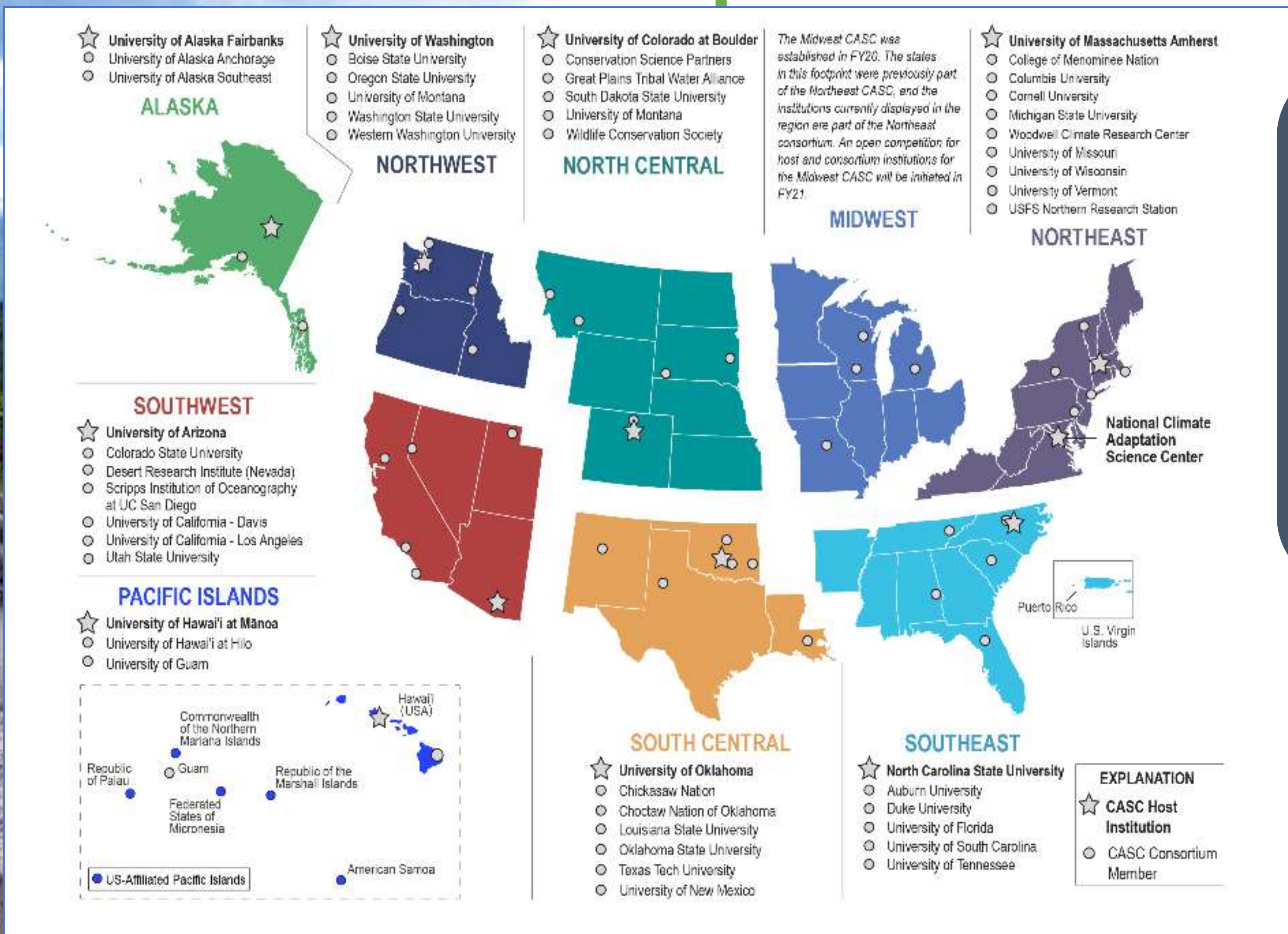
Translational Invasion Ecology & Climate Change: Bridging research and practice to address the greatest drivers of global change

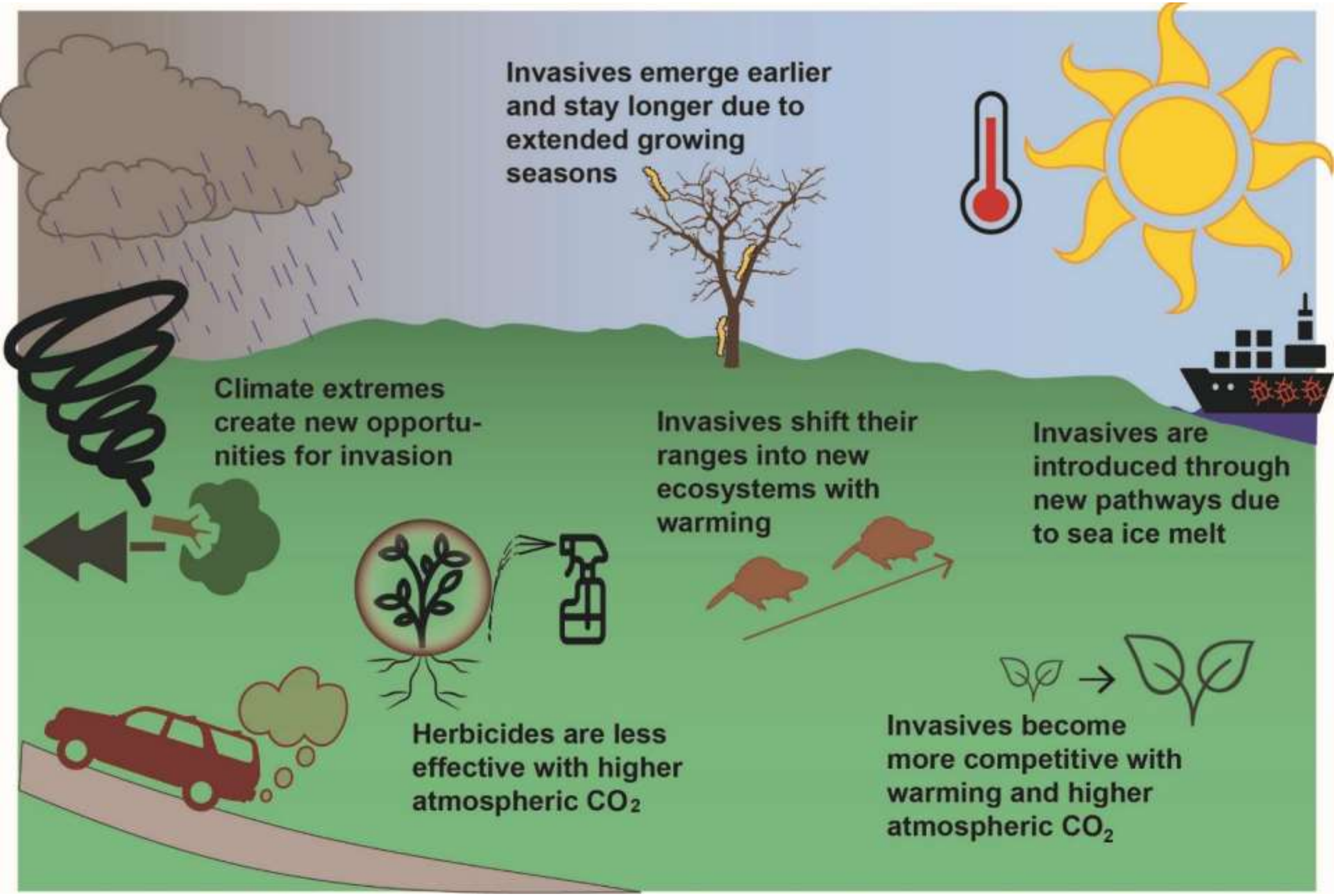
Toni Lyn Morelli
U.S. Geological Survey
Northeast Climate Adaptation Science Center

CASC

MISSION:
Actionable science to help fish, wildlife,& ecosystems **adapt to a changing climate.**



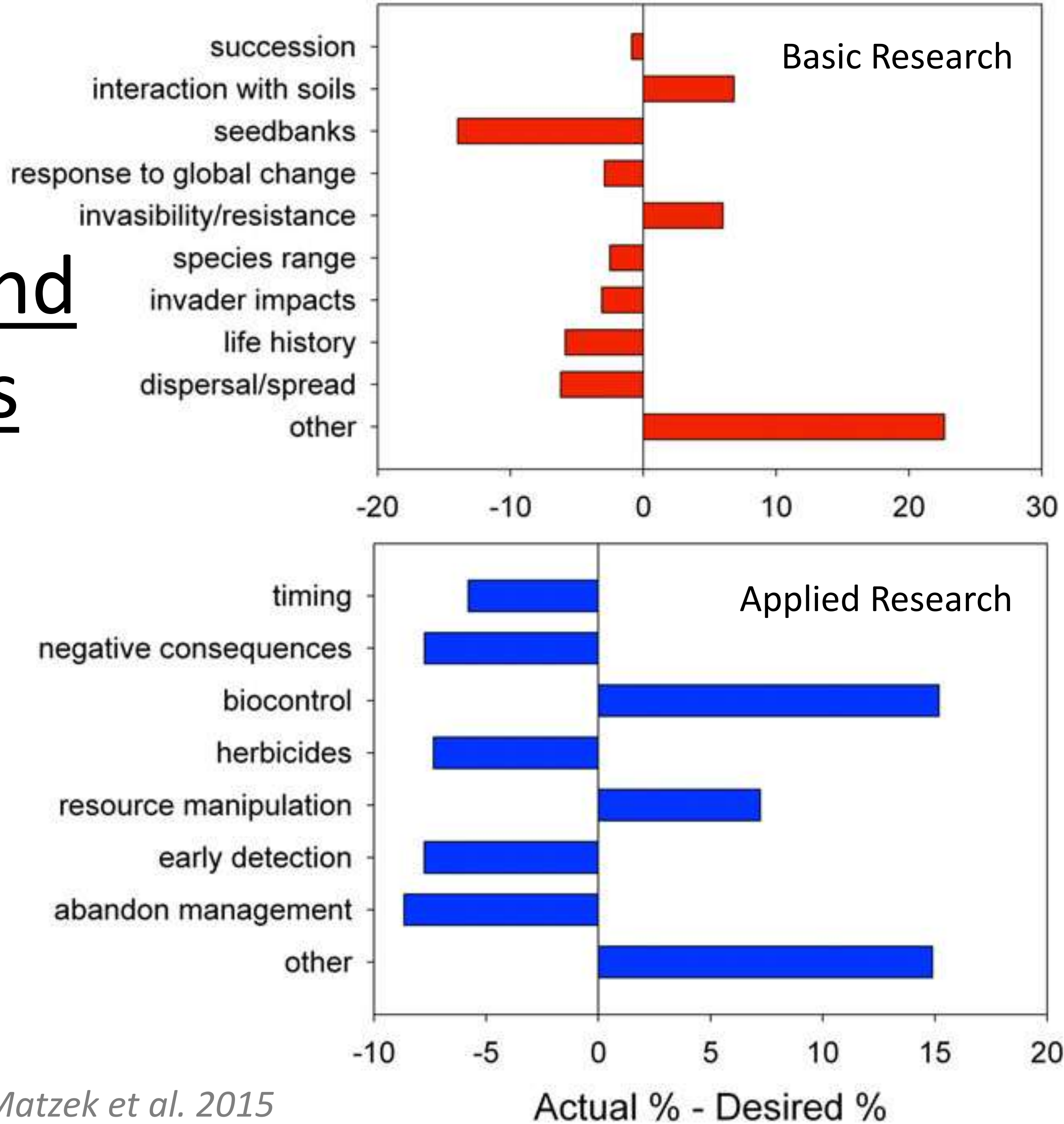
Federal – University Partnership
+Advancing science
+ Working groups
+ Fellows program
+Training
+Communication



