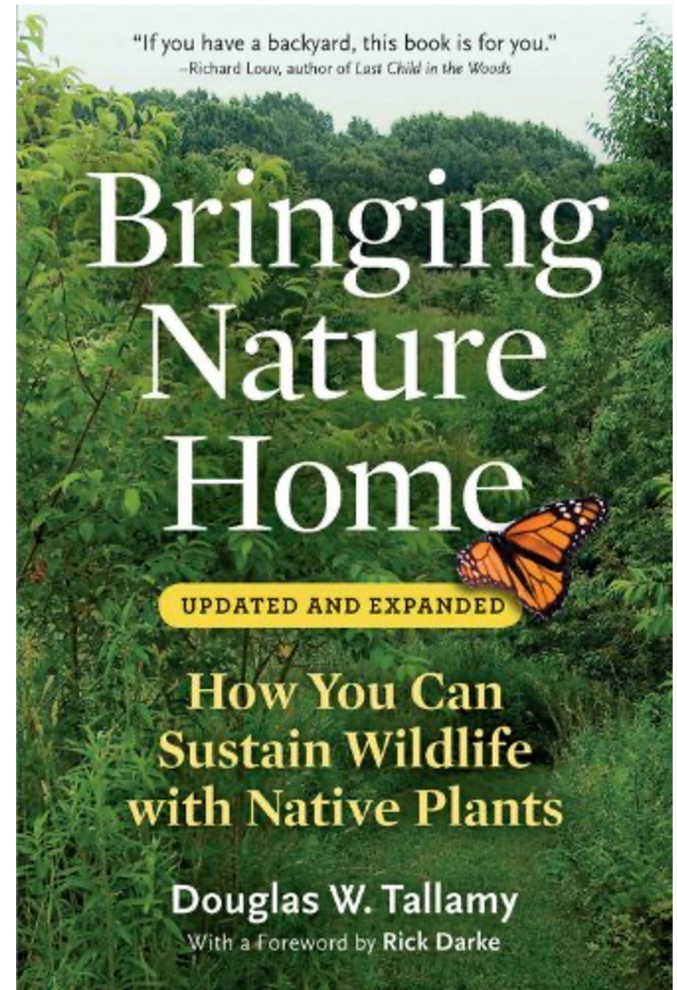


What Pollinator Plants are Blooming *Now*



3. Gardening as an ecological tool

“Chances are, you have never thought of **your garden**—indeed, of all of the space on your property—as a **wildlife preserve that represents the last chance we have for sustaining plants and animals that were once common throughout the U.S.** But that is exactly the role our suburban landscapes are now playing and will play even more in the near future.” - Doug Tallamy



Gardens as 'stepping stones' (habitat patches)

Landscaping that promotes native flora and fauna:

Ecological landscaping reduces the risk of introducing invasive species and supports wildlife.



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**What Pollinator Plants
are Blooming *Now***



Gardens as 'stepping stones' (habitat patches)

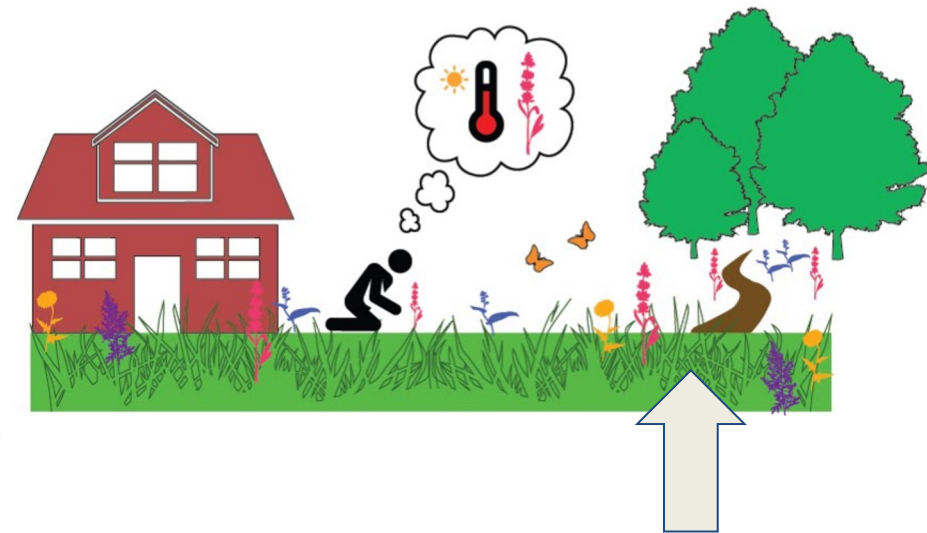
Landscaping that promotes native flora and fauna:

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Climate-smart native gardening:

Assisting the range shifts of native plants helps flora and fauna 'keep up' with climate change.



Tool for assisted migration with climate change

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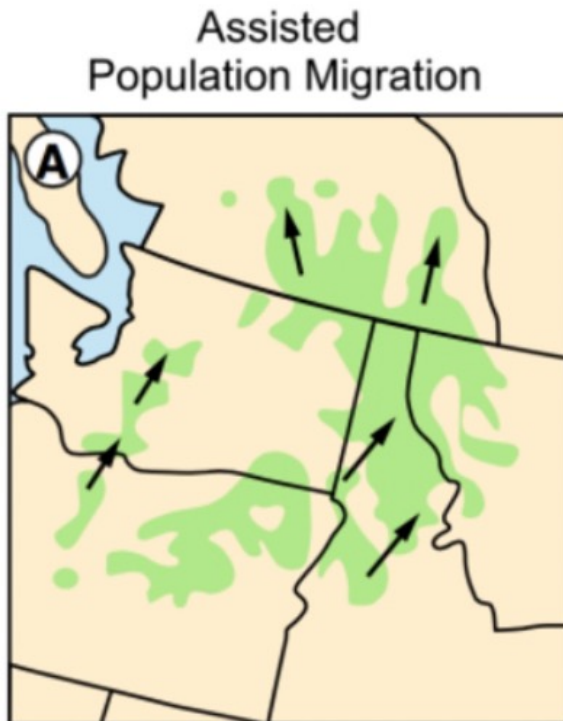
Tool for **assisted migration** with climate change

Assisted migration

- The intentional introduction of species outside of their historic ranges into more climatically favorable regions

Assisted migration could refer to several different strategies

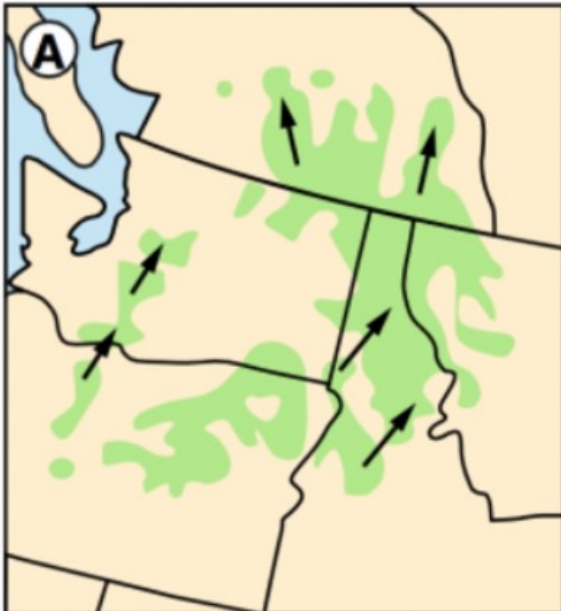
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Moving seed sources or populations to new locations within the historical species range

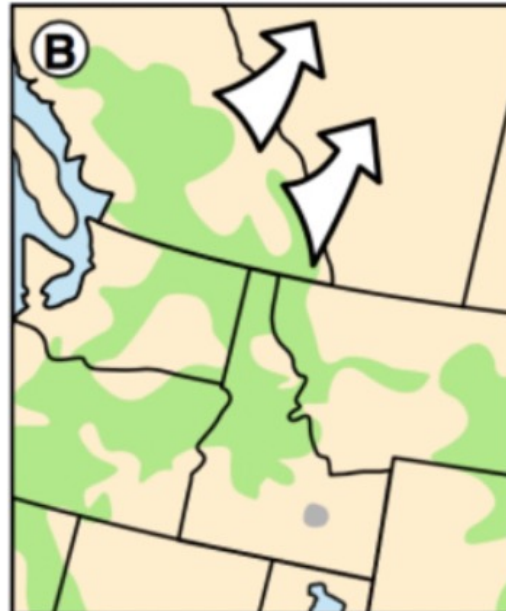
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Assisted
Population Migration



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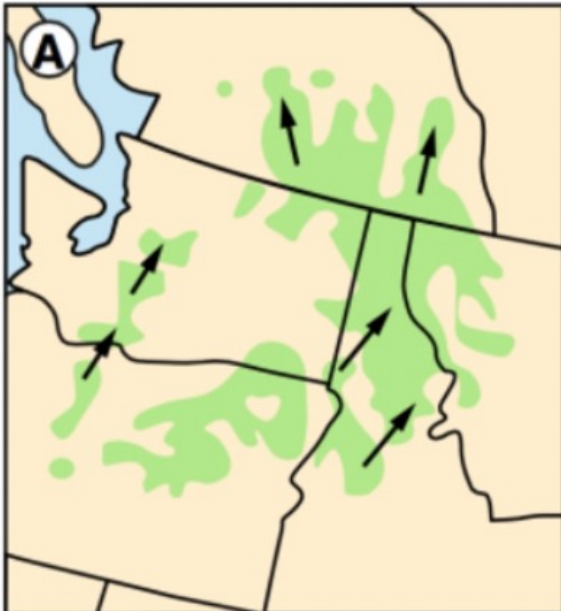
Assisted
Range Expansion



