Flipping the script on adaptive capacity:

Characterizing invasive species' ability to persist in place or shift in space

Lindsey Thurman, Ph.D.
USGS Northwest Climate Adaptation Science Center
lthurman@usgs.gov

USGS science for a changing world

NORTHWEST Climate Adaptation Science Center

The RISCC Network is a ***partnership*** of regional agencies and organizations dedicated to helping ***practitioners address the nexus of climate change and invasive species***, including plants, animals, and pathogens.

Northwest RISCC MANAGEMENT NETWORK

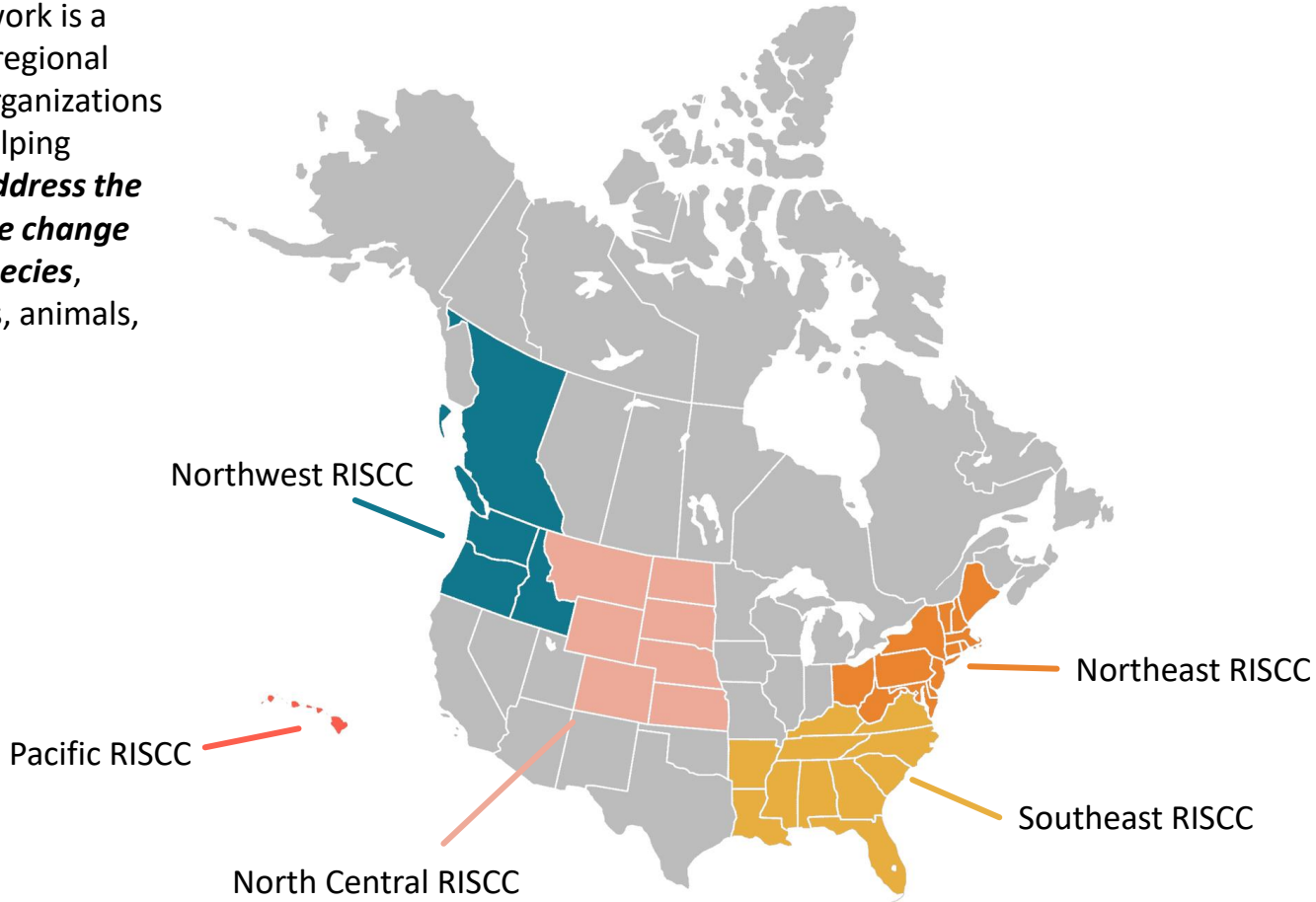
Northwest Regional Invasive Species and Climate Change (NW RISCC) Network

nwriscc.org

USGS science for a changing world

NORTHWEST Climate Adaptation Science Center

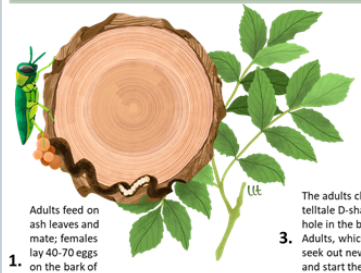
The RISCC Network is a ***partnership*** of regional agencies and organizations dedicated to helping ***practitioners address the nexus of climate change and invasive species***, including plants, animals, and pathogens.



Regional Invasive Species & Climate Change *Management Challenge*

Managing the Threat of Emerald Ash Borer Invasion in a Changing Climate

Summary: In June 2022, the emerald ash borer (*Agrilus planipennis*; "EAB") was discovered in Forest Grove, OR, marking its first appearance west of the Rocky Mountains. Forest managers fear for the future of Oregon ash (*Fraxinus latifolia*) and at least 8 other tree species found only in western North America. Climate change may broaden the threat of EAB invasion[1] and requires climate-smart, proactive management to sustain healthy forests.



- Native to Asia
- First detected in U.S. in Michigan (2002), now present in at least 35 states & 5 provinces
- Infects all 16 species of N. American ash
- Primary cause of nationwide ash decline, with widespread economic impacts

1. Adults feed on ash leaves and mate; females lay 40-70 eggs on the bark of trees about 3-4 weeks before dying.

2. After hatching, the larvae bore into the tree to feed, creating S-shaped tunnels in the cambium. They remain for 1-2 years, then pupate into adults.