Northeast RISCC Management Regional Invasive Species & Climate Change

Bradley et al. 2019
https://doi.org/10.7275/mrf6-p616

Mismatch between researchers and stakeholders

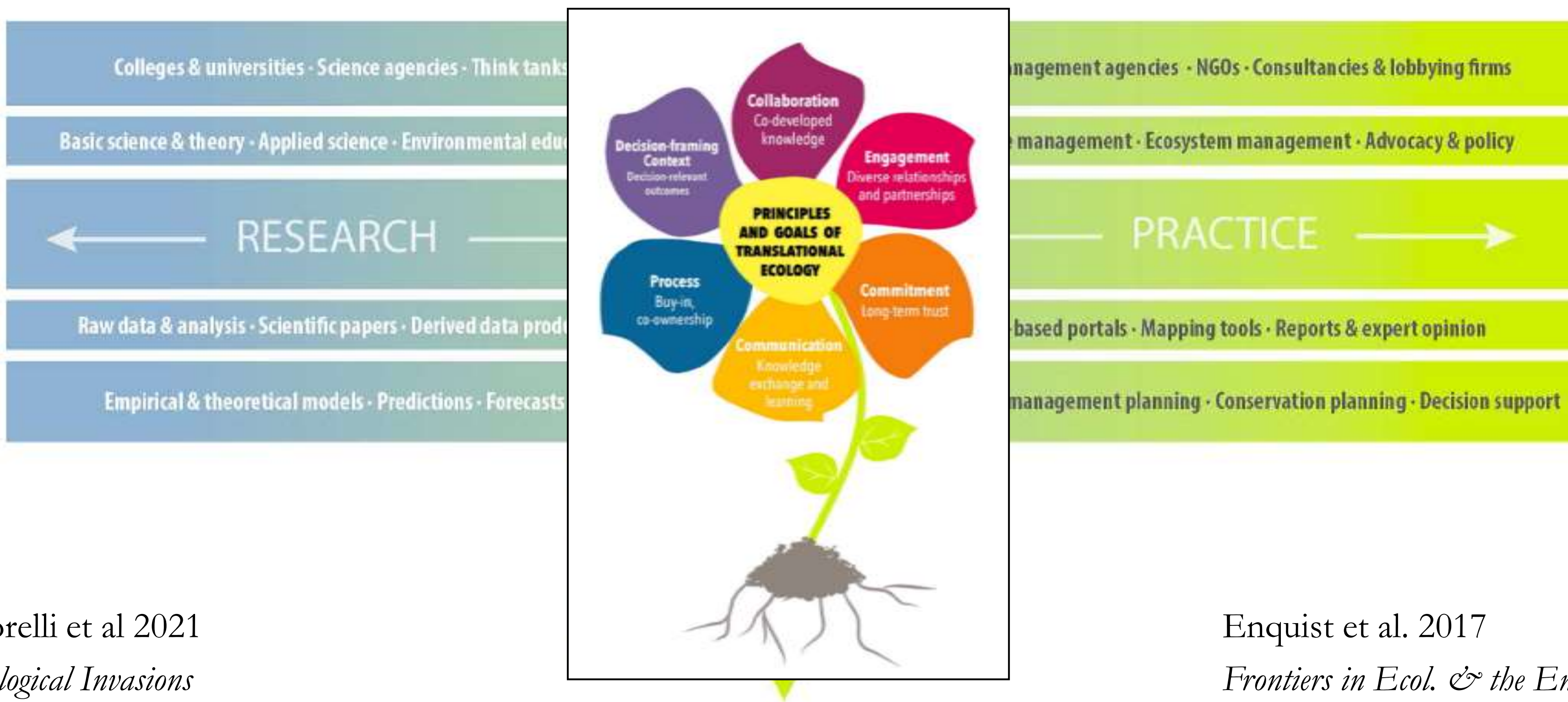


Matzek et al. 2015

Translational Invasion Ecology

Translational Invasion Ecology

An approach that embodies an intentional and inclusive process in which researchers, stakeholders, and decision makers collaborate to develop and implement research via joint consideration of the sociological, ecological, economic, and political contexts of the problem of invasive species.

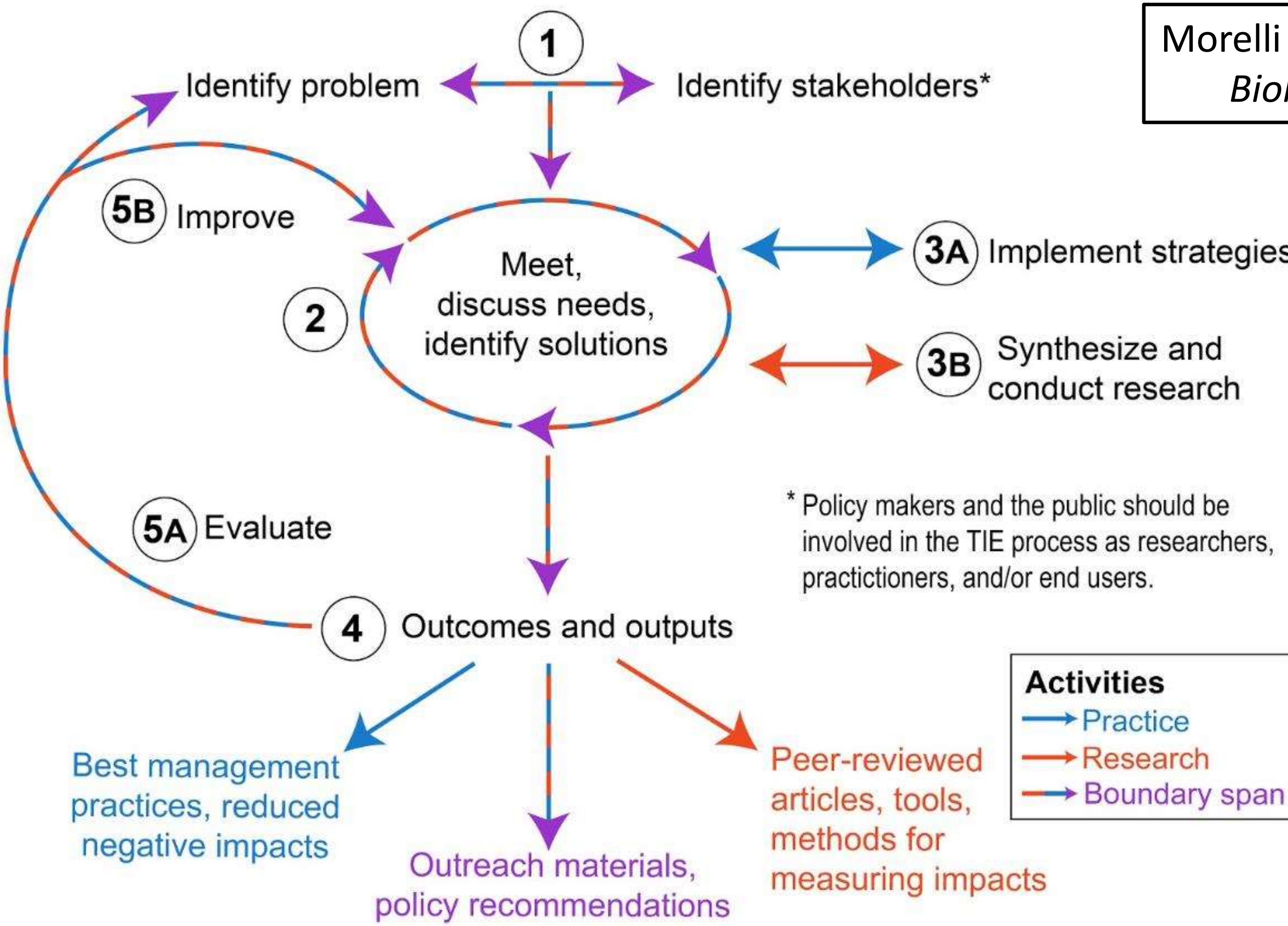


Morelli et al 2021
Biological Invasions

Enquist et al. 2017
Frontiers in Ecol. & the Environ.

Translational Invasion Ecology: Bridging research and practice to address one of the greatest threats to biodiversity

Morelli et al 2021
Biological Invasions



Northeast RISCC MANAGEMENT NETWORK

Leadership team
+ our favorite
invasives

Northeast
RISCC
MANAGEMENT NETWORK

Founded in 2016

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, **sharing** the needs of managers to researchers, **building** stronger scientist-manager communities, and **conducting** priority **research**.