Moving populations from their current range to suitable areas beyond the historical species range

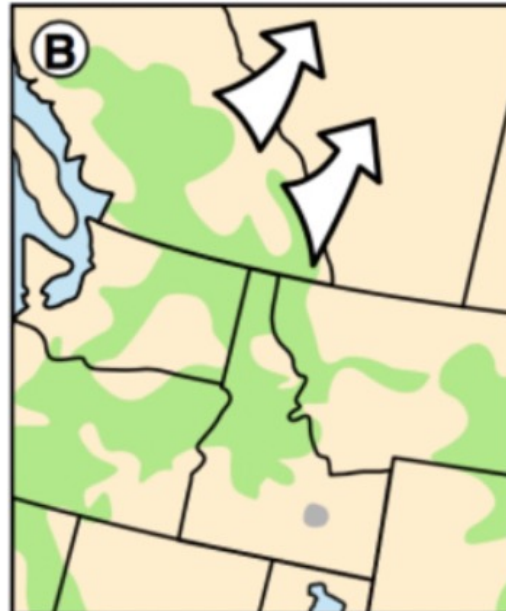
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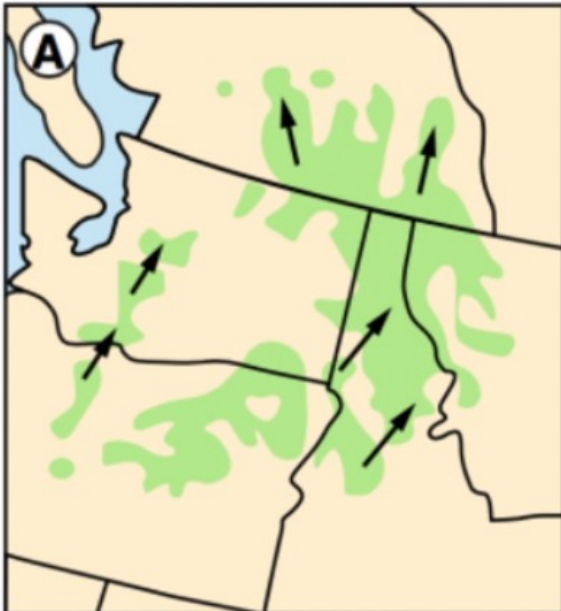
Assisted
Species Migration



Moving populations to a location far outside the historical species range, beyond locations accessible by natural dispersal

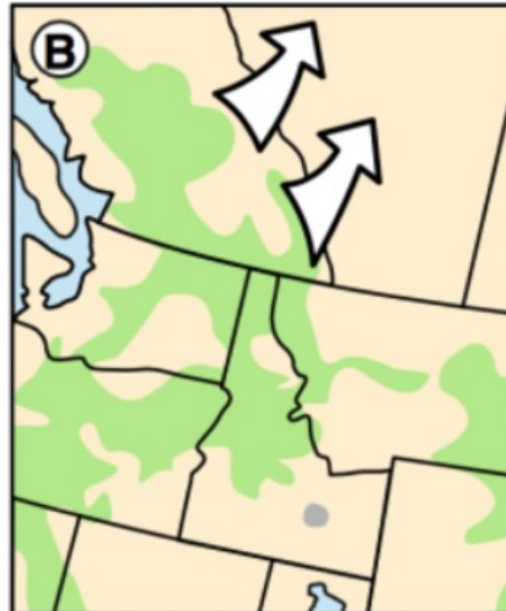
Risks differ with strategy

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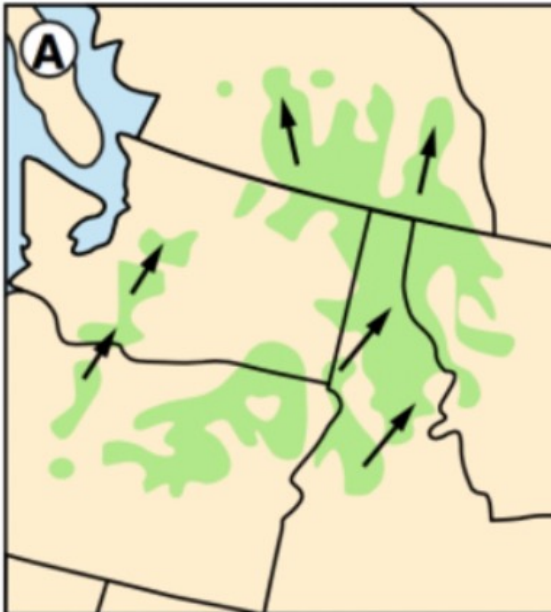


Moving populations to a location far outside the historical species range, beyond locations accessible by natural dispersal

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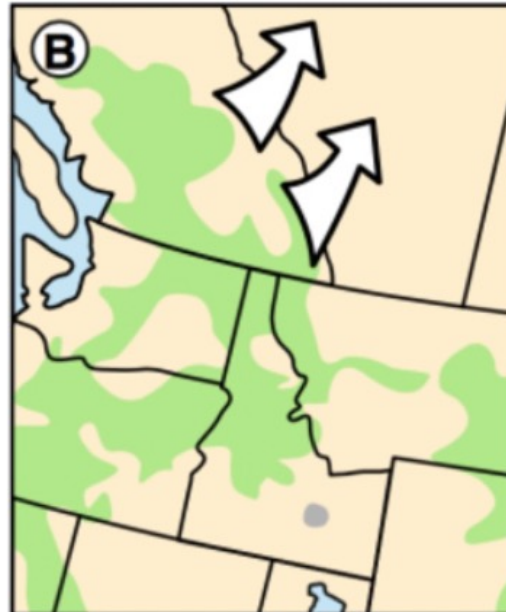
Can cause invasions

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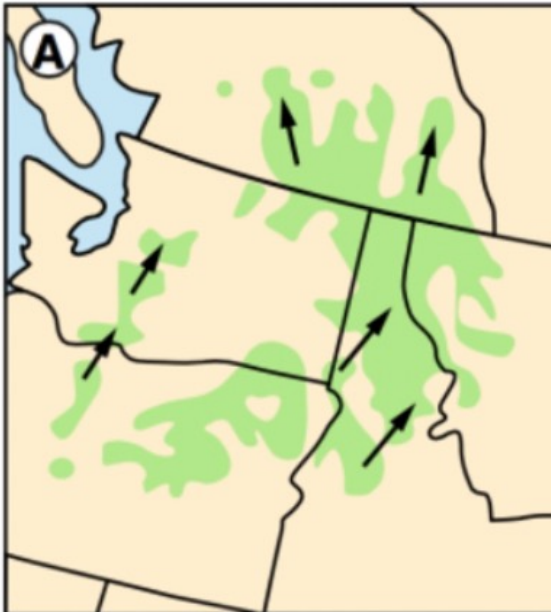
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Safest bet!

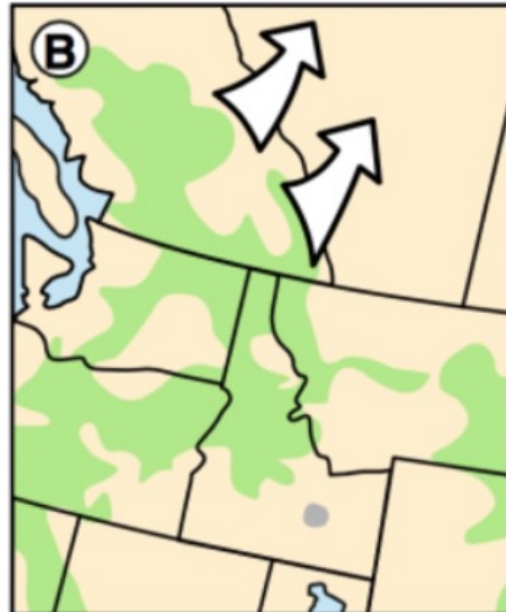
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Moving populations to new locations within the historical species range

Moving populations to new locations within the historical species range

- **EXAMPLE:** Tug Hill State Forest in NY planted native, warm-adapted trees to reduce future disturbance and resist invasions with climate change



