Center for Conservation Biology
University of California, Riverside

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# Leveraging monitoring data to evaluate impacts of *Brassica tournefortii* in a desert sand dune community

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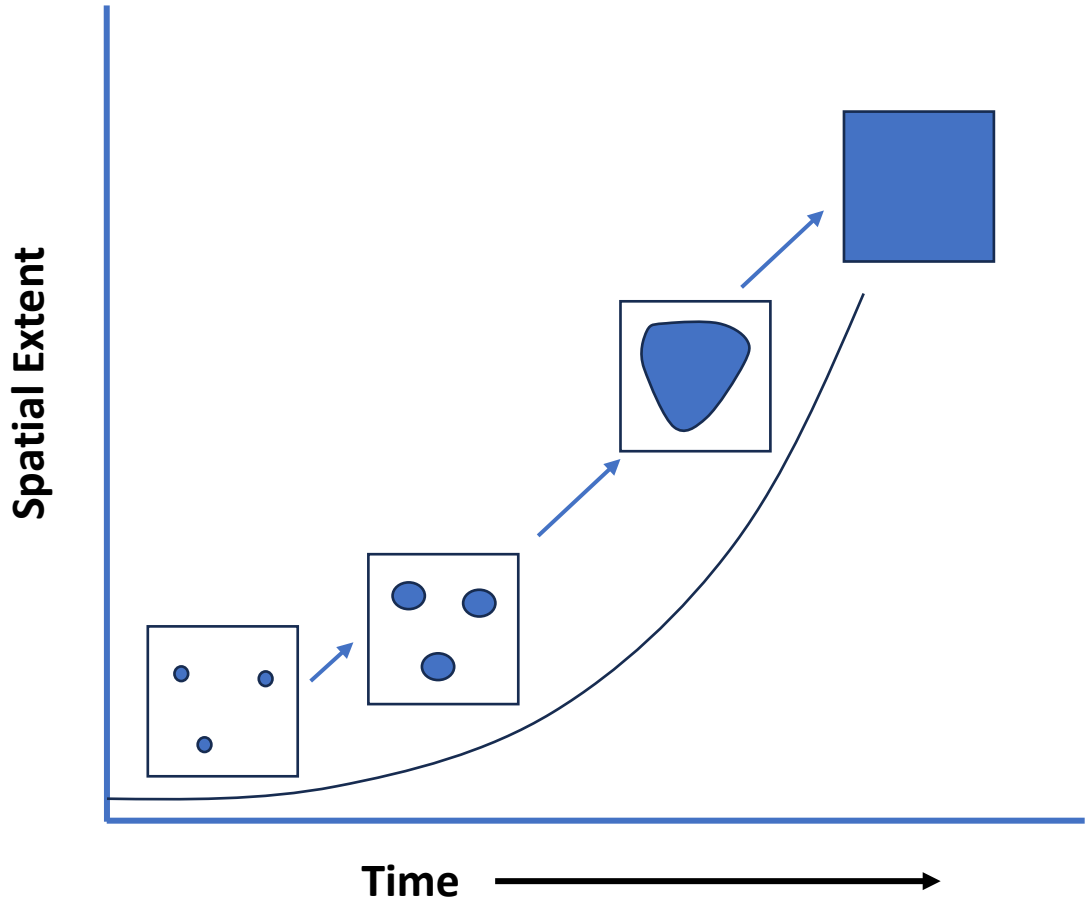
# How do we determine when a plant invader is problematic?




# Abundance as a gauge of invasiveness

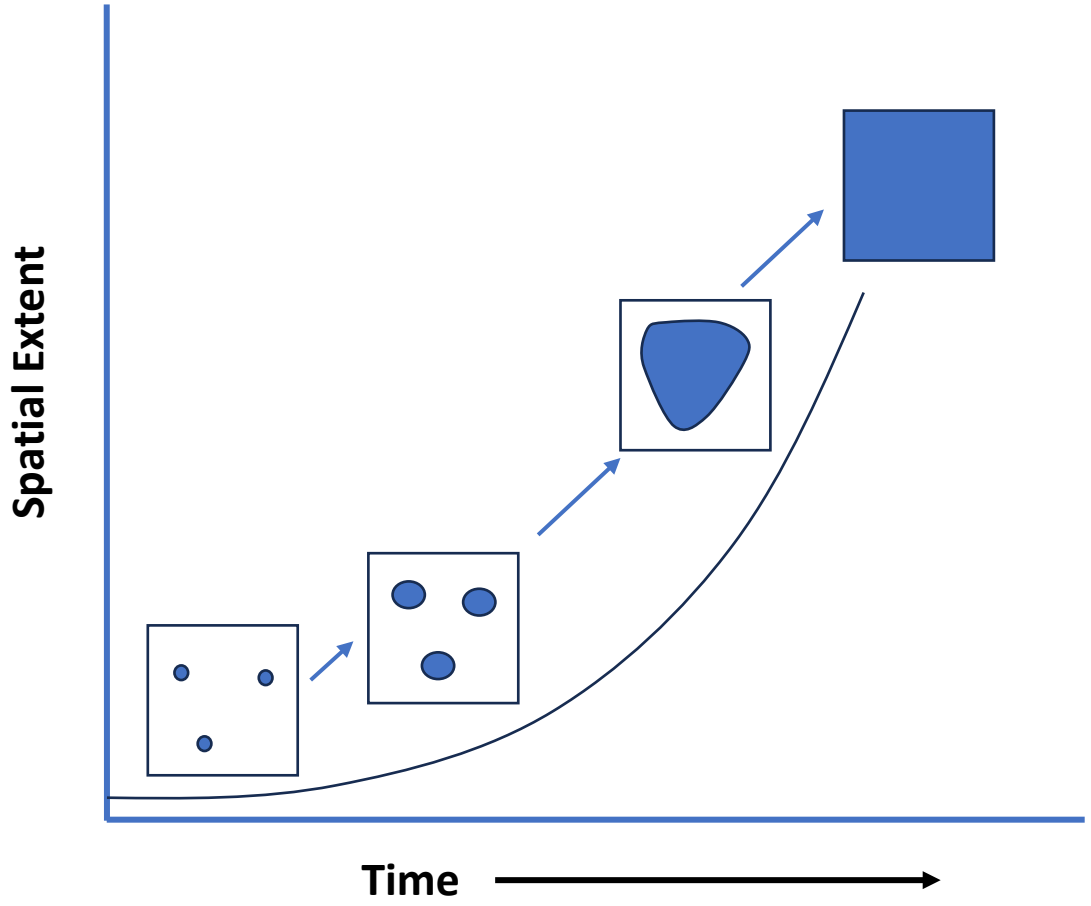



With time invader increases in abundance and in spatial extent

*Image: Billions of canary-yellow orbs drape southern Arizona's desert like a fungal carpet this spring Zach Duncan*