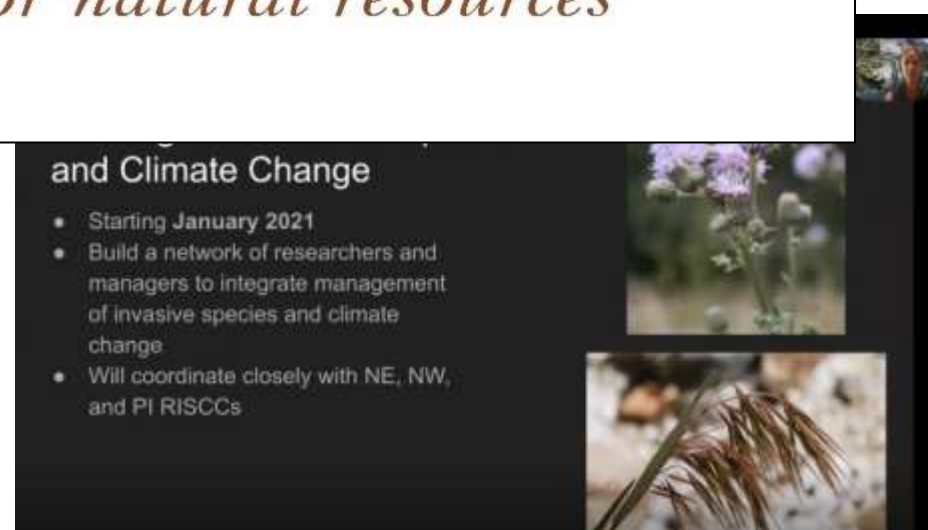
Foster and support a network of
~900 invasive species practitioners,
educators, and researchers

Continental Network

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

CLIMATE ADAPTATION LEADERSHIP AWARD

for natural resources



Understanding manager needs

Surveys

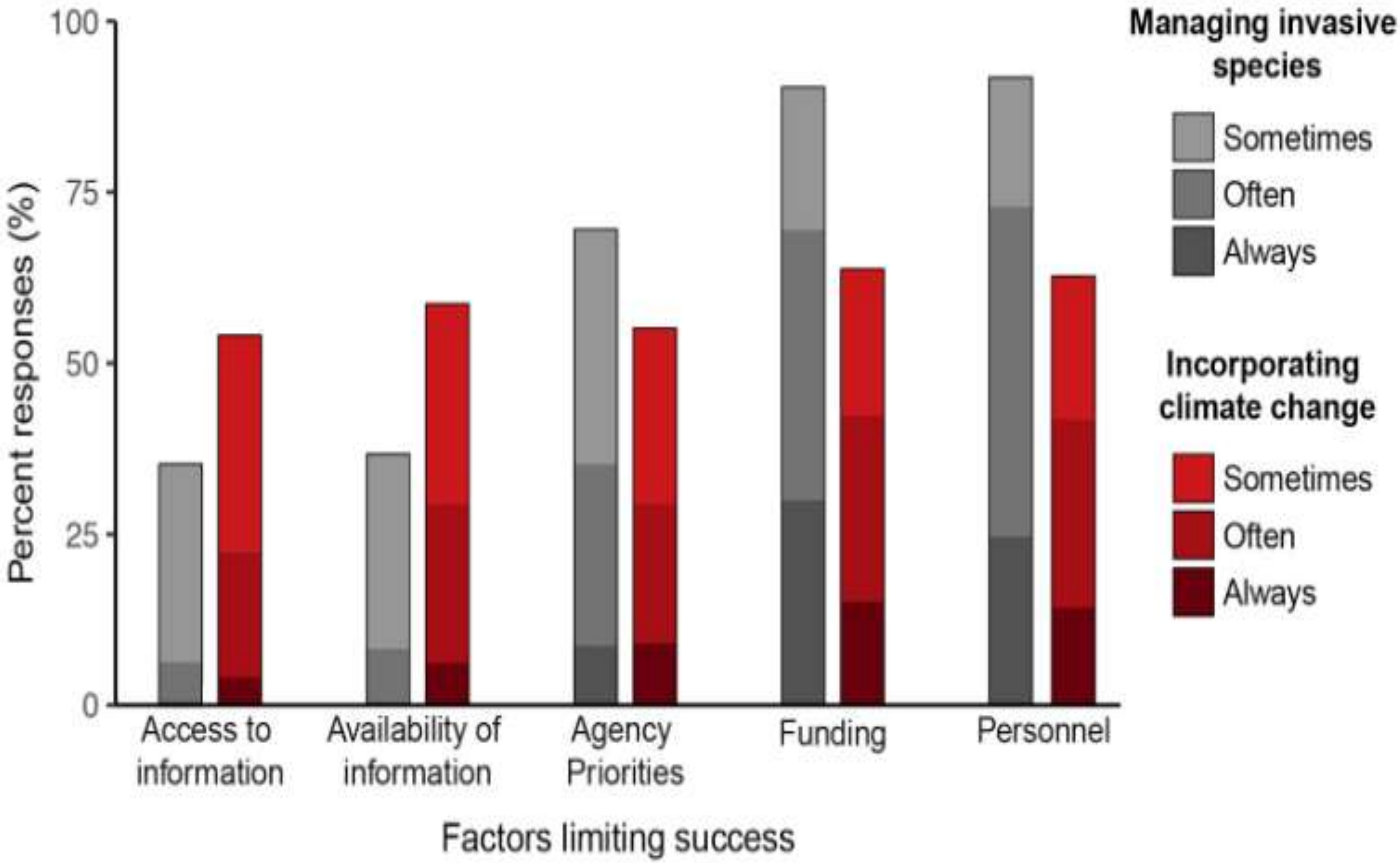
Biol Invasions
https://doi.org/10.1007/s10530-019-02087-6

ORIGINAL PAPER

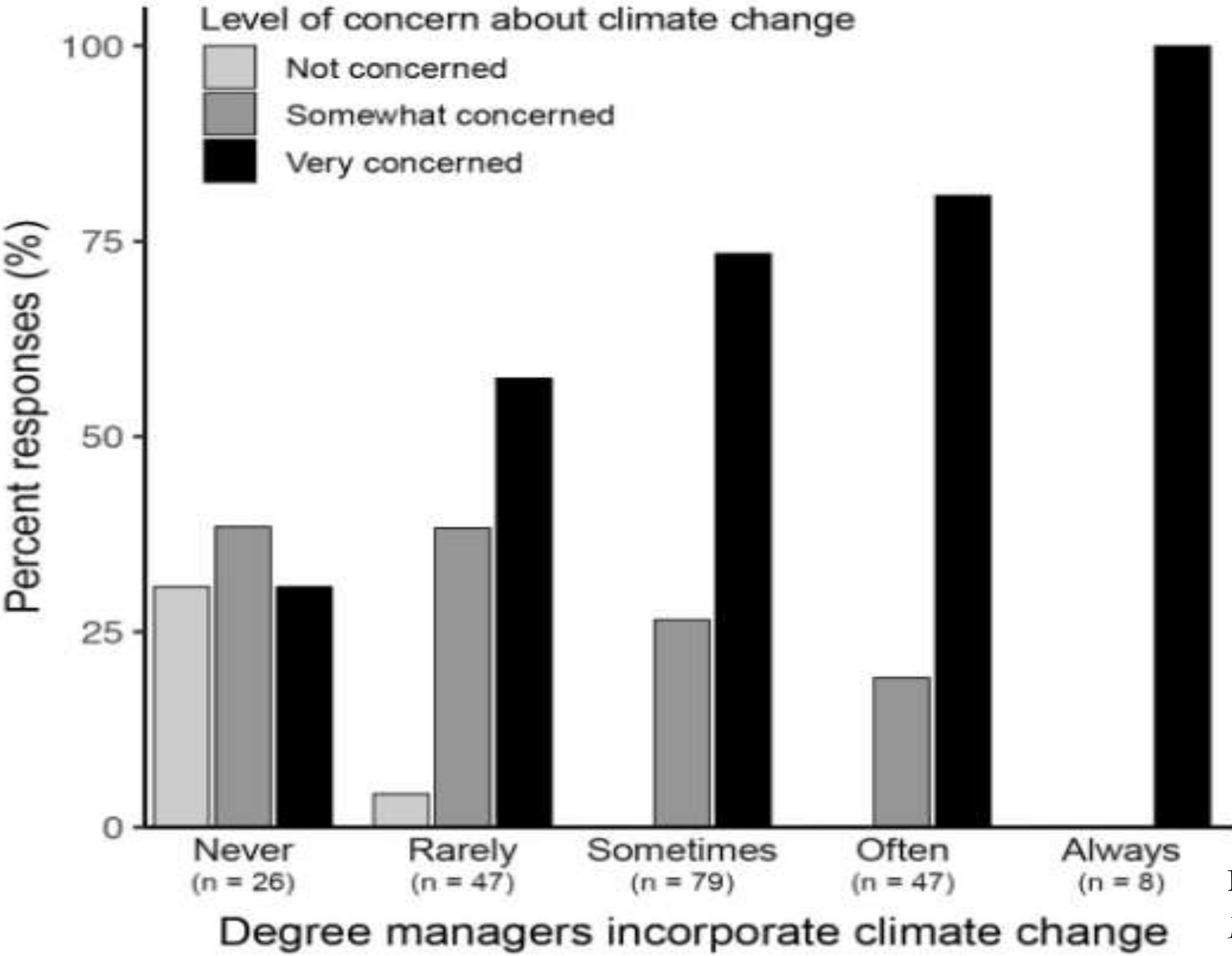
Incorporating climate change into invasive species management: insights from managers

Evelyn M. Beaury · Emily J. Fusco · Michelle R. Jackson · Brittany B. Laginhas · Toni Lyn Morelli · Jenica M. Allen · Valerie J. Pasquarella · Bethany A. Bradley

Lack of information is a barrier to including climate change in management actions