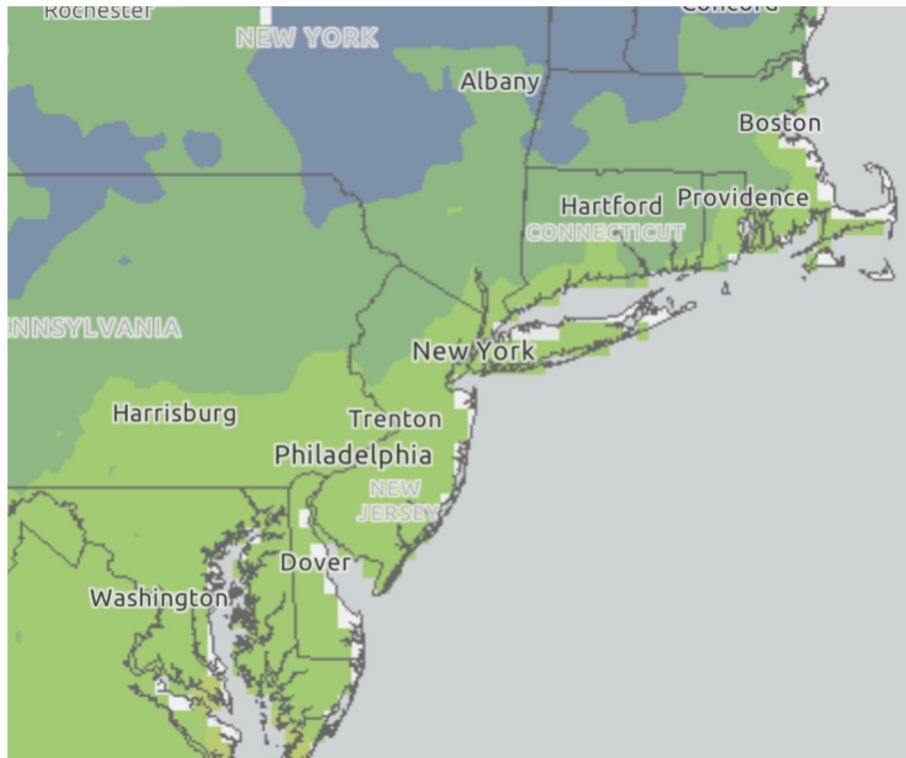
STORIES IN NEW YORK

Growing a Climate Resilient Forest on Tug Hill

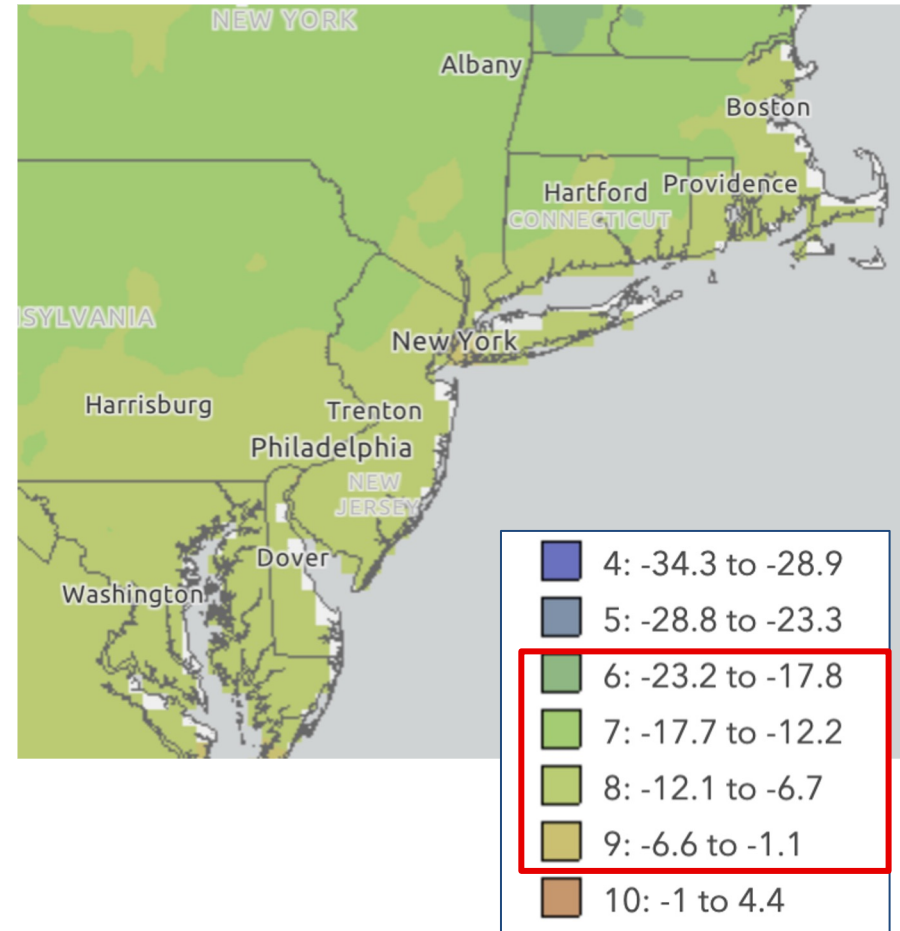
By Kate Frazer, Associate Director, New York Marketing and Communications | July 27, 2020

Moving populations to new locations within the historical species range

Historical hardiness zones (1980-2009)



Predicted shift 2040+



Gardens and assisted migration

Introducing warm-adapted populations to northern range margins

Gardening with climate-smart native plants in the Northeast



Northeast Regional Invasive Species & Climate Management Change



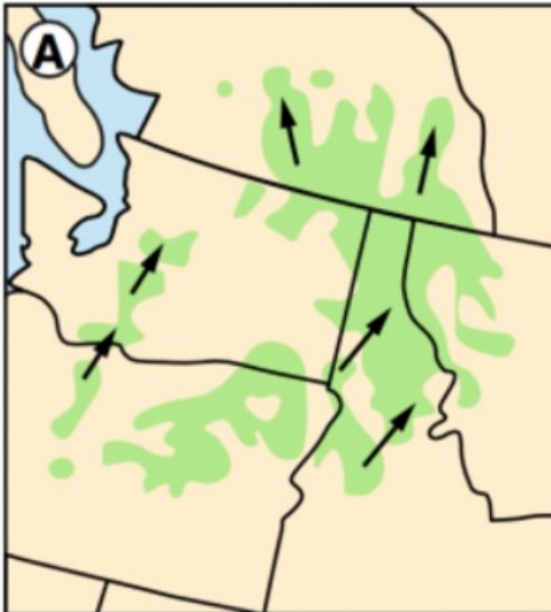
		Climate-smart native plants				
	Species	Growth Form	Hardiness Zones	Planting Conditions	Benefits	
Native Grasses	Big blue stem (<i>Andropogon gerardii</i>)	Grass	4-9	☀️ 💧	☒ ☒	
	Canada wild rye (<i>Elymus canadensis</i>)	Grass	3-8	☀️ 💧	🦋 ☒	
	Indian grass (<i>Sorghastrum nutans</i>)	Grass	4-9	☀️ 💧	🦋	
	Little bluestem (<i>Schizachyrium scoparium</i>)	Grass	3-9	☀️ 💧	☒ ☒	
	Sideoats grama (<i>Bouteloua curtipendula</i>)	Grass	4-9	☀️ 💧	🌸 🦋 ☒	
Native Flowering Herbs	Beardtongue (<i>Penstemon digitalis</i>)	Herb	3-8	☀️ 💧	🌸 🦋 🦋 ☒ ☒	
	Blazing star (<i>Liatris spicata</i>)	Herb	3-8	☀️ 💧	🌸 🦋 🦋 ☒	
	Blue false indigo (<i>Baptisia australis</i>)	Herb	3-9	☀️ ☀️ 💧	🌸 🍎 🦋 ☒ ☒	
	Blue flag iris (<i>Iris versicolor</i>)	Herb	3-9	☀️ ☀️ 💧	🌸 ☒ ☒	
	Blue lobelia (<i>Lobelia siphilitica</i>)	Herb	4-9	☀️ ☀️ 💧	🌸 ☒ ☒	
	Butterfly weed (<i>Asclepias tuberosa</i>)	Herb	3-9	☀️ 💧	🌸 🦋 ☒ ☒	
	Cardinal flower (<i>Lobelia cardinalis</i>)	Herb	3-9	☀️ ☀️ 💧	🌸 🦋 🦋 ☒ ☒	
	Foam flower (<i>Tiarella cordifolia</i>)	Herb	4-9	☀️ ☀️ 💧	🌸 ☒ ☒	
	Ironweed (<i>Vernonia noveboracensis</i>)	Herb	5-9	☀️ 💧	🌸 🦋 ☒ ☒	
	Joe pye weed (<i>Eutrochium fistulosum</i>)	Herb	4-8	☀️ ☀️ 💧	🌸 🦋 ☒ ☒	
	Lance leaf coreopsis (<i>Coreopsis lanceolata</i>)	Herb	4-9	☀️ 💧	🌸 🦋 ☒	
	Monkey flower (<i>Mimulus ringens</i>)	Herb	4-9	☀️ ☀️ 💧	🌸 ☒ ☒	
	New England aster (<i>Symphotrichum novae-angliae</i>)	Herb	4-8	☀️ 💧	🌸 🦋 🦋	
	Obedient plant (<i>Physostegia virginiana</i>)	Herb	3-9	☀️ 💧	🌸 🦋 ☒	
	White turtlehead (<i>Chelone glabra</i>)	Herb	3-8	☀️ 💧	🌸 🦋 ☒	

Risks differ with strategy

Safest bet!

