Impacts of species invasions in a changing world

Cascade Sorte
University of California, Irvine

ICAIS – 30 October 2019

Twitter: @CascadeJBS

Acknowledgments

Collaborators

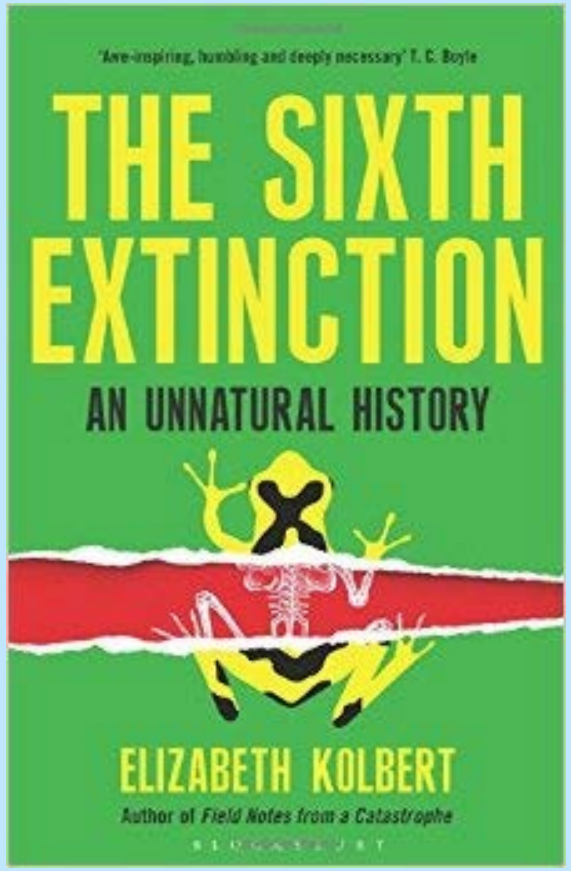
Bethany Bradley Amy Henry

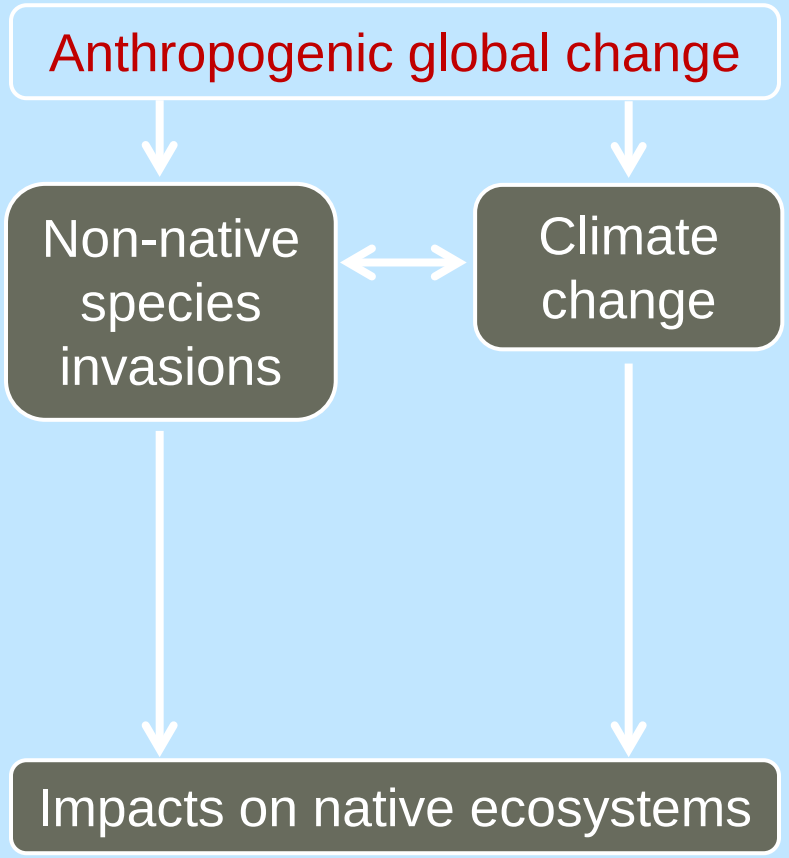
InvasiBES collaboration
(led by Belinda Gallardo & Montse Vila)

Funding sources

Belmont Forum/Biodiversa
National Science Foundation
University of California - Irvine

Biodiversity is declining & threats are increasing

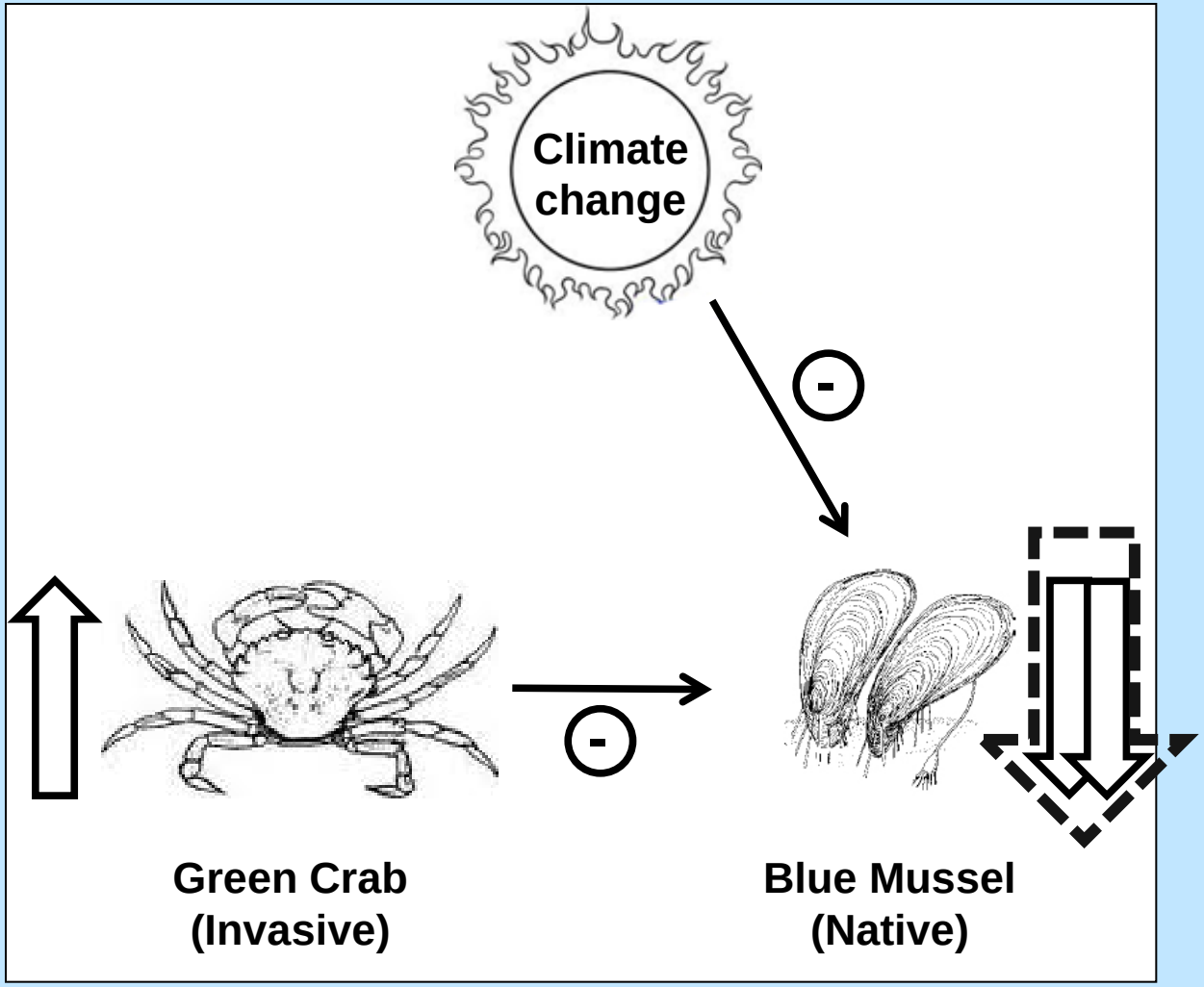




Climate change & invasions

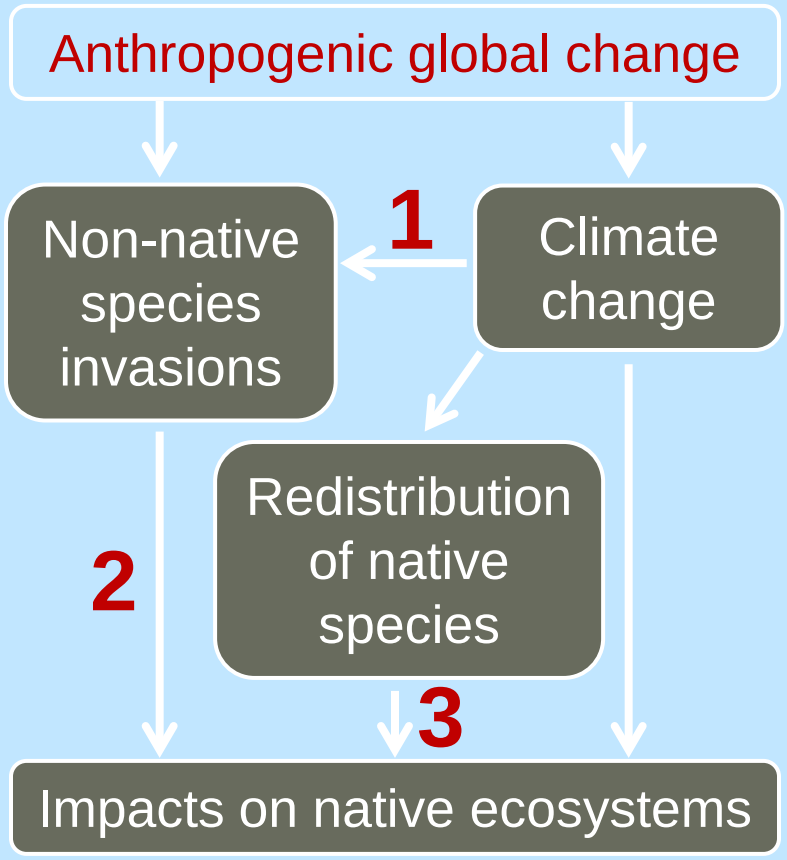
Both *individually* threaten biodiversity & could also *interact*

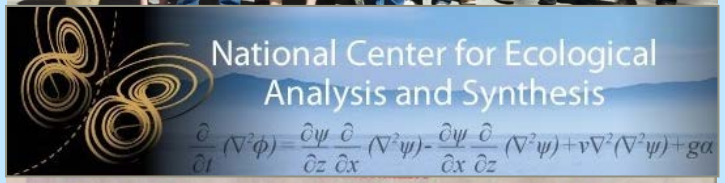
leading to synergestic negative impacts on native species



Sorte 2014 *CABI publishing*

Outline


Anthropogenic global change
Non-native species invasions
1
Climate change
2
Redistribution of native species
3
Impacts on native ecosystems


National Center for Ecological Analysis and Synthesis


CLIMATE INVADER
Mollusk from Baja: A search for dark unicorn snails migrating up the California coast could show how global temperature shifts change the landscape

Climate change & invasion success: mechanism 1

Same traits determining climate change “winners”
could also confer invasion success

