Implications of Climate Change for Invasive Species

Carrie Brown-Lima
Director, NY Invasive Species Research Institute
Cornell University

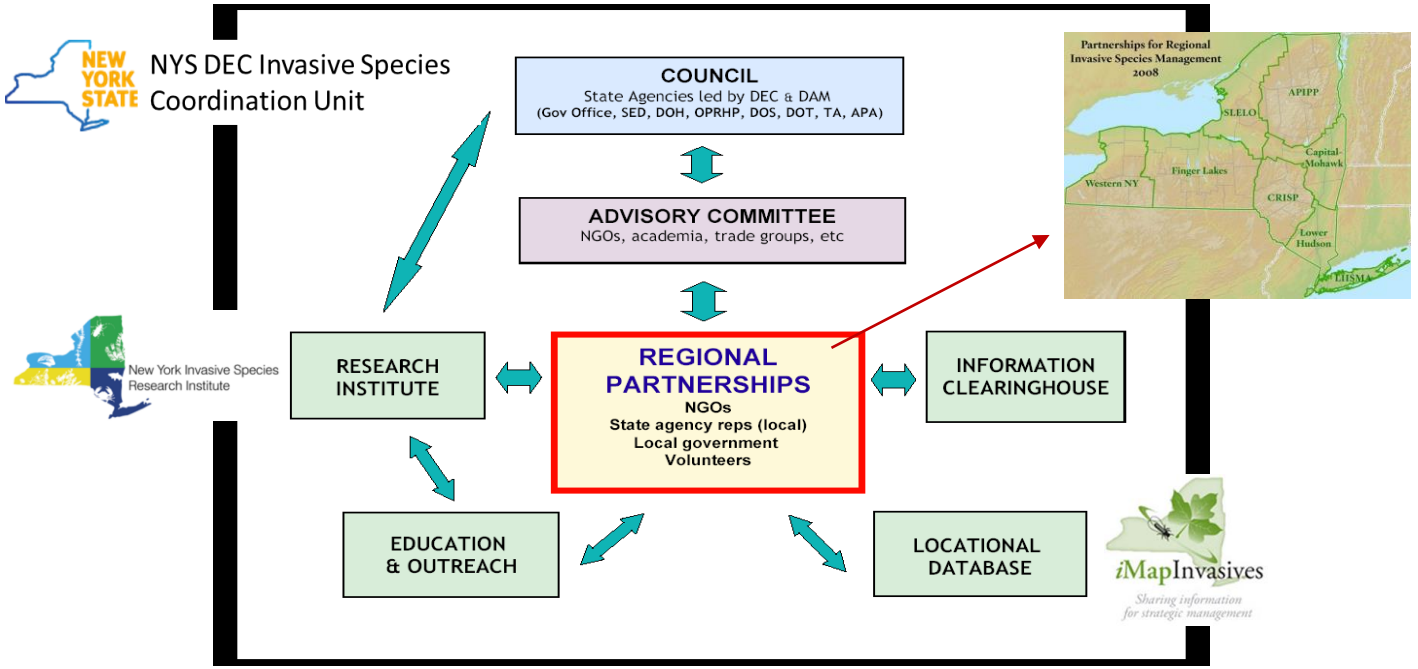
The New York Invasive Species Research Institute

Established in 2008 to work at the interface of research and management with the mission:

*"to coordinate invasive species **research** to help prevent and manage the **impact** of invasive species in New York State and beyond"*

PI: Dr. Bernd Blossey, Cornell University

New York State Invasive Species Network



Role of NYISRI to connect IS network with relevant research to improve the scientific basis of invasive species prevention and management and solicit research needs

Invasive Species and Climate Change

The White House

Office of the Press Secretary

For Immediate Release December 05, 2016

Executive Order -- Safeguarding the Nation from the Impacts of Invasive Species

EXECUTIVE ORDER

"How can we manage for upcoming biological invasions in light of climate change?"

"Federal agencies shall consider the impacts of climate change when working on issues relevant to the prevention, eradication and control of invasive species including research and monitoring efforts and integrate invasive species into Federal climate change coordinating frameworks and initiatives."

NRC Research Press

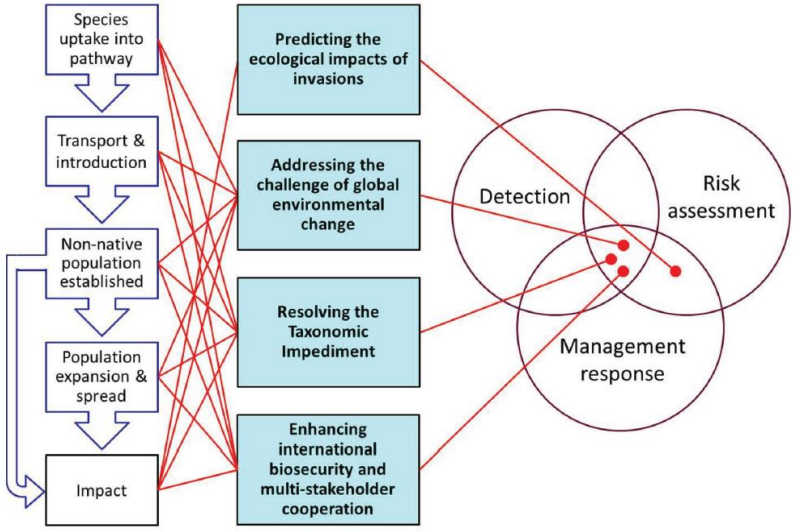
REVIEW

Four priority areas to advance invasion science in the face of rapid environmental change

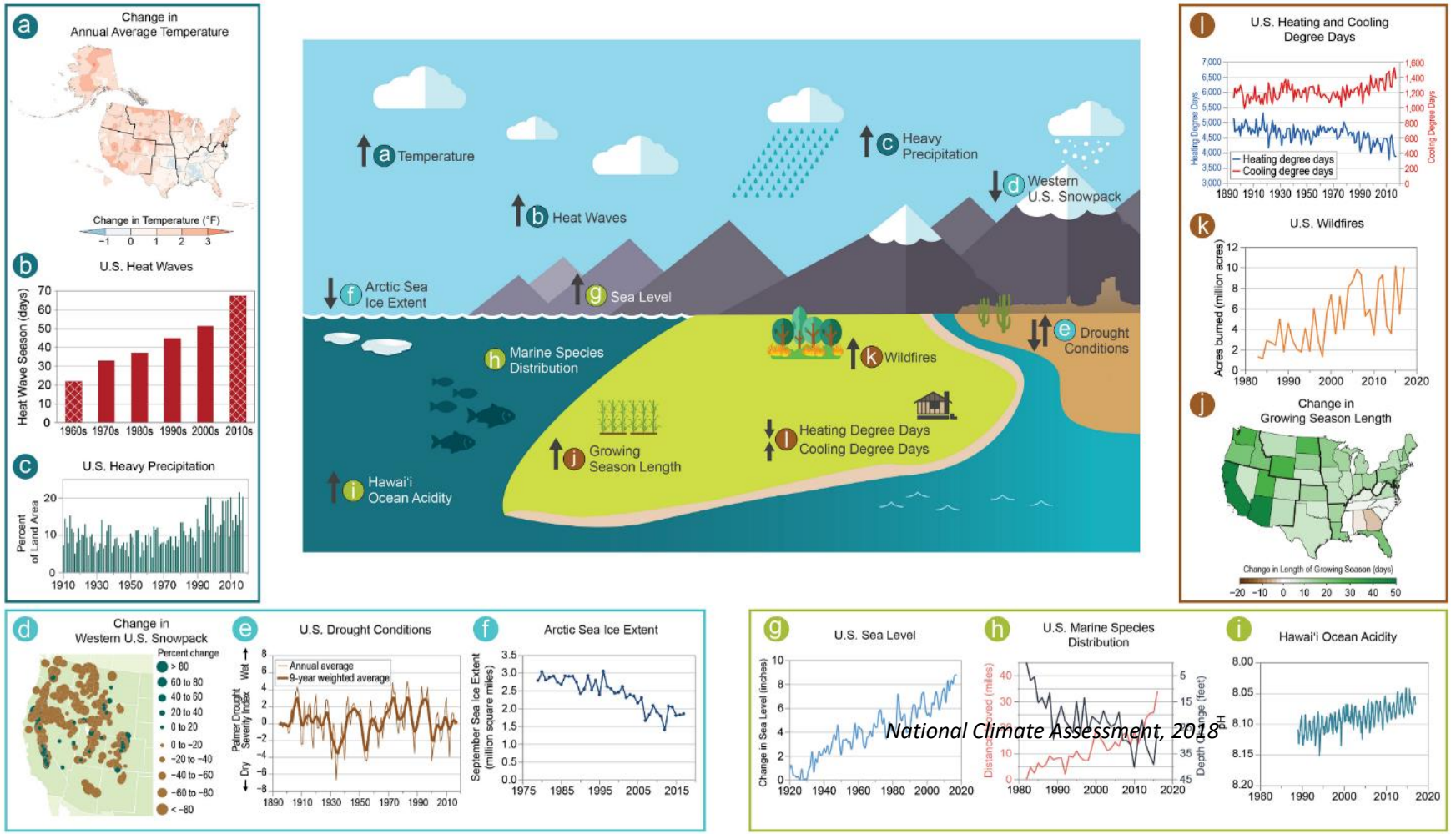
Anthony Ricciardi, Josephine C. Iacarella, David C. Aldridge, Tim M. Blackburn, James T. Carlton, Jane A. Catford, Jaimie T.A. Dick, Philip E. Hulme, Jonathan M. Jeschke, Andrew M. Liebhold, Julie L. Lockwood, Hugh J. MacIsaac, Laura A. Meyerson, Petr Pyšek, David M. Richardson, Gregory M. Ruiz, Daniel Simberloff, Montserrat Vilà, and David A. Wardle