3. The adults chew a telltale D-shaped exit hole in the bark. Adults, which can fly, seek out new trees and start the cycle again.

Fig. 1. (a) Adult EAB and exit hole. (b) EAB tunnels in the trunk of a tree.

EAB invasion presents a significant threat to the Pacific Northwest where endemic Oregon ash and other ash tree species are abundant along riparian corridors in western Oregon and Washington. **Ash species provide important food and habitat resources along streams, rivers, and wetlands** where soils can be poorly draining and where seasonally high water-tables can exclude nearly all other tree species.

Northwest RISCC Management Network

Managing the Threat of Emerald Ash Borer Invasion in a Changing Climate

In Search of Climate Refugia

- EAB life cycle requires strong seasonality, with a long, cold winter season.
- Climate change could limit the southward invasion range if warming is enough to constrain EAB life cycle and survivorship.[4]
- Some ash species can survive increased temperatures of 3.5°C - 4.1°C, suggesting potential resilience to climate warming[5] and refugia from EAB in the southern portion of species ranges (but more information on refugia is needed).
- The entire North American range of ash species is invadable by EAB[6] but shifts in invasion range could be limited by the northern extent of ash (and ash densities), locations of potential ash refugia, return intervals of extreme cold events, and control measures.[4,7]
- Mid-winter warming events can cause a reduction in EAB cold tolerance ("deacclimation") and may limit survival and range expansion if followed by severe cold snaps (as expected under climate change).[8] However, evidence of extreme phenotypic plasticity in temperature tolerance suggests EAB may have great potential to withstand temperature extremes and variability.[6]
- Within the range of Oregon ash, minimum winter temperatures *do not* reach the supercooling points (i.e., coldest temperature at which EAB can no longer resist hard-freezing and die) reported from Canada and the Eastern U.S (**Fig. 2**).
  - Reported EAB supercooling points range from -35.3°C to -25°C.[8,9,10]
  - Most of North America, including the U.S. Northwest and southern British Columbia, does not experience extreme cold events frequently enough to kill EAB.[7,11]

Fig. 2. 30-year normals of minimum winter temperatures (analyzed using PRISM downscaled climate data).

Climate-Smart Solutions

Oregon Dept. of Forestry is collecting 1 million seeds of Oregon ash to capture genetic diversity and support future breeding and provenancing programs.[12]
Other potential strategies include:

- Planting climate-adapted replacement species.[13,14,15]
- Deploying biological control agents (e.g., parasitoids) informed by host-parasite dynamics under climate change.[16,17]
- Identifying climate refugia for ash where either ash/EAB phenology or distribution is mismatched.
- Employing a risk matrix to evaluate relative threat of climate change to EAB invasion and identify ash species that need to have strategies developed, be evaluated further, or monitored.[18]
- Climate-informed Early Detection & Rapid Response (EDRR).[19]

https://www.oregon.gov/odf/Documents/forestmanagement/emerald-ash-borer-response-plan-for-oregon.pdf

References: [1] Olson et al. 2021; [2] Simberloff & Von Holle 1999; [3] Grinde et al. 2022; [4] Liang & Fei 2014; [5] Steiner et al 2021; [6] Duell et al. (2022); [7] Cuddington et al 2018; [8] Sobek-Swant et al 2012; [9] Crosthwaite et al 2011; [10] Venette & Abrahamson 2010; [11] DeSantis et al 2013; [12] https://www.fs.usda.gov/rsl/GeneticConservation_Ash.html ; [13] Iverson et al 2016; [14] Palik et al 2021; [15] Looney et al 2017; [16] Gould et al 2020; [17] Duan et al 2020; [18] Iverson et al 2012; [19] Pontius & Hallett 2014

NORTHWEST Climate Adaptation Science Center

EcoAdapt

Authors: Lindsey L. Thurman (USGS NW Climate Adaptation Science Center); Deborah A. Rudnick (EcoAdapt). Illustrations by L. Thurman.

Northwest RISCC Management Network

Team-Up Webinar November 3rd @ 11 am PT

The Northwest Regional invasive Species & Climate Change (NW RISCC) Network presents:

On the Horizon: Managing the Invasion of Emerald Ash Borer in the Pacific Northwest

A team-up style webinar to showcase lessons learned from the emerald ash borer invasion of North America and a discussion on proactive management opportunities.

Nathan Siegert, PhD
Forest Entomologist
State & Private Forestry, Eastern Region Forest Health Protection
USDA Forest Service

Anthony D'Amato, PhD
Professor of Silviculture & Applied Forest Ecology, Director of Forestry Program
University of Vermont

Richard Sniezko, PhD
Center Geneticist
Dorena Genetic Resource Center
USDA Forest Service