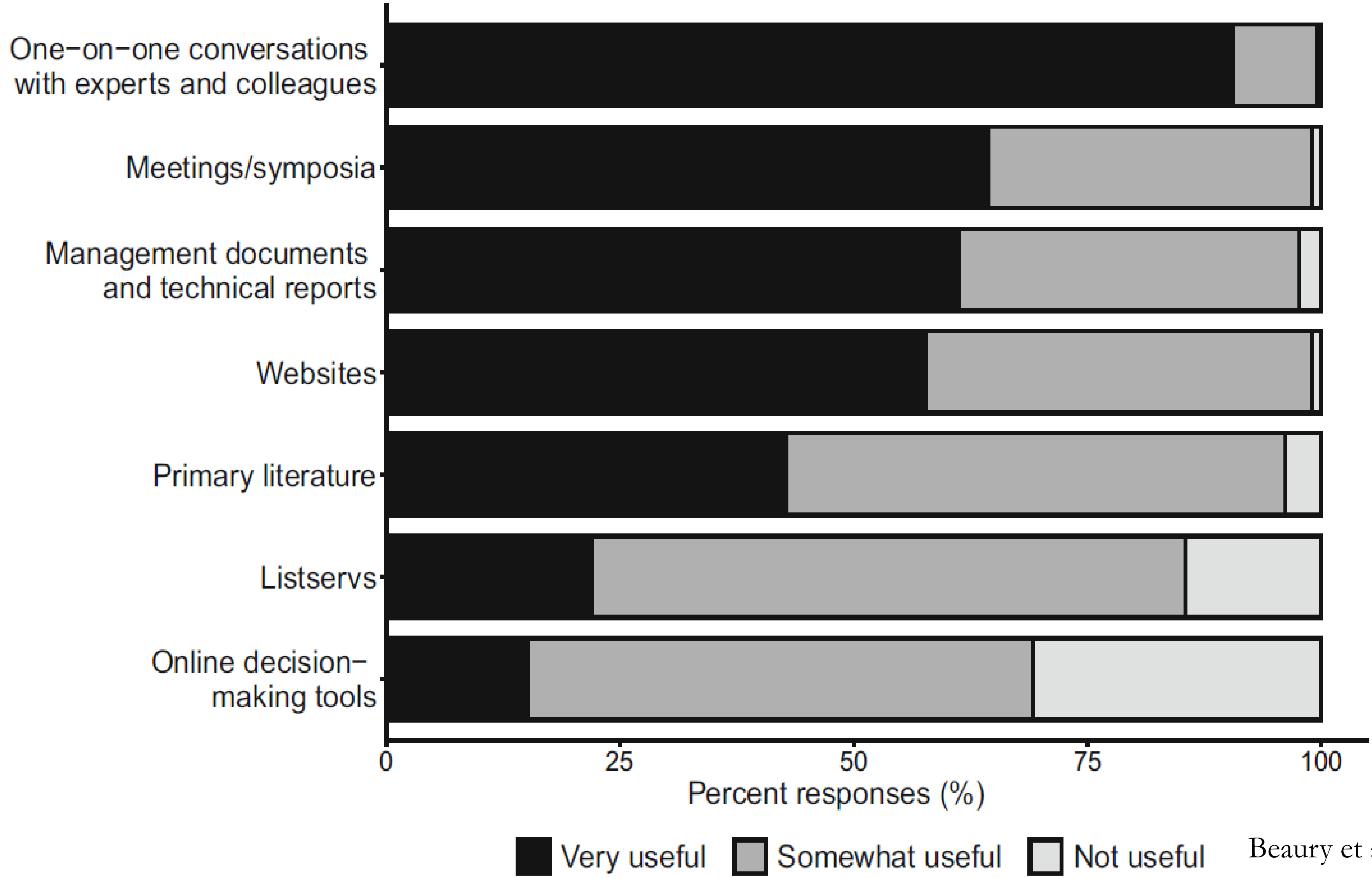
Concerned managers are taking action



Beaury et al 2019
Biological Invasions

Understanding manager needs

Sources of information



Beaury et al 2019
Biological Invasions

<u>Meeting manager needs</u>
Network Building

Symposia + workshops

- 2016, 2017, & 2018 at UMass
- 2019 at NAISMA
- Feb 2021 & 2022 Virtual
- Feb 2023 Planned Virtual

Meeting manager needs
Research Summaries

In this super-cool research, Lombardo and Elkinton demonstrated adaptation to colder winters by an invasive insect, lessening a barrier to its spread.

Lombardo, J. A. & Elkinton, J. S. 2017. Environmental adaptation in an asexual invasive insect. Ecol. Evol. 7, 5123–5130.

Summary:

The hemlock woolly adelgid (HWA, *Adelges tsugae*) was introduced to Virginia in the 1950s and is now present in much of the Northeast. Cold winter temperatures kill HWA and currently limit its northward spread. Warming winter temperatures reduce this barrier over time, but does local adaptation also play a role? Lombardo and Elkinton tested whether HWA displays local adaptation to cold temperatures by collecting them along a latitudinal gradient (from Kentucky to Massachusetts) and determining the cold hardiness of HWA from different latitudes by supercooling them. They also raised a new generation of the adelgids in a common setting before supercooling them, to distinguish between environmental acclimation versus genetic adaptation. HWA from colder sites froze at lower temperatures, even in a common setting, suggesting that HWA from northern sites had adapted to the colder climate. Both warming winters and selection for cold hardiness may exacerbate the spread of this invasive insect.

Take-home points:

- HWA has quickly adapted to local climate conditions in its invasive range, despite asexual reproduction which can limit adaptive capacity.
- Hemlock decline from HWA is likely to be slower in the northern parts of hemlock's range, but HWA will eventually occupy hemlock's full range.
- Climate change and continued adaptation will hasten HWA's northward

NELF Explorer

Visit the New England Landscape Futures Explorer:
https://newenglandlandscapes.org/

The New England Landscape Futures Explorer is brought to you by Harvard Forest and the 100+ citizens who helped define this project. Funding for this project comes from the National Science Foundation and from Highstead. See website for full details.

Summary:

In this Tool Summary we introduce the New England Landscape Futures (NELF) Explorer from the Harvard Forest, a department of Harvard University. This tool explores the simulation of five different possible land use futures for New England, as articulated by stakeholders from throughout the region, for every decade from 2010 through 2060. One of these scenarios is the business as usual scenario, or the continuation of recent trends in land-use patterns (e.g., forest loss due to development). The other four scenarios represent divergent alternative scenarios that incorporate multiple changes to land use, including planning for the consequences of climate change. For more detailed information on the scenarios, see the Voices from the Land publication or the storymap that guides you through the details of each scenario.

You can use this explorer to compare how different land-use scenarios impact concerns for management such as development or connectivity in different regions of the Northeast. For example, a scenario with higher rates of low density development may create more pathways for invasive species movement than a scenario with higher rates of conservation. Check out these land use maps in your area to see which communities might be impacted by

Meeting manager needs
Management Challenges

~4,000 Downloads

Climate-smart native pla…

	Species	Growth Form	Hardiness Zones
Native Grasses	Big blue stem (*Andropogon gerardii*)	Grass	4-9
	Canada wild rye (*Elymus canadensis*)	Grass	3-8
	Indian grass (*Sorghastrum nutans*)	Grass	4-9
	Little bluestem (*Schizachyrium scoparium*)	Grass	3-9
	Sideoats grama (*Bouteloua curtipendula*)	Grass	4-9
Native Flowering Herbs	Beardtongue (*Penstemon digitalis*)	Herb	3-8
	Blazing star (*Liatris spicata*)	Herb	3-8
	Blue false indigo (*Baptisia australis*)	Herb	3-9
	Blue flag iris (*Iris versicolor*)	Herb	3-9
	Blue lobelia (*Lobelia siphilitica*)	Herb	4-9
	Butterfly weed (*Asclepias tuberosa*)	Herb	3-9
	Cardinal flower (*Lobelia cardinalis*)	Herb	3-9
	Foam flower (*Tiarella cordifolia*)	Herb	4-9
	Ironweed (*Vernonia noveboracensis*)	Herb	5-9
	Joe pye weed (*Eutrochium fistulosum*)	Herb	4-8
	Lance leaf coreopsis (*Coreopsis lanceolata*)	Herb	4-9
	Monkey flower (*Mimulus ringens*)	Herb	4-9
	New England aster (*Symphyotrichum novae-angliae*)	Herb	4-8
	Obedient plant (*Physostegia virginiana*)	Herb	3-9
	White turtlehead (*Chelone glabra*)	Herb	3-8
Native Shrubs	American hazelnut (*Corylus americana*)	Shrub	4-9
	Buttonbush (*Cephalanthus occidentalis*)	Shrub	5-9
	Coastal sweet-pepperbush (*Clethra alnifolia*)	Shrub	3-9
	Deerberry (*Vaccinium stamineum*)	Shrub	5-9
	Eastern wahoo (*Euonymus atropurpureus*)	Shrub	3-7
	Highbush blueberry (*Vaccinium corymbosum*)	Shrub	4-8
	Mountain laurel (*Kalmia latifolia*)	Shrub	4-9
	Nannyberry viburnum (*Viburnum lentago*)	Shrub	2-8
	Ninebark (*Physocarpus opulifolius*)	Shrub	2-8
	Northern bush honeysuckle (*Diervilla lonicera*)	Shrub	3-7
	Northern spicebush (*Lindera benzoin*)	Shrub	4-9
Native Trees	American hornbeam (*Carpinus caroliniana*)	Tree (small)	3-9
	Bladdernut (*Staphylea trifoliata*)	Tree (small)	4-8
	Gray dogwood (*Cornus racemosa*)	Tree (small)	4-8
	Pussy willow (*Salix discolor*)	Tree (small)	4-8
	Serviceberry (*Amelanchier canadensis*)	Tree (small)	4-8
	Striped maple (*Acer pennsylvanicum*)	Tree (small)	3-7
	Witch-hazel (*Hamamelis virginiana*)	Tree (small)	3-8
	Hophornbeam (*Ostrya virginiana*)	Tree	3-9
	Kentucky coffeetree (*Gymnocladus dioica*)	Tree	3-8
	Persimmon (*Diospyros virginiana*)	Tree	4-9

KEY: Dry, Medium, Wet, Part shade, Full sun, Supports pollinators, Supports birds, Showy flowers, Showy/edible fruit, Low maintenance, Deer resistant

in the Northeast

…egional Invasive …pecies & Climate …hange

Definitions

USDA Plant Hardiness Zone: Zones based on minimum temperature that are used to determine where plants can grow.

Non-native: A species unlikely to have arrived without human assistance.

Invasive: A species that is established and spreading with negative impacts to native species and ecosystems.

Climate-smart gardening: Planting for present and future conditions using native species adapted to both current and future hardiness zones.

Learn more about invasive species & climate change at: risccnetwork.org

https://doi.org/10.7275/mvej-dr35

Sources

Biota of North America Program
Climate Voyager, State climate office of North Carolina
Go Botany, version 3.1.3. Native Plant Trust.
IUCN Red List of Threatened Species
Larry Weaner Landscape Architects
Native Plant Resources. Cornell Cooperative Extension
Plant Finder. Missouri Botanical Garden
Plant Selection and Design. U. New Hampshire Cooperative Extension
Planting for Resilience: Selecting Urban Trees in Massachusetts. A. McElhinney et al. 2019
Ten Tough New Native Shrub Alternatives for Barberry and Burning Bush. J. Lubell
USDA 2012 Plant Hardiness Zones Map. USDA-ARS
USDA Plant Sheets & Plant Guide. USDA NRCS
Why Native? Benefits of planting native species in a changing climate. RISCC Management Challenge E. Fusco et al. 2019
WorldClim - Global Climate Data
Images: Lady Bird Johnson Wildflower Center, Minnesota Wildflowers
Journal Articles: Burghardt et al. 2010 Ecosphere; Garden et al. 2015 Parasites & Vectors; Morandin & Kremen 2013 Eco App; Pimentel et al. 2005 Ecol Econ; Poelen et al. 2014 Ecol Info; Simberloff et al. 2012 Ecology; Tallamy & Shropshire 2009 Conserv Biol

Authors:
B. Bradley*, A. Bayer, B. Griffin, S. Joubran, B. Laginhas, L. Munro, S. Talbot, J. Allen, A. Barker-Plotkin, E. Beaury, C. Brown-Lima, E. Fusco, H. Mount, B. Servais, and T. L. Morelli
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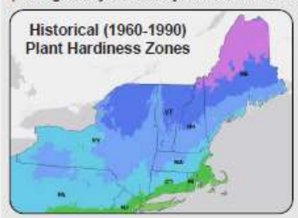
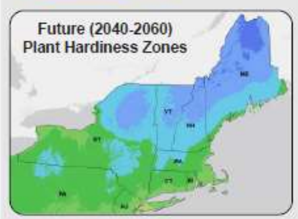
…t Gardening

Rapidly warming temperatures mean that native species will have to move hundreds of miles in coming decades just to keep up. Our gardens can help native species shift their ranges and adapt to climate change. Native plantings today seed ecosystems of the future.