A second priority is to ***understand the potential synergistic effects of multiple co-occurring stressors- particularly involving climate change—on the establishment and impact of non-native species***.

Climate adaptation and mitigation strategies will need to consider the possible consequences of promoting non-native species, and appropriate management responses to non-native species will need to be developed.



Indicators of Climate Change

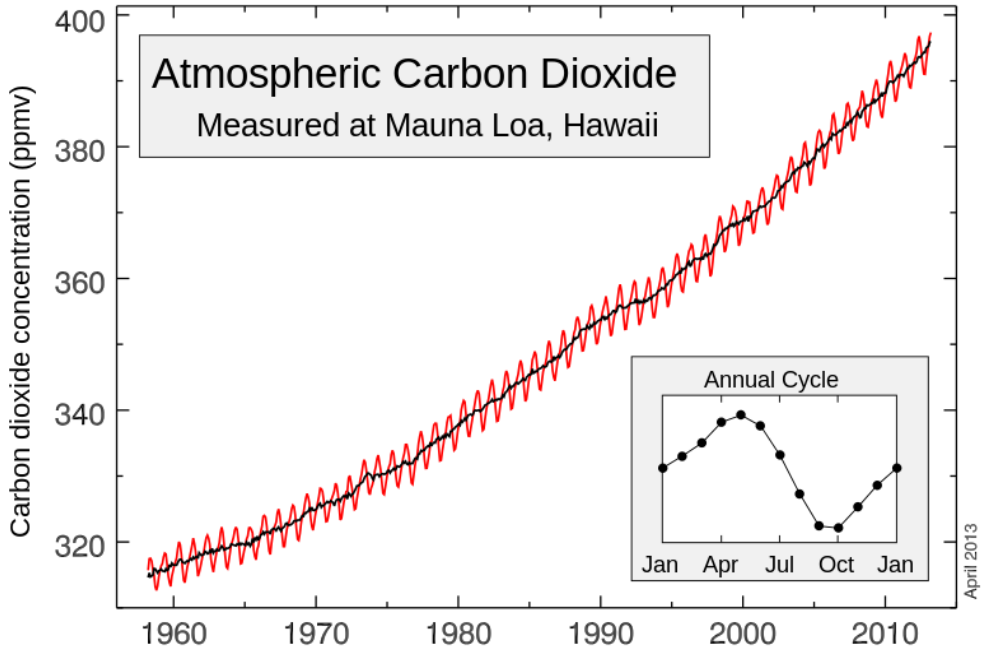


National Climate Assessment, 2018

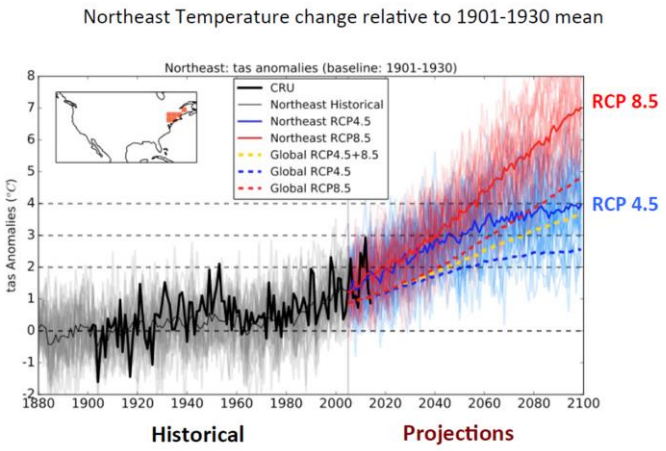
Rising CO_2

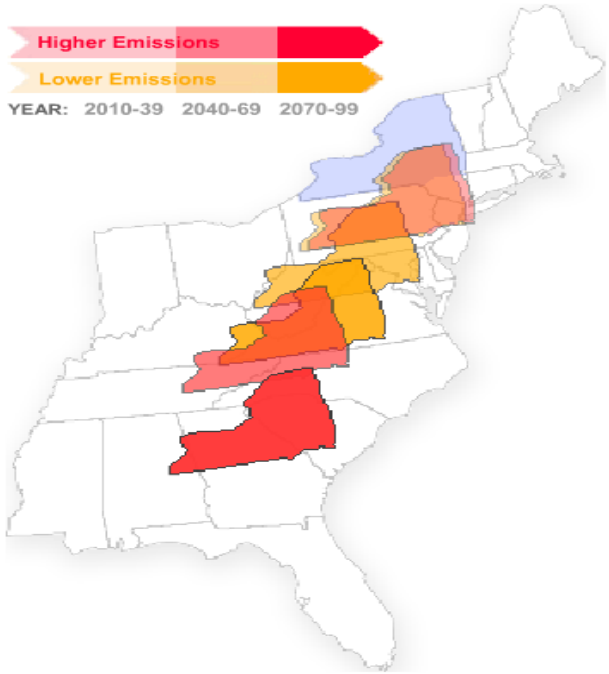
Atmospheric CO_2

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



Northeast average temperature rise

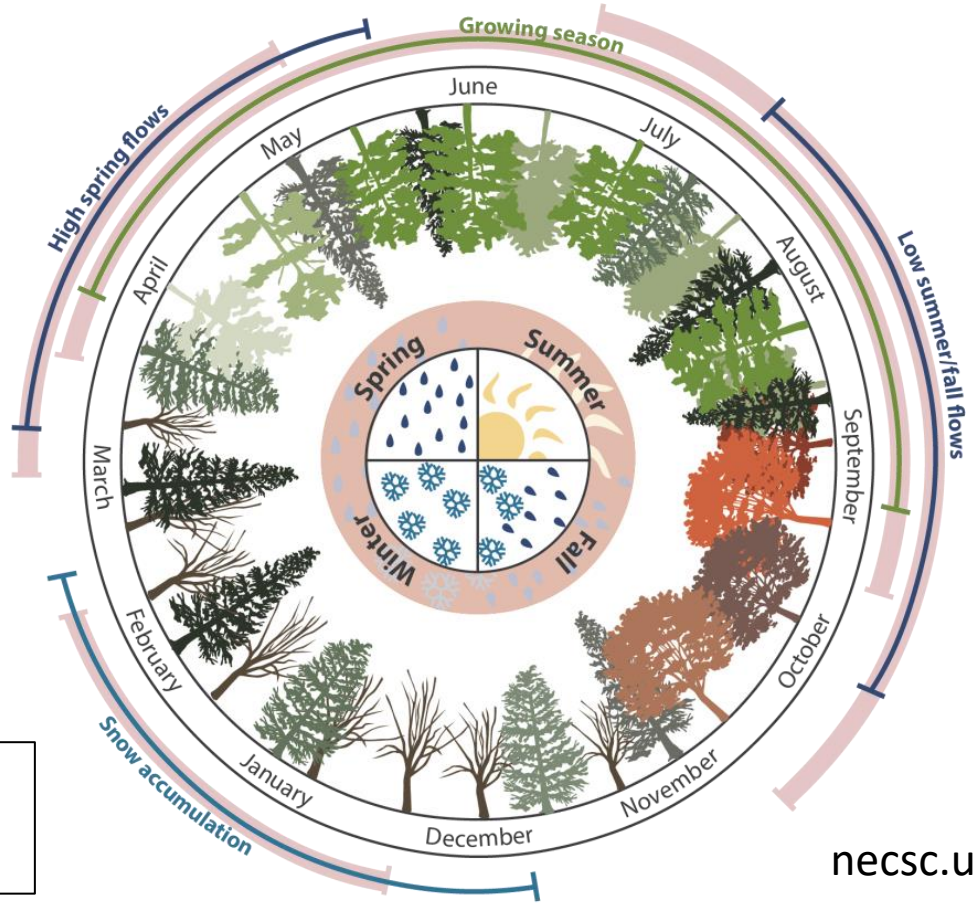




http://www.ucsusa.org/global_warming/science_and_impacts/impacts/global-warming-northeast-migrating-states.html