Read more about our speakers here

Register at: https://tinyurl.com/nwriscEAB

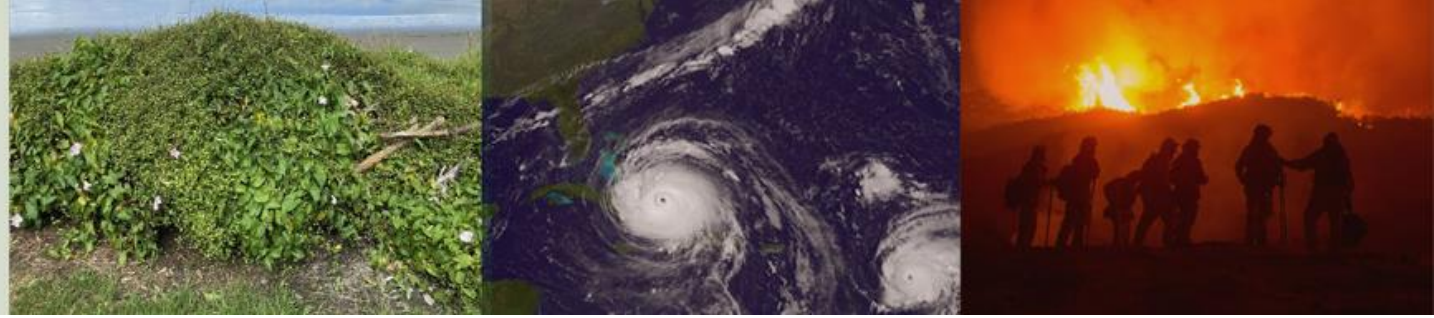
NWRISCC.org

@NWRISCC

USGS science for a changing world

NORTHWEST Climate Adaptation Science Center


Welcome to the 2023 Northwest Regional Invasive Species & Climate Change Symposium!
Nicole DeCrappeo, NW CASC Director
Northwest RISCC MANAGEMENT NETWORK
NORTHWEST Climate Adaptation Science Center
USGS science for a changing world
ESA
CLIMATE IMPACTS GROUP
Play (k)



International Invasive Species and Climate Change Conference (IISCCC)

Jan 30-21, 2024

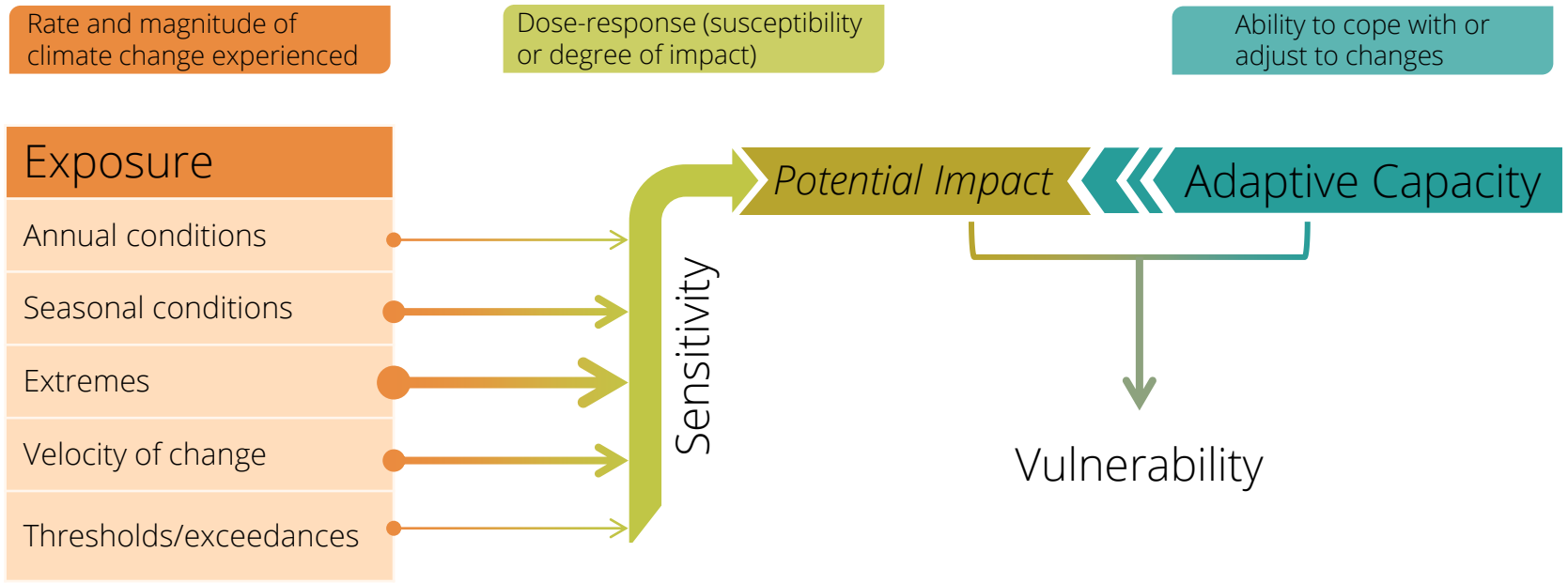
- New arrivals and emerging invasion pathways
- Managing invasive species in a changing climate
- Practitioner success stories
- Lessons learned from island ecosystems

USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

Climate change vulnerability

The degree to which a physical, biological, or socio-economic system is susceptible to and unable to cope with adverse impacts of climate change (USGCRP 2019)

Climate change vulnerability



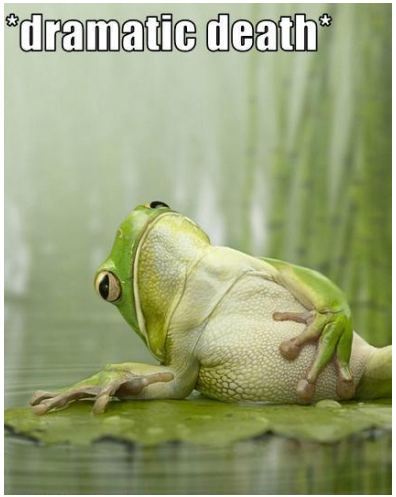
Adaptive Capacity 101

I. Meshcheryakovova

Persist in place
(adapt *in situ* /acclimate)

S. McMillan

Shift in space
(move to track suitable climate)