Adapted from Peters et al 2004 PNAS

# Abundance as a gauge of invasiveness

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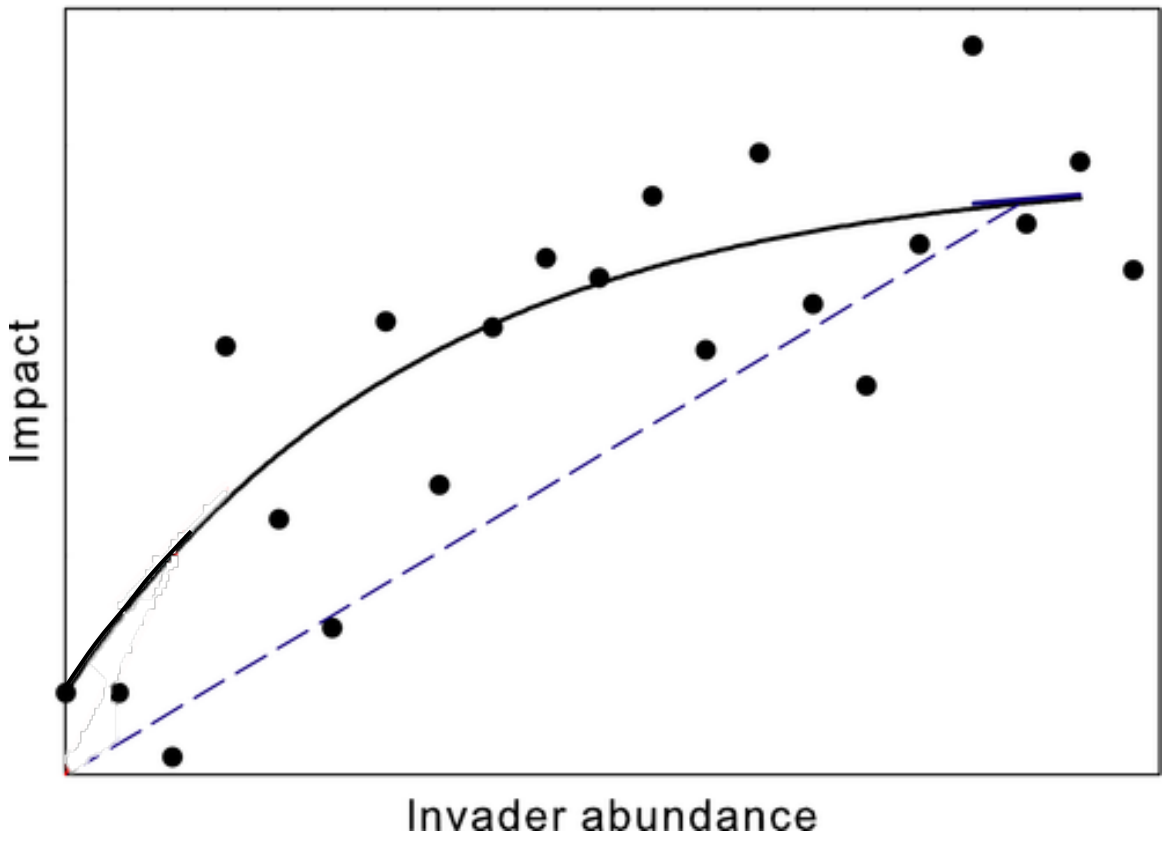
# Abundance-Impact relationships

- “impact” => Response of resident community

  (e.g., change in native diversity/ native richness/native cover)

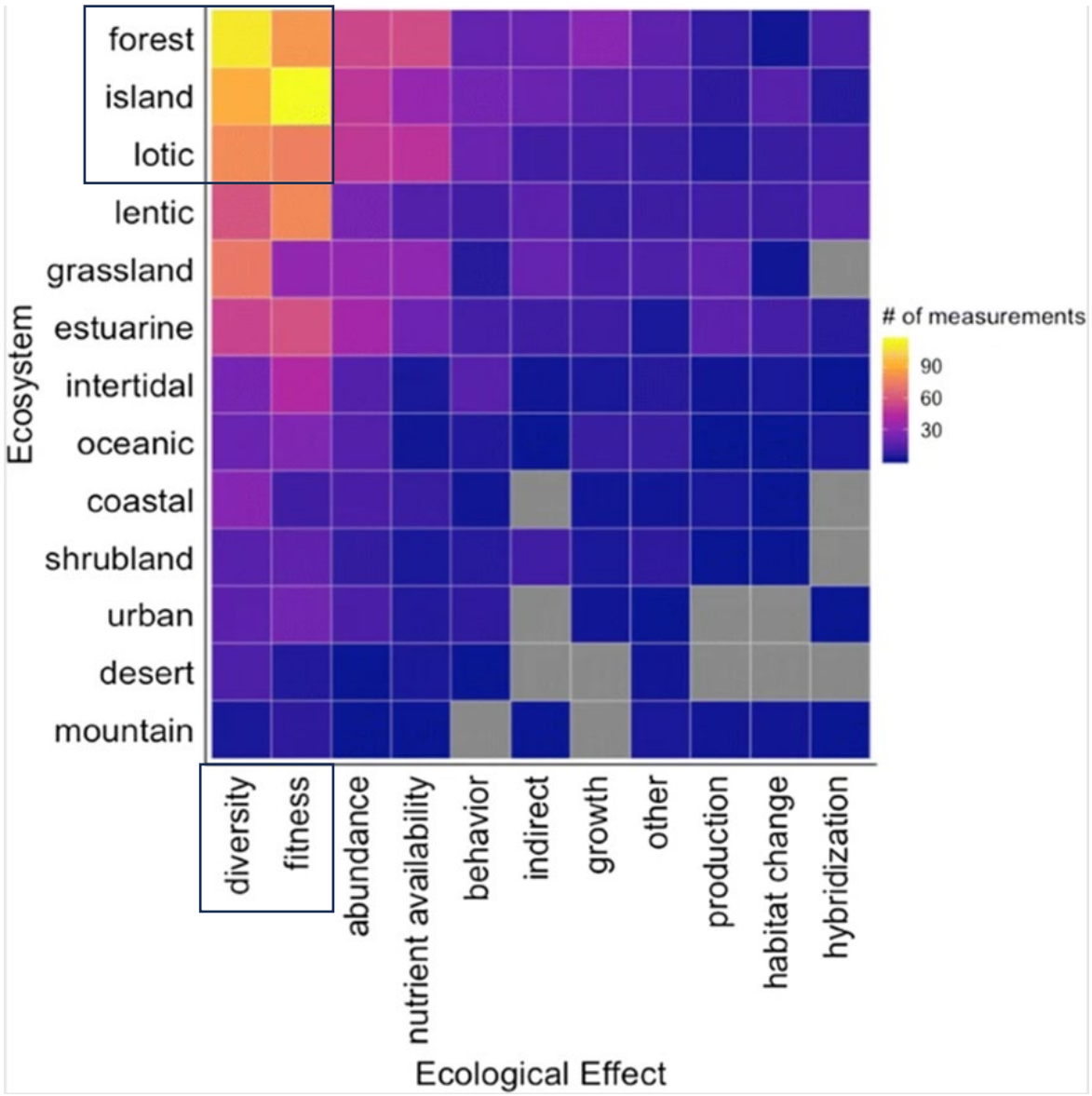
- Invader impact increases as the abundance of the invader increases