Climate change & invasion success: mechanism 1

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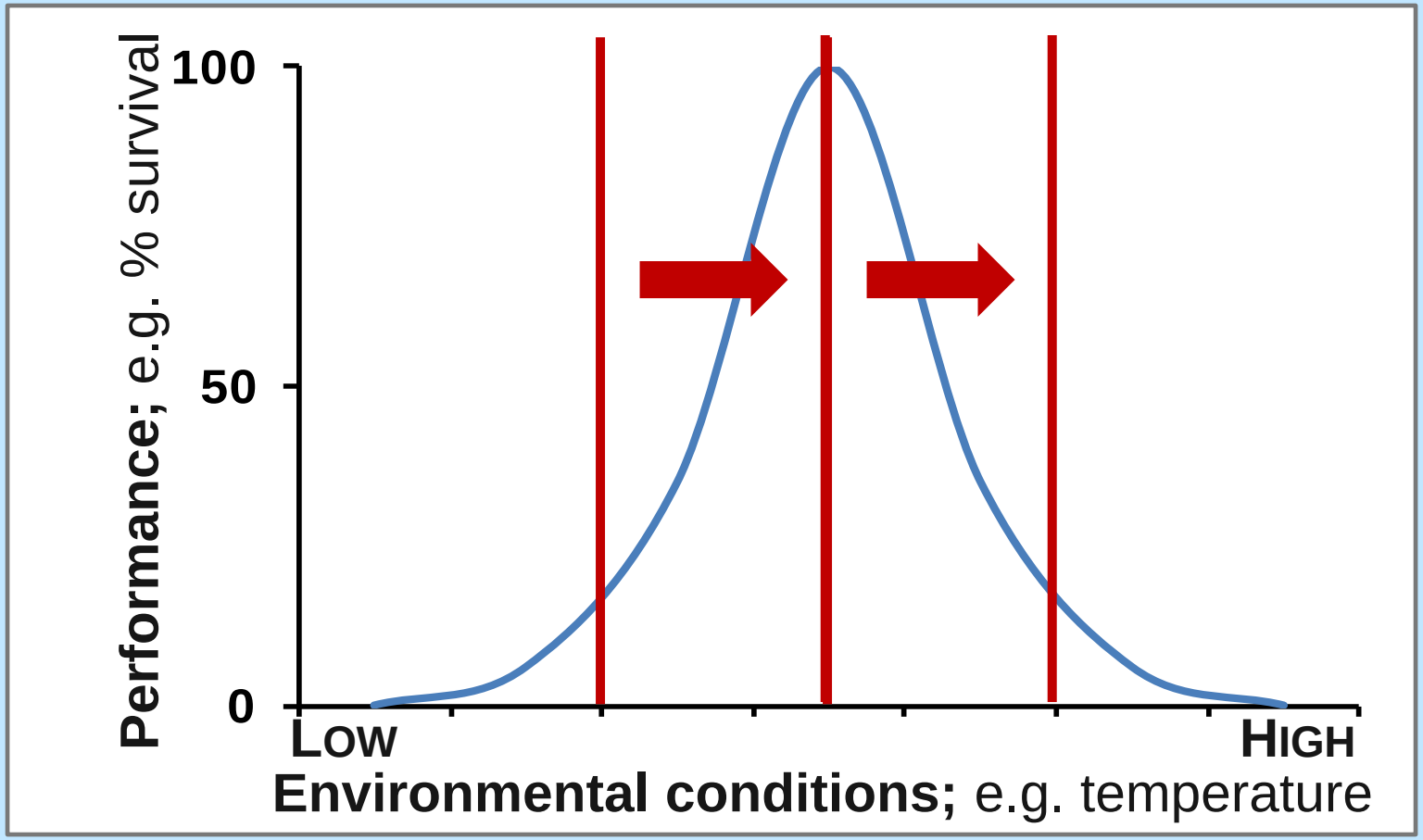
Ecophysiological approach to predict response to climate change



Climate change & invasion success: mechanism 1

Same traits determining climate change “winners”
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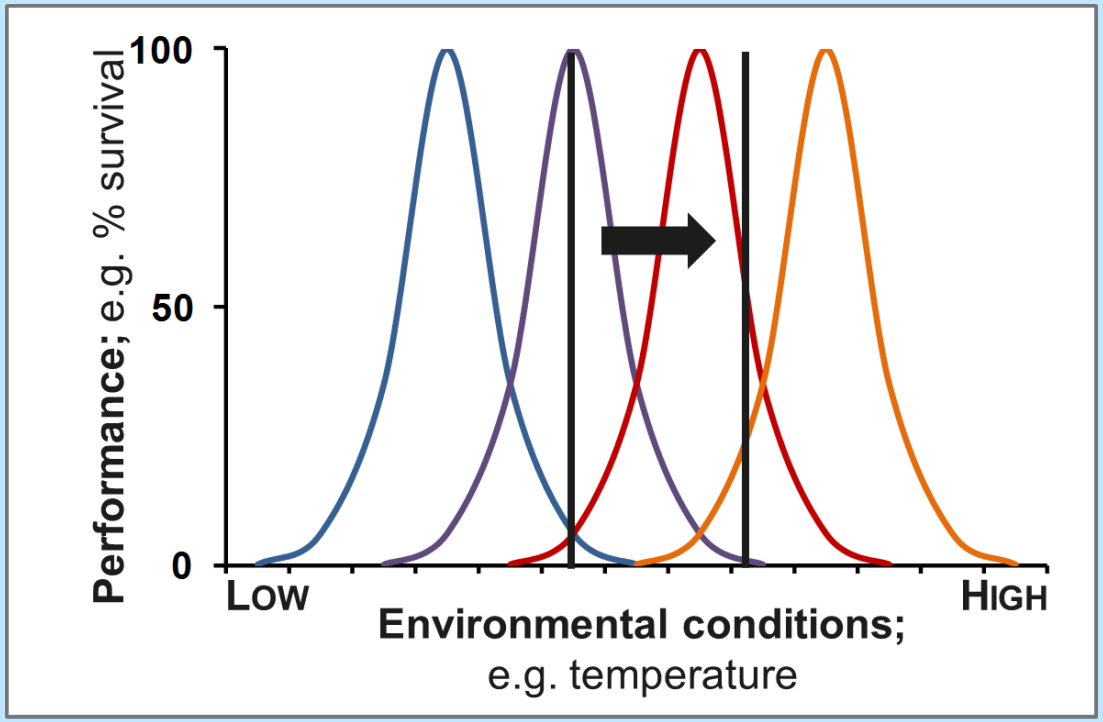
Performance curves for multiple species



Climate change favors species with thermal tolerances that are:

- Higher (warmer)

Climate change & invasion success: mechanism 1

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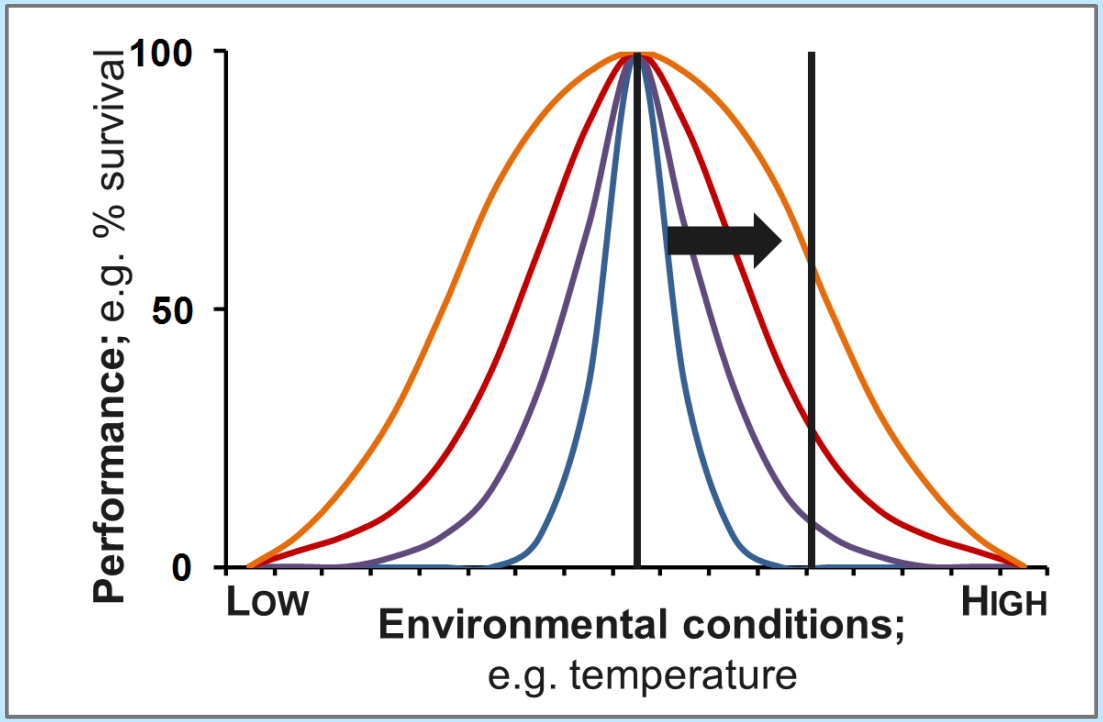
Performance curves for multiple species

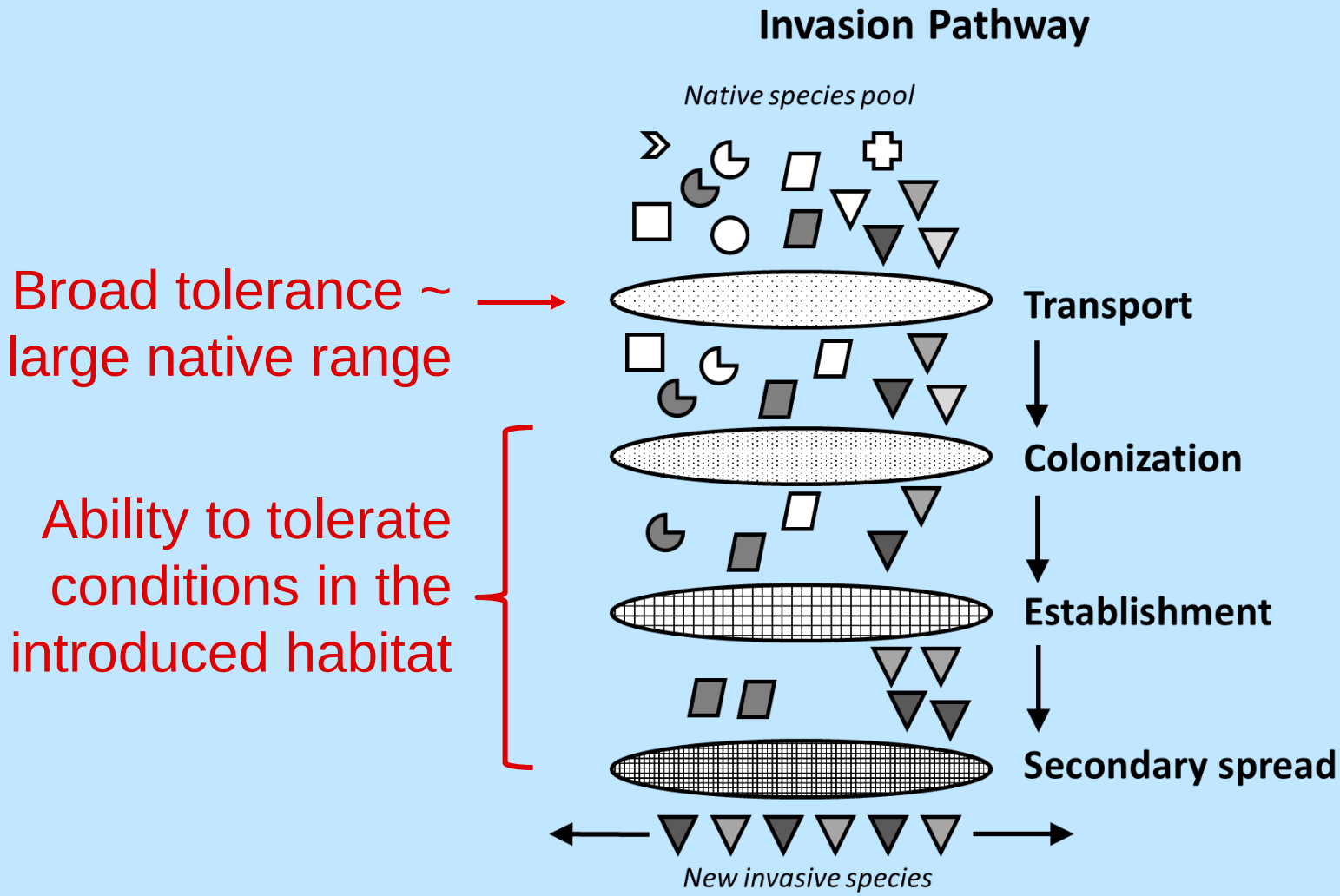


Climate change favors species with thermal tolerances that are:

- Higher (warmer)
- Broader

Climate change & invasion success: mechanism 1

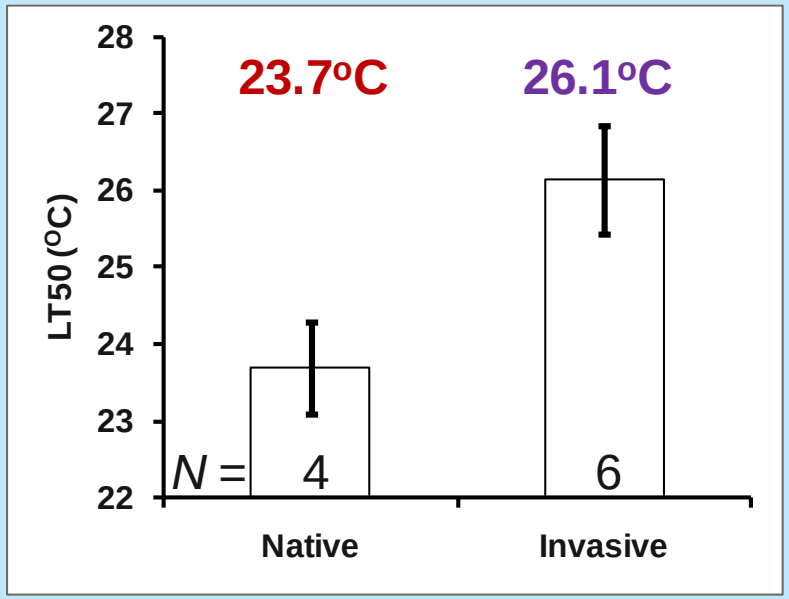
Warm- and broadly-tolerant species favored by climate change could also be more successful invaders



Climate change & invasion success: mechanism 1

Warm- and broadly-tolerant species favored by climate change could also be more successful invaders

Evidence from marine fouling community



Sorte et al. 2010 *Ecology*

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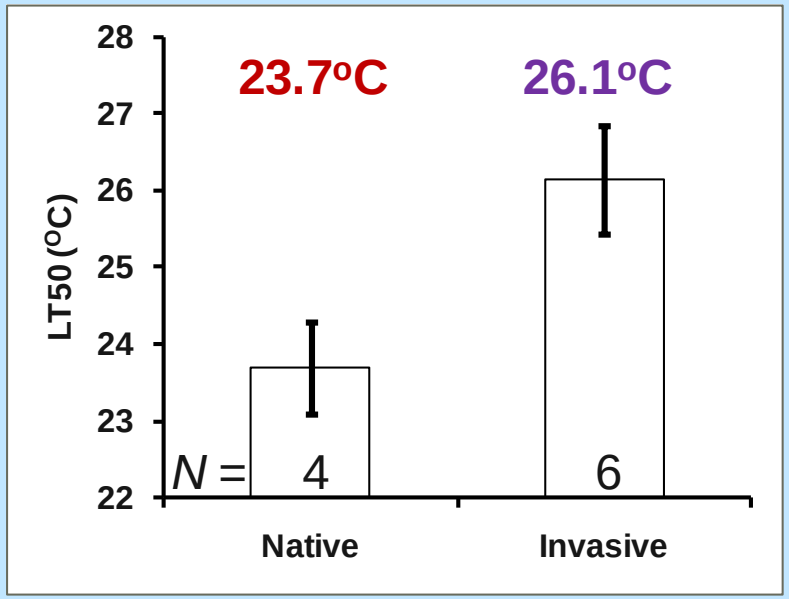

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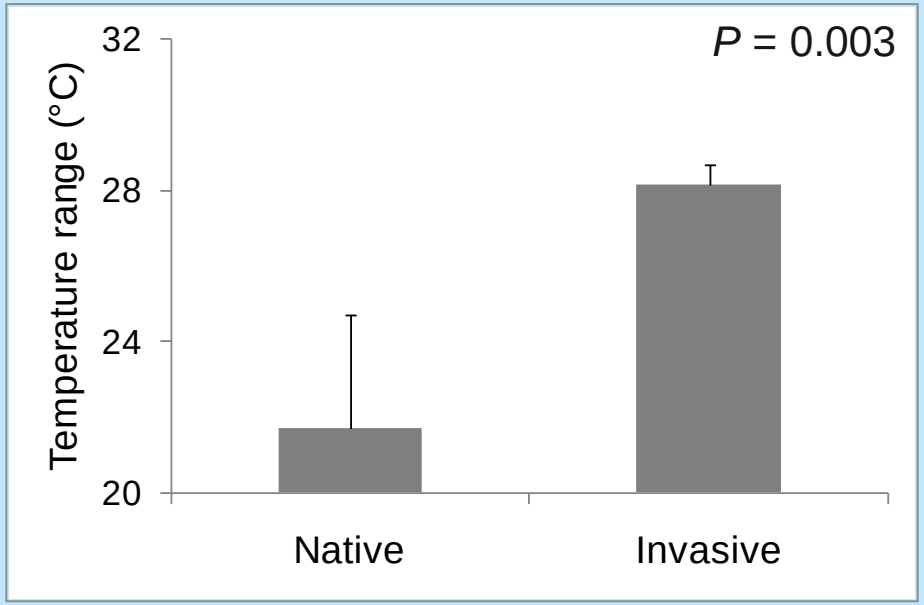


Zerebecki & Sorte 2011 *PLoS ONE*

As compared to native species, invasive species have higher thermal tolerances & broader temperature ranges

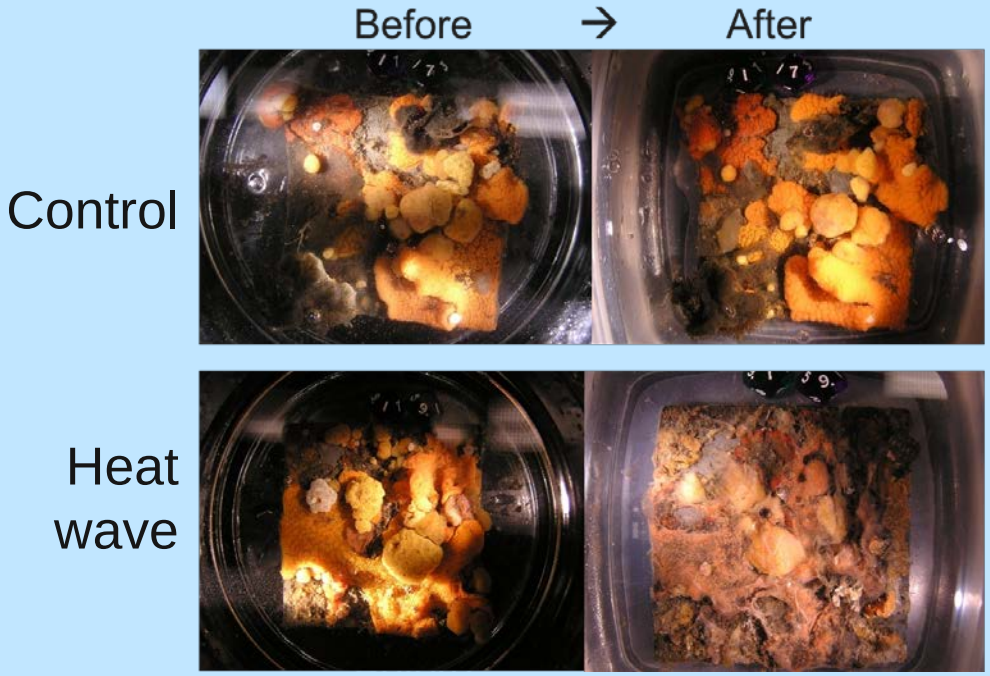
Climate change & invasion success: mechanism 2

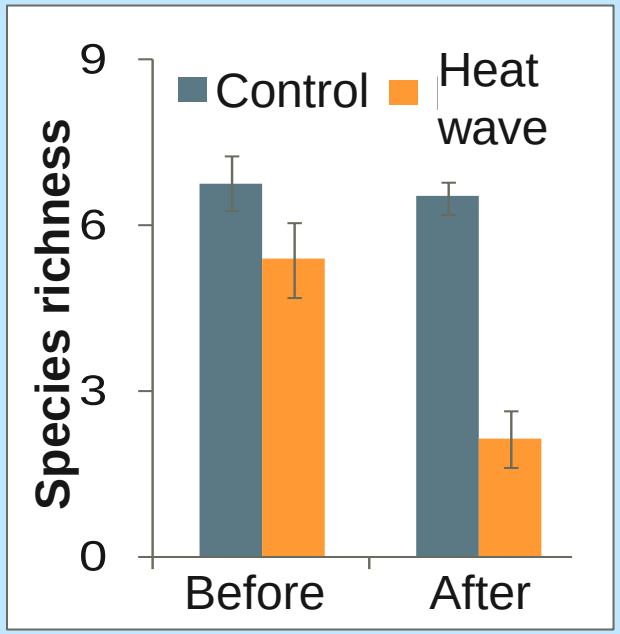
Invasive species could be more resistant to disturbance

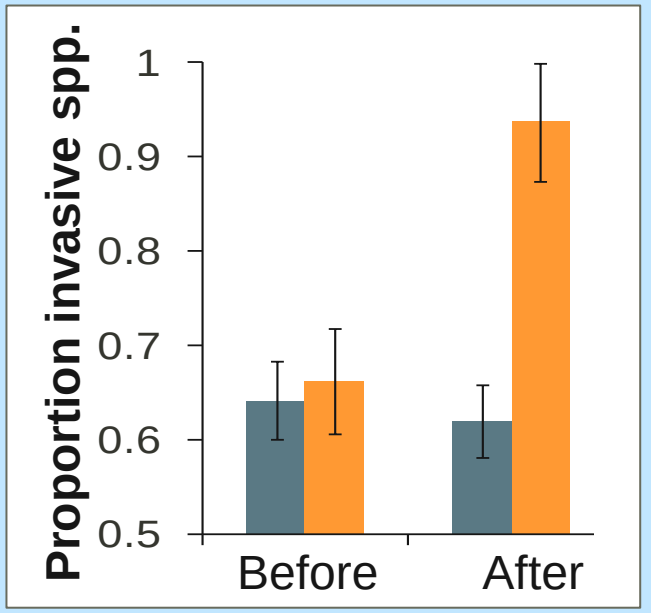
Climate change & invasion success: mechanism 2

Invasive species could be more resistant to disturbance

Applied simulated heat wave to marine fouling community







Sorte et al. 2010 *Oikos*

Heat wave decreased species richness & increased relative abundance of invasive species