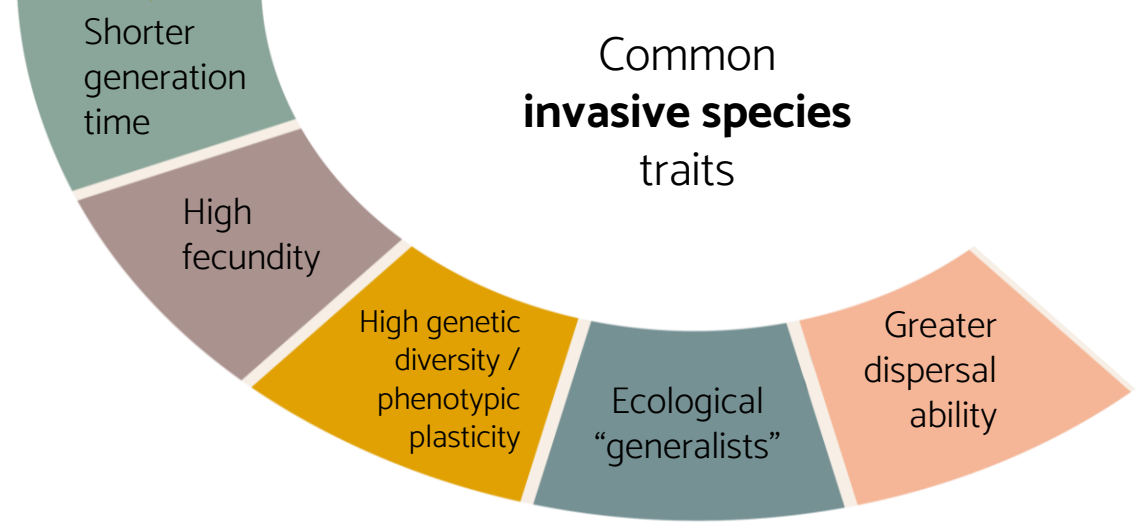


ICanHasCheezburger.com

Perish
(local/rangewide extinction)

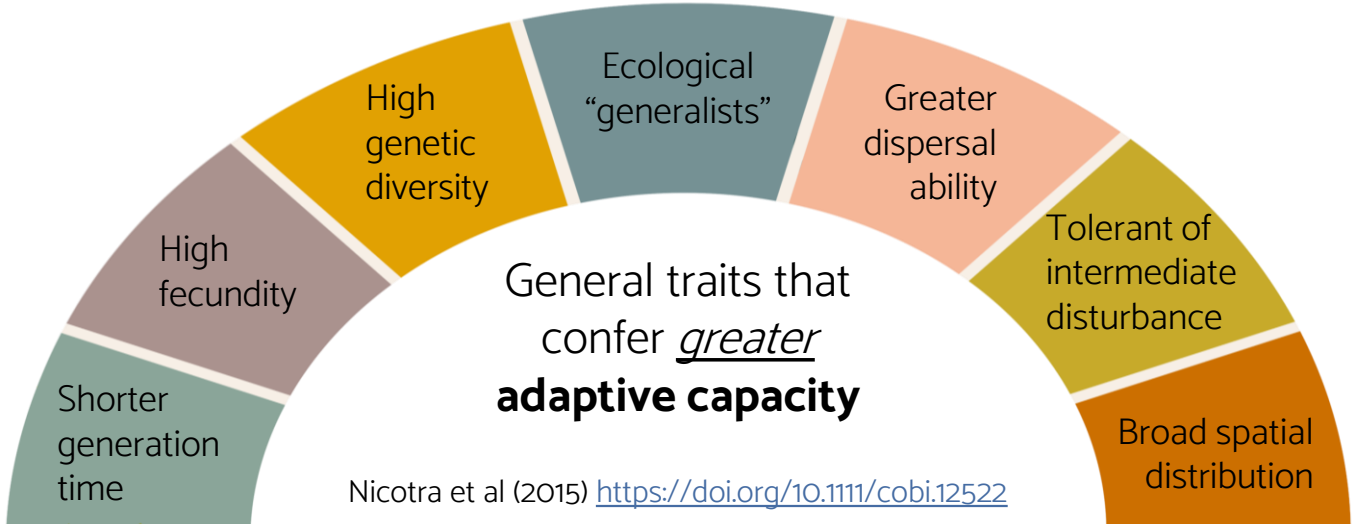
Persist in place or shift in space? Evaluating the adaptive capacity of species to climate change.
Thurman et al (2020) https://doi.org/10.1002/fee.2253

USGS science for a changing world
NORTHWEST Climate Adaptation Science Center



Common **invasive species** traits

- Prior successful invasions
- Linked to human activities
- Good competitor
- Fast growth
- Few predators
- Tolerance of a wide range of environmental conditions (ecological competence)



General traits that confer *greater* **adaptive capacity**

Nicotra et al (2015) https://doi.org/10.1111/cobi.12522

USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

Adaptive Capacity

"The potential, capability, or ability of a species, ecosystem or human system to **adjust** to climate change, to **moderate** potential damage, to **take advantage** of opportunities, or to **respond** to the consequences."

Survive

IPCC AR5 (2014)