Modified from Strayer, 2020

# Impact studies are primarily

1) Within highly productive systems
2) Focus on diversity & fitness responses




Crystal-Ornelas & Lockwood, 2020

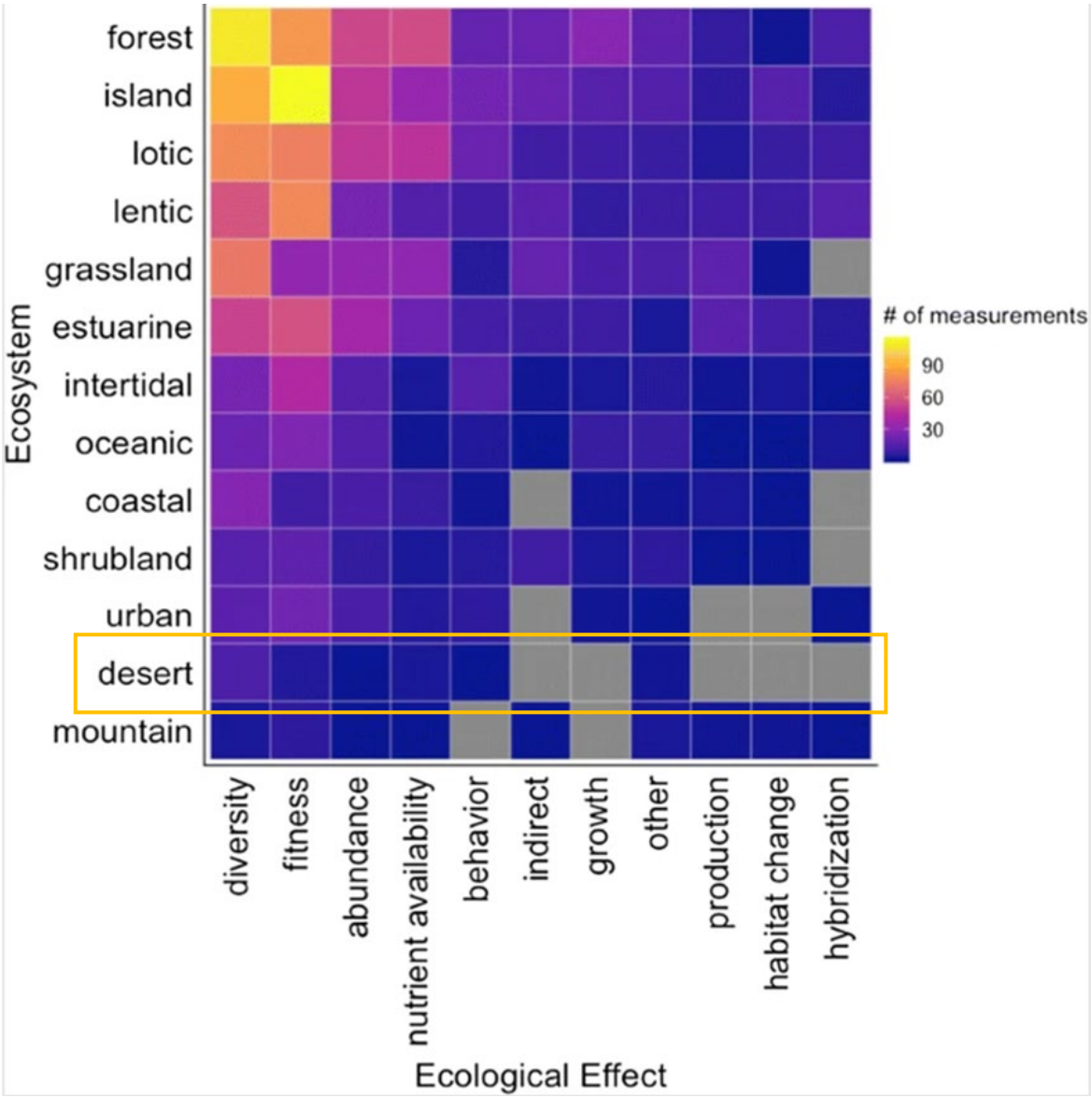
# Impact studies are primarily

1) Within highly productive systems
2) Focus on diversity & fitness responses

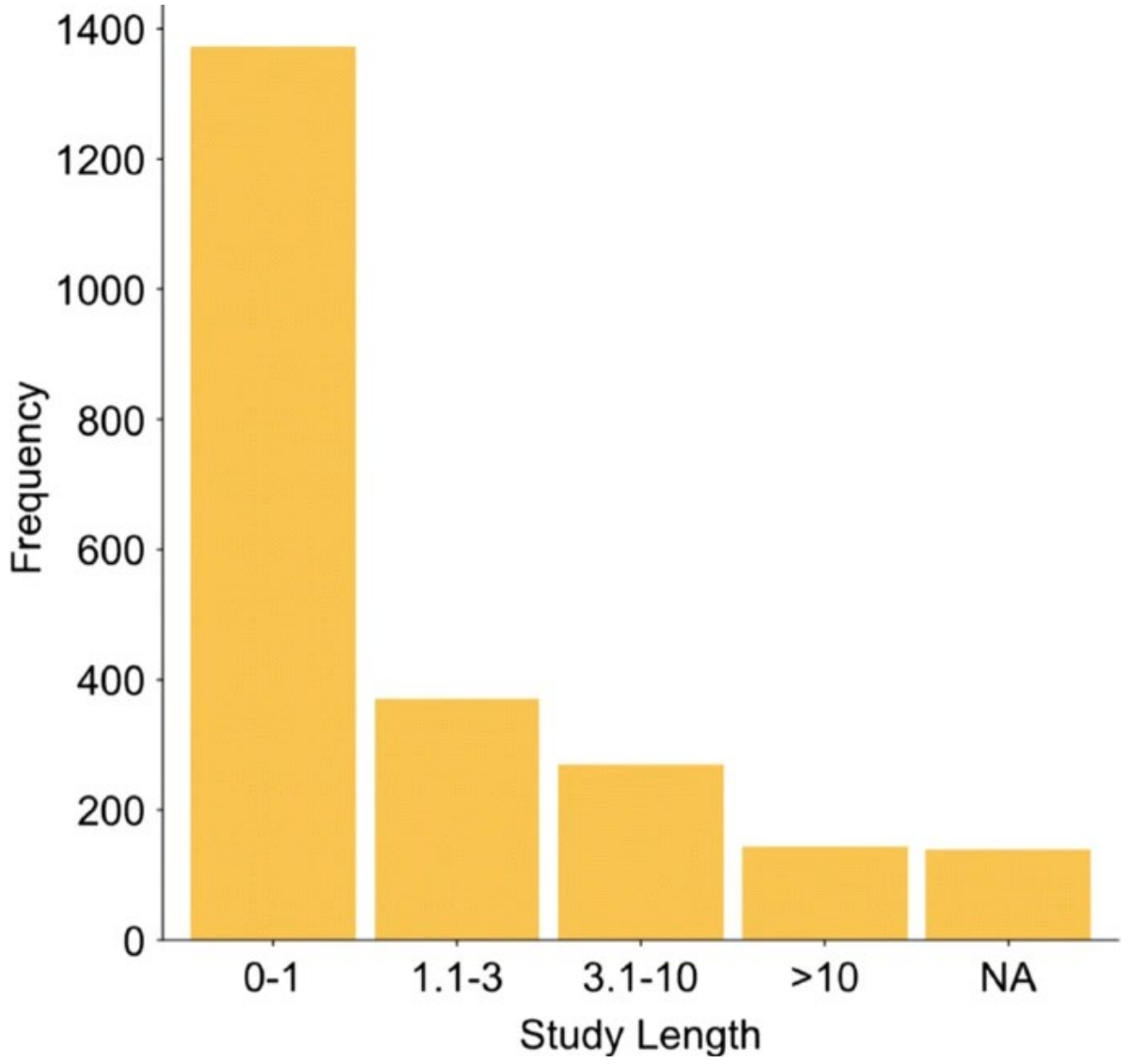
Deserts have historically been resistant to invasion