Historical (1960-1990) Plant Hardiness Zones



Future (2040-2060) Plant Hardiness Zones



Average Annual Minimum Temperature (°F)

-40° to -35°	3a	-20° to -15°	5a	0° to 5°	7a
-35° to -30°	3b	-15° to -10°	5b	5° to 10°	7b
-30° to -25°	4a	-10° to -5°	6a	10° to 15°	8a
-25° to -20°	4b	-5° to 0°	6b	15° to 20°	8b

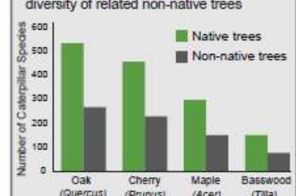
Why Native?

An estimated 80% of ornamental plants for sale are non-native. This means that the average yard does a poor job of supporting native flora and fauna. By shifting our plantings towards natives, we can dramatically increase the diversity of bees, butterflies, birds and other animals. In contrast, non-native plants do not support local food webs and can become invasive. Native plants increase biodiversity and reduce risks associated with invasive species, which supports resilient ecosystems in the face of climate change. Look inside for some ideas!

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

Native trees support twice the caterpillar diversity of related non-native trees



More caterpillars in your yard might sound alarming, but most are eaten by nesting birds, and many later become butterflies.

Costs of Non-native Plants

Non-native plants are 40x more likely to become invasive than native garden plants.

Invasive plants cost the U.S. an estimated $20 billion per year to manage and control.

Invasive Japanese barberry supports 3x more deer ticks, which carry Lyme disease.

Common plantings that have become invasive and should be replaced:

For a full list, contact your state's extension program

What are some climate-smart management options?

Survey + workshop at NAISMA to learn about climate-smart actions invasive species managers are already taking

Northeast RISCC Management

Regional Invasive Species & Climate Change

Management Challenge

Taking Action:

Managing invasive species in the context of climate change

Summary

Climate change is likely to alter the timing and effect of invasive species management, as well as the suite of specie we are managing. Despite concern about the effects of climate change, lack of information about how and when to tak action is a barrier to climate-smart invasive species management. Here, we outline strategies for incorporating climat change into management along with examples of tools that can inform proactive decision-making.

Motivations for incorporating climate change into management

1. Invasives may emerge earlier and persist longer in response to longer growing seasons
2. Warming causes invasives to shift their ranges into new ecosystems
3. Invasives are introduced via new shipping pathways due to sea ice melt
4. Extreme weather events and sea level rise cause disturbance that creates new opportunities for invasion
5. Herbicides may be less effective with higher atmospheric CO_2
6. Invasives become more competitive with warming and higher atmospheric CO_2

Strategic Planning

Recommendations:

- Prioritize land conservation and management action based on vulnera-bility to climate change and invasion.
- Increase restoration, management, and early detection & rapid response in areas vulnerable to disturbance caused by extreme weather events.
- Advocate for invasive species management funding to be included in climate change adaptation and response plans.

Example: Mount Grace Land Trust protected lands identified as resilient to climate change (Fig. 1) using TNC's resilient land tool. These lands are high priority for preventative invasive species management and monitoring.

Fig 1. Site prioritized by TNC's resilient land tool (maps.tnc.org/resilientland).

Preventative Management

Recommendations:

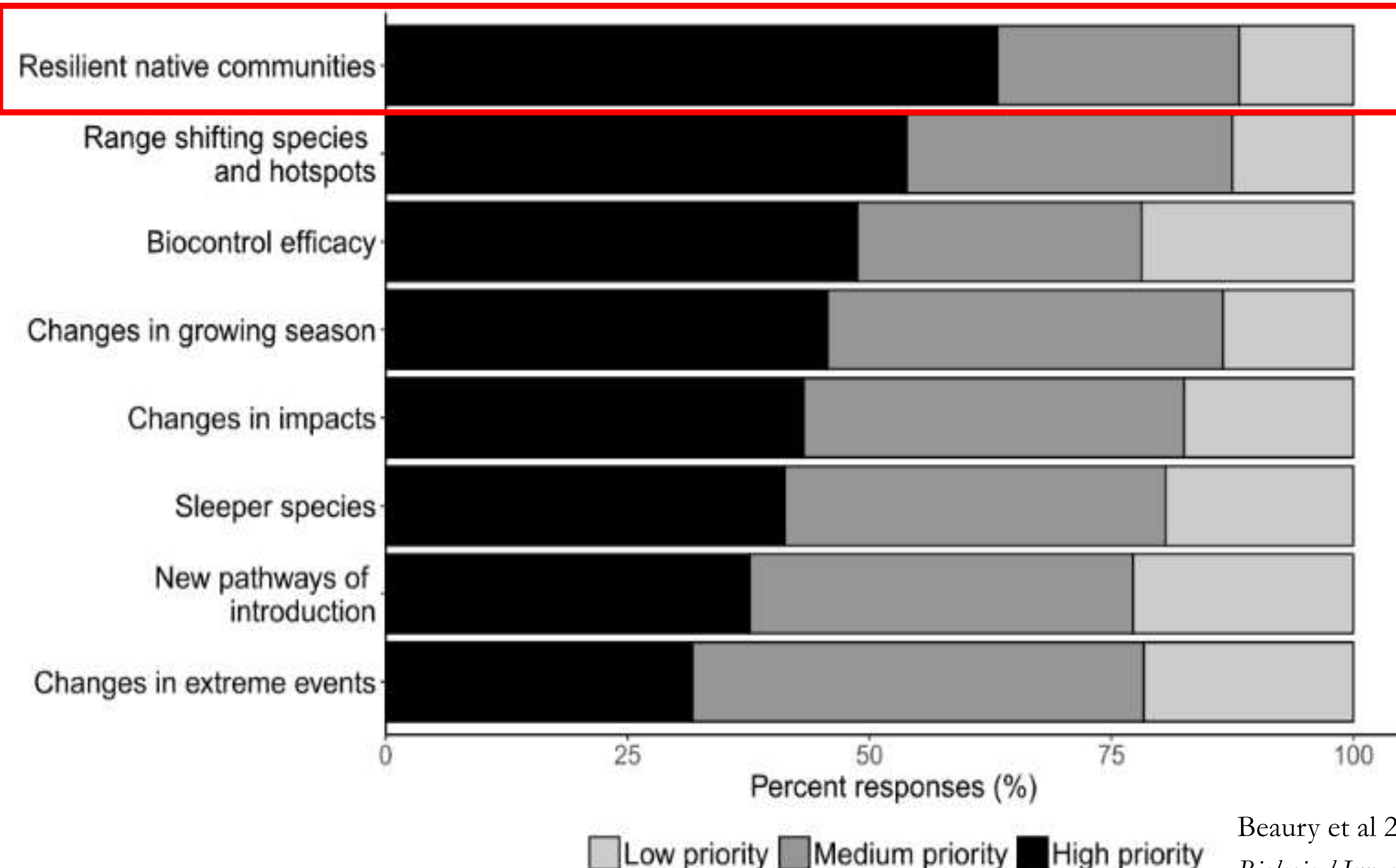
- Plant species native to Eastern North America that are resistant to climate change (e.g., drought-tolerant, broad hardiness zones; Fig. 2).
- Develop watch lists and proactive management plans for invasive species predicted to shift into your region.
- Prioritize treatment of existing invasive species predicted to spread or increase in abundance with climate change.
- Monitor non-natives for increases in populations ('sleeper species').

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

Fig 2. Climate Voyager maps future hard ness zones (climate.ncsu.edu/voyager/)

Understanding manager needs

Research priorities



Beaury et al 2019
Biological Invasions

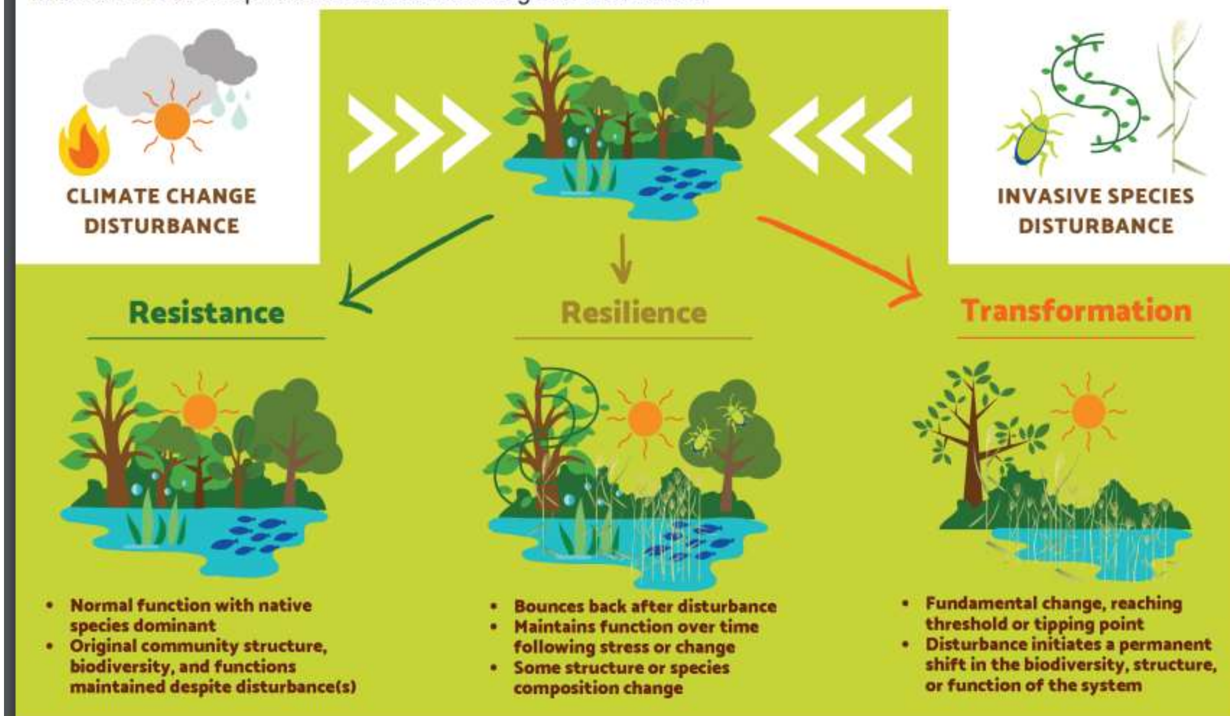
Embracing the Future:
Promoting adaptation and resilience to invasive species and climate change

Summary

Climate change and invasive species can interact to increase disturbances and magnify changes in ecosystem form and function (Double Trouble). Increasing resilience is one of several management approaches for enabling healthy ecosystems to persist despite these changes. While resilience can be complicated and take many forms, it can generally be thought of as the "ability [of an ecosystem] to experience disturbances or environmental change without changing to a fundamentally different state" [Holling, 1973].