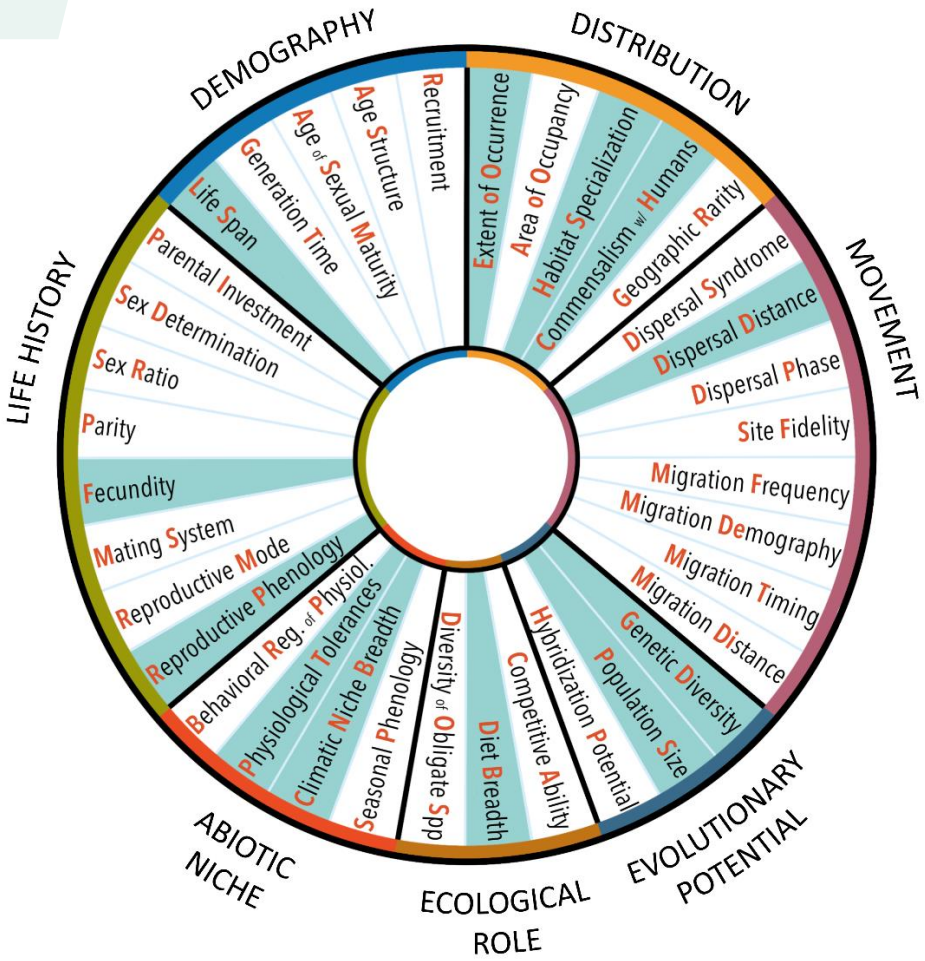
Invasive Potential

"The potential, capability, or ability of a species, ecosystem or human system to **adjust** to climate change, to **moderate** potential damage, to **take advantage** of opportunities, or to **respond** to the consequences."

Thrive

IPCC AR5 (2014)