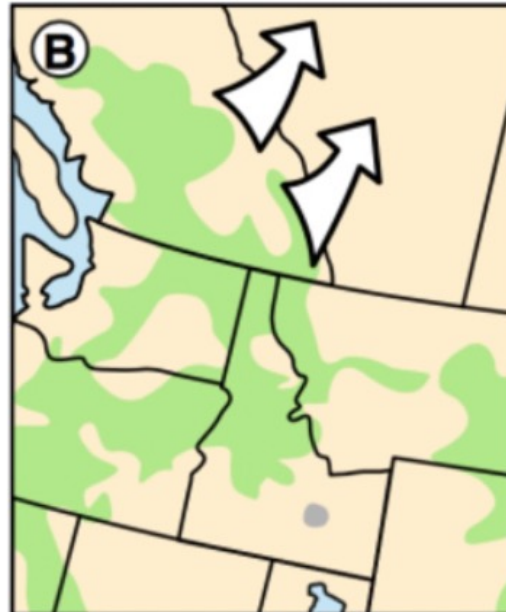
Can cause invasions

Assisted
Population Migration



Moving populations to new locations within the historical species range

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Range Expansion



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Species Migration



Moving populations to a location far outside the historical species range, beyond locations accessible by natural dispersal

3. Gardening as an ecological tool

Moving populations to a location far outside the historical species range, beyond locations accessible by natural dispersal

- **EXAMPLE:** *Torreya taxifolia*, “believed to be the most endangered conifer tree”
- Pre-glacial range in Appalachians, but now restricted to cooler/montane microclimates of Florida
- Slow-growing & unable to disperse northward

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Scrappy Group of Citizen Scientists Rallies Around One of World’s Rarest Trees



Assisted Species Migration



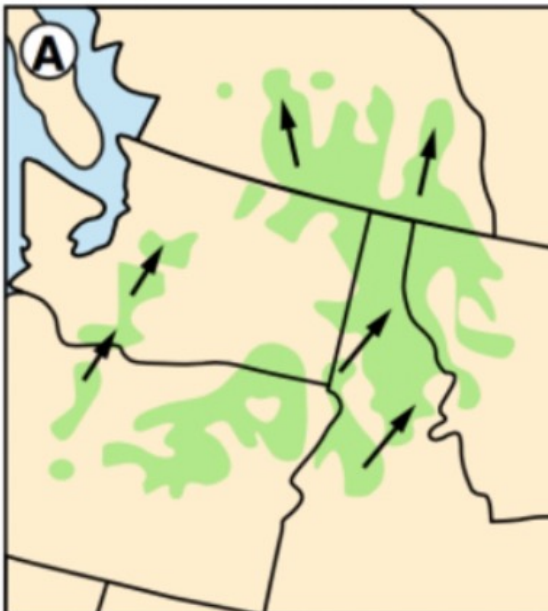
LEFT: A fleshy sarcotesta surrounds the single large seed of *T. tax*
RIGHT: Connie Barlow with **STATE CHAMPION** *Torreya californica* near Santa Cruz CA, 2005.

Take home point:

- Approaches to assisted migration vary in risk
- But, doing nothing is also doing harm

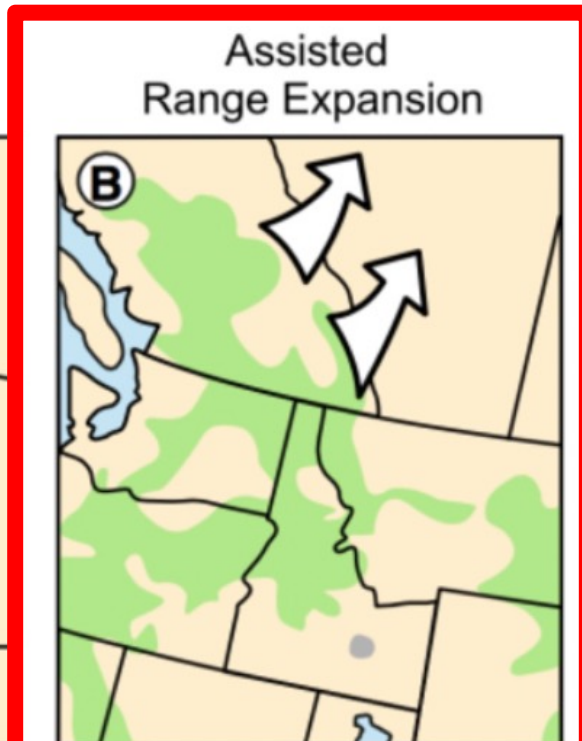
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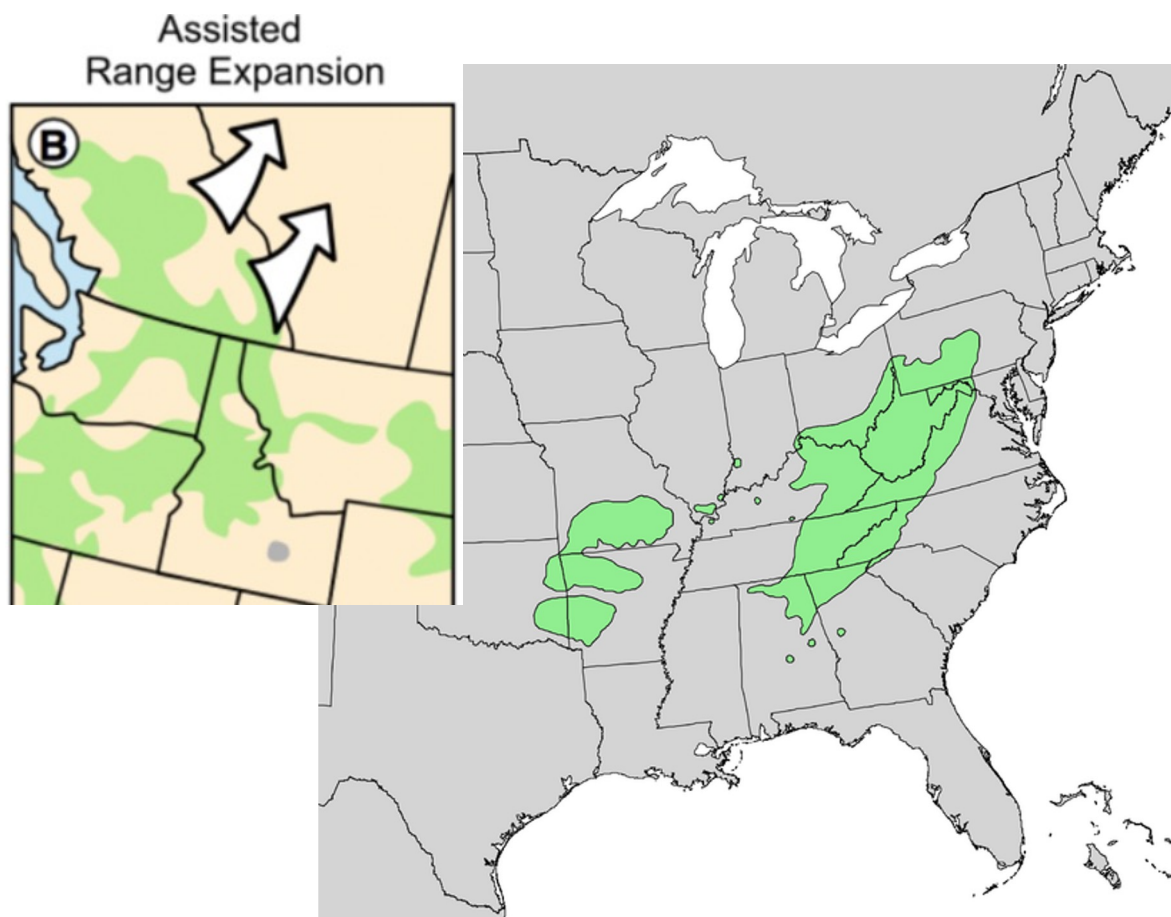
Can be a safe bet!

Assisted
Species Migration



4. Minimizing risks

Risks of moving populations from their current range to suitable areas beyond the historical species range