UCS USA

Seasons are Shifting

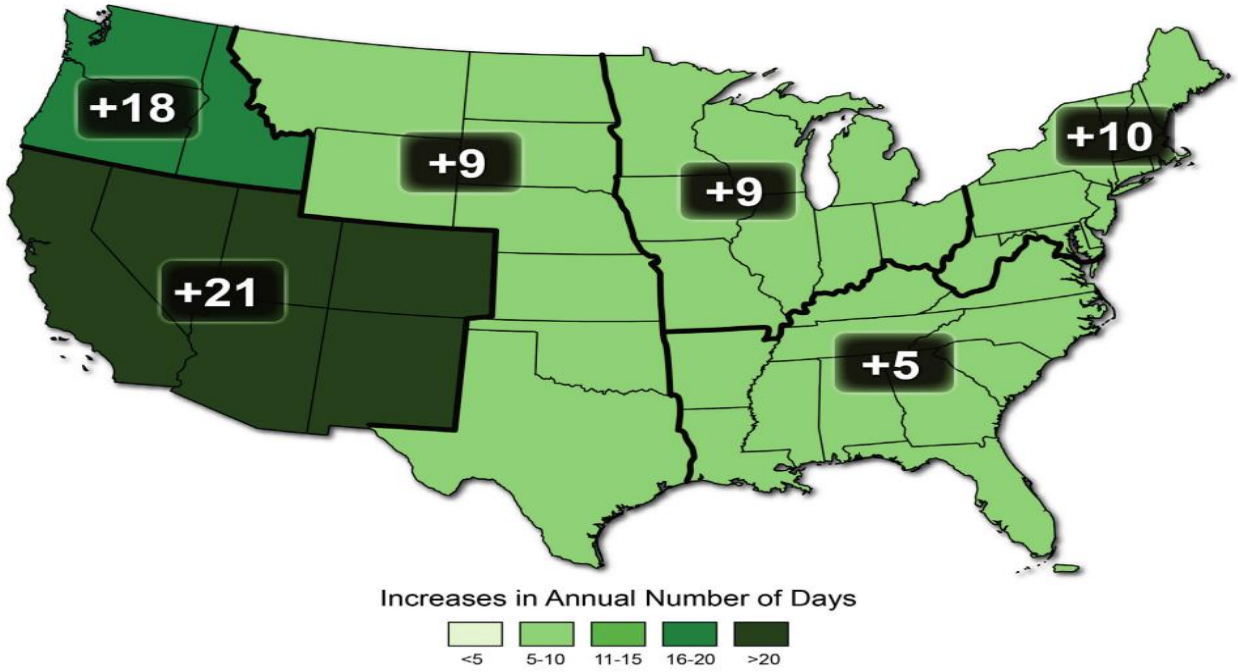


NECASC
Northeast Climate Adaptation Science Center

necsc.umass.edu

“Milder winters”

Observed changes in frost-free season (1991-2012)



- Frost free and growing seasons have increased nationally since 1980s
- Largest increases in west, continued lengthening is projected
- Earlier spring snow melt, less snow overall
- Lake ice forms later, melts earlier

2014 NCA report

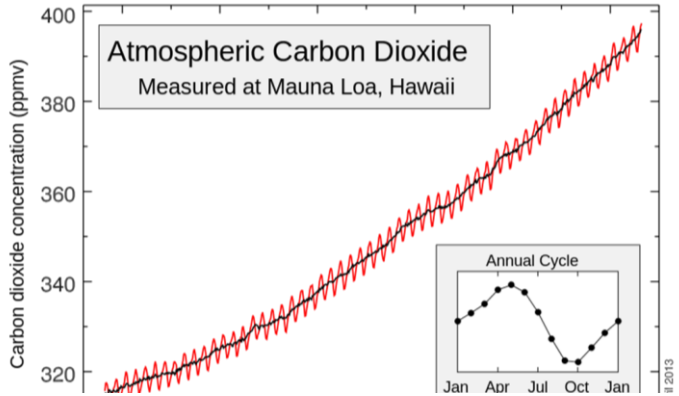
Figure source: NOAA National Climate Data Center

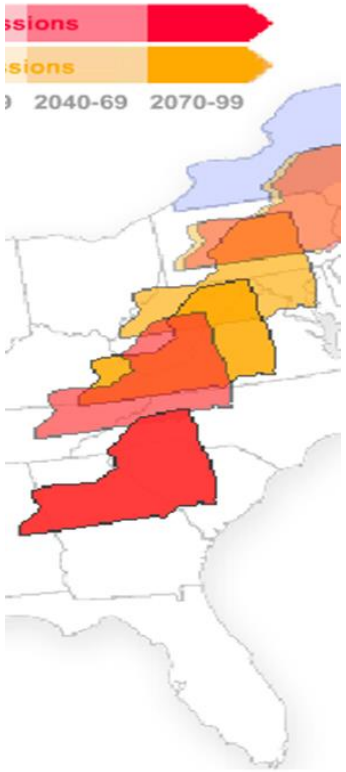
Increasing frequency of temperature and precipitation extremes
and also extreme weather events

Hurricane Sandy damage in Newark Watershed

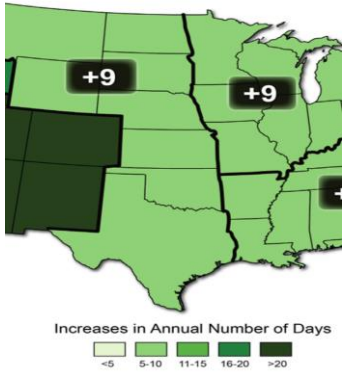
Red River flood near Fargo, ND

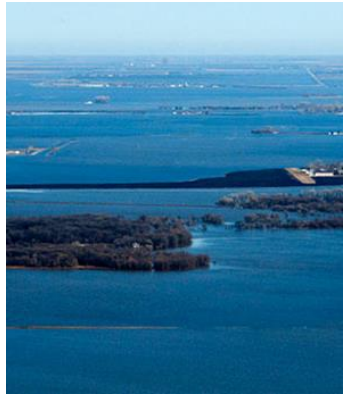
Heat waves/droughts cause fires in the West