The accumulating effects of climate change, invasive species, or interacting effects of multiple disturbances can push an ecosystem past a tipping point and into a new ecological state. These alternative states are characterized by a different suite of species or functions, which are difficult or impossible to recover from (e.g. a shift from a closed-canopy to an open-canopy forested wetland). Actions to increase resilience help an ecosystem to maintain or return to its fundamental structure or function after a disturbance.

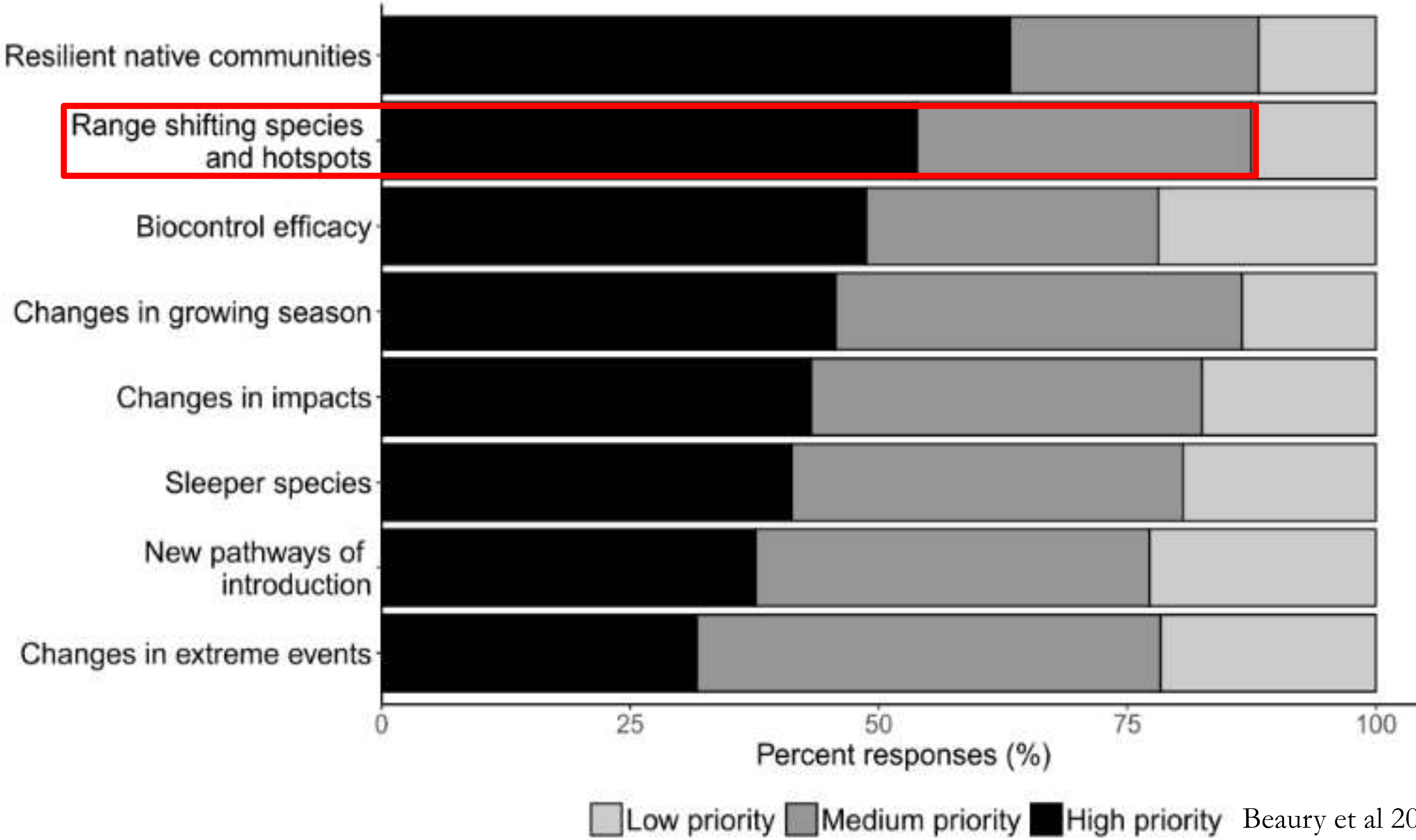
Resilience falls in the middle of a spectrum of management goals ranging from preventing change (resistance) to promoting change (transformation) in the species composition, structure, or functions provided by an ecosystem. Clear management goals (See Table) and an understanding of the range of disturbances affecting focal ecosystems are necessary for deciding between managing for resistance, resilience, or transformation and what actions are required for successful management outcomes.



Authors: Bianca Lopez, Carrie Brown-Lima, Justin Dalaba, Annette Evans, Meghan Graham MacLean, Toni Lyn Morelli*

Understanding manager needs

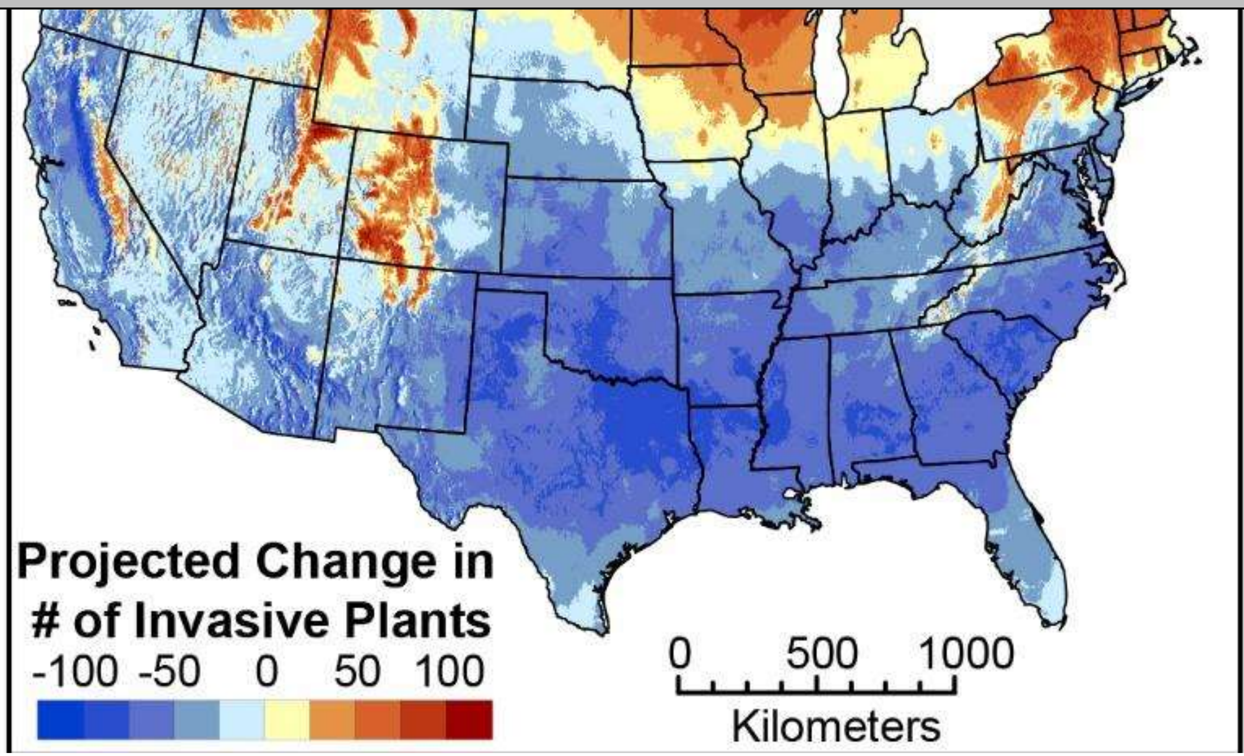
Research priorities



Beaury et al 2019
Biological Invasions

Range shifts can occur for many species

Use range shift projections for many species to generate <u>state or county lists</u>