Climate change & invasion success: mechanism 3

Invasive species could better capitalize on increased resource availability

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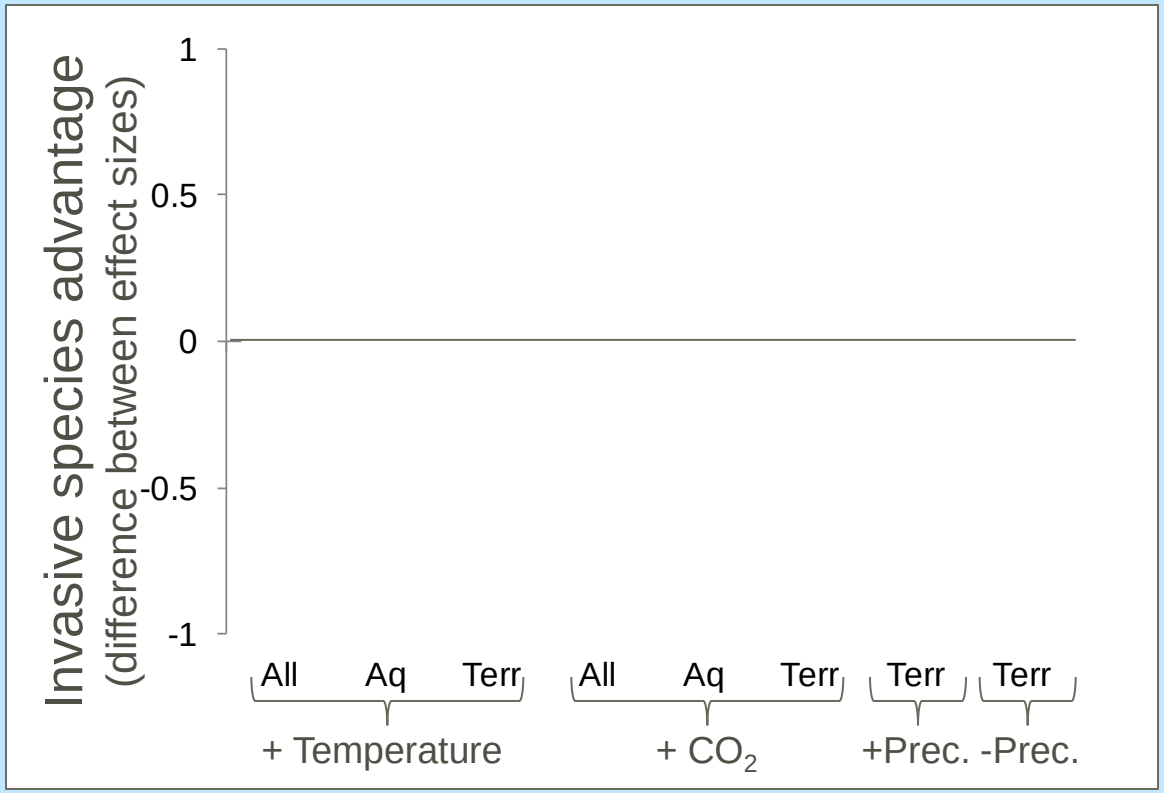
Invasive species could better capitalize on increased resource availability

Cross-system meta-analysis; 204 native & 157 invasive species



Invasive species respond more positively

Native species respond more positively

Sorte et al. 2013 *Ecology Letters*

Climate change & invasion success: mechanism 3

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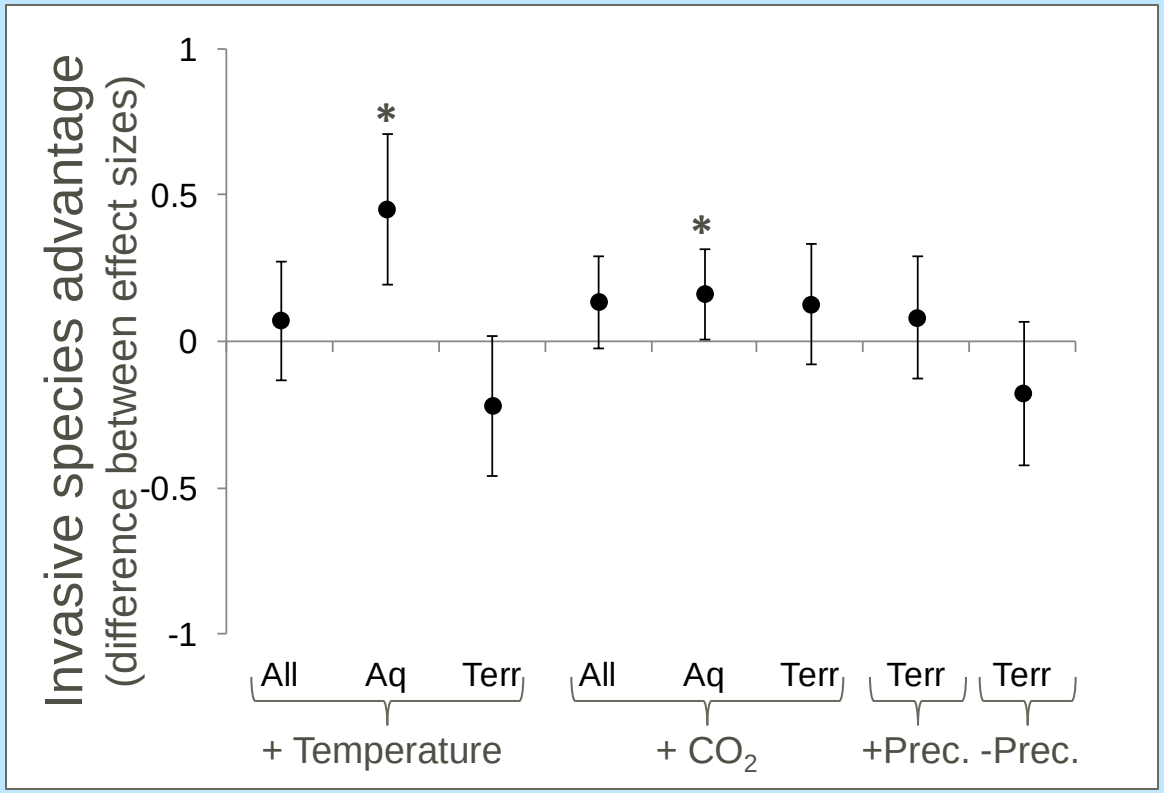


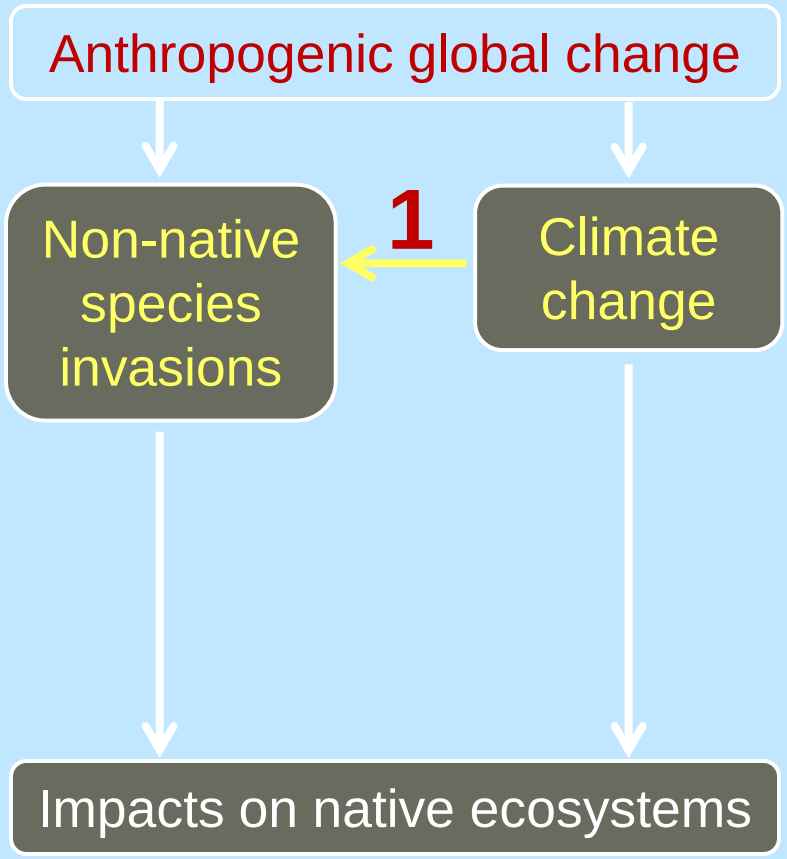
Invasive species respond more positively

Native species respond more positively

Sorte et al. 2013 *Ecology Letters*

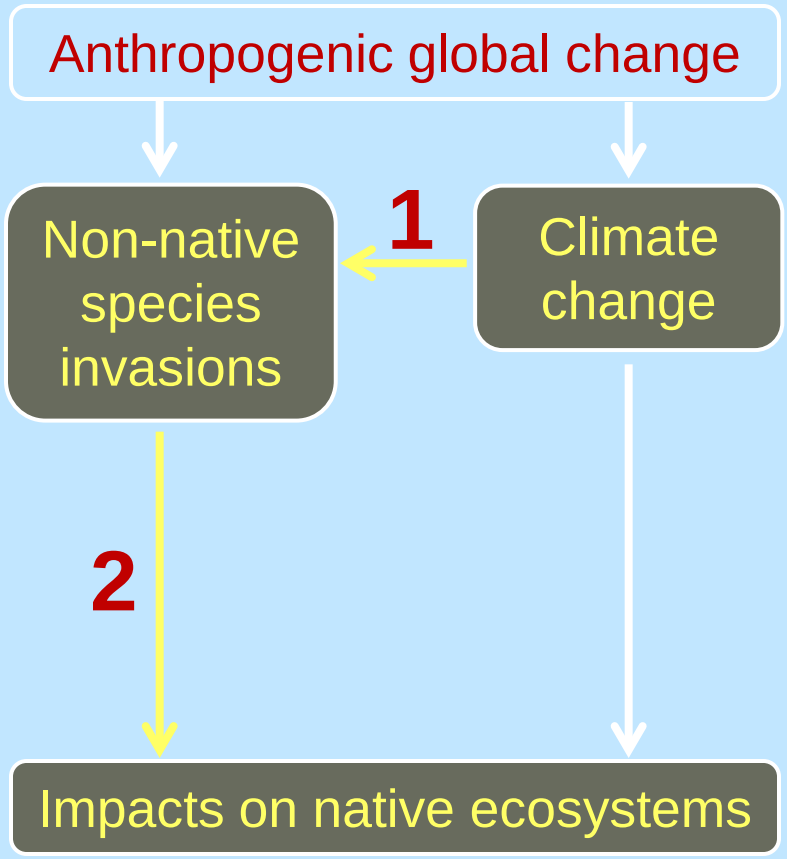
Invasive species favored *except* when resource availability (precipitation) *decreased*

Climate change & invasion success



1. Invader abundance likely to increase because:
   - traits of climate change “winners”
   - disturbance can abruptly increase dominance
   - increased resources can favor invaders

Climate change & invasion impacts



USA-EU Working Group

Defining impact: is it synonymous with success?

Reference	Total impact (I)[a]
Parker et al. (1999)	$I = A \times R \times E$
Thiele et al. (2010)	$I = \Sigma(A_j \times R_j \times E_j)$
Lockwood et al. (2007)	$I = A \times R \times (E \times \mathrm{Ft} \times \mathrm{Fe} \times \mathrm{Fs})$
Ricciardi (2003)	$I = A \times C \times \mathrm{EF}$
Ricciardi et al. (2011)	$I = A \times C \times \mathrm{EF}$; modified by propagule pressure
Strayer et al. (2006)	I depends on invader, resident biota, abiotic environment and species interactions, and is modified by time
Thomsen et al.	I depends on unique and universal interacting attributes of the invader, resident biota, resource levels and abiotic conditions

Thomsen et al. 2011 *Environ Research*

Function of:

- Abundance
- Range size

} *"success"*

- Per capita effect
- *Recipient community (e.g. distinctiveness)*

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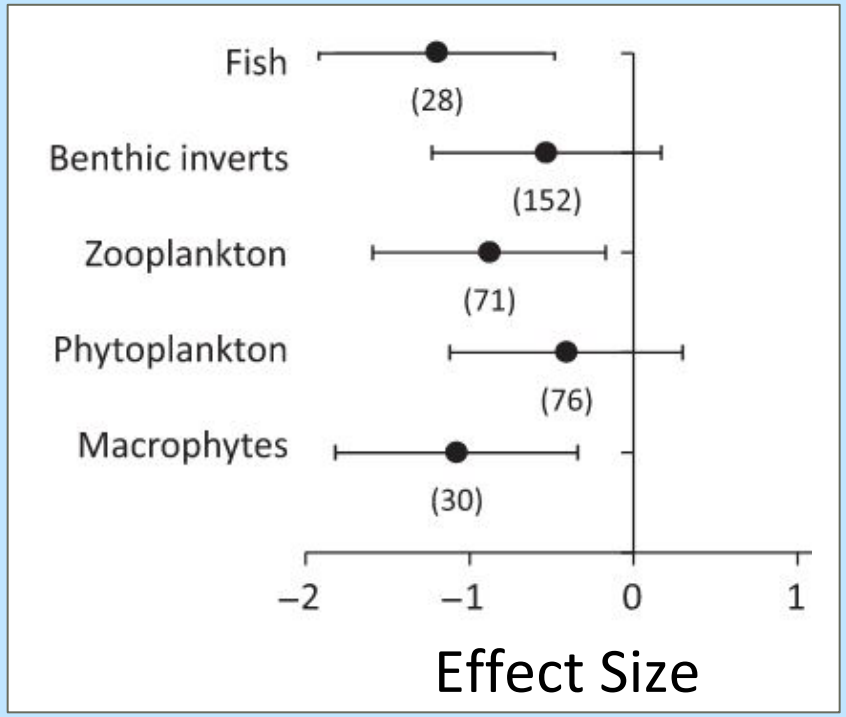
Thomsen et al. 2011 *Environ Research*

Function of:

- Abundance → *Responses of native species*
- Range size
- Per capita effect
- *Recipient community (e.g. distinctiveness)*

Defining impact: is it synonymous with success?