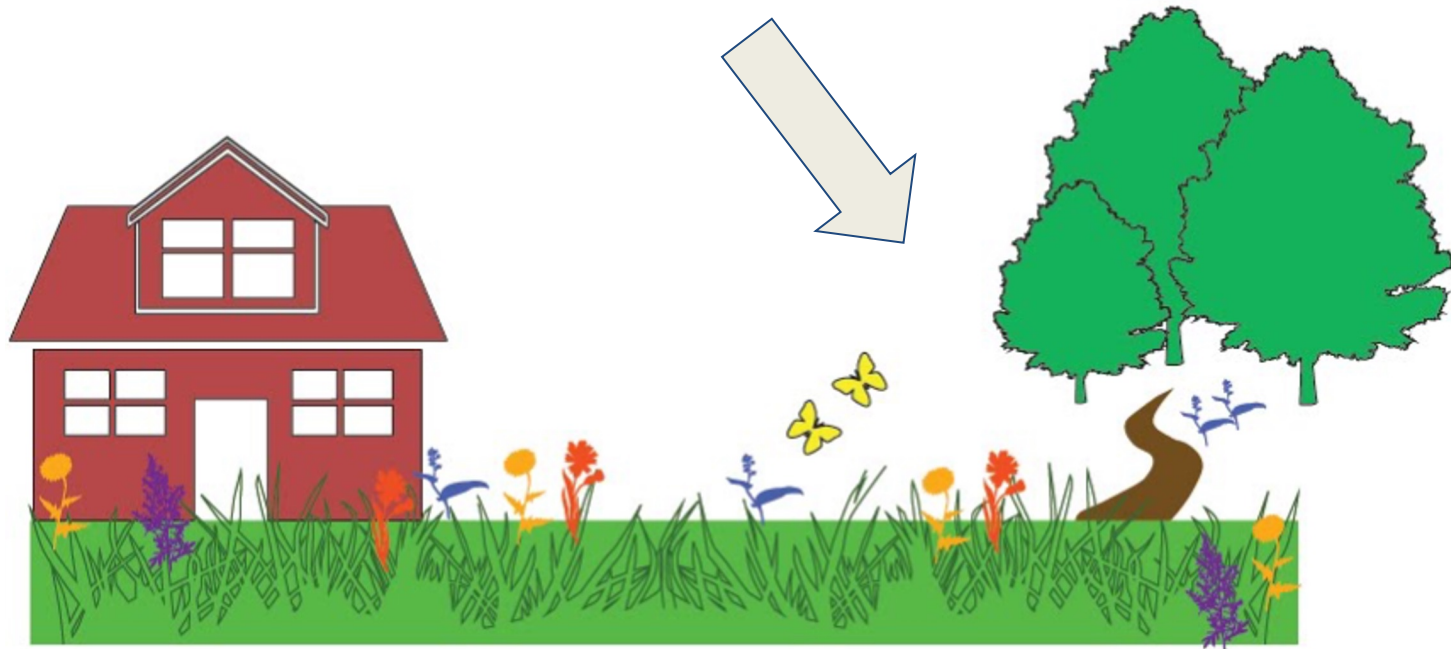


Native range in green



Black locust – now
considered invasive

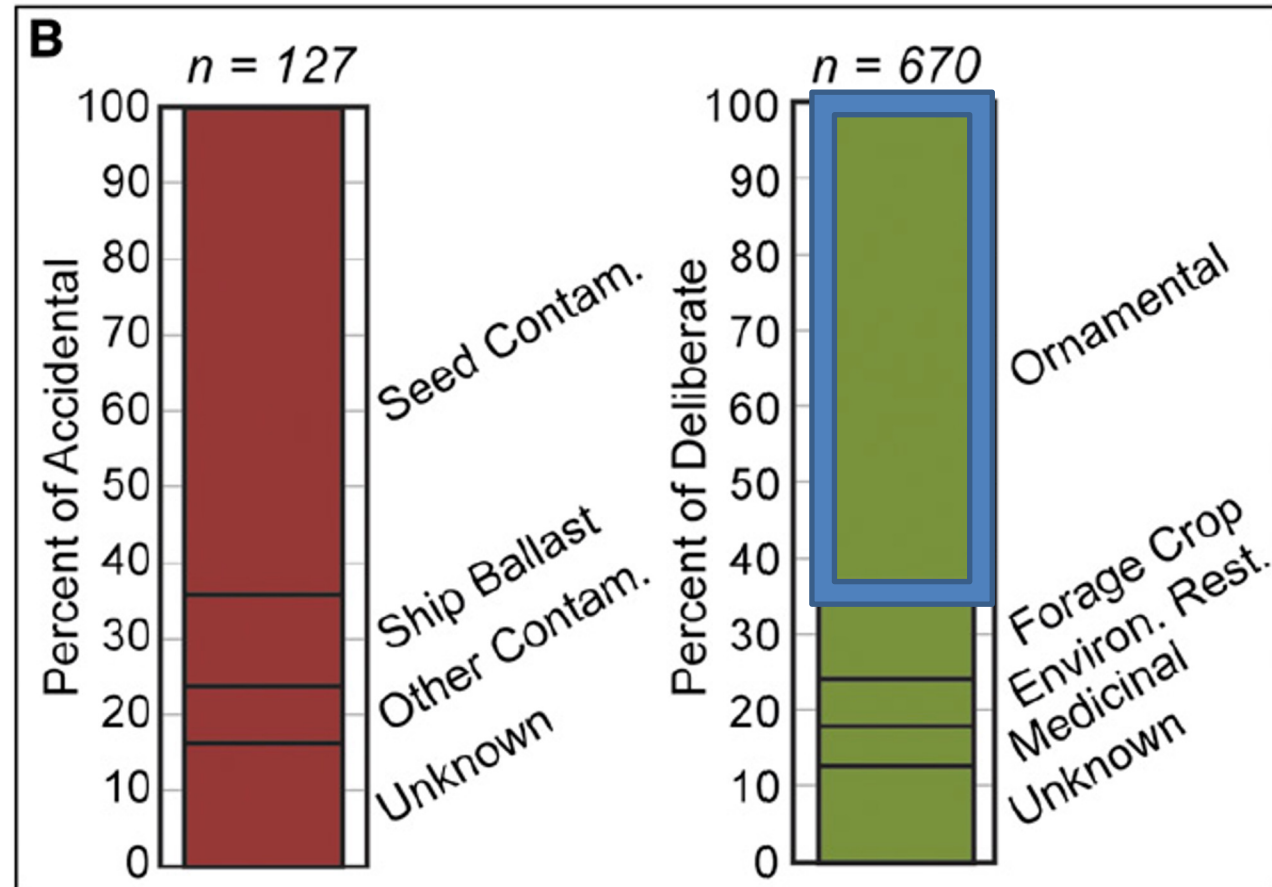
Risks of moving populations from their current range to suitable areas beyond the historical species range



Introduced ornamental species
become invasive

Gardens as a pathway for invasions

Nursery imports are the primary introduction pathway of invasive plants



Gardens as a pathway for invasions



Purple loosestrife, *Lythrum salicaria*



Chinese silvergrass, *Miscanthus sinensis*

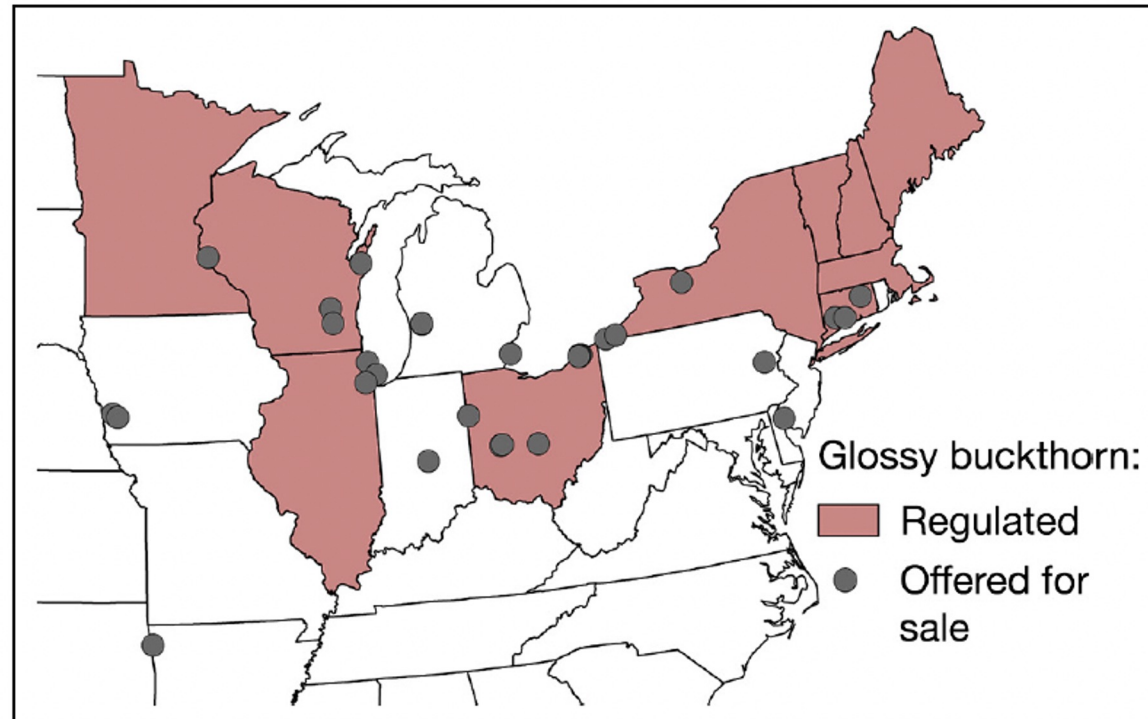


Japanese barberry, *Berberis thunbergii*

Gardens as a pathway for invasions

61% of ~1300 U.S. invasive plants are still marketed as ornamentals

Including federal noxious weeds and state prohibited plants



Gardens as a pathway for invasions

Sudden oak death



70% of non-native forest pests in the U.S. arrived as contaminants on nursery plant imports.