Allen & Bradley, 2016

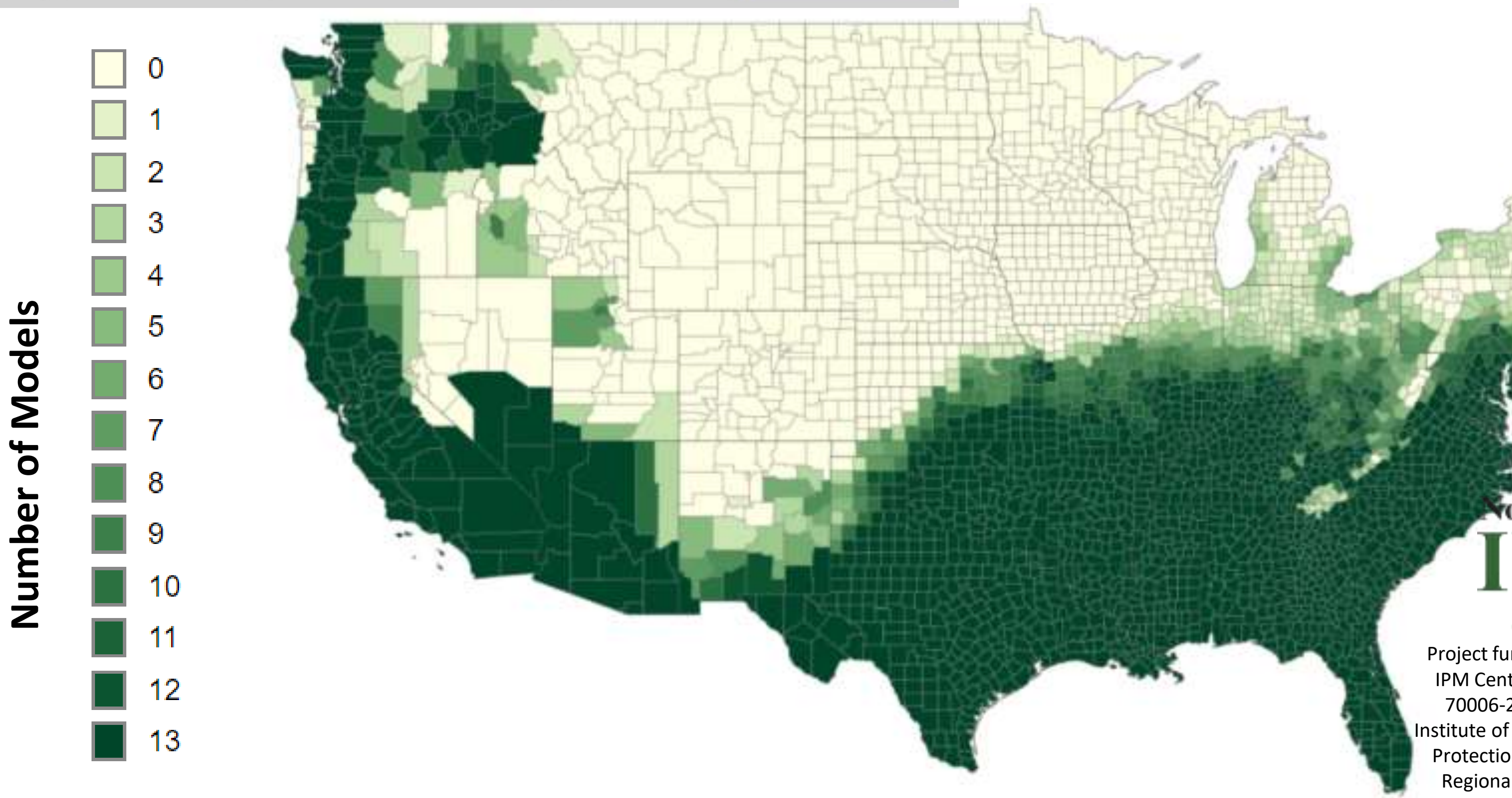
Where are invasive plants likely to move?

EDDMapS
find · map · track

giant reed
***Arundo donax* L.**
This species is Introduced in the United States

States | Counties | Points | List | Species Info
Distribution | Record Density | Literature vs Observation | Future Range | Future Certainty

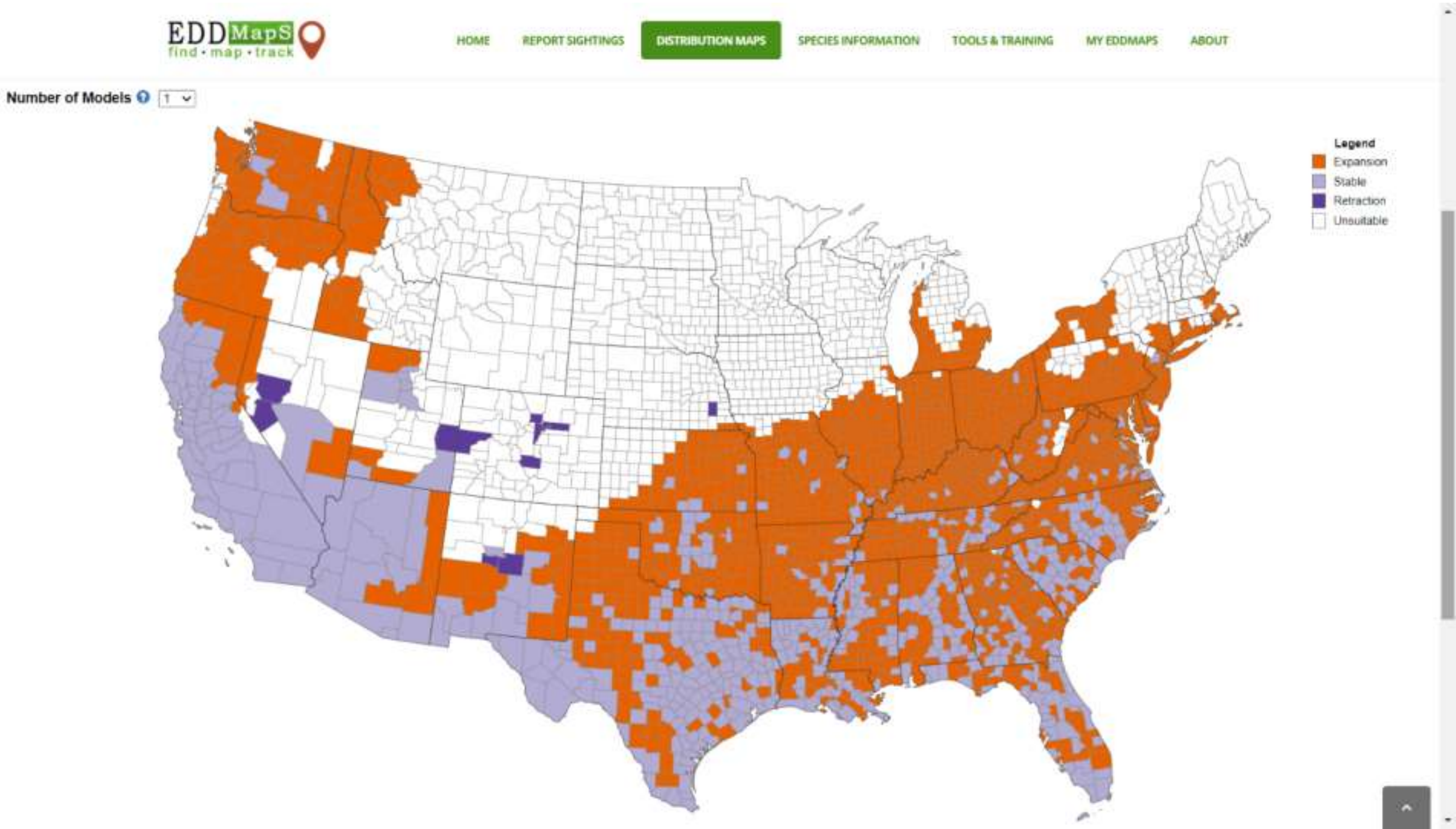
Research led by Jenica Allen



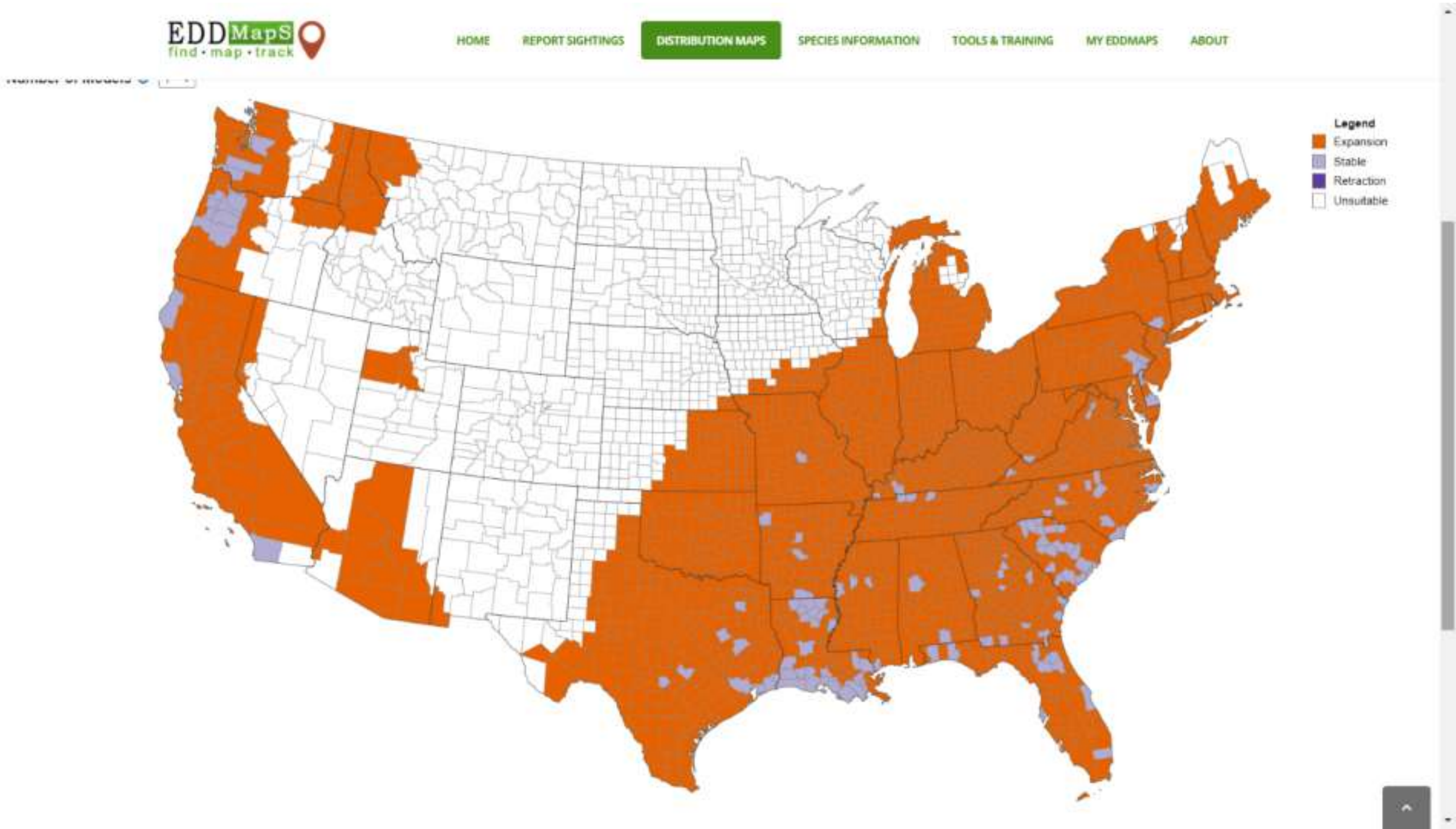
Northeastern IPM Center

Project funded by the Northeastern IPM Center through Grant #2014-70006-22484 from the National Institute of Food and Agriculture, Crop Protection and Pest Management, Regional Coordination Program.

giant reed
Arundo donax L.



water primrose
Ludwigia grandiflora ssp. hexapetala



What about native range-shifters?

nature climate change

Review Article | Published: 30 April 2020

Adjusting the lens of invasion biology to focus on the impacts of climate-driven range shifts