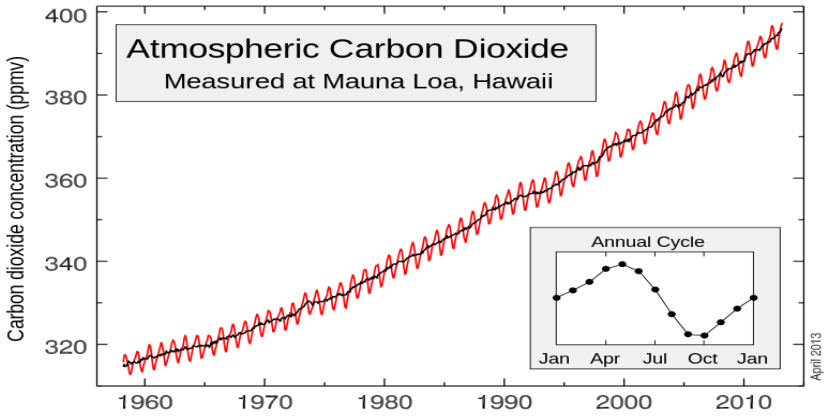


Under these conditions, many invasive species are given a competitive edge

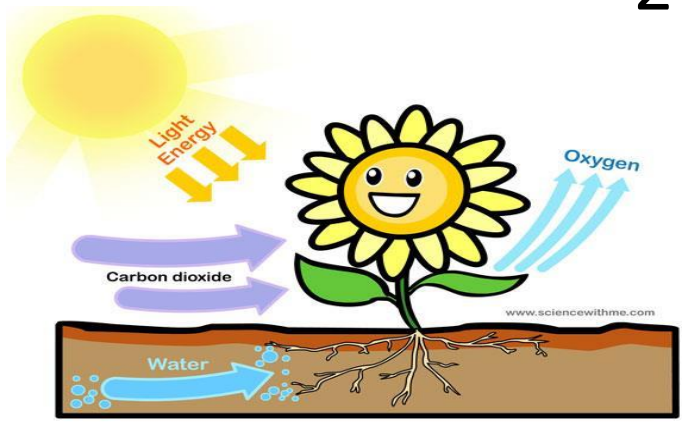




Rising CO_2

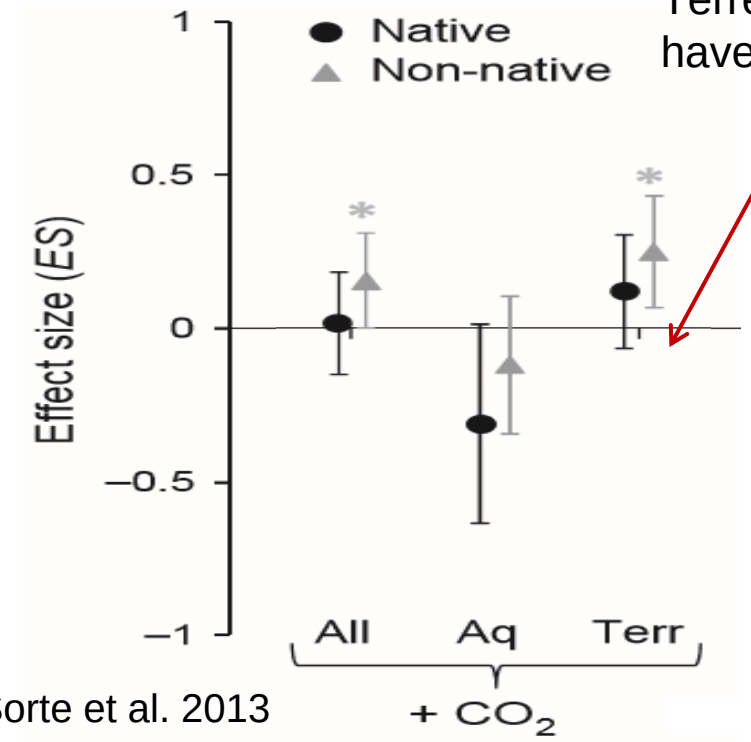


Plants ❤ CO_2



Rising CO_2

Invasive plants do better still



Sorte et al. 2013

Terrestrial <u>invasive</u> plants have a larger <u>advantage</u>

Bigger…… and harder to kill

Differential efficacy of the herbicide glyphosate to control the aggressive perennial weed, Canada thistle, at ambient and future CO2 concentrations. Credit: Ziska et al. 2004.

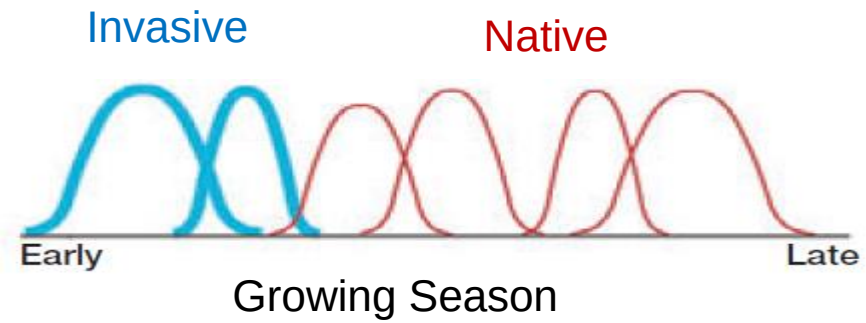
Creating new pathways

Melting of Arctic sea ice opens new direct route for invasive species introduction

Warming temperatures

Milder winters and priority effects:

Some invasive plants show earlier spring green-up



Wolkovich & Cleland 2011

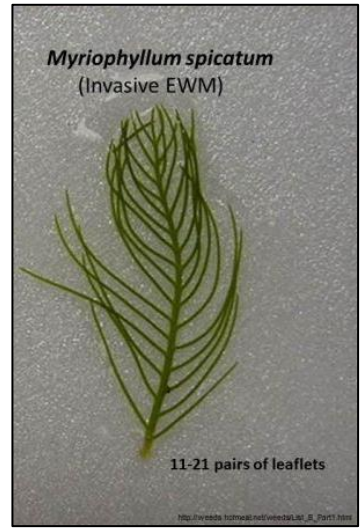

Barberry (*B. thunbergii*)


Garlic mustard (*A. petiolata*)


Honeysuckle (*L. maackii*)


Buckthorn (*R. cathartica*)

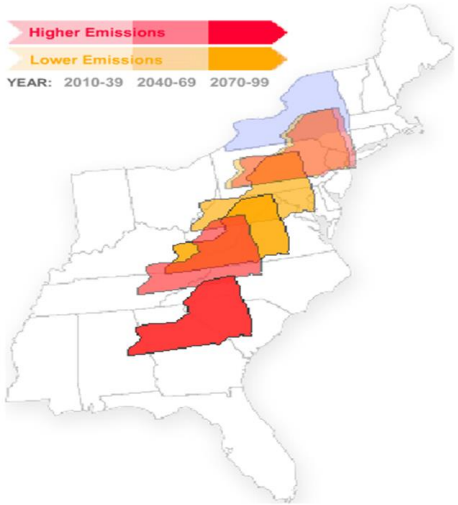
Warming temperature

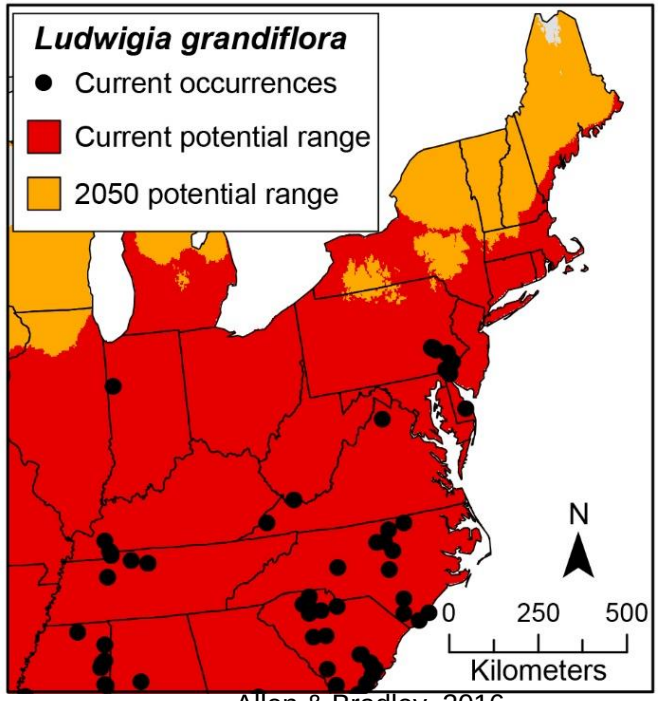


Warmer water gives a competitive advantage for some invasives, results in growth and longer growing season