=

low number of impact studies in these systems



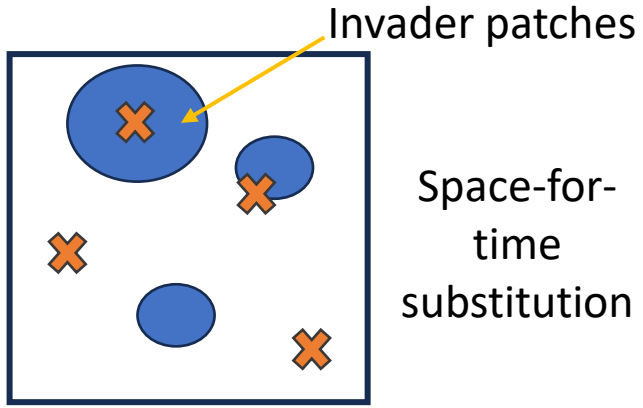

Crystal-Ornelas & Lockwood, 2020

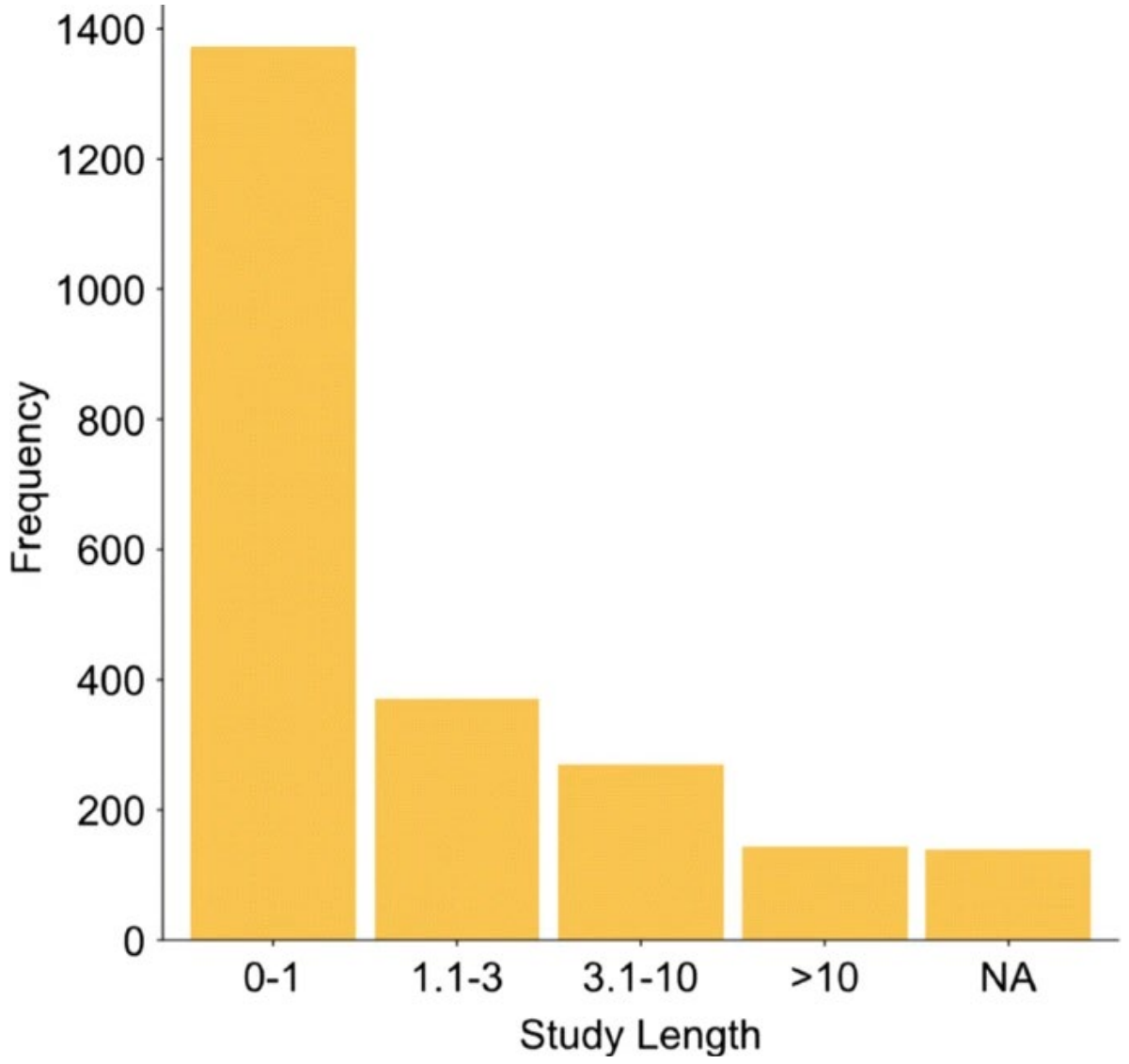



Crystal-Ornelas & Lockwood, 2020

# Most invader impact studies are conducted over SHORT-TIME scales

- 74% of invader impact studies are over short scales ranging from 0-3 years



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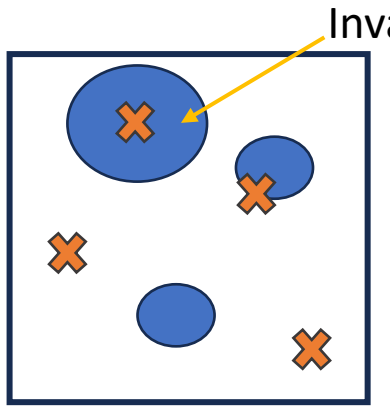