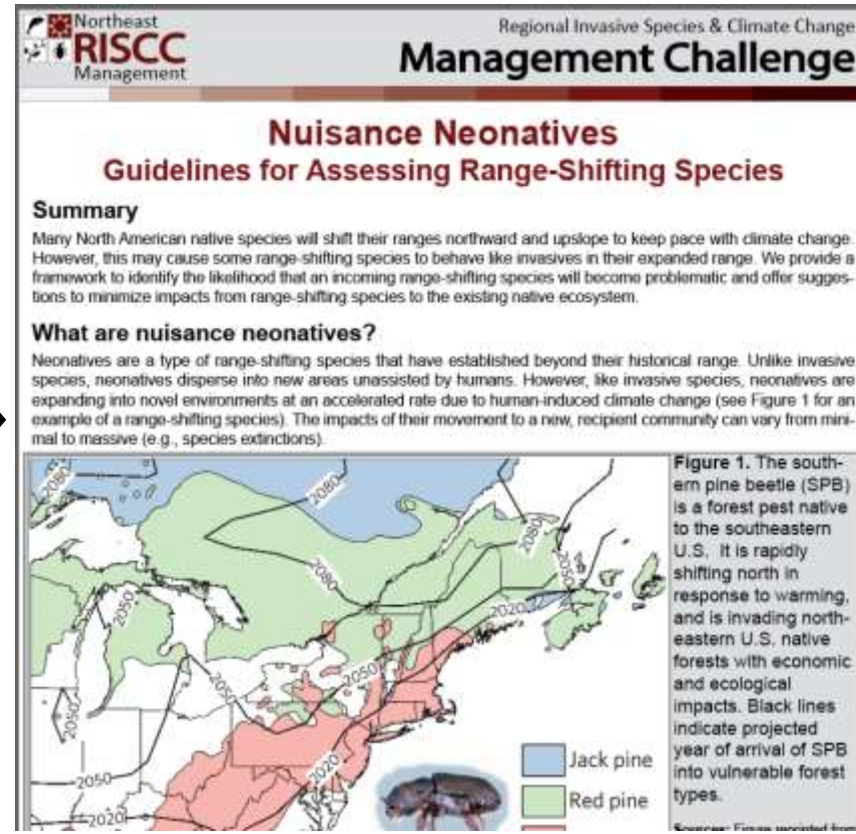
Piper D. Wallingford, Toni Lyn Morelli, Jenica M. Allen, Evelyn M. Beaury, Dana M. Blumenthal, Bethany A. Bradley, Jeffrey S. Dukes, Regan Early, Emily J. Fusco, Deborah E. Goldberg, Inés Ibáñez, Brittany B. Laginhas, Montserrat Vilà & Cascade J. B. Sorte

Nature Climate Change (2020) | Cite this article

Metrics

Abstract

As Earth's climate rapidly changes, species range shifts are considered key to species persistence. However, some range-shifting species will alter community structure and ecosystem processes. By adapting existing invasion risk assessment frameworks, we can identify characteristics shared with high-impact introductions and thus predict



Northeast RISCC Management

Regional Invasive Species & Climate Change

Management Challenge

Nuisance Neonatives

Guidelines for Assessing Range-Shifting Species

Summary

Many North American native species will shift their ranges northward and upslope to keep pace with climate change. However, this may cause some range-shifting species to behave like invasives in their expanded range. We provide a framework to identify the likelihood that an incoming range-shifting species will become problematic and offer suggestions to minimize impacts from range-shifting species to the existing native ecosystem.

What are nuisance neonatives?

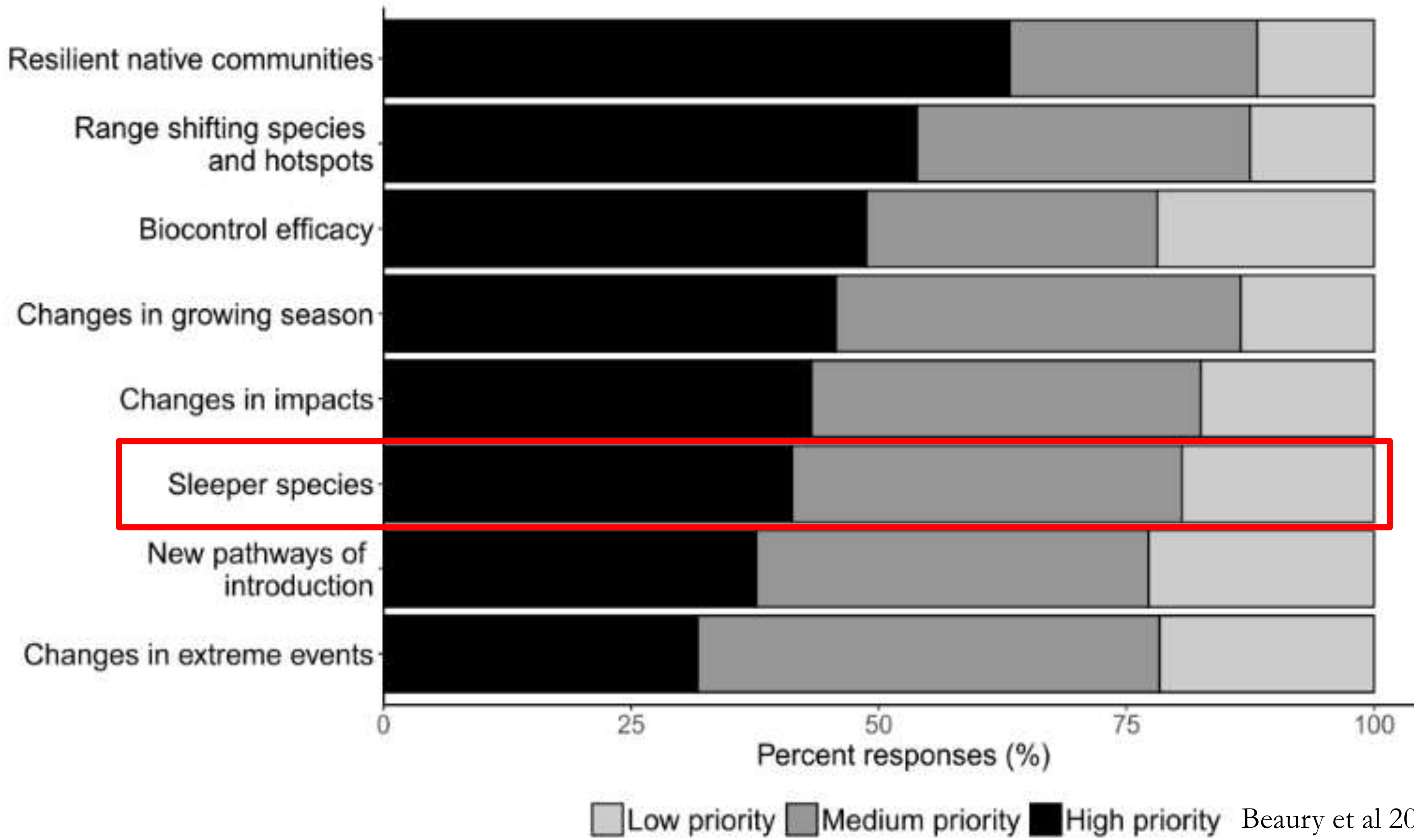
Neonatives are a type of range-shifting species that have established beyond their historical range. Unlike invasive species, neonatives disperse into new areas unassisted by humans. However, like invasive species, neonatives are expanding into novel environments at an accelerated rate due to human-induced climate change (see Figure 1 for an example of a range-shifting species). The impacts of their movement to a new, recipient community can vary from minimal to massive (e.g., species extinctions).

Figure 1. The southern pine beetle (SPB) is a forest pest native to the southeastern U.S. It is rapidly shifting north in response to warming, and is invading northeastern U.S. native forests with economic and ecological impacts. Black lines indicate projected year of arrival of SPB into vulnerable forest types.

Wallingford/Morelli et al. 2020

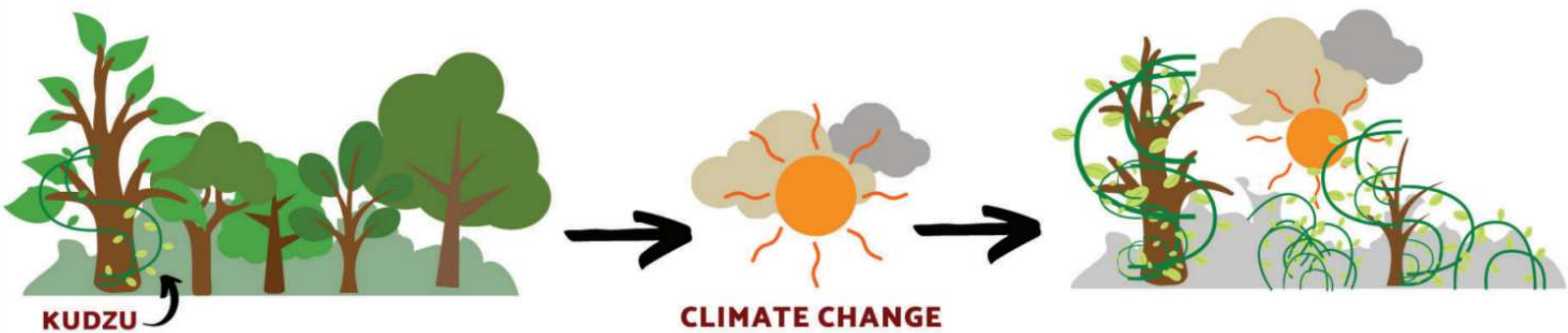
Understanding manager needs

Research priorities



Beaury et al 2019
Biological Invasions

Identifying Sleeper Species



A **sleeper species** (e.g., kudzu in New England) is a non-native that is established but not yet invasive because it is limited by biotic or abiotic conditions (e.g., temperature).

An **invasive species** is a non-native species that spreads, causing negative ecological and/or socioeconomic impacts (e.g., kudzu in the southeastern U.S. kills plants by smothering).

Lessons Learned

- Start with talking to stakeholders
- Keep the focus on CC x IS
- Expect to put some time in
- Use meetings to do work
- Respect people's incentives, strengths, and limitations
- Be flexible
- Be inclusive

Risccnetwork.org

Regional Invasive Species & Climate Change (RISCC) Management Networks

Welcome!

The RISCC management networks reduce the joint effects of climate change and invasive species by synthesizing relevant science, sharing the needs and knowledge of managers, building stronger scientist-manager communities, and conducting priority research.

Explore resources for your region:

PACIFIC ISLANDS NORTHWEST NORTH CENTRAL SOUTHEAST NORTHEAST

Questions?