Warming temperature

(Invasive) species respond by shifting their ranges



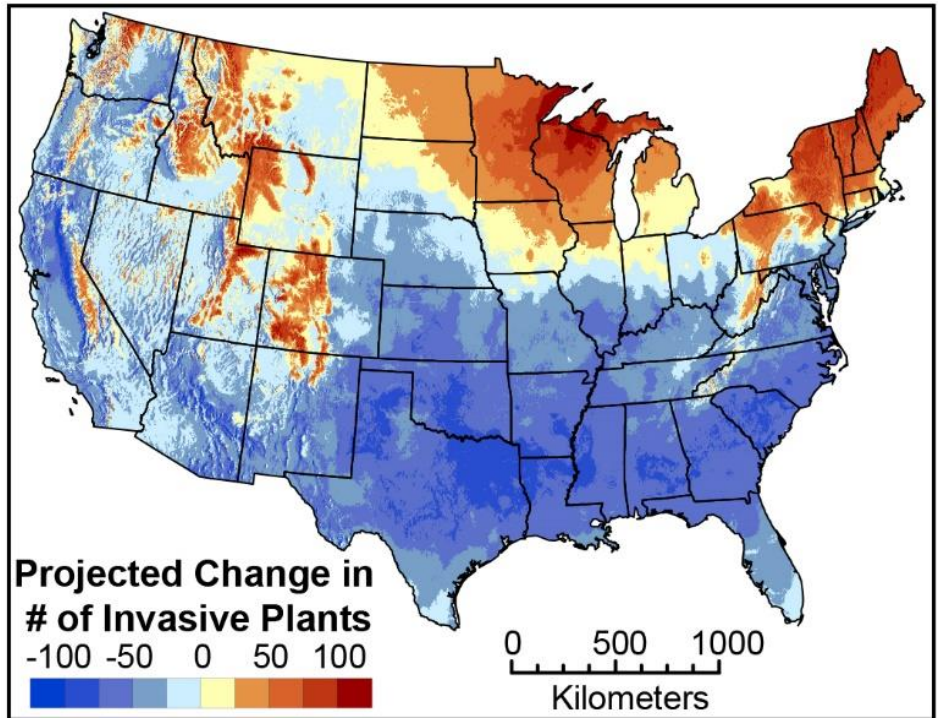


Allen & Bradley, 2016

Photo: Alain Dutartre

Warming temperature

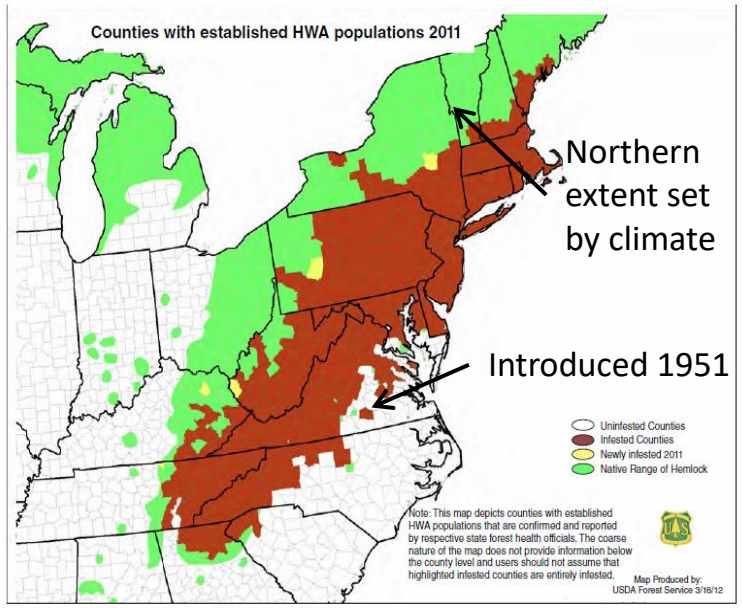
The northeast is a hotspot of future invasion



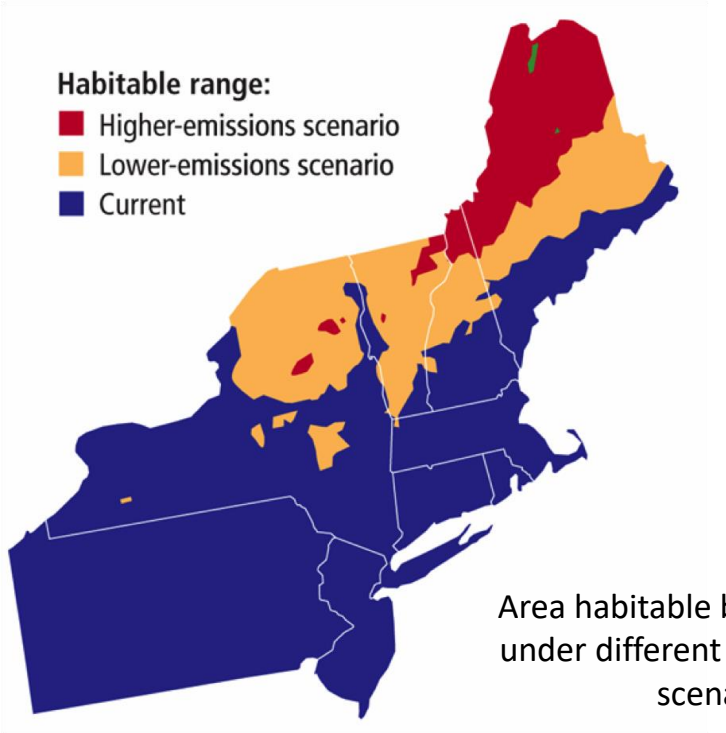
Allen & Bradley, 2016

Warming temperature

Forest pests such as Hemlock Woolly Adelgid will continue to spread
Northward as the climate warms



Source: Northeast Climate Impact Assessment, 2006
Slide by G. Lovett



Area habitable by HWA in 2100 under different CO2 emissions scenarios

Warming temperature

Range expansion of temperature-limited aquatic species

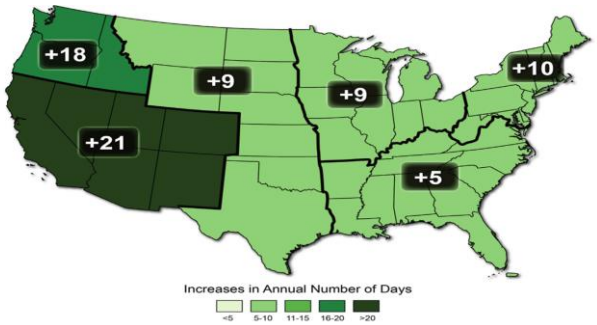
Water Hyacinth

Asian Clam

Warming temperature

Changes in disturbance regime favors invasive species

ex: ice scouring effect removed



Warming temperature

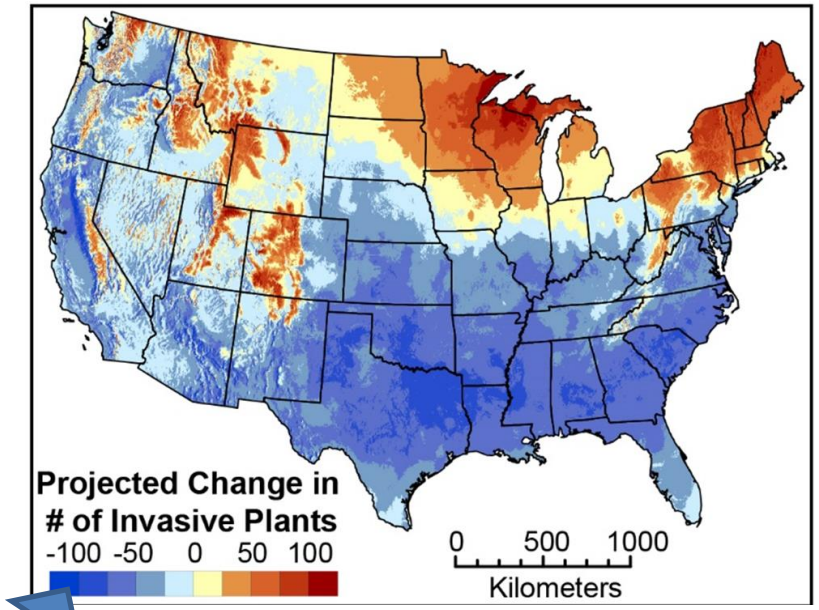
Increased spread and impact of wildlife and human diseases

Asian tiger mosquito, *Aedes albopictus*

Bat with White-Nose syndrome (WNS)

Warming temperature

Does not always benefit invasive species

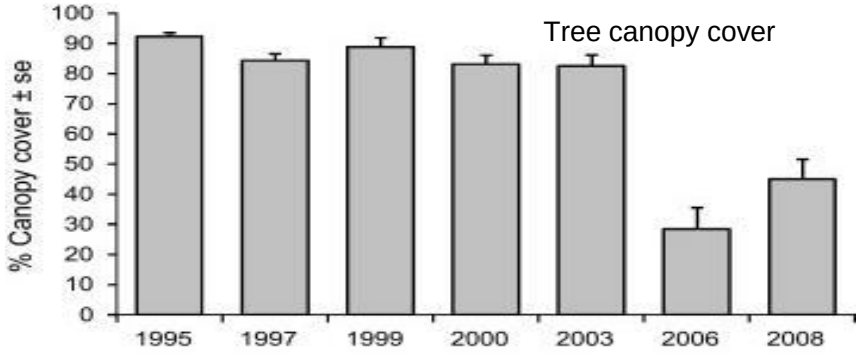


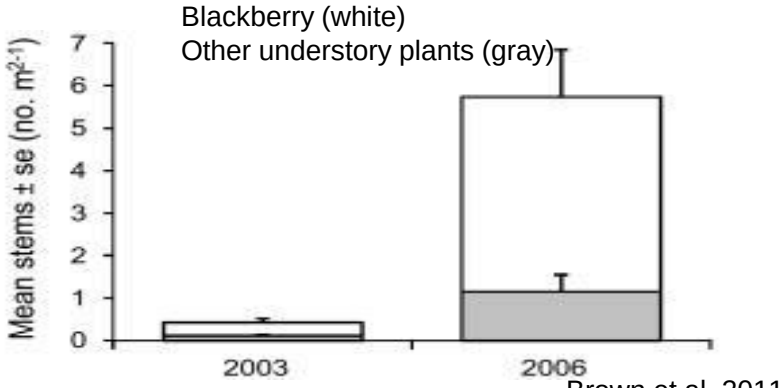
Responses are species and context specific!