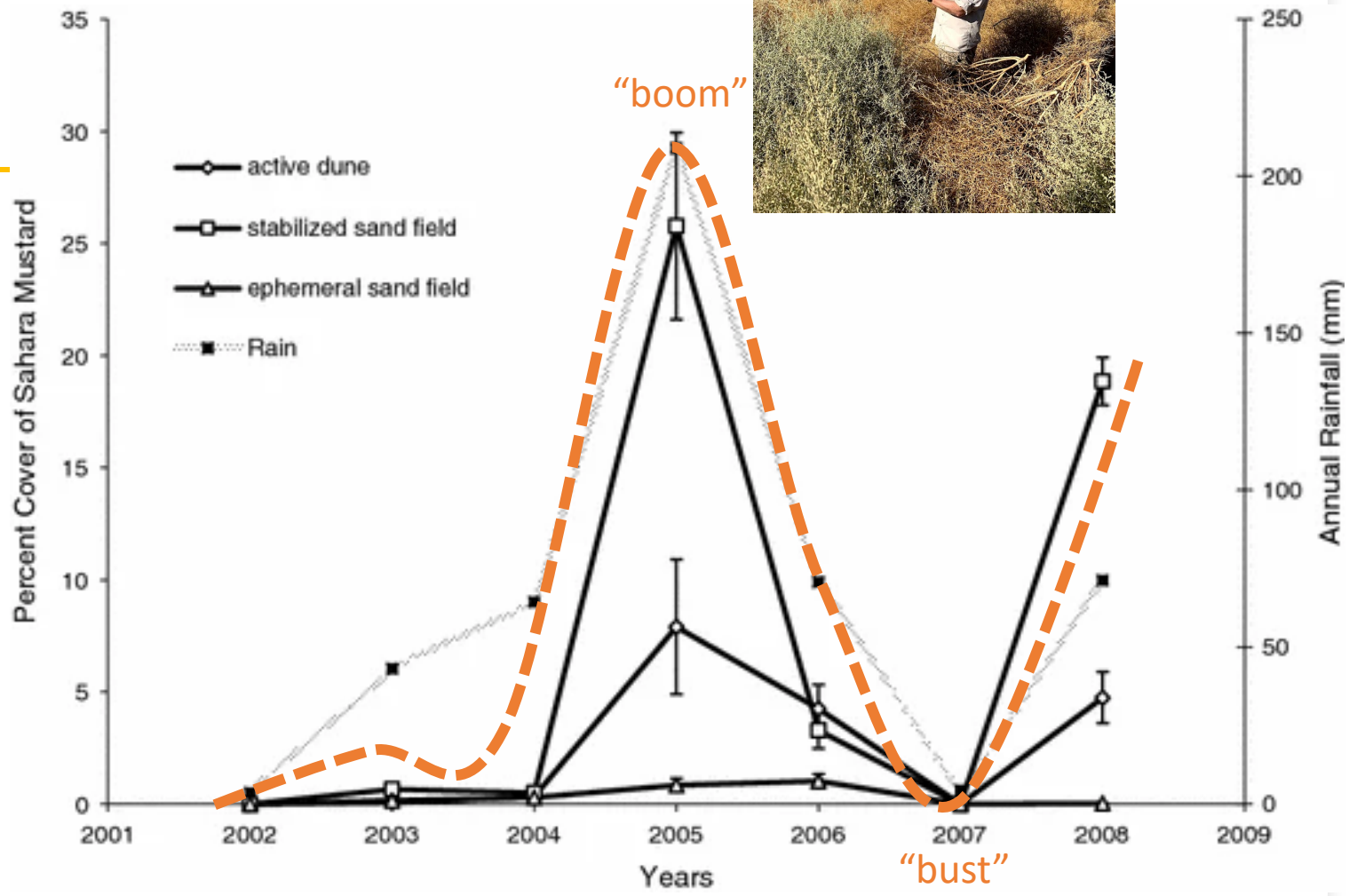

Space-for-time substitution

Deserts have variable rainfall => Challenging to determine LONG-TERM impacts of invader on resident community

# Assessment of invader impact may be skewed based on time frame

- Invader abundance changes over time often with rainfall

One Sahara Mustard single individual during a wet year




Sahara mustard abundance in sand dune community

Barrows et al. 2009

# Assessment of invader impact may be skewed based on time frame

- Invader abundance changes over time often with rainfall
- Resident diversity also changes over time

Plant communities in Sahara Mustard invaded sand dune community in different years