*Invader **presence** reduces native population sizes*



Gallardo et al. 2016

How does impact change with increasing invader abundance?

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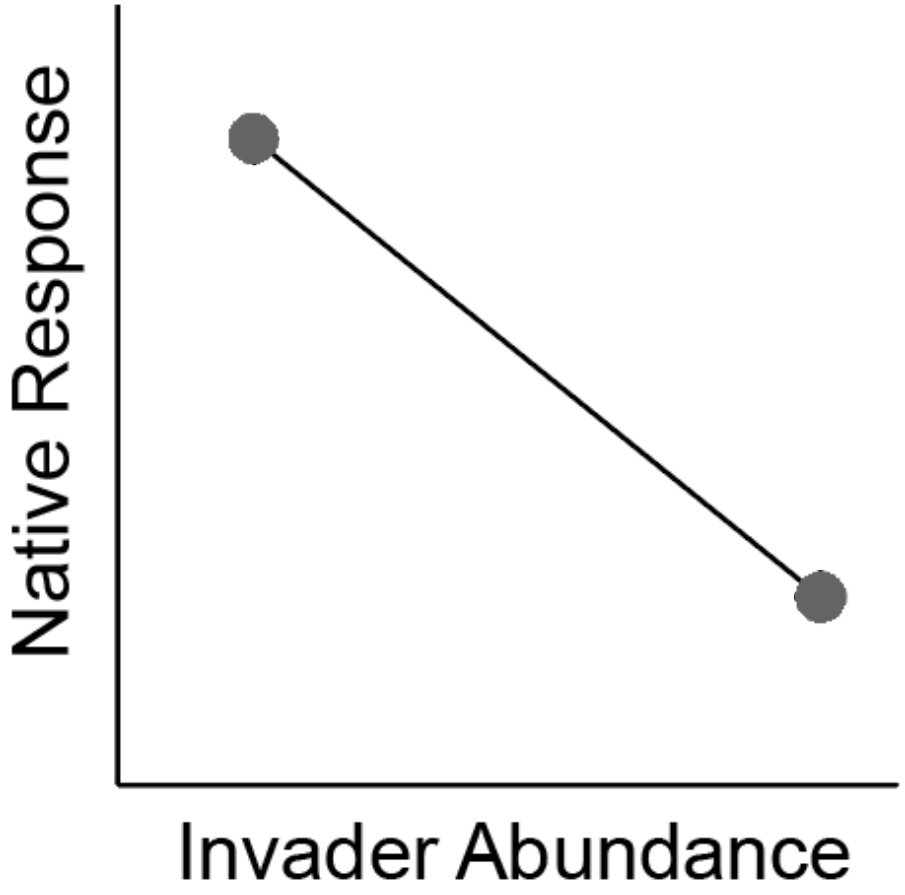
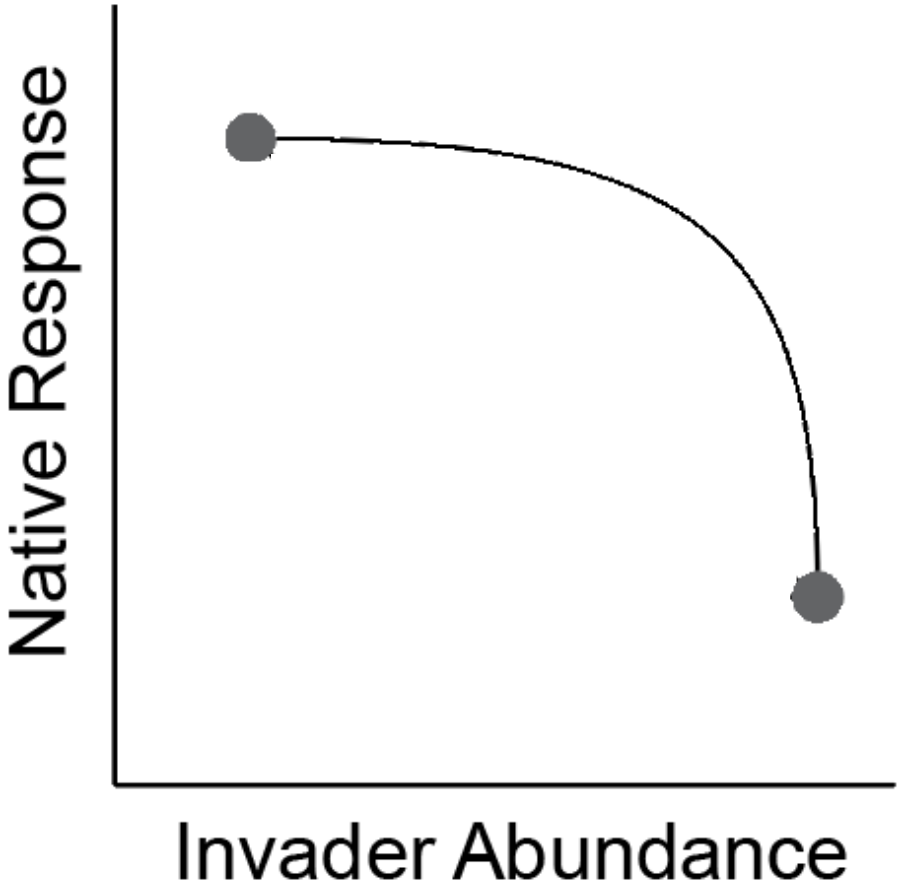


Linear negative impact
(decrease in native response)

Adapted from Yokomizo et al., 2009

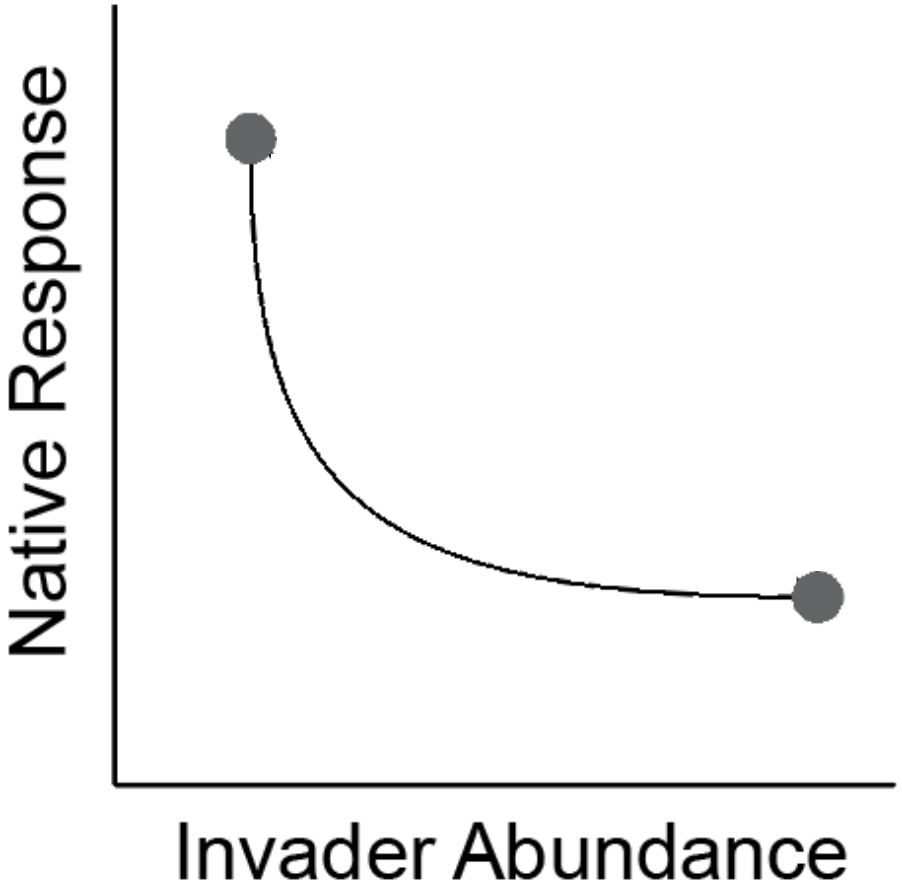
How does impact change with increasing invader abundance?



Adapted from Yokomizo et al., 2009

Increase in impact occurs only at **high** invader abundance

How does impact change with increasing invader abundance?

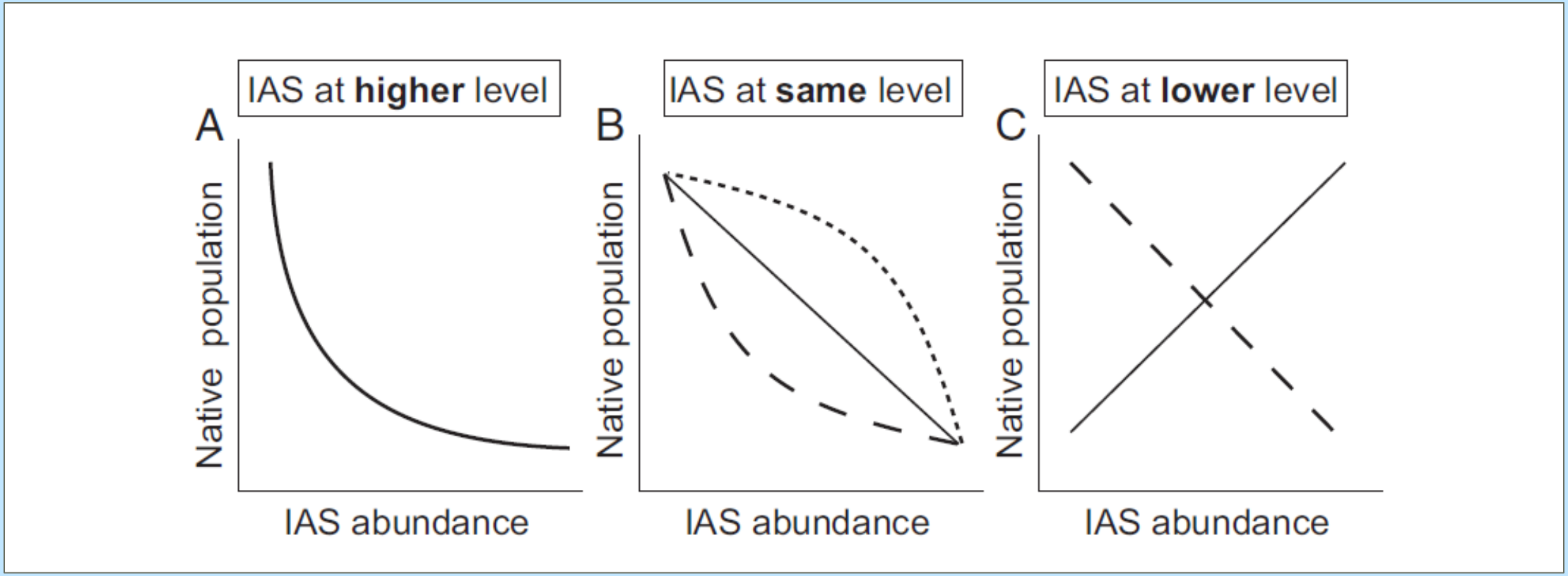


Adapted from Yokomizo et al., 2009

Increase in impact occurs at **low** invader abundance

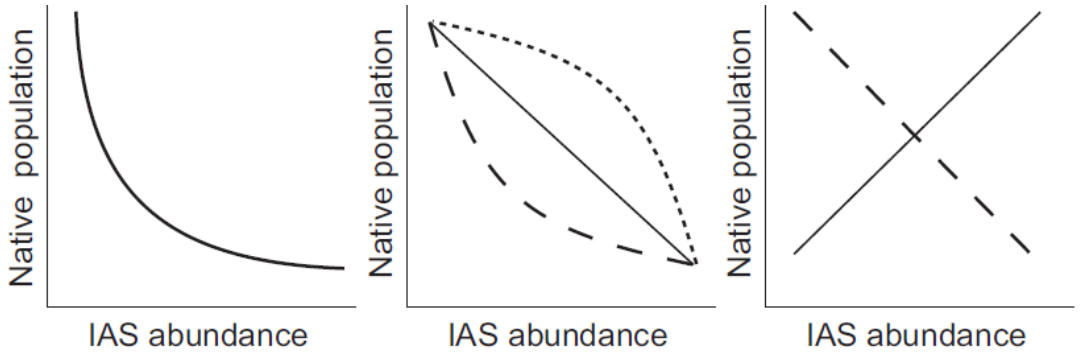
How does impact change with increasing invader abundance?