Increased extreme events

Extreme events cause native species mortality and allow invasive species opportunities to take over

Understory (invasive) plants thrive following disturbance from Hurricane Katrina. Duration of effect unknown.





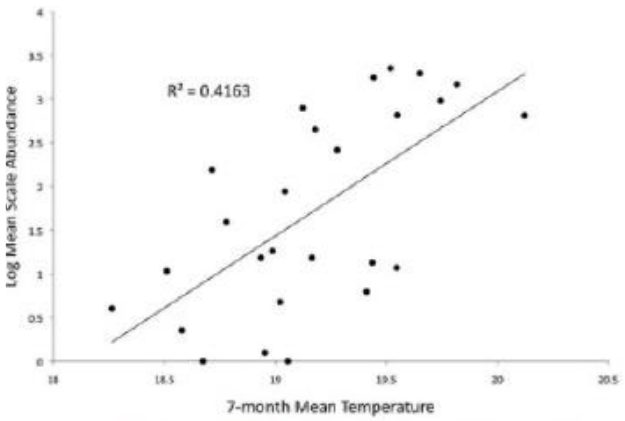
Brown et al. 2011

Increased extreme events

Warmer climate + drought= more stressed trees and more abundant pests

- Gloomy scale insects, *Melanaspis tenebricosa and red maples*
- Warmer, more drought-stressed trees harbored more successful pests than cooler, less drought-stressed trees.
- As cities and natural habitats become hotter and drier, damaging scale insects will become more abundant.

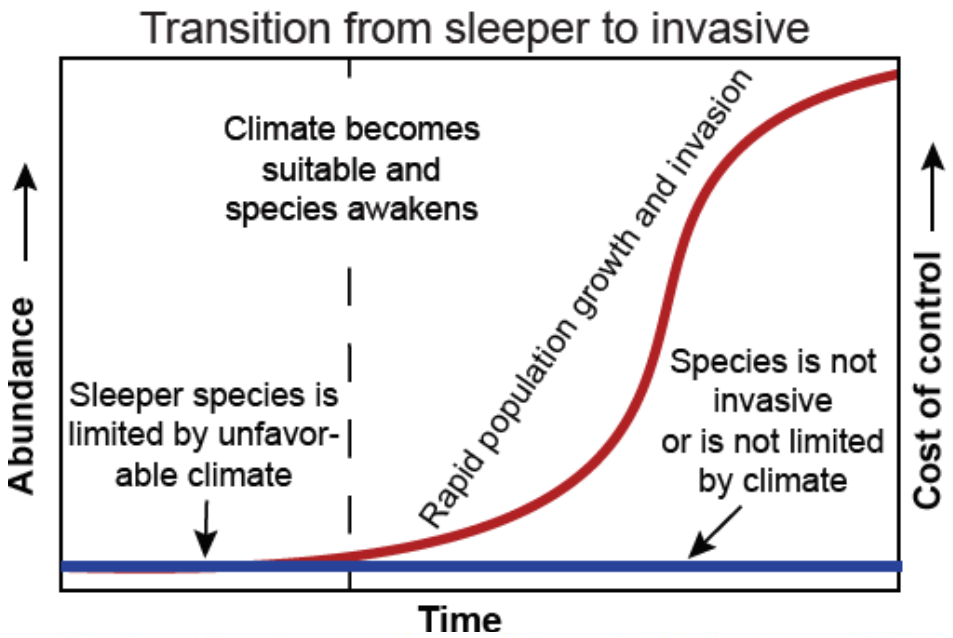
Adam Dale (UF) and Steven Frank (NCSU)



Linear regression of seven-month mean temperature and log mean scale abundance per 0.6 m of maple twig ($\log(y) = 229.95+1.65x$).

Additional considerations

“Unknown” future invaders: “Sleeper Species”



Bradley, Bethany A.; Beaury, Evelyn; Fusco, Emily J.; Laginhas, Brittany; Morelli, Toni Lyn; and Pasquarella, Valerie, "Regional Invasive Species & Climate Change Management Challenge: Preparing for sleeper species" (2018). *Environmental Conservation Educational Materials*. 2.
https://doi.org/10.7275/R5F18WXT

- Non-native species that are present but not invasive because growth is limited by biotic or abiotic conditions
- Often climate is the limiting factor and if climate becomes suitable, the species will proliferate

Additional considerations

Examples of sleeper species

A) Acorn barnacle (*Austrominius modestus*), a cold-intolerant species first introduced around 1955 off the U.K. coast, did not become invasive until 50 years later after a series of mild winters. **B)** Mayweed chamomile (*Anthemis cotula*) was introduced to Massachusetts over a century ago. Its ability to respond quickly to climate change may give the plant a competitive advantage, shifting it from naturalized to invasive. **C)** First discovered in New York in 2004, Sirex woodwasp (*Sirex noctilio*) currently impacts stressed pines. Increasingly frequent disturbance events due to climate change may lead to greater damage from this forest pest.

Bradley, Bethany A.; Beaury, Evelyn; Fusco, Emily J.; Laginhas, Brittany; Morelli, Toni Lyn; and Pasquarella, Valerie, "Regional Invasive Species & Climate Change Management Challenge: Preparing for sleeper species" (2018). *Environmental Conservation Educational Materials*. 2.
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Additional considerations

Reduced efficacy of control methods

Differential efficacy of the herbicide glyphosate to control the aggressive perennial weed, Canada thistle, at ambient and future CO2 concentrations. Credit: Ziska et al. 2004.

Additional considerations

Intersection of biological control and climate change are being explored….

Climate change effects on behavioral and physiological ecology of predator–prey interactions: Implications for conservation biological control

Oswald J. Schmitz [a,*], Brandon T. Barton [b]

[a] School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511, USA
[b] Department of Zoology, University of Wisconsin, Madison, WI, USA

ECOLOGY LETTERS

Ecology Letters, (2015) 18: 48–56 doi: 10.1111/ele.12391

LETTER

Climate warming increases biological control agent impact on a non-target species

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Insect Science

Climate change and biological control: the consequences of increasing temperatures on host–parasitoid interactions

Michael J Furlong and Myron P Zalucki

CrossMark

Update on Climate Change

Climate Change: Resetting Plant-Insect Interactions[1]

Evan H. DeLucia*, Paul D. Nabity, Jorge A. Zavala, and May R. Berenbaum

Department of Plant Biology (E.H.D., P.D.N.) and Department of Entomology (M.R.B.), University of Illinois, Urbana, Illinois 61801; and Catedra de Bioquimica/Instituto de Investigacion en Biociencias Agricolas y Ambientales, Facultad de Agronomia, University of Buenos Aires, Buenos Aires C1417DSE, Argentina (J.A.Z.)