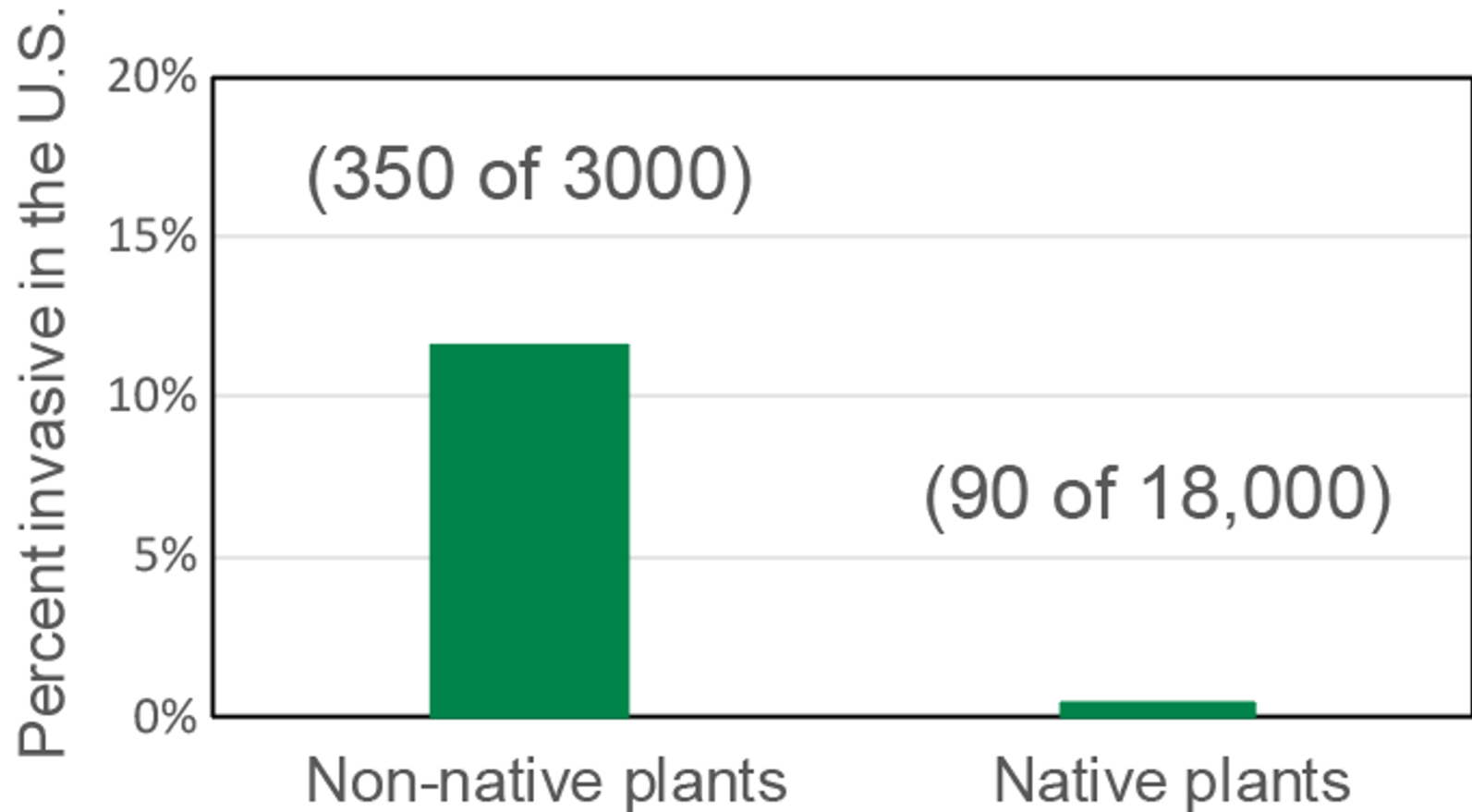


Hemlock wooly adelgid

60% of nursery plants are non-native to the U.S.



Non-native plants are 40x more likely to be invasive than native plants



Non-native plants provide fewer ecological benefits

Benefits of Native Plants



50% higher abundance of **native birds**



9x higher abundance of **rare birds**

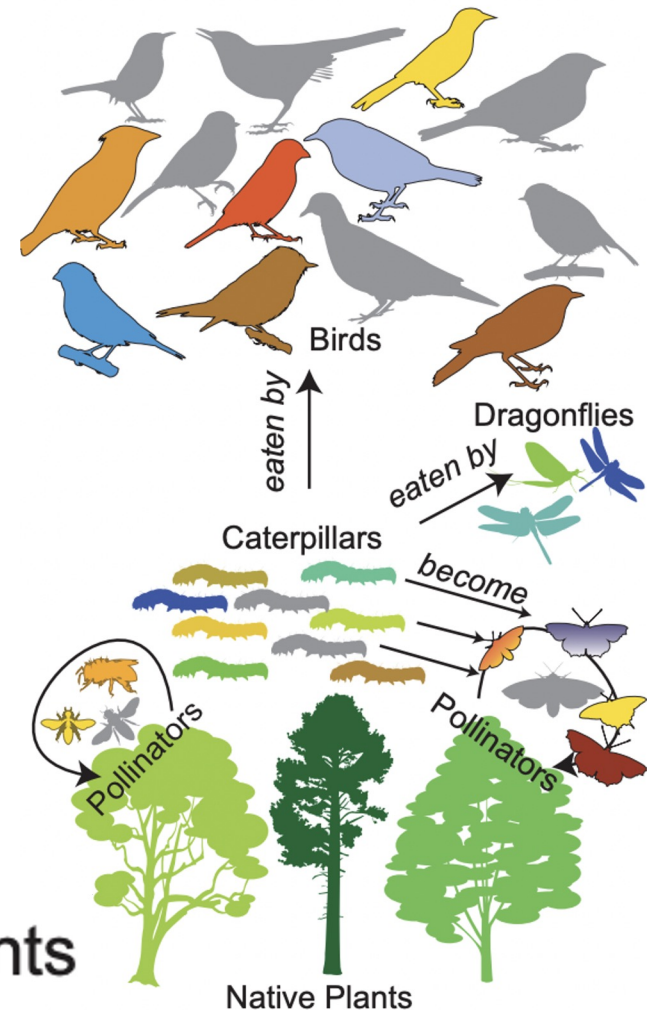


3x more **butterfly species**



2x higher abundance of **native bees**

Landscaping with **native** plants

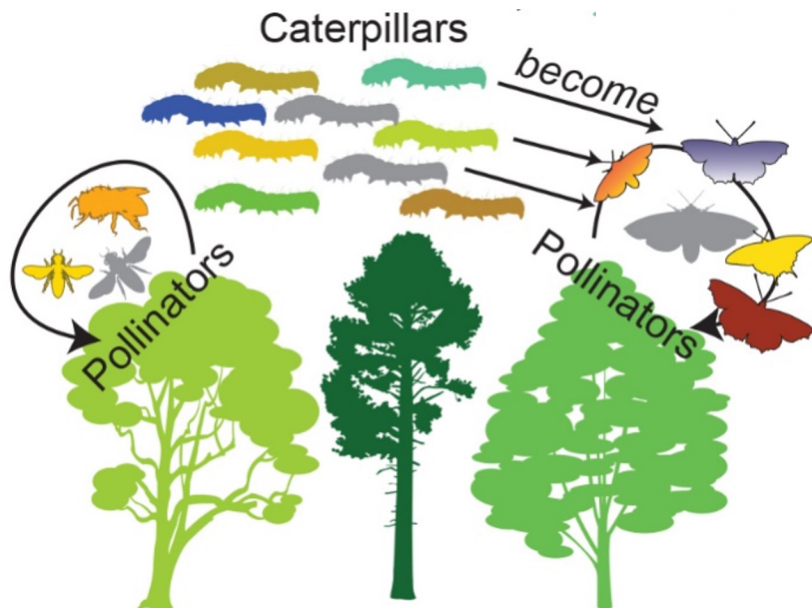


Aim for **less than 30%** non-native plants

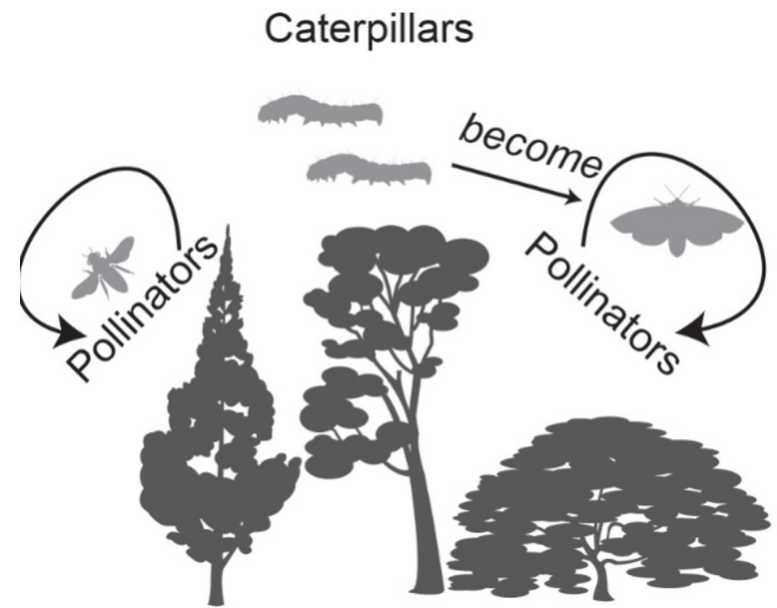
Why are non-natives so much more likely to become invasive?

- Release from natural enemies

Native plants are eaten by many native insects



Non-native plants are not



Why are non-natives so much more likely to become invasive?

- Lack of co-evolution creates advantages



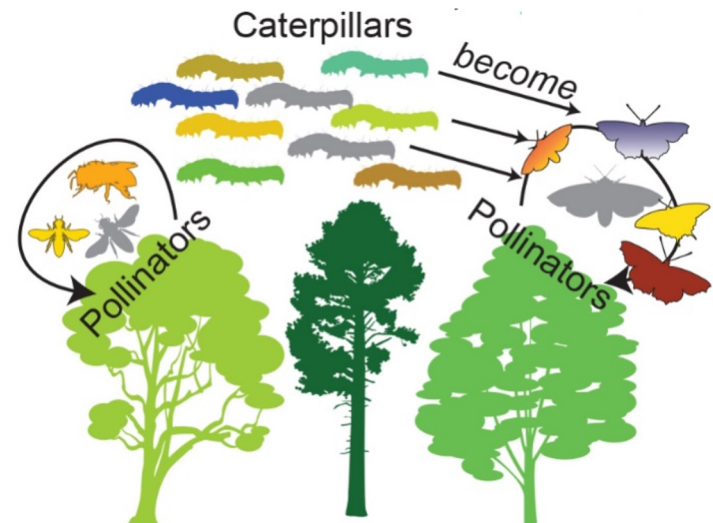
Japanese chestnut
Blight resistant



American chestnut
Susceptible to blight

Take home point #1:

- Gardens can help species move, but moving some species is riskier than others
- Non-native species are more likely to become invasive + provide fewer ecological benefits