Cross-system meta-analysis: data from 1,258 studies in 201 papers

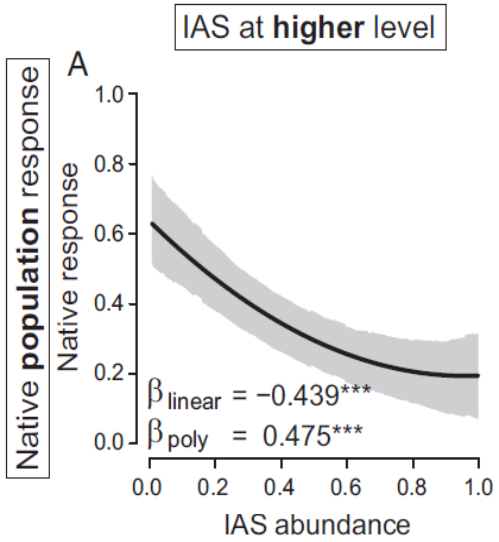


How does impact change with increasing invader abundance?

Predictions



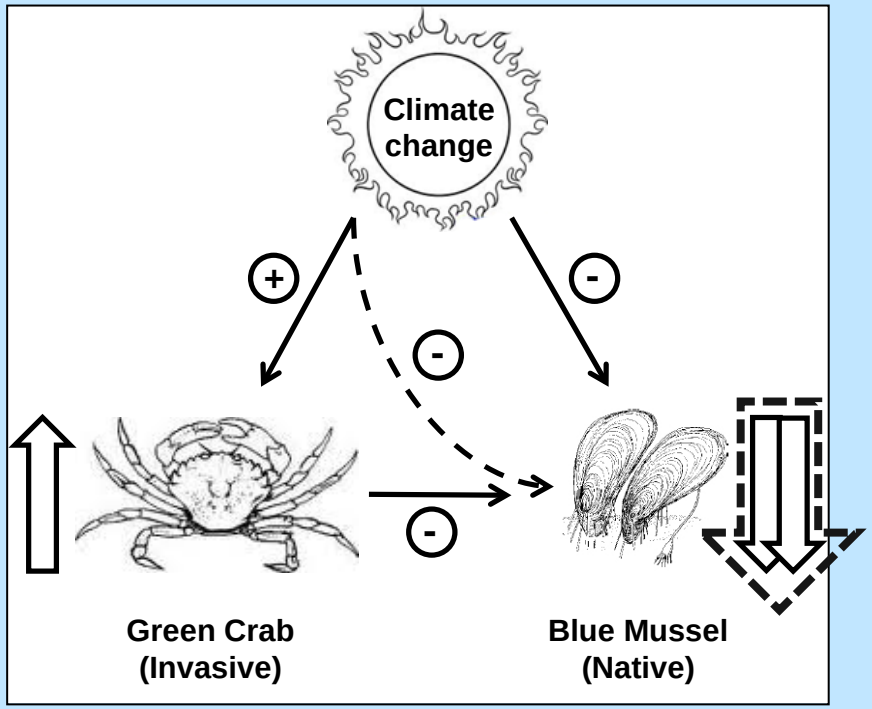
Results



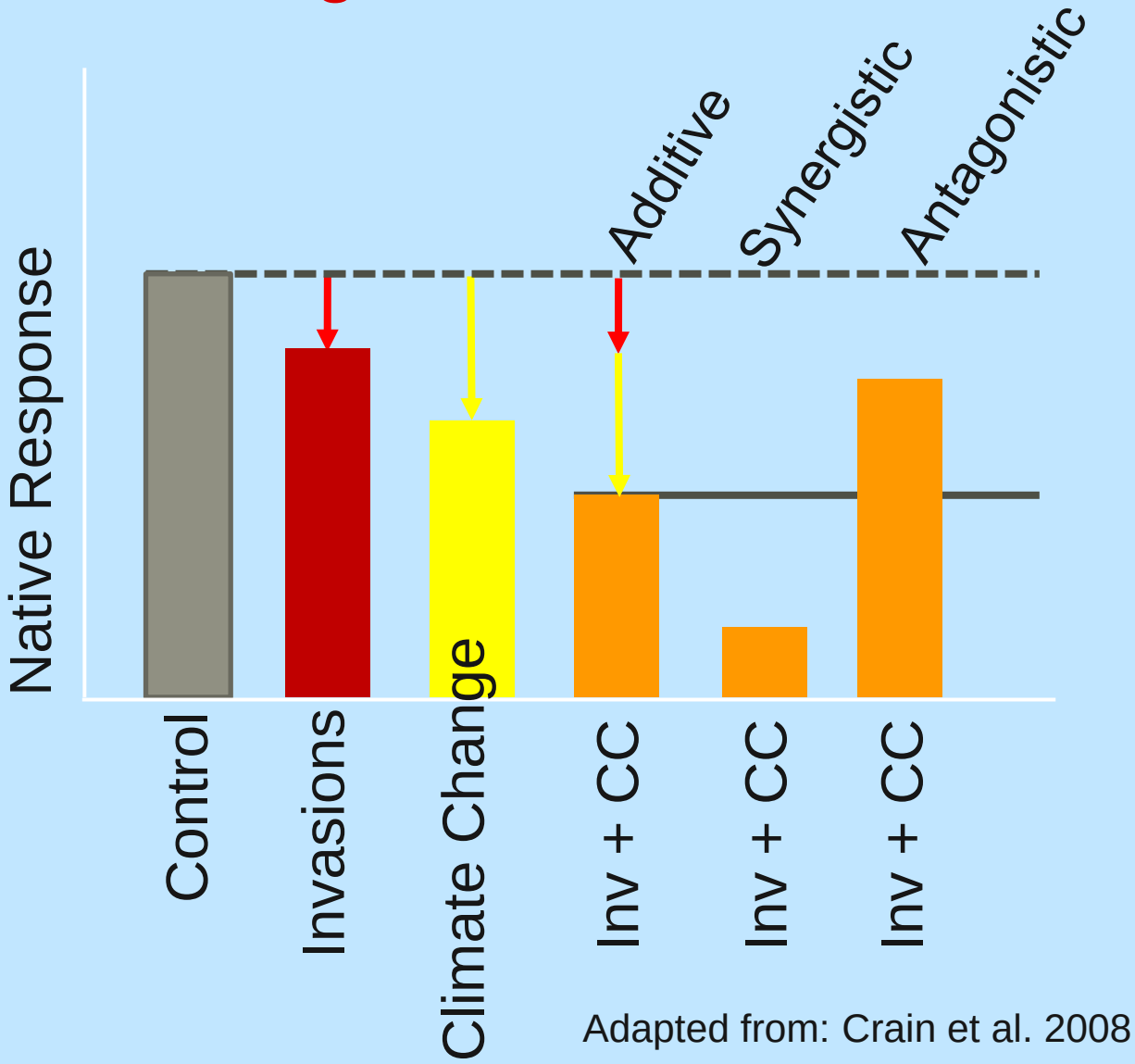
- Impacts increase with abundance – beginning at **low** abundance – for predators/competitors
- Importance of management at low levels of invasion

Bradley … Sorte 2019 *PNAS*

In progress: cross-ecosystem meta-analysis of impacts of Invasions, Climate Change, Inv x CC

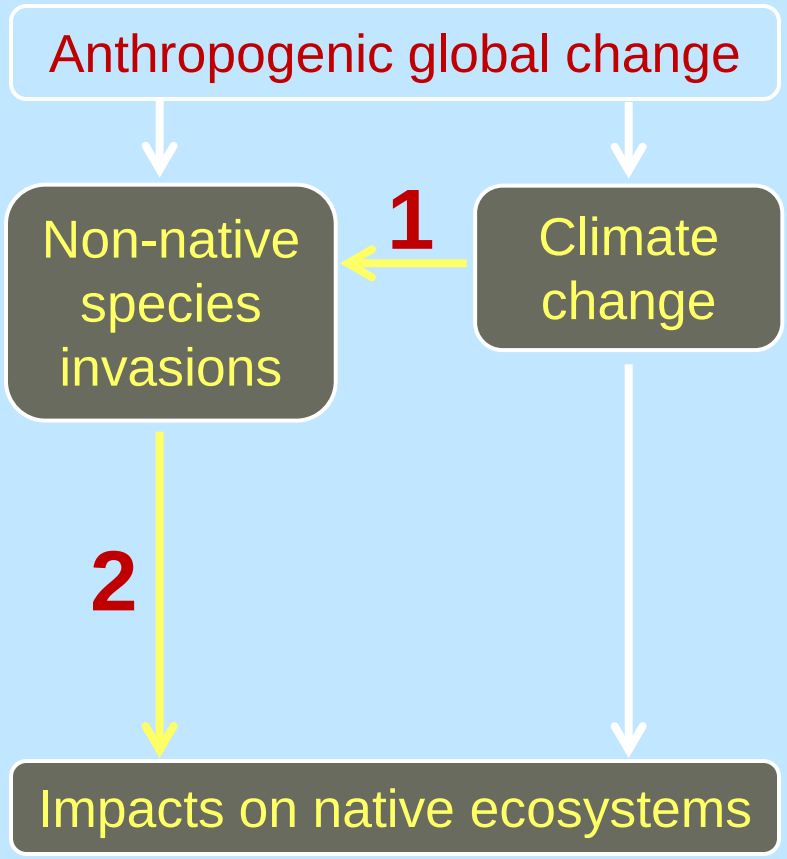


Sorte 2014 *CABI*



Adapted from: Crain et al. 2008

Will climate change increase the impacts of invasive species?