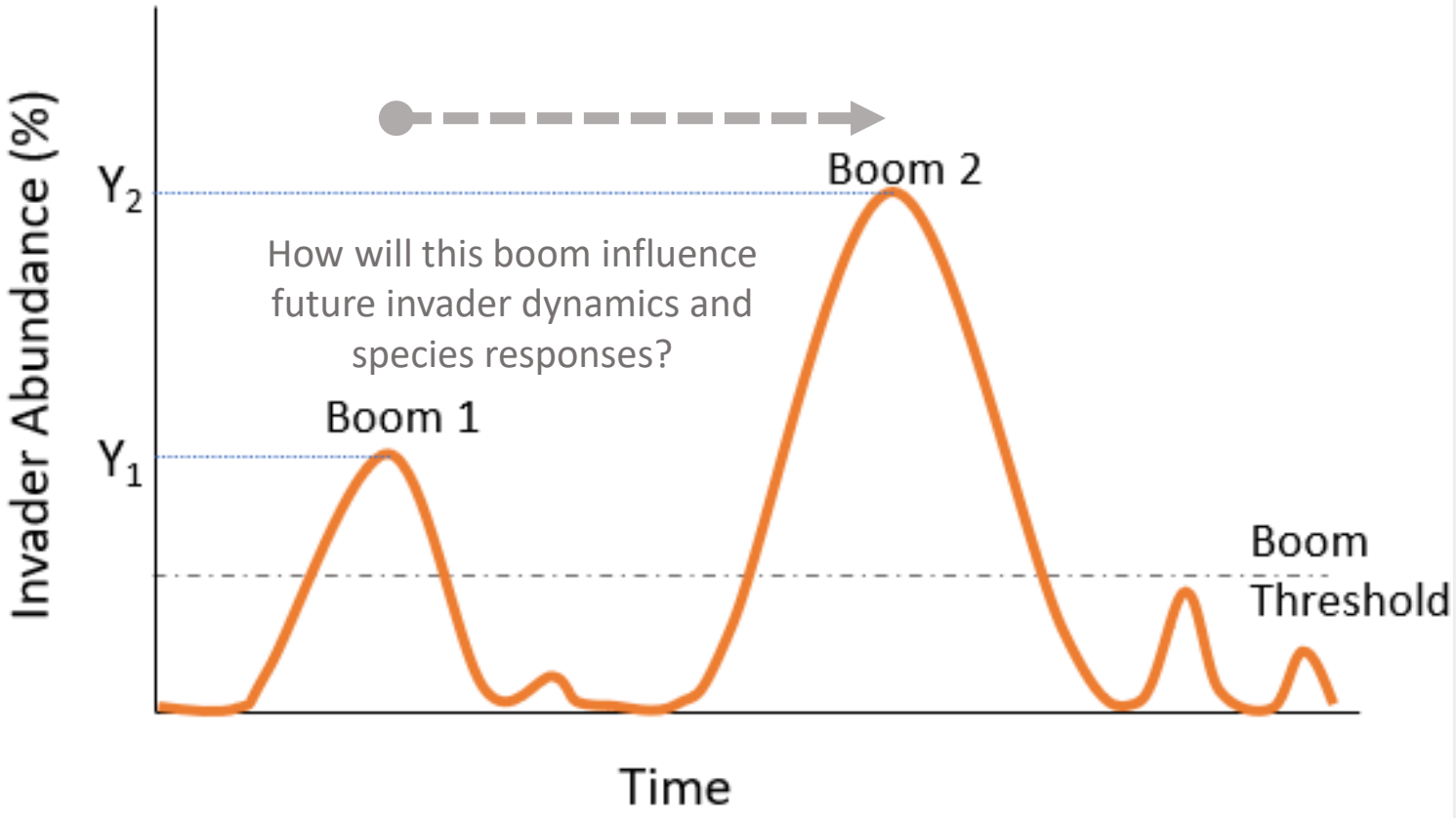
Photos: Cameron Barrows

# How to quantify impacts of invader with cyclical abundance dynamics?

# Quantifying impacts of cyclical dynamics can be challenging

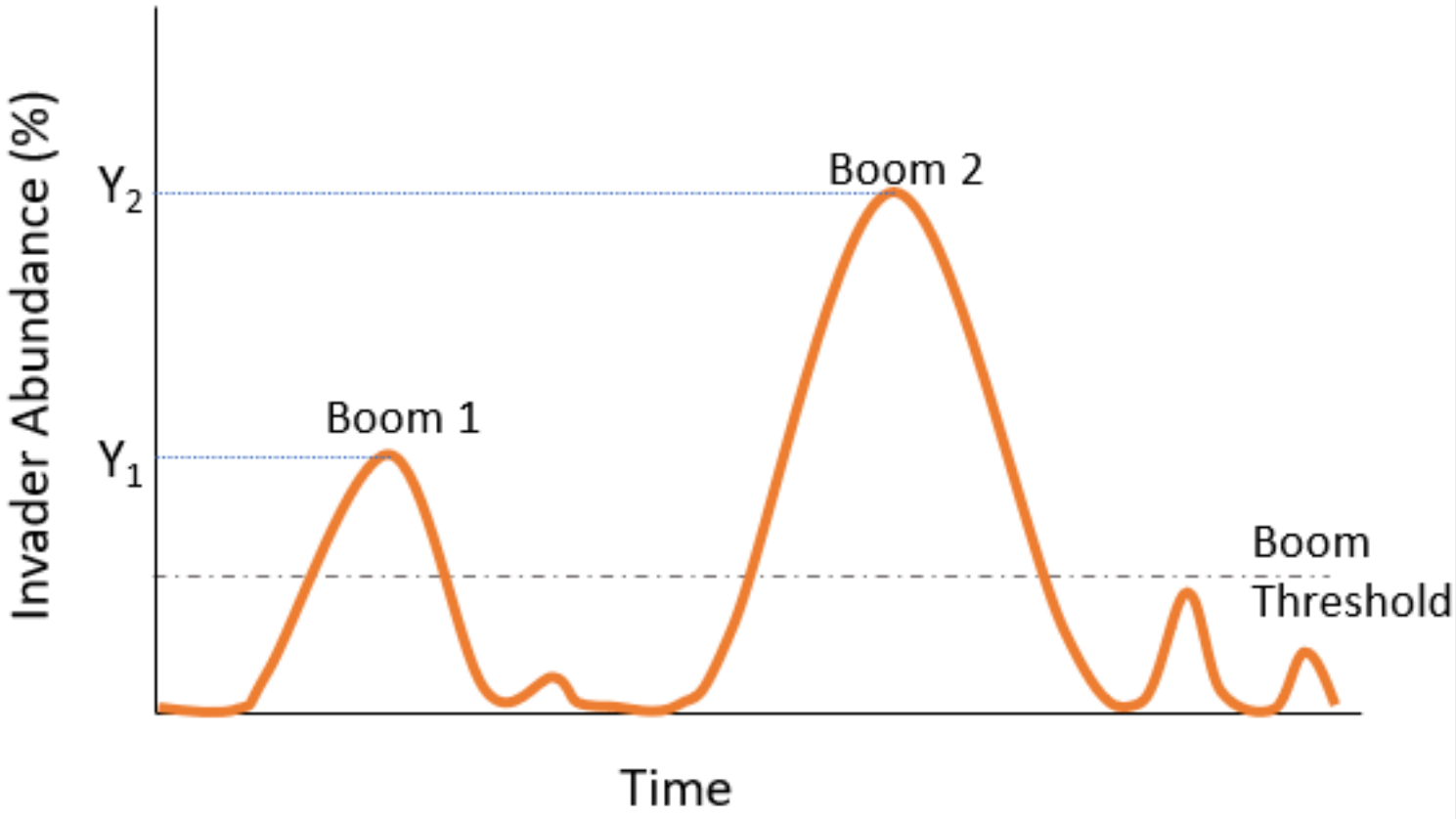
**Carryover Effects:**

- Events that occur during one growing season can influence performance in a future growing season



# Identifying attributes of an invader regime

- Identifying Boom threshold
- Magnitude of Boom – maximum invader abundance averaged over boom events
- Frequency of Boom events – the number of boom events



# *Brassica tournefortii*

**Sahara mustard**

Native to Northern Africa, Middle East, and Southern Europe

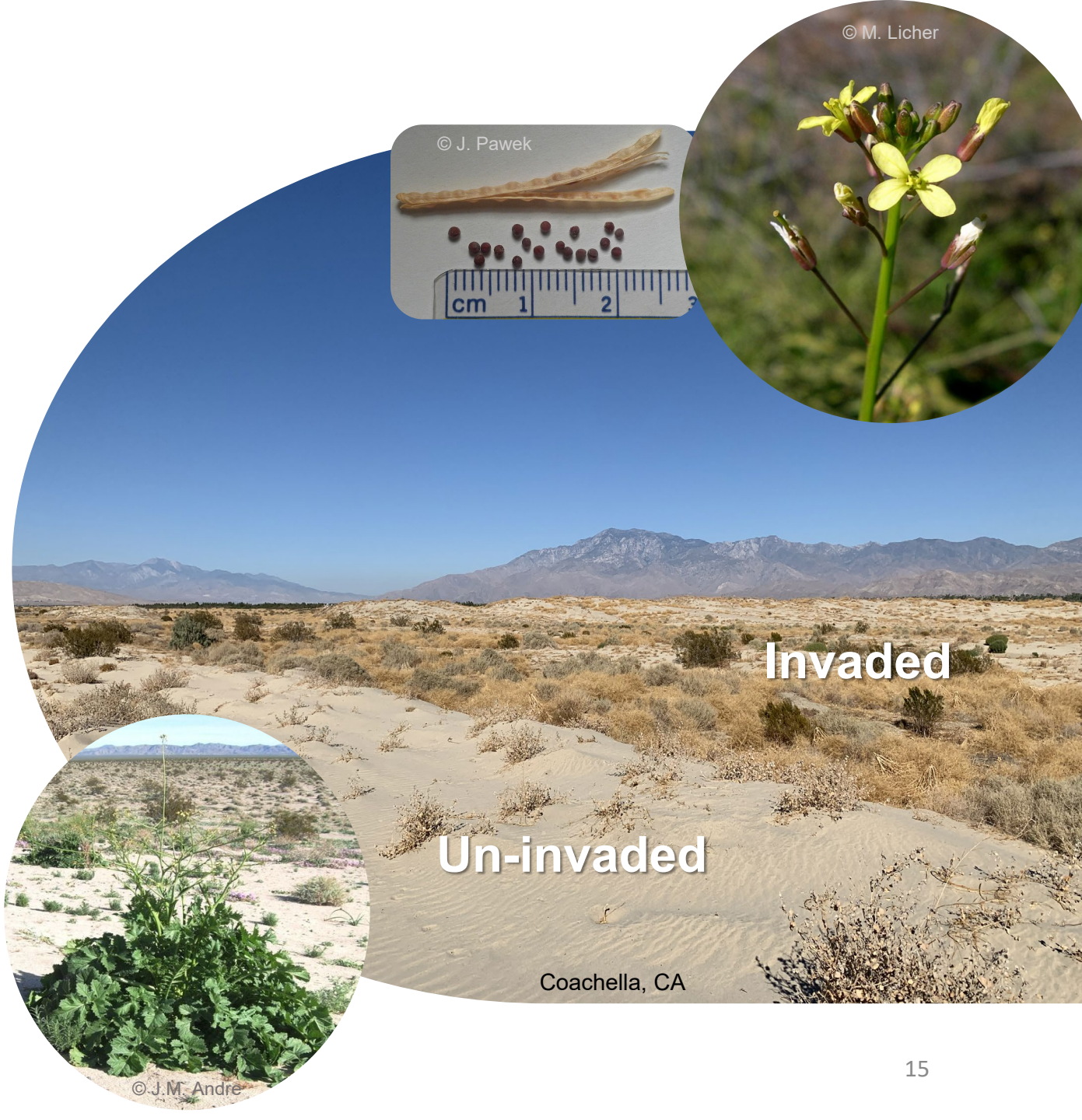
Introduced to North America via CA in 1920s