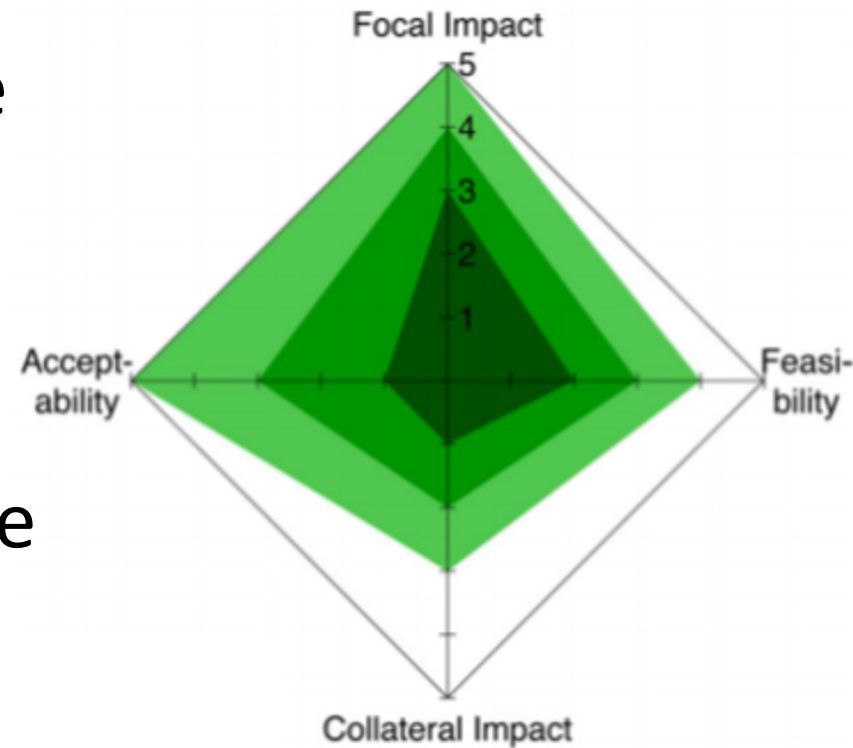
Risks vs. benefits of assisted migration for native species

Focal Impact: Will it help the target species?

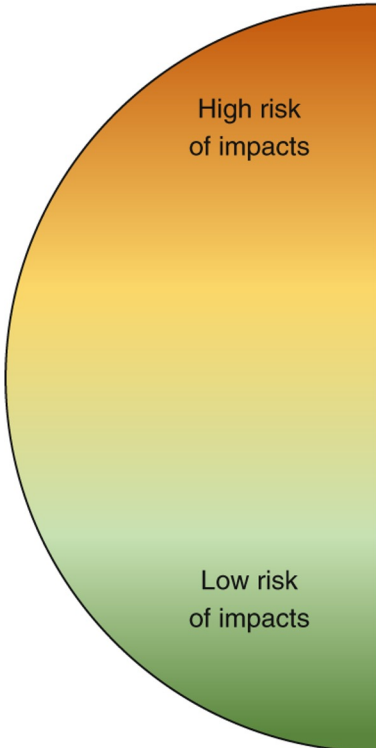
Feasibility: Can we even grow/translocate it?

Collateral Impact: What's the risk for the recipient ecosystem?

Acceptability: Will people support this action?



Predicting collateral impact using traits associated with invasion

	Propagule or dispersal pressure (species)	Abiotic effects (community)	Biotic characteristics	
			Species	Community
 <p>High risk of impacts</p> <p>Low risk of impacts</p>	<p>High fecundity</p> <p>Wide dispersal</p> <p>Continuous propagules</p> <p>High genetic diversity</p>	<p>History of disturbance</p> <p>Increasing environmental stress</p> <p>Breach of biogeographic barriers</p>	<p>Invasive elsewhere</p> <p>Abundant in home range</p> <p>Fast growth</p> <p>Generalists</p> <p>Foundation species or ecosystem engineers</p> <p>Pathogen carriers</p>	<p>Rare community</p> <p>Naïve prey</p> <p>Enemy release</p>
	<p>Low fecundity</p> <p>Limited dispersal</p>	<p>Resilient or resistant to disturbance</p> <p>Similar environmental conditions</p>	<p>Threatened or endangered</p> <p>Endemic</p> <p>Obligate mutualist</p> <p>Specialists</p>	<p>Shared evolutionary history</p> <p>Biotic resistance</p>

Regulations as a mechanism for reducing invasion risk

Federal noxious weed list

- ~100 species
- Focus on national border
- Preventing interstate trade



State prohibited plant lists

- ~600 species
- Focus on state borders
- Preventing within-state movement



Federal and individual state lists: <https://www.nationalplantboard.org/state-law--regulation-summaries.html>

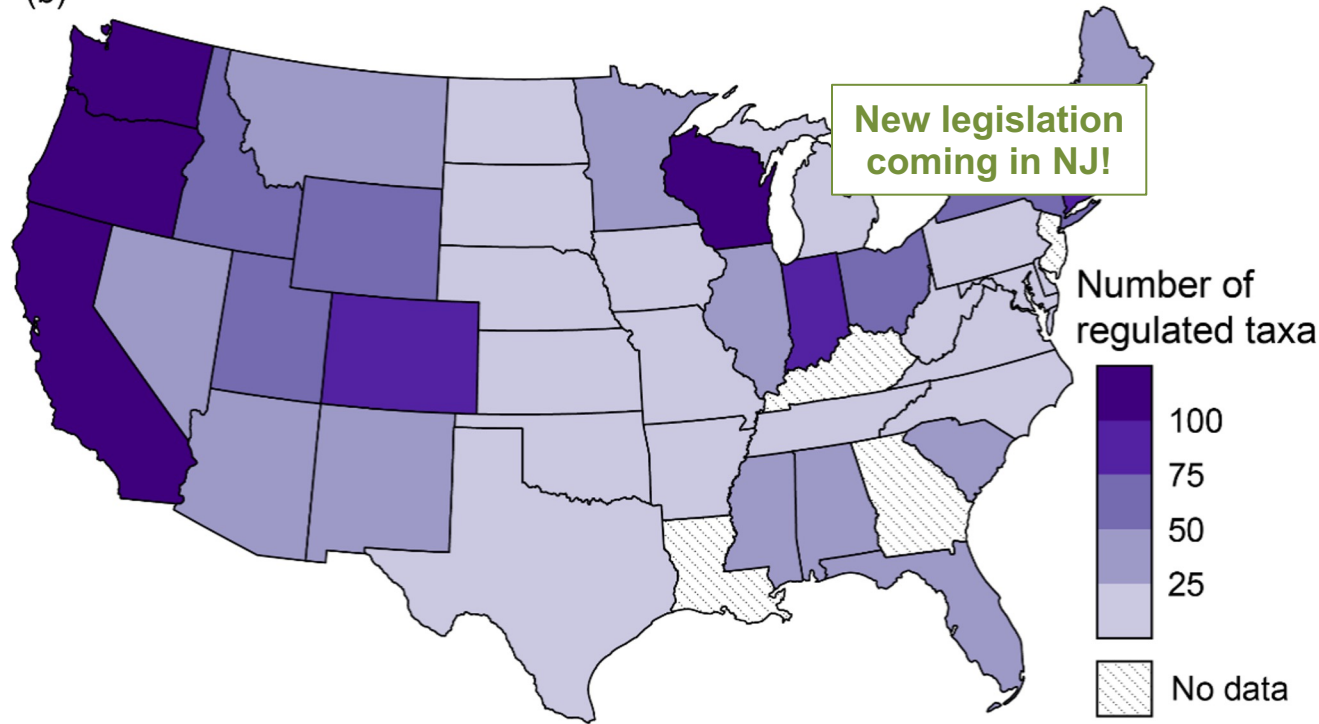
State watch lists for range shifting species: eddmaps.org/rangeshiftlisting/

Collated list for the northeast: <https://scholarworks.umass.edu/data/146/>

Regulations as a mechanism for reducing invasion risk

Regulations are inconsistent but effective within states

(b)



Neighboring states have <20% overlap in regulated species

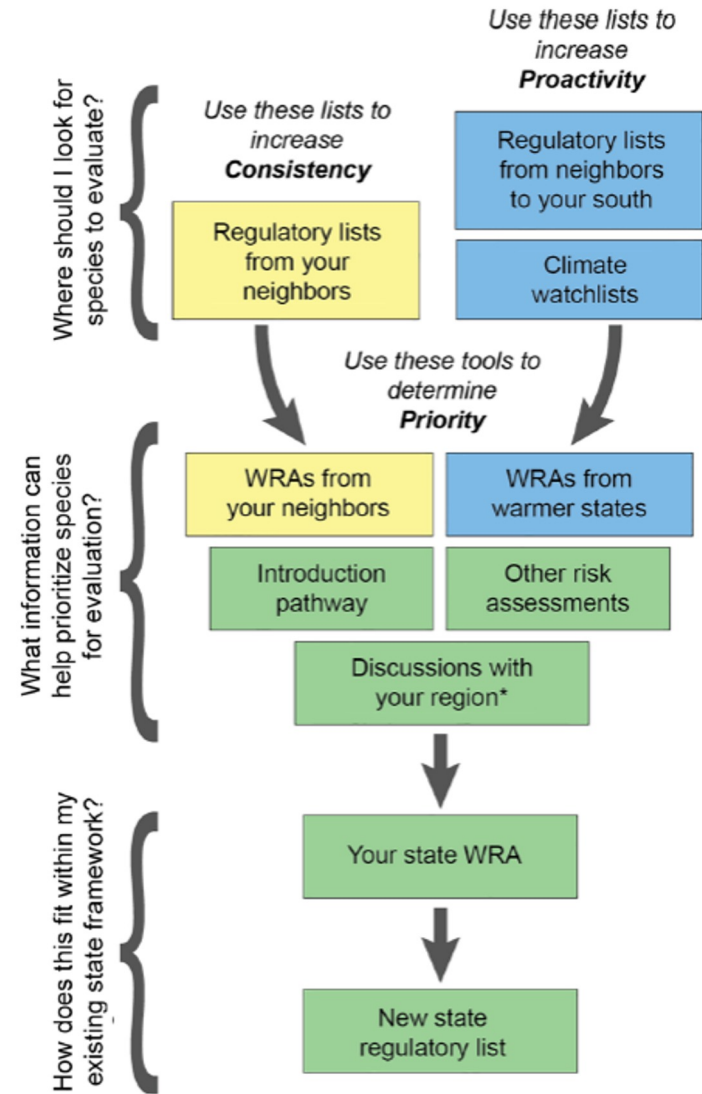
Several states still lack a regulatory list

Regulations as a mechanism for reducing invasion risk

Increase consistency:

- Evaluating species on your neighbors lists
- Sharing completed weed risk assessments

Think about what plants are leaving your state and moving elsewhere!