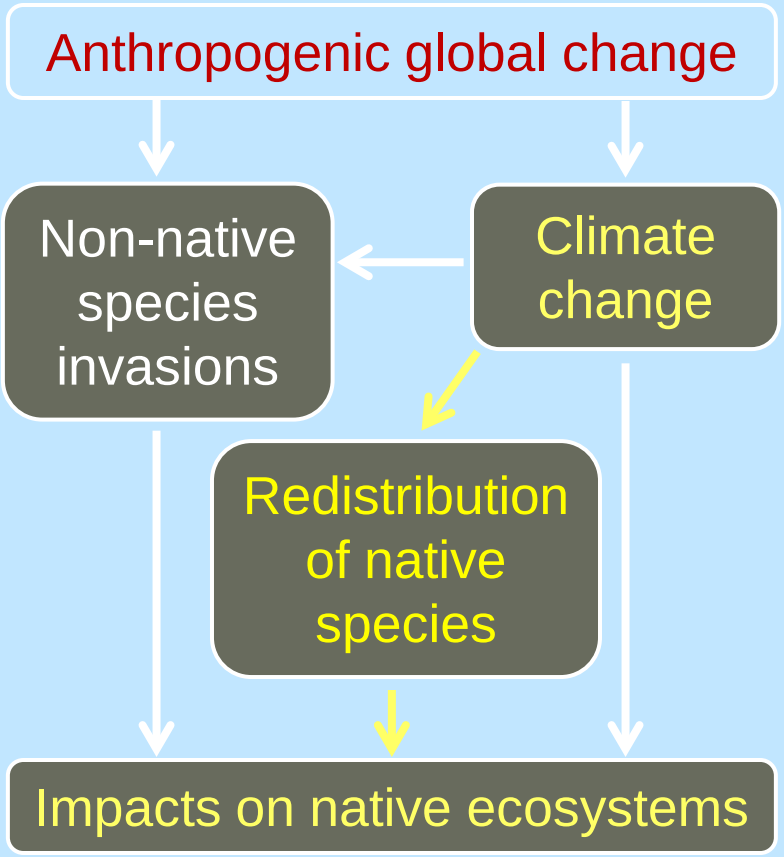
2. Increases in invaders negatively impact natives at low abundance for predators/competitors

PNAS

Disentangling the abundance–impact relationship for invasive species

Bethany A. Bradley[a,b,1], Brittany B. Laginhas[b], Raj Whitlock[c], Jenica M. Allen[d], Amanda E. Bates[e], Genevieve Bernatchez[f], Jeffrey M. Diez[g], Regan Early[h], Jonathan Lenoir[i], Montserrat Vilà[j], and Cascade J. B. Sorte[f]

Impacts of native species spreading with climate change




THE ORANGE COUNTY REGISTER

Saturday, February 24, 2018 $1.50 FOUNDED IN 1905 FACEBOOK.COM/OCREGISTER TWITTER.COM/OCREGISTER

ENVIRONMENT

?CLIMATE INVADER

Mollusk from Baja: A search for dark unicorn snails migrating up the California coast could show how global temperature shifts change the landscape

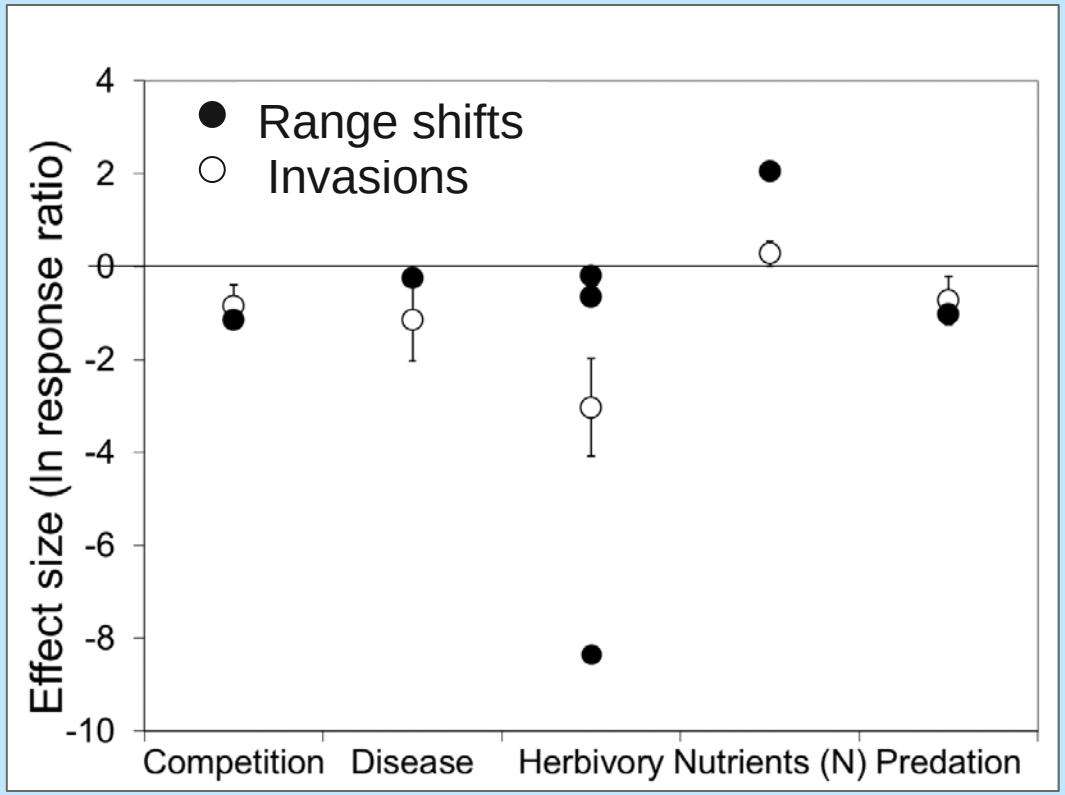
Impacts of native species spreading with climate change

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2010) **19**, 303–316

META-ANALYSIS

Marine range shifts and species introductions: comparative spread rates and community impacts

Cascade J. B. Sorte[1]*, Susan L. Williams[1] and James T. Carlton[2]

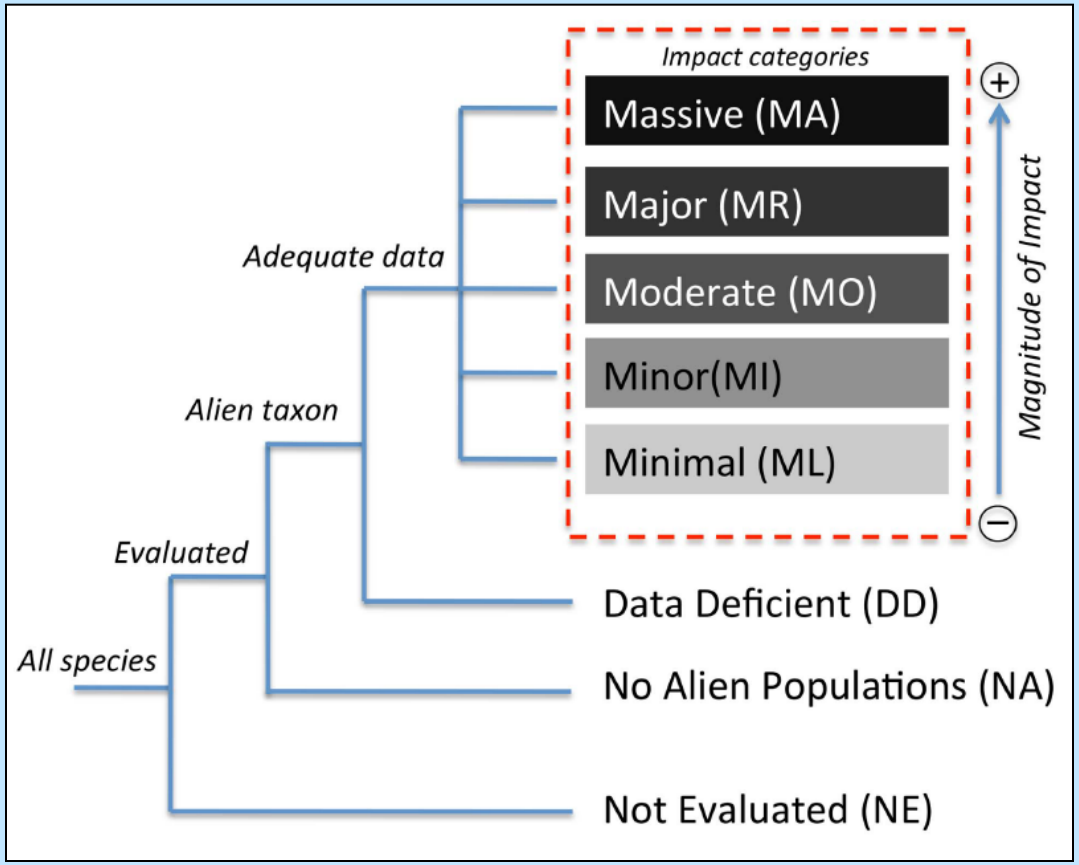


Sorte et al. 2010 *Glob Ecol Biogeogr*

- Meta-analysis comparing impacts of invasion and native spread
- Impacts of native range shifts of similar magnitude as those of non-native species invasions
- Great majority of shifting species understudied, particularly impacts

Impacts risk assessment for range shifting species

- EICAT (Environmental Impact Classification of Alien Taxa)
- Synthesis approach (literature review)
- Assigns impact by category based on research done anywhere (not just invaded range)



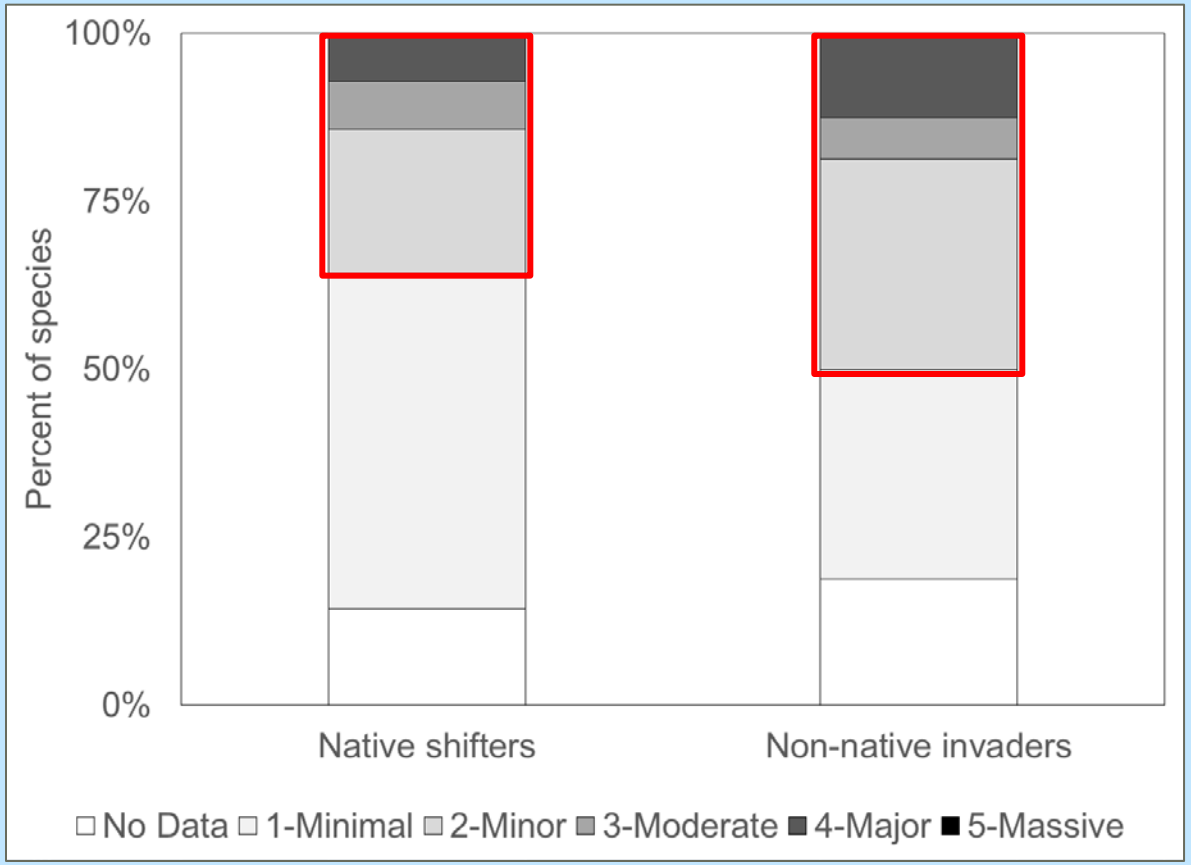
Blackburn et al. 2014 *PLOS Biol.*

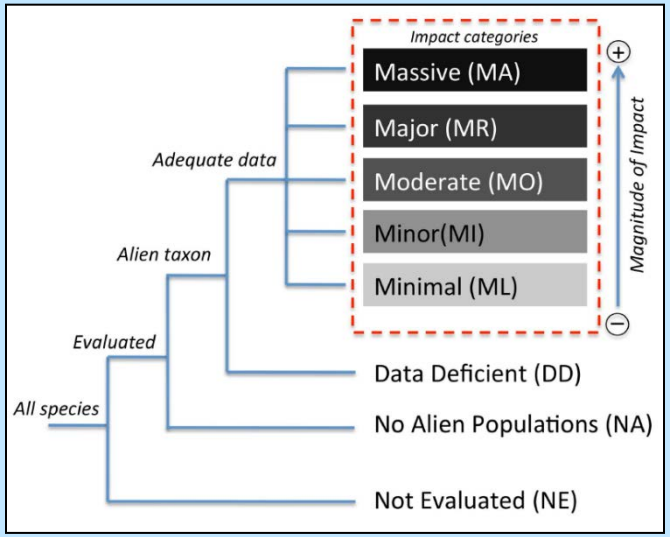
Impacts risk assessment for range shifting species