AC Framework

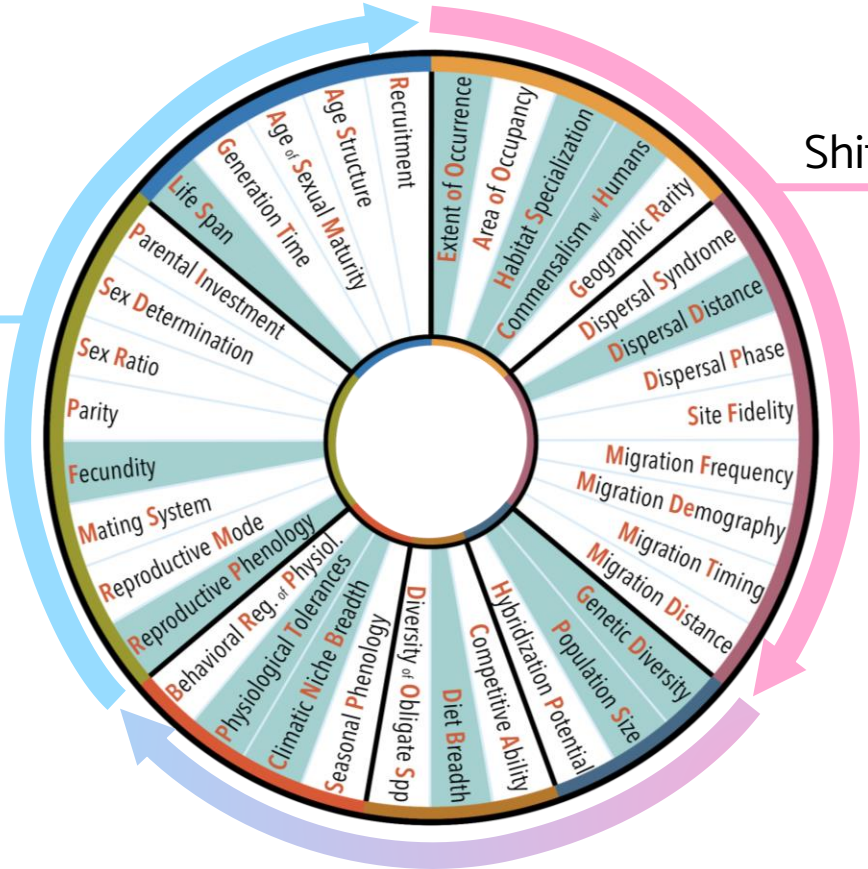


- 36 attributes
- 7 complexes (groups)
- 12 core attributes

Thurman et al (2020) https://doi.org/10.1002/fee.2253

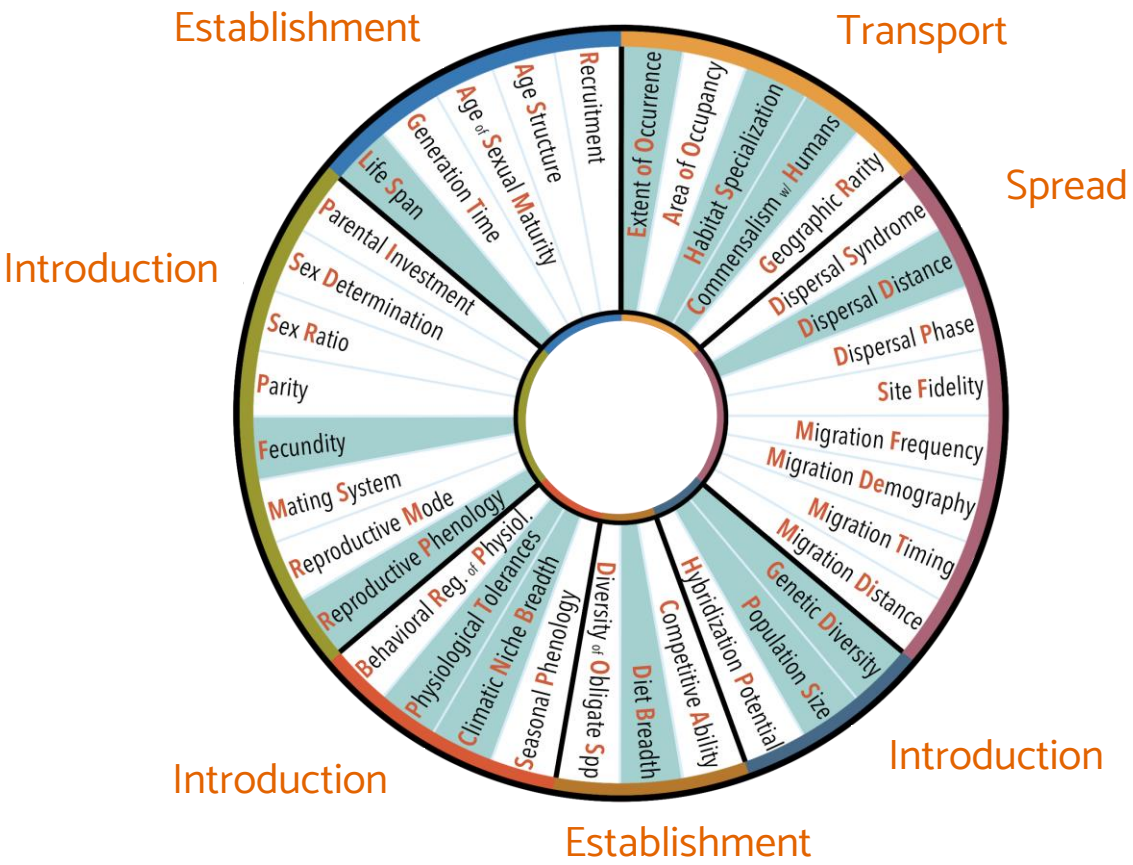
USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

AC Framework



Thurman et al (2020) https://doi.org/10.1002/fee.2253

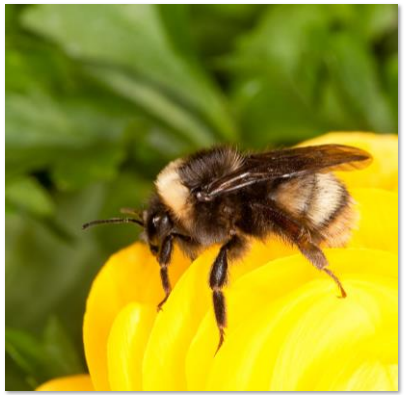
AC Framework



USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

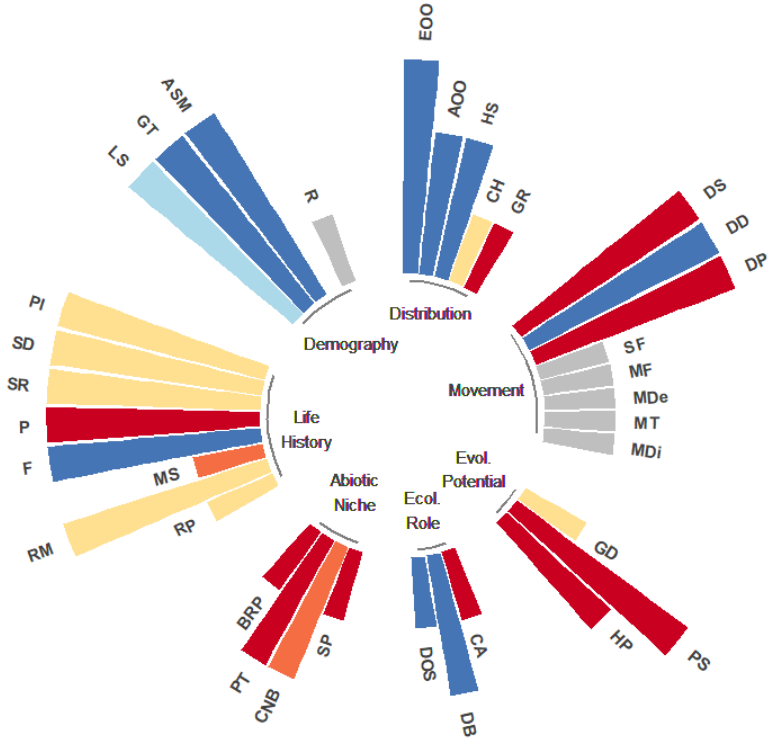
Thurman et al (2020) https://doi.org/10.1002/fee.2253