Invasive in Southwestern United States & Northern Mexico drylands

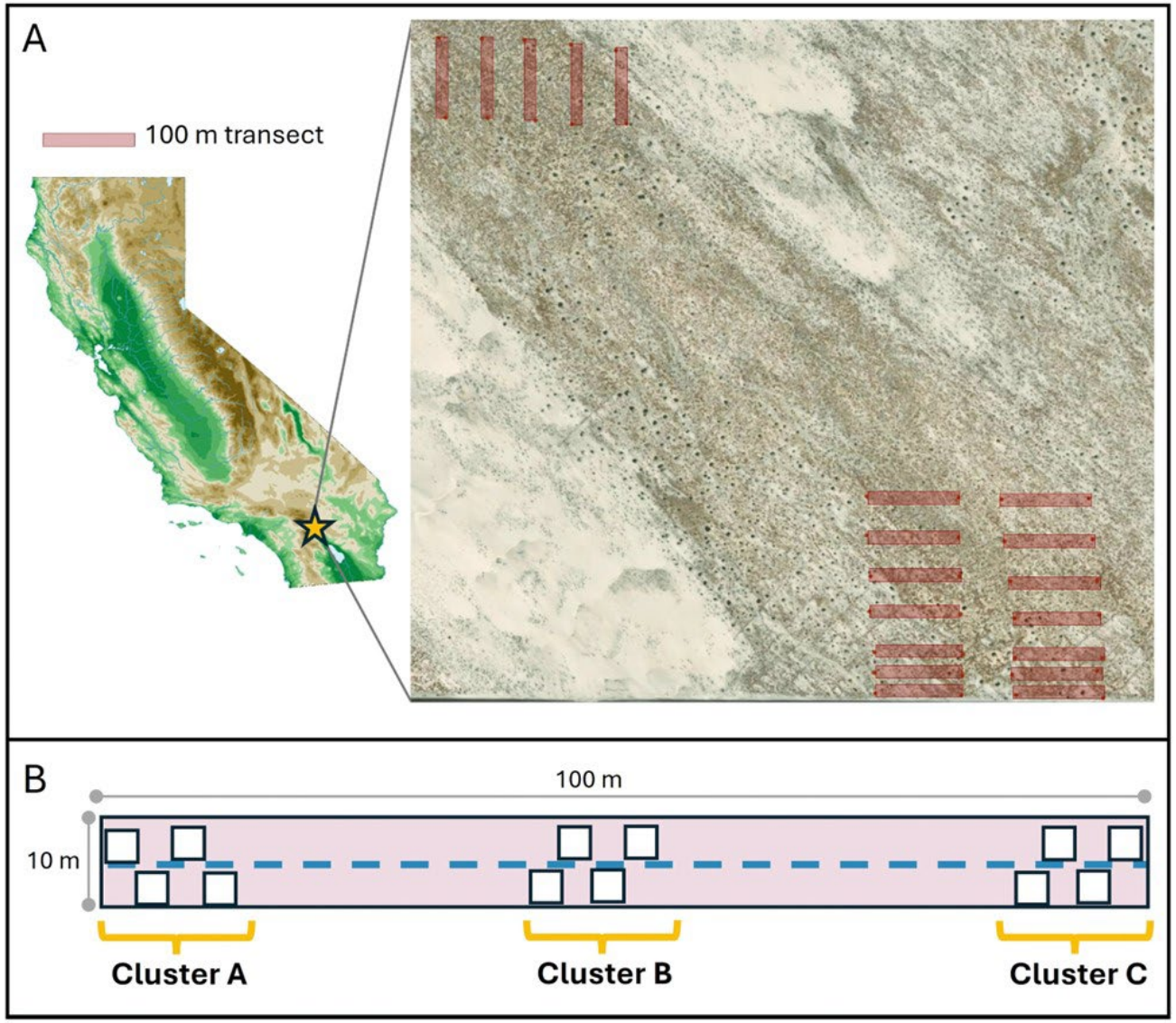
Highly plastic morphologically

Plant abundance varies over time

Individuals can produce ~15,000 seeds



# Leveraged Long-term Data Set

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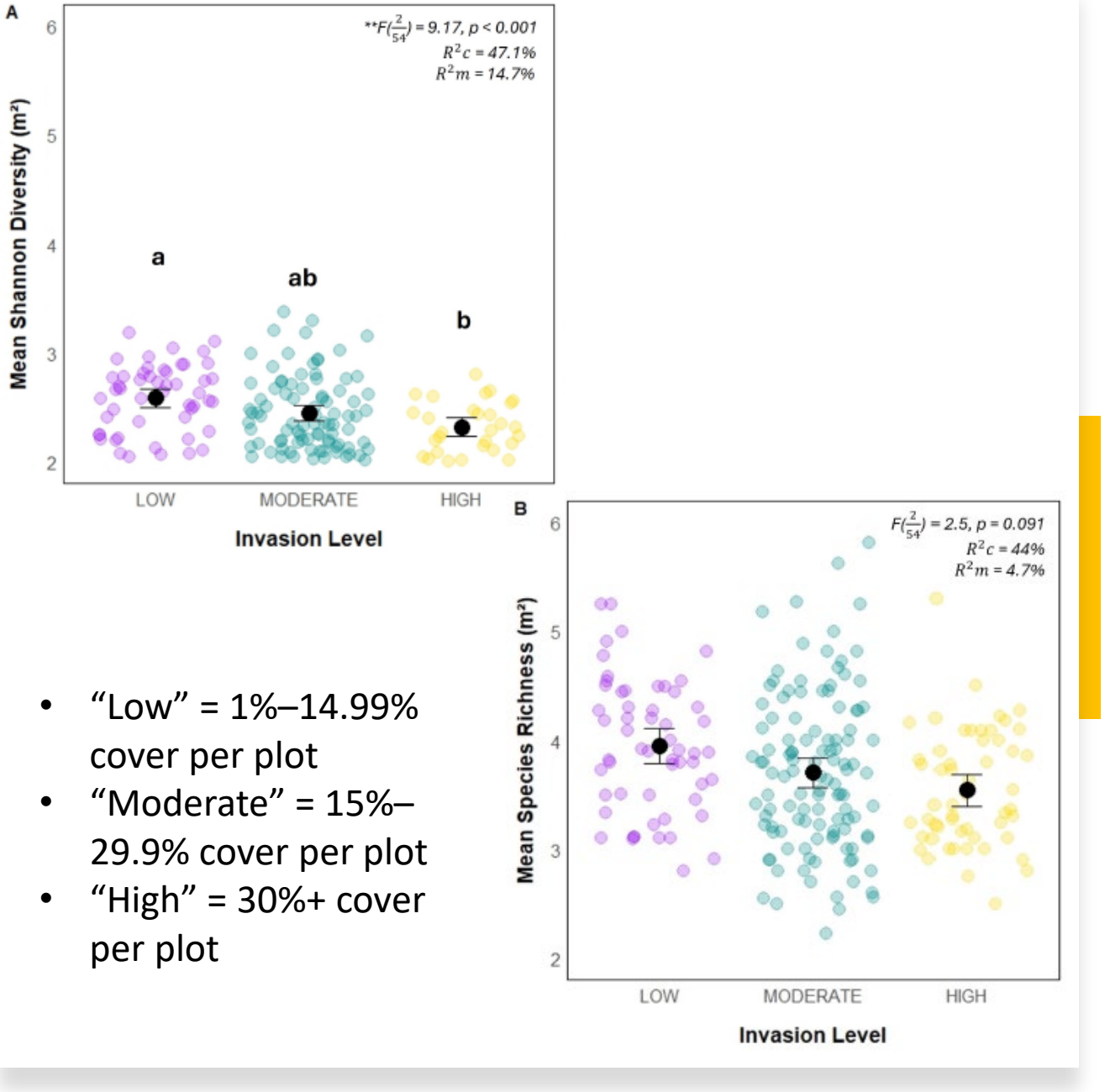
## Stabilized sand fields