14 range shifting species from U.S. West Coast

+ 16 non-native species (of same/paired taxa) from

NEMESIS (National Exotic Marine & Estuarine Species Information System)



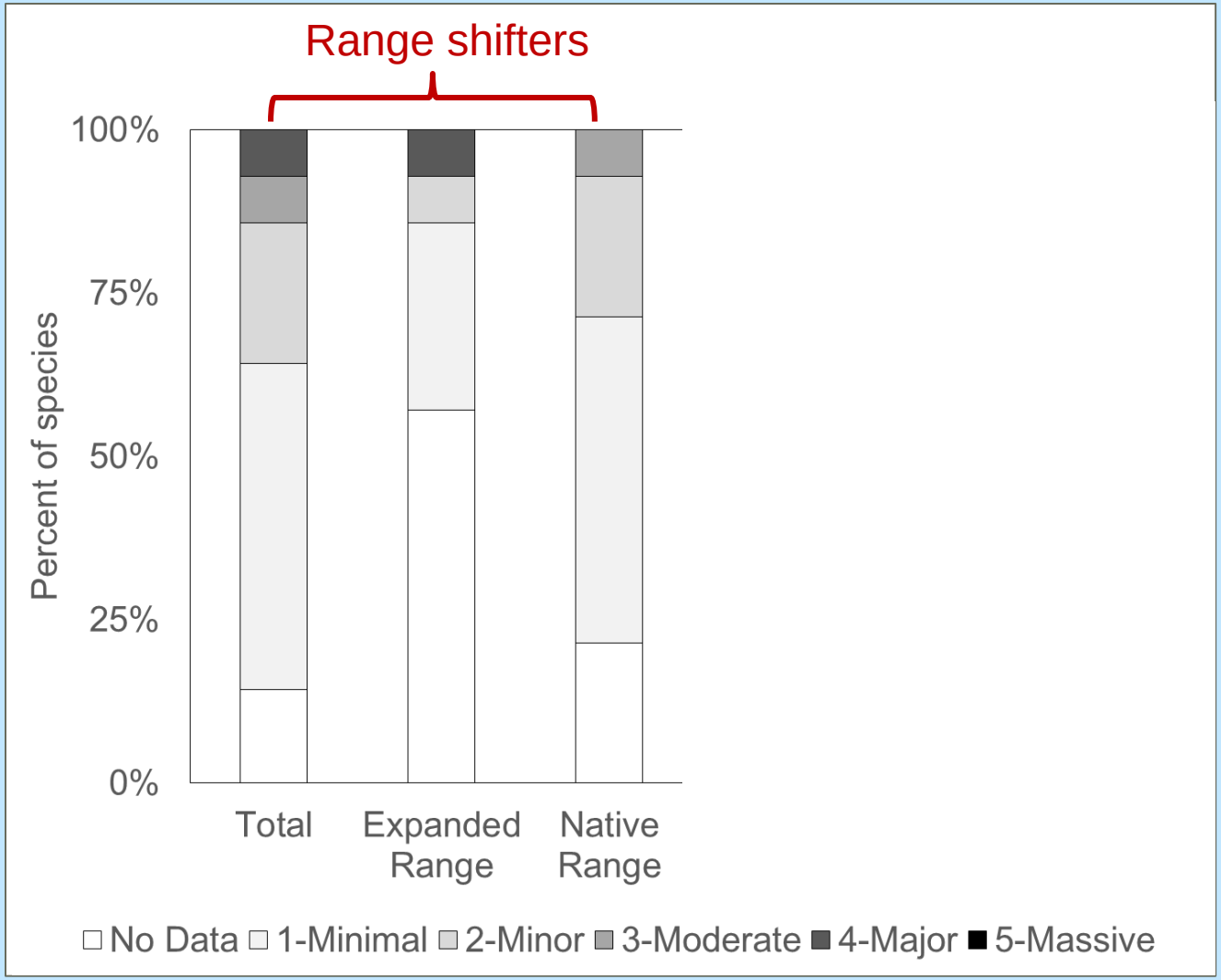


Blackburn et al. 2014 *PLOS Biol.*

Average/median EICAT scores
Native shifters: 1.7 / 1
Non-native invaders: 2.0 / 2

Impacts risk assessment for range shifting species

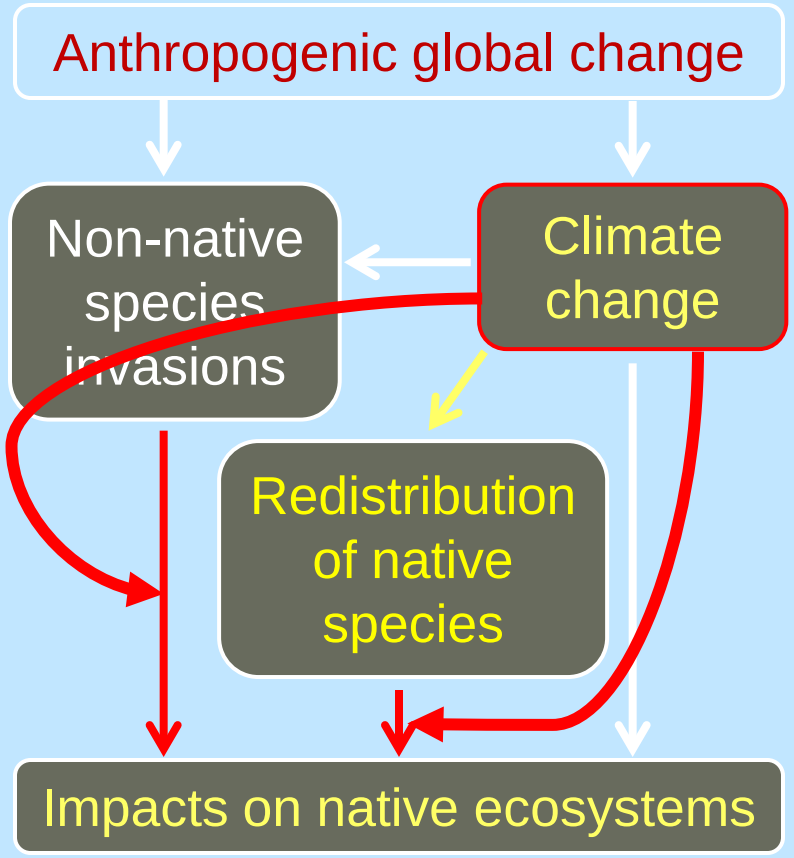
Comparing risk assessment from native vs. expanded/invaded ranges

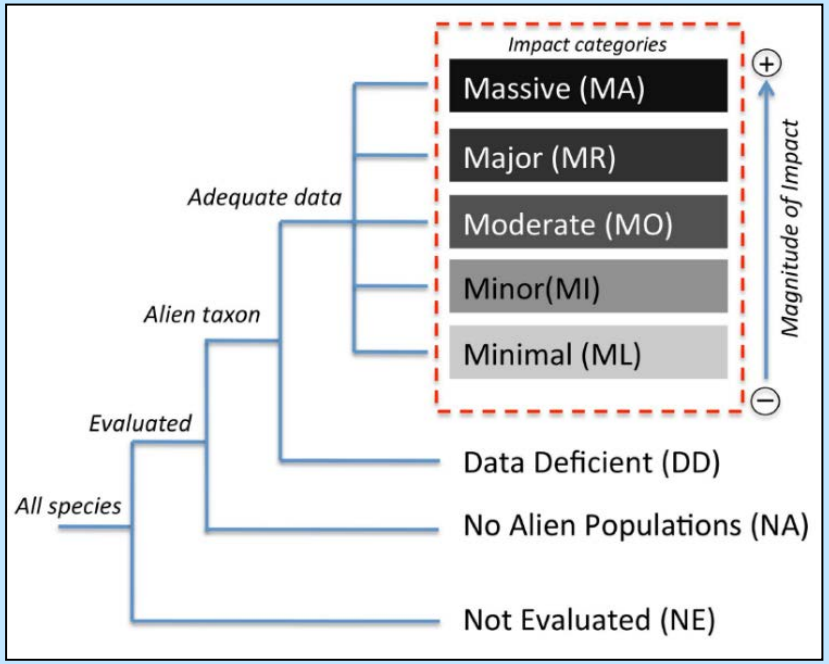


- Range shifters often data deficient in expanded range
- Invaders often studied in either the invaded or native range (few in both)
- For both, median impact **same** for expanded/invaded vs. native range
- Mean impact **slightly higher** for expanded/invaded vs. native range

Impacts risk assessment for range shifting species

Next steps: incorporate changing climate into impacts risk assessment





Blackburn et al. 2014 *PLOS Biol.*

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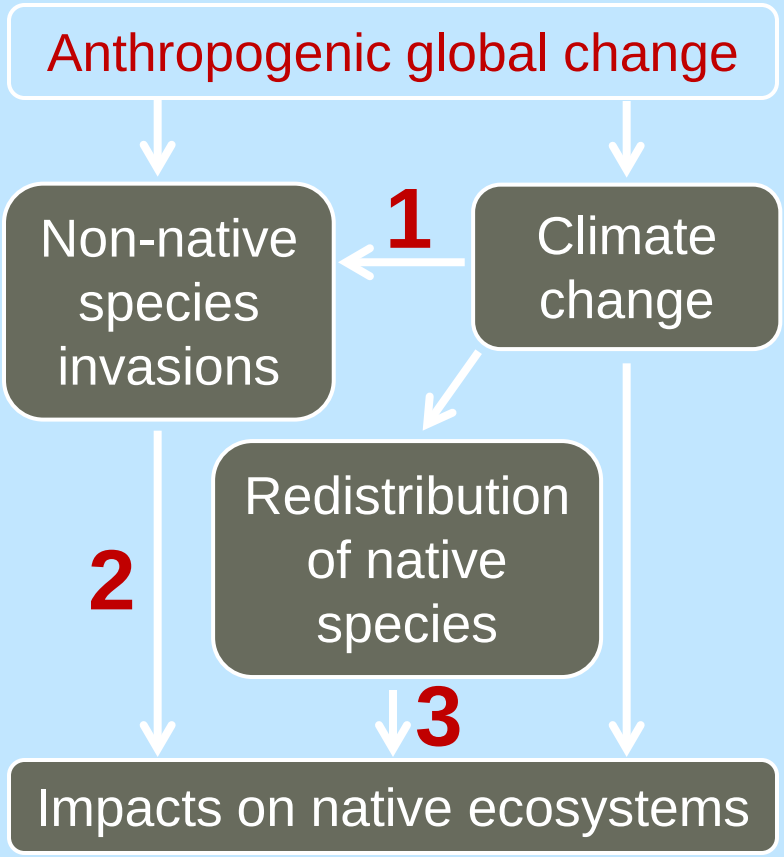

1. Invader abundance likely to increase:
   - Higher/broader thermal tolerance
   - Greater resistance to disturbance
   - Ability to capitalize on increased resources
2. Impacts on natives accrue rapidly at low invader population sizes for predators/competitors
3. Range shifting species less often impact natives but potential for maximum impacts as invasives
4. Future aim to incorporate climate change into risk assessment protocols

cascadesorte.org csorte@uci.edu @CascadeJBS