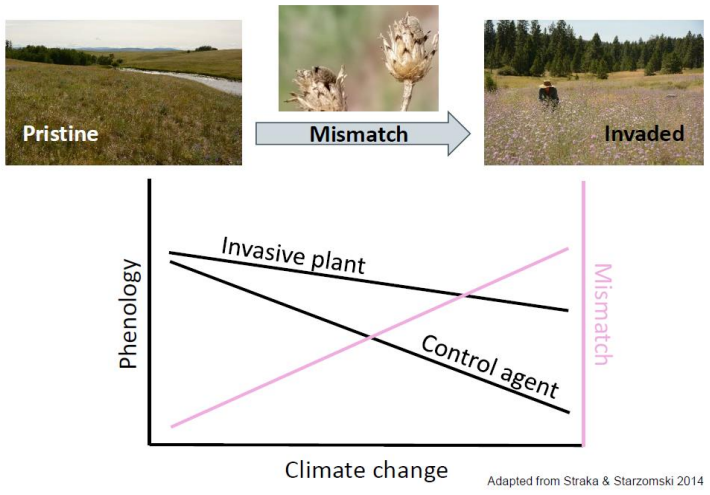
Biocontrol of invasive weeds under climate change: progress, challenges and management implications

Yan Sun[1], Jianqing Ding[2], Evan Siemann[3] and Stephen R Keller[4]

Additional considerations

Biological controls for invasive species may become less effective due to climate change

- Decoupling of phenology of a biocontrol agent and its target invasive species
- Change in growth and reproductive rate of both agent and target
- Change in range of the agent and target



Graphic by Dave Ensing

Additional considerations

Reduced carbon sequestration due to forest pests

Biomass losses resulting from insect and disease invasions in US forests

Songlin Fei[a,1], Randall S. Morin[b], Christopher M. Oswalt[c], and Andrew M. Liebhold[d]

[a]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47906; [b]Northern Research Station, Forest Service, US Department of Agriculture, Newtown Square, PA 19073; [c]Southern Research Station, Forest Service, US Department of Agriculture, Knoxville, TN 37919; and [d]Northern Research Station, Forest Service, US Department of Agriculture, Morganton, WV 26505

Edited by Daniel S. Simberloff, The University of Tennessee, Knoxville, TN, and approved July 16, 2019 (received for review December 4, 2018)

ARTICLE

DOI: 10.1038/s41467-018-04096-w OPEN

Invasive alien pests threaten the carbon stored in Europe's forests

Rupert Seidl[1], Günther Klonner[2], Werner Rammer[1], Franz Essl[2], Adam Moreno[1,3], Mathias Neumann[1] & Stefan Dullinger[2]

Additional considerations

Nuisance Neonatives?

- Neonatives are native range-shifting species that have established themselves beyond their historical range.

Black Locust is a high-risk neonative tree expanding its native range (Appalachian region) due to climate change. This species thrives in a variety of habitats - making it a strong competitor. It is a nitrogen-fixer, which may promote other invasive species, even in resilient areas. Ornamental trade spreads this species in and beyond its native and neonative ranges. Outside the U.S., it is invasive.

Climate Change's 'Opportunities' for Invasive Species

- Increased growth and density of invasives due to higher CO_2
- "Hardier" invasives under higher CO2 show resistance to herbicide treatment
- Potential reduced effectiveness of biocontrols if phenology is mismatched
- Earlier green-up (via priority effects or greater plasticity) for invasives and other competitive advantages
- Northward shifts for invasives due to warmer temperatures and milder winters
- Increased new establishment due to increased disturbance
- Waking up "sleeper" invasive species
- Carbon storage opportunities lost to invasive species
- Facilitating the spread of both wildlife and human diseases
- Native species -"neonatives" -becoming a nuisance

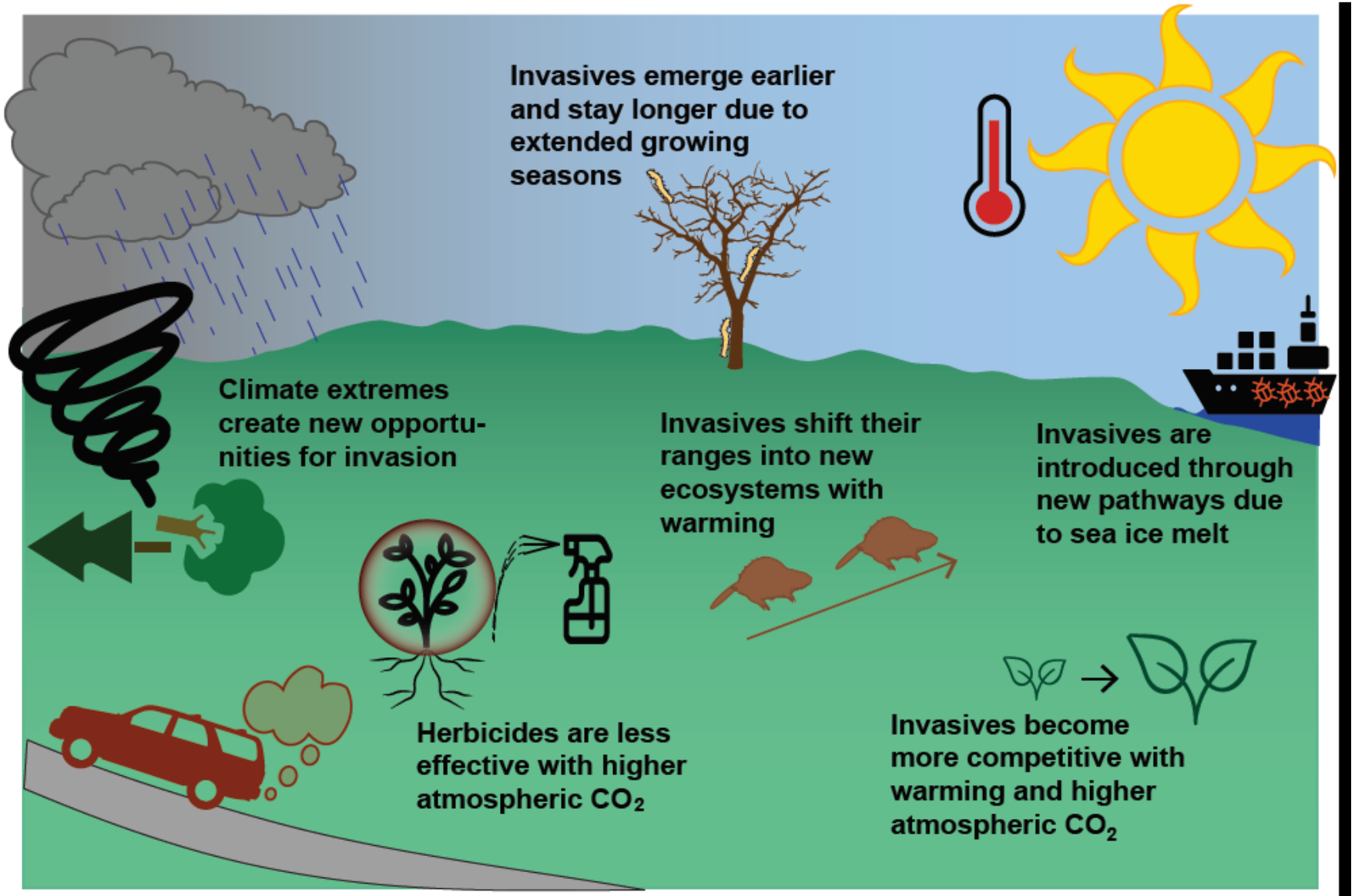


Figure 1. Major interactions between non-native invasive species and climate change.

Bradley et al. 2020
risccnetwork.org

Invasive Species and Climate Change

The White House

Office of the Press Secretary

For Immediate Release December 05, 2016

Executive Order -- Safeguarding the Nation from the Impacts of Invasive Species

EXECUTIVE ORDER

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"How can we manage for upcoming biological invasions in light of climate change?"

"Federal agencies shall consider the impacts of climate change when working on issues relevant to the prevention, eradication and control of invasive species including research and monitoring efforts and integrate invasive species into Federal climate change coordinating frameworks and initiatives."

Northeast RISCC Regional Invasive Species & Climate Change Management

Founded in 2016 to address the question

"How can we manage biological invasions in light of climate change?"