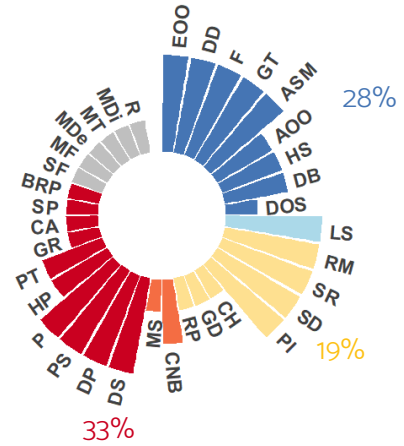
AC Framework



S. Ausmus

Western bumble bee
Bombus occidentalis





AC
- high
- moderately high
- moderate
- moderately low
- low
- unknown

Evidence: Low Mod High

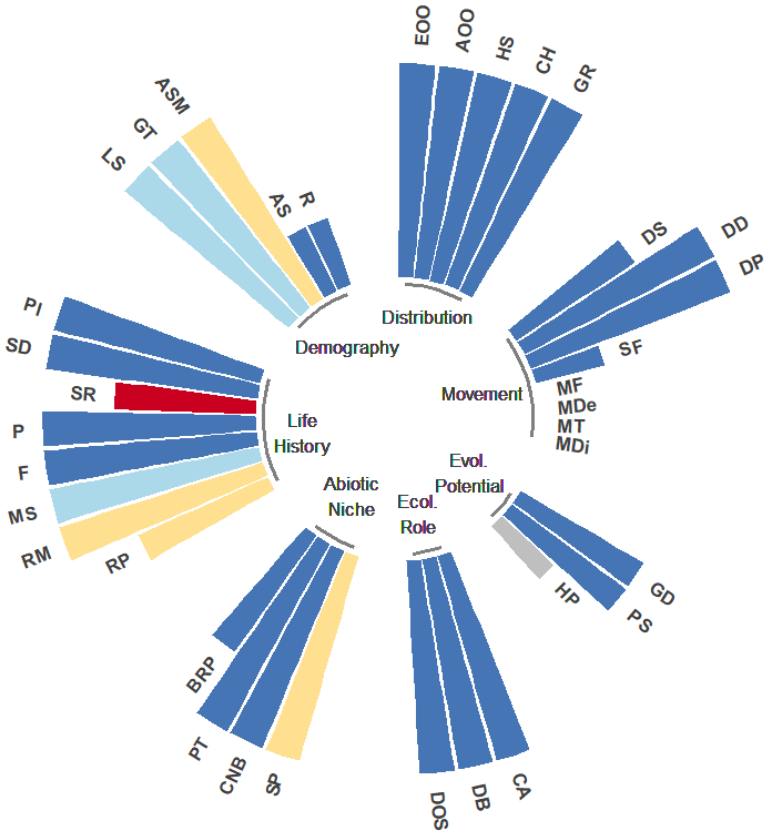
USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

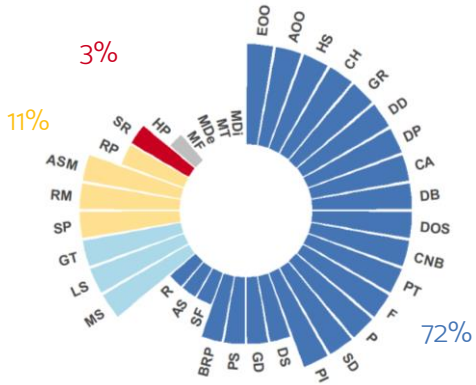
Preliminary information. Subject to revision.

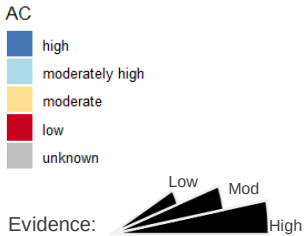
AC Framework

Y. Helfman

American bullfrog
Lithobates catesbeianus



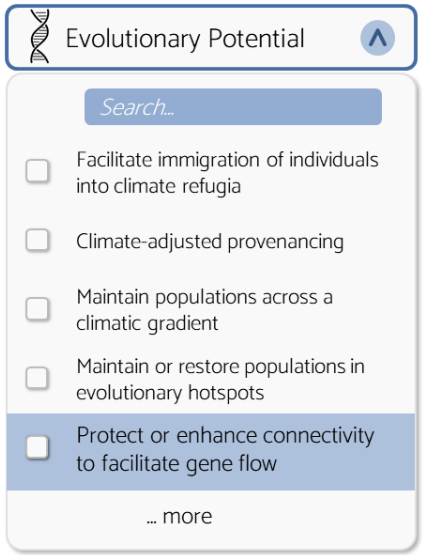




USGS science for a changing world
NORTHWEST Climate Adaptation Science Center

Preliminary information. Subject to revision.

AC-informed Adaptation Menu



Action

Protect or enhance connectivity to facilitate gene flow among populations at sites with suitable future climates through maintenance of critical connectivity pinch points, removal of movement barriers (e.g., dam removal or decommissioning roads), or installation of passages (e.g., fish ladders, road culverts, wildlife overpasses, etc.).

Goals

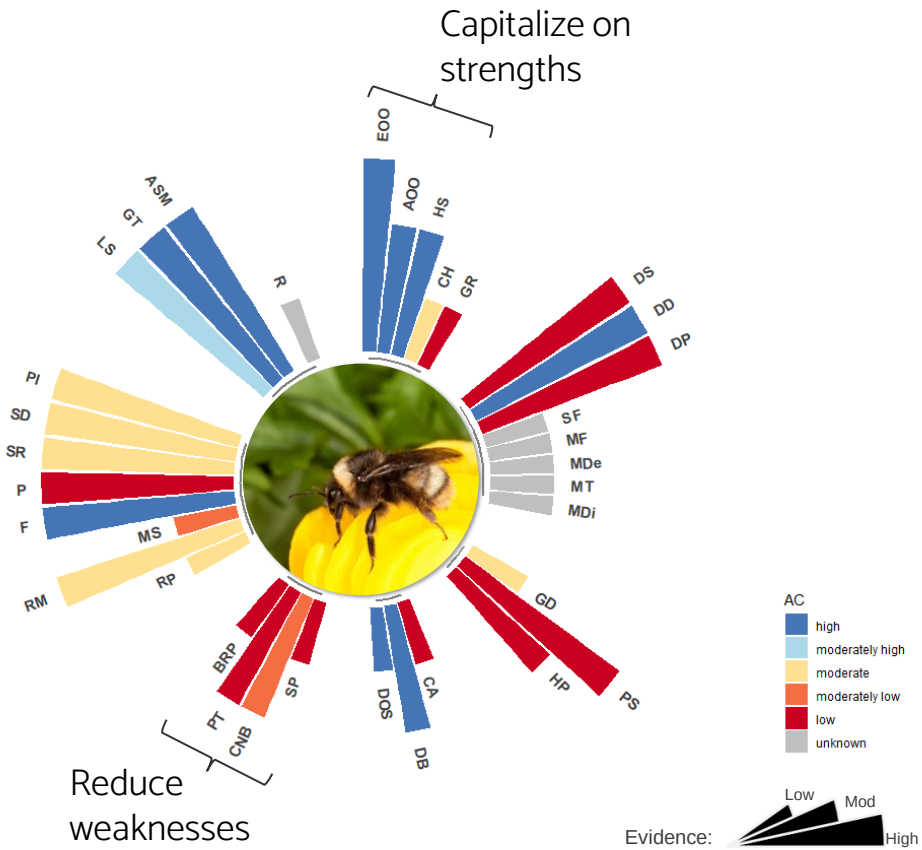
- Allow for optimal gene flow among populations and increase genetic diversity, especially across broader spatial extents and at the 'leading edge' of the species' range.
- Increase effective dispersal.
- Reduce potential for genetic drift.
- Avoid swamping local adaptation (homogenization) and minimize risk of disease transmission.
- Minimize loss of isolated populations to stochastic events.