Preventing species movement using watch lists

Northeast RISCC Management
Regional Invasive Species & Climate Change
Management Challenge

Prioritizing range-shifting invasive plants High-impact species coming to the Northeast

Summary

Prevention of new invasions is a cost-effective way to manage invasive species and is most effective when invaders are identified and prioritized before they arrive. Climate change is projected to bring nearly 100 new invasive plants to the Northeast. However, these plants are likely to have different types of impacts, making some higher concern than others. Here, we summarize the results of original RISCC research that identifies high-impact range-shifting invasive plants based on their potential impacts.

Why is risk higher in the Northeast?

Because invasive plants are more prevalent in states to our south and many species are shifting their ranges poleward in response to climate warming, the Northeast is a hotspot of risk from range-shifting species (red areas in Figure 1). A study by Allen & Bradley (2016) modeled the current and potential ranges by 2050 for 896 invasive plants in the continental U.S. Up to 100 new invasive plants are likely to shift into Northeast states with climate change.

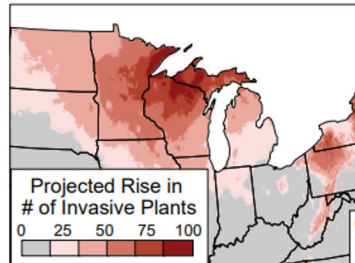


Fig 1. Projected number of new invasive plants

Northeast RISCC Management
Regional Invasive Species & Climate Change
Management Challenge

Do Not Sell!

Ornamental invasive plants to avoid with climate change

Summary

Climate change is likely to bring dozens of new invasive plants to the Northeast. Despite their invasive tendencies, many of these species are sold as ornamental plants in slightly warmer climates, but are not yet a large part of nursery sales in the Northeast. By avoiding these species, we protect our native ecosystems from future invasive species impacts. We also present alternative native plants that provide similar aesthetics while also supporting biodiversity.

Ornamentals as Invasives

About 50% of invasive plants were introduced via horticultural trade, including the majority of Northeast invasive plants. The past is a good indicator of the future unless behaviors change.

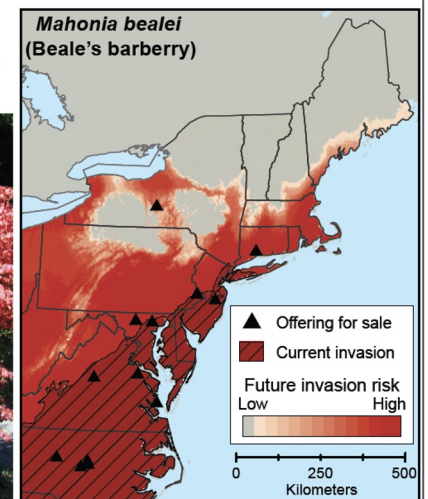


Fig. 1. Northeastern invasive plants with ornamental origins.

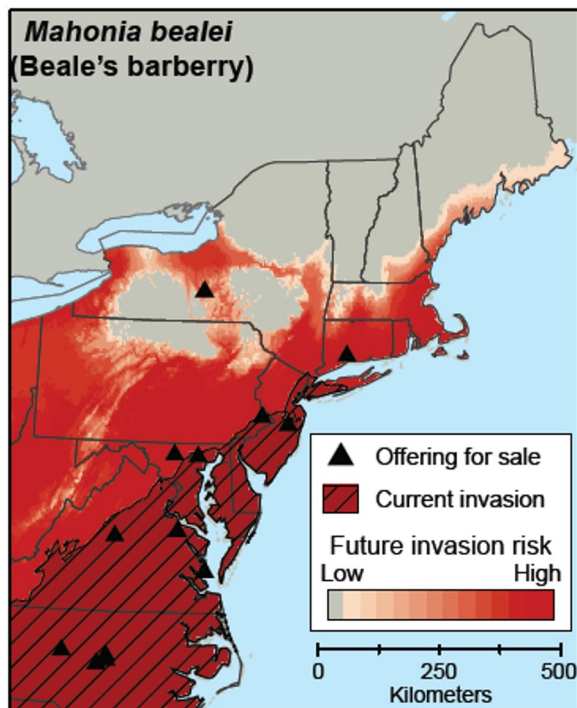
Fig. 2. Current and potential range map with

<https://www.risccnetwork.org/management-challenges>

Preventing species movement using watch lists

Do Not Sell!

Ornamental invasive plants to avoid with climate change



Do Not Sell 🚫

Mahonia bealei (Beale's barberry)



Ecological Impacts: Spreads rapidly into natural areas. Similar characteristics to other invasive barberries (e.g., *Berberis thunbergii*).

Vulnerable Ecosystems: Forests.

Akebia quinata (chocolate vine)



Ecological Impacts: Crowds out native understory species as thick ground cover, can over top shrubs and trees.

Vulnerable Ecosystems: Forest edges, wetlands.

Native Alternative 👍

Aronia melanocarpa (black chokeberry)



Zones
3 - 8

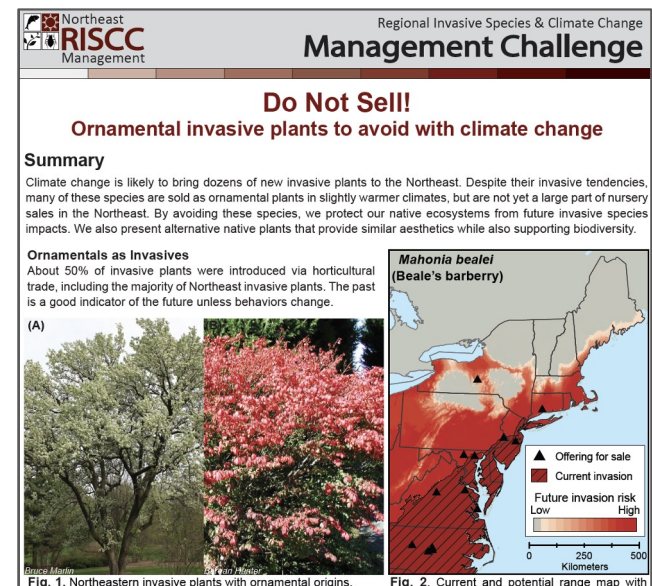
Lonicera sempervirens (coral honeysuckle)



Zones
4 - 9

Take home point #2:

- We have tools for predicting potential risks of assisted migration
- Continuing to plant non-native species perpetuates invasion risk, especially under climate change
- Geographically informed watch lists can facilitate prevention



Gardens as 'stepping stones' to seed ecosystems of the future



Prioritize gardening with climate-resilient native biodiversity

Resources

Climate Change

Resilient MA: <https://resilientma.org>

- State level climate assessment/clearinghouse for information
- One stop shop for tools and information

Gardening in a Warmer World:

<https://climatechange.cornell.edu/gardening/>

Climate Change Response Framework:

<https://forestadaptation.org/>

Climate Explorer: https://crt-climate-explorer.nemac.org/variables/?id=days_tmax_it_32f&left=historical&leftyear=avg&right=rcp85&rightyear=2050&extent=-75.2%2C-69.84%2C41.2%2C43.52&zoom=8

Invasive Species

Invasive species and climate change interactions: <https://www.risccnetwork.org/>

National Invasive Species Information:

<https://www.invasivespeciesinfo.gov/>

Planting Guides

Selecting Climate Resilient Urban Trees:
<https://www.umass.edu/newsoffice/article/umass-amherst-scientists-create-urban-tree>

Climate Smart Gardening:

https://scholarworks.umass.edu/eco_ed_materials/8/

Native Plant Trust:

<http://www.nativeplanttrust.org/>

Climate Voyager for Hardiness Zone Maps:

<http://climate.ncsu.edu/voyager/>

Forest Resiliency:

<https://masswoods.org/sites/masswoods.net/files/Forest-Resiliency.pdf>

Grow Native Massachusetts

<https://www.grownativemass.org/>

- **Want to know more about invasive species & climate change? Join the RISCC listserv!** Email "ne_riscc-l-request@cornell.edu" with the subject "join" to sign up.
- <https://www.risccnetwork.org/>

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