Bethany Bradley
Professor
University of Massachusetts, Amherst

Toni Lyn Morelli
USGS Research Ecologist
Northeast Climate Adaptation Science Center

UMass Amherst

USGS science for a changing world

NYISRI New York Invasive Species Research Institute

Cornell University

NECASC Northeast Climate Adaptation Science Center

Northeast RISCC Management
Regional Invasive Species & Climate Change

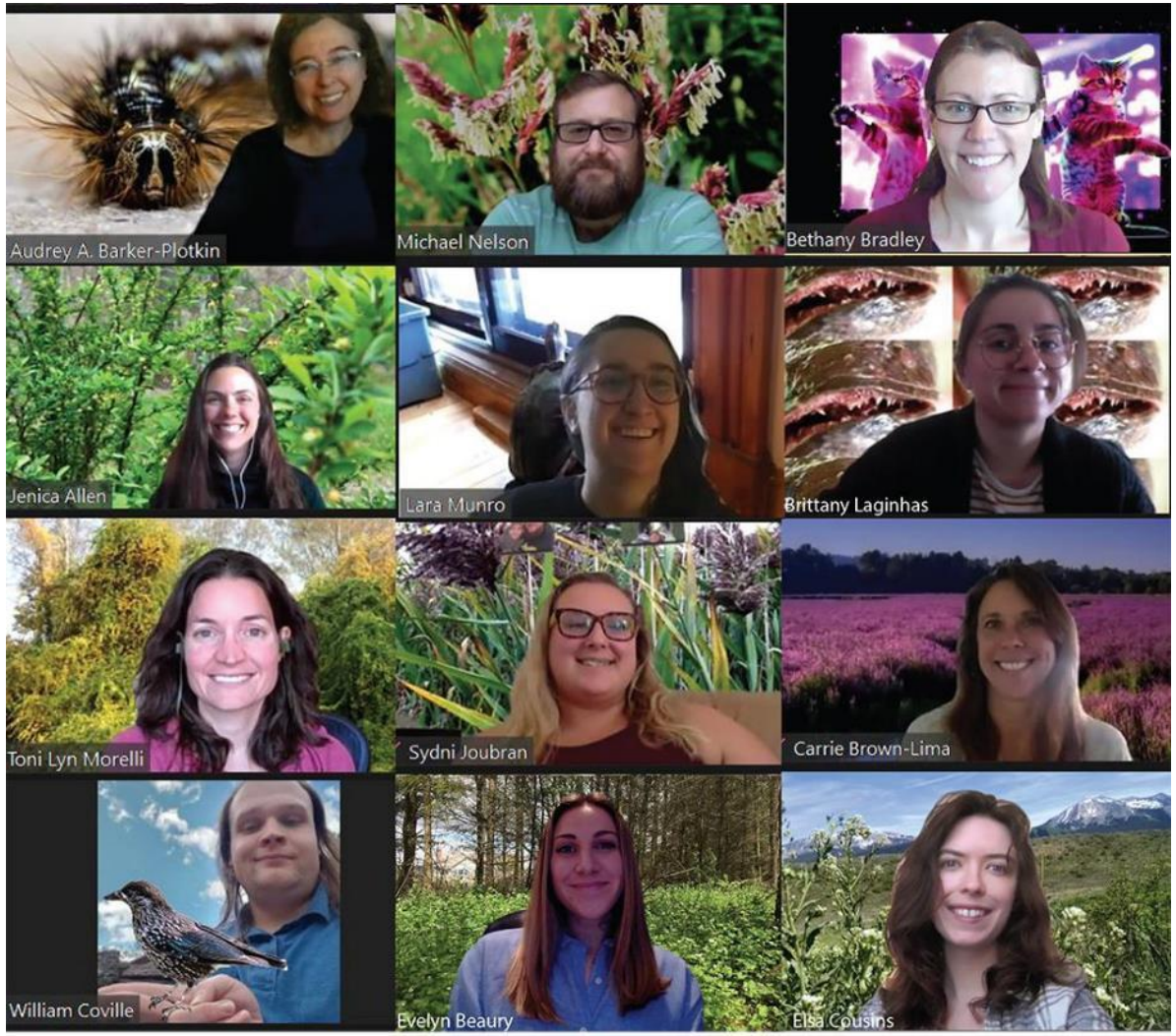
Mission Statement:

The Northeast Regional Invasive Species & Climate Change (RISCC) Management Network aims to reduce the compounding effects of invasive species and climate change by **synthesizing** relevant science, **communicating** the needs of managers to researchers, **building** stronger scientist-manager communities, and **conducting** priority **research**.

Northeast RISCC Regional Invasive Species & Climate Change Management

Leadership team:

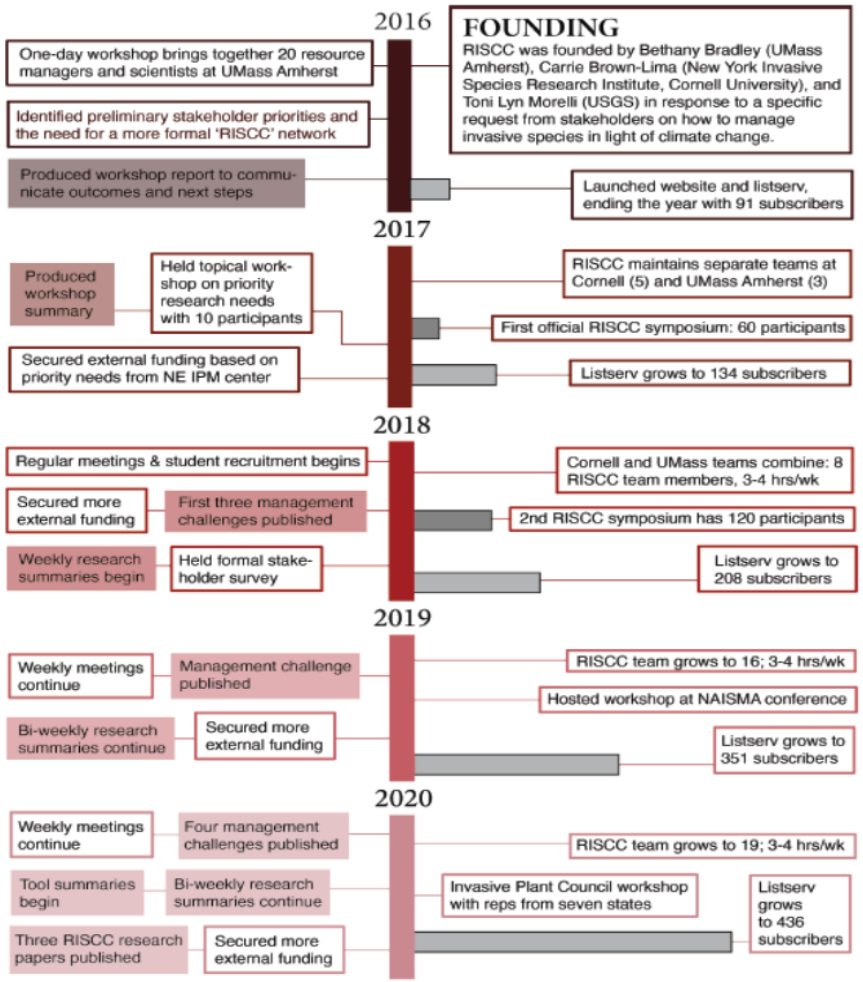
Supports a network of nearly 600 invasive species researchers and managers



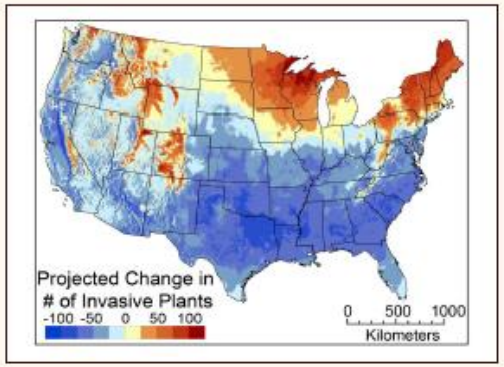
Leadership team + our favorite invasives

Northeast RISCC Management

Regional Invasive Species & Climate Change



What RISCC Does



BOUNDARY SPANNING
(Figure 1 Steps 1 & 2)

Connect managers and researchers at symposia and workshops.

Survey and synthesize manager needs

Communicate needs to researchers

ORIGINAL RESEARCH

Conduct original research using the TIE framework

Identify problems, discuss with stakeholders, conduct research, produce manager-focused materials, evaluate and improve

RESEARCH TRANSLATION & SYNTHESIS

Summarize information for managers through research and tool summaries

Create management challenges that synthesize the current state of knowledge about a topic

COMMUNICATION & IMPLEMENTATION

Host webinars on invasive species, research, climate change, or RISCC itself

Communicate research summaries and updates over list-serv

Make research and tools accessible

Create tools

Not just the Northeast…..

- Concerns, information needs, and science priorities are similar across regions

- North-Central RISCC, Pacific Islands RISCC and Northwest RISCC being established

Northeast RISCC Regional Invasive Species & Climate Change Management

risccnetwork.org

NYISRI New York Invasive Species Research Institute

nyisri.org

cjb37@cornell.edu

Have a seat at our table!

UMass Amherst USGS science for a changing world NYISRI New York Invasive Species Research Institute Cornell University NE CASC Northeast Climate Adaptation Science Center