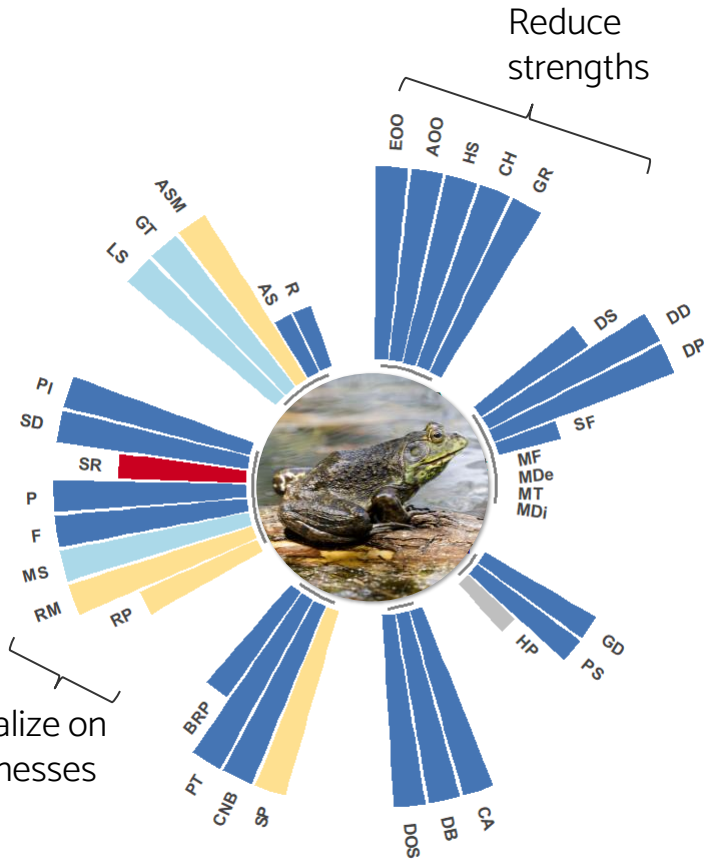
Examples

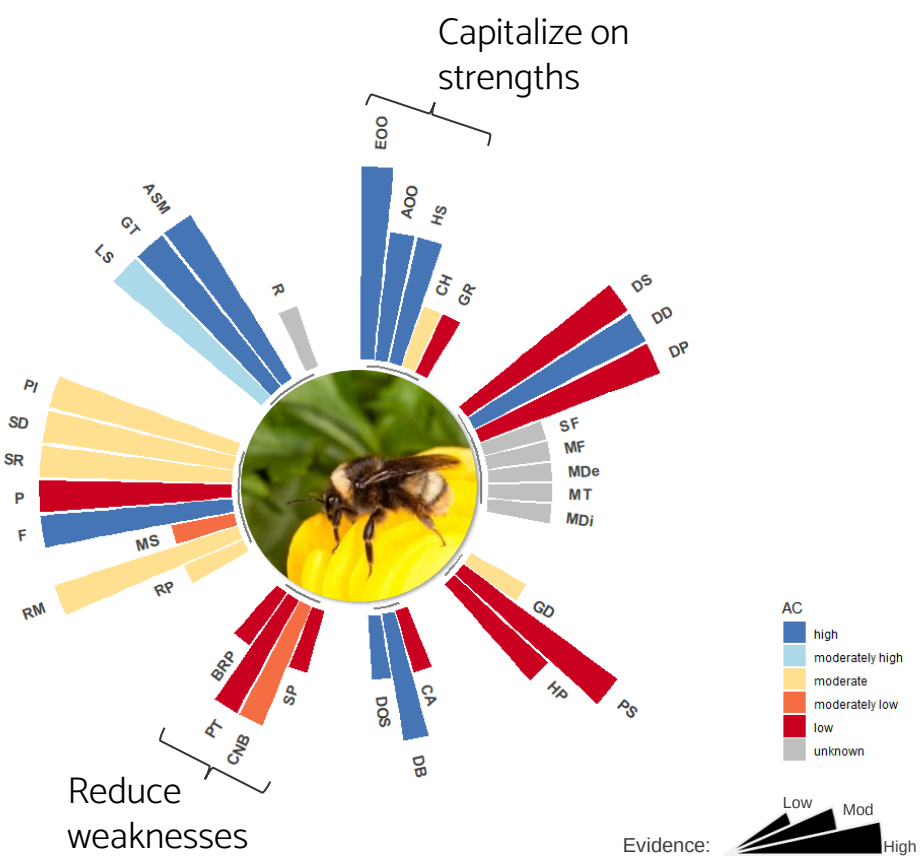
- Low-quality habitat corridors as movement conduits for two butterfly species (Haddad & Tewksbury 2005)
- Long-term viability of Department of the Interior bison under current management and potential metapopulation management strategies (Hartway et al 2020)
- Pacific lamprey recolonization of a Pacific Northwest river following dam removal (Jolley et al 2018)

Thurman et al (2022) https://doi.org/10.1111/cobi.13838

Bridging Research & Practice







AC Quick Reference Guide & Resources

https://tinyurl.com/AC-how-to

Adaptive Capacity Working Group
Est. Oct 2017
USGS Powell Center, Ft. Collins

NORTHWEST
Climate Adaptation
Science Center

NATIONAL
Climate Adaptation
Science Center

MIDWEST
Climate Adaptation
Science Center

Australian
National
University

MONASH
University