Data set: 2003-2019
19 - 0.1 hectare transects
228 quadrats

Native & Non-native abundance

# High plant diversity in sandfield system is observed time




- "Low" = 1%–14.99% cover per plot
- "Moderate" = 15%–29.9% cover per plot
- "High" = 30%+ cover per plot

# How does invasion level impact community diversity and richness?

- Community Diversity decreased slightly along the invasion gradient
- Species richness did not vary between levels
- Differences are small between levels

Linear-mixed effect model

# Determining Sahara Mustard Boom

- Identified plots without Sahara mustard
- Identified the mode of the raw maximum percentage vegetative cover of the dominant annual native species (*A. villosa, C. claviformis, and O. deltoides*) in this system = 60% cover

Photo: David Greenberger CC-BY-NC 4.0

Photo: Steve Matson

Photo: Stan Shebs

# Determining Sahara Mustard Boom

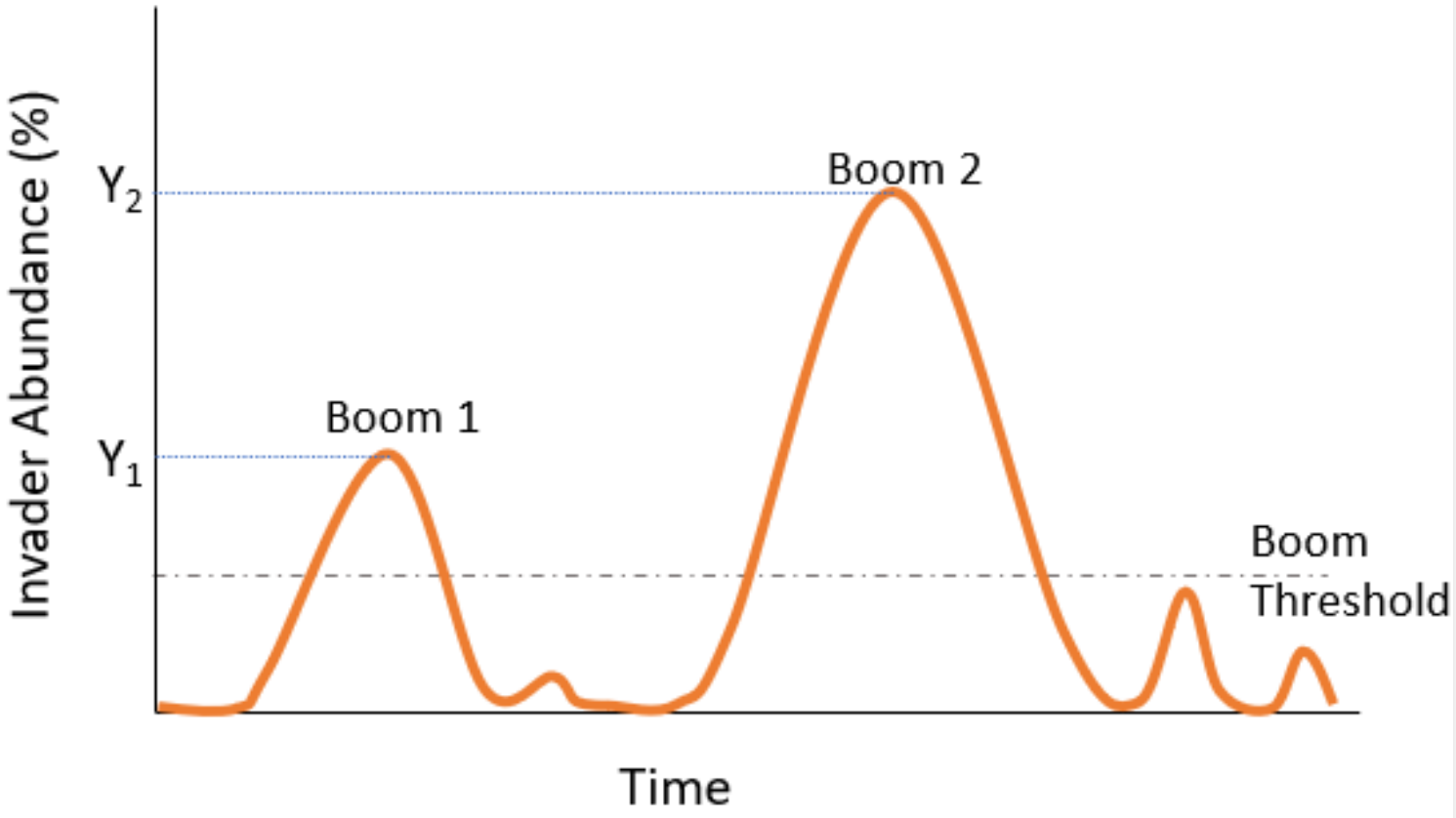
- Assessed the cover of Sahara mustard
- Ranged from 0 to 99%!
- Average of 15% over 16 years
- Estimated boom threshold at 30% (1/2 of native maximum cover & 2x long-term average)

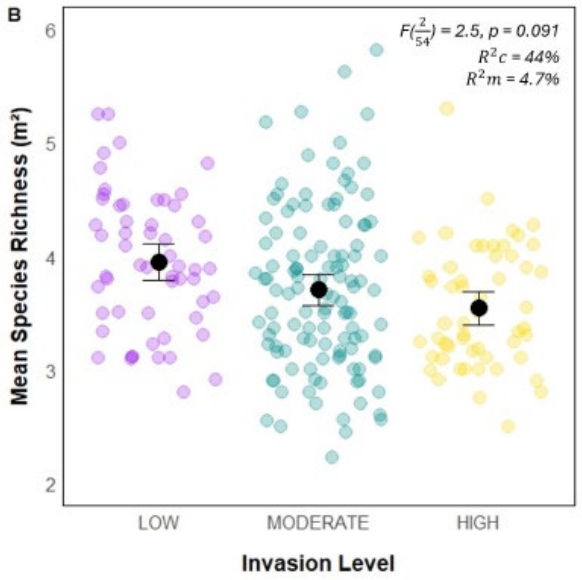
Photo: Lynn Sweet

Photo: Cameron Barrows

# Quantifying Sahara Mustard invader regime attributes

- Magnitude of Boom – maximum invader abundance averaged over boom events (average of Ys)
- Frequency of Boom events – the number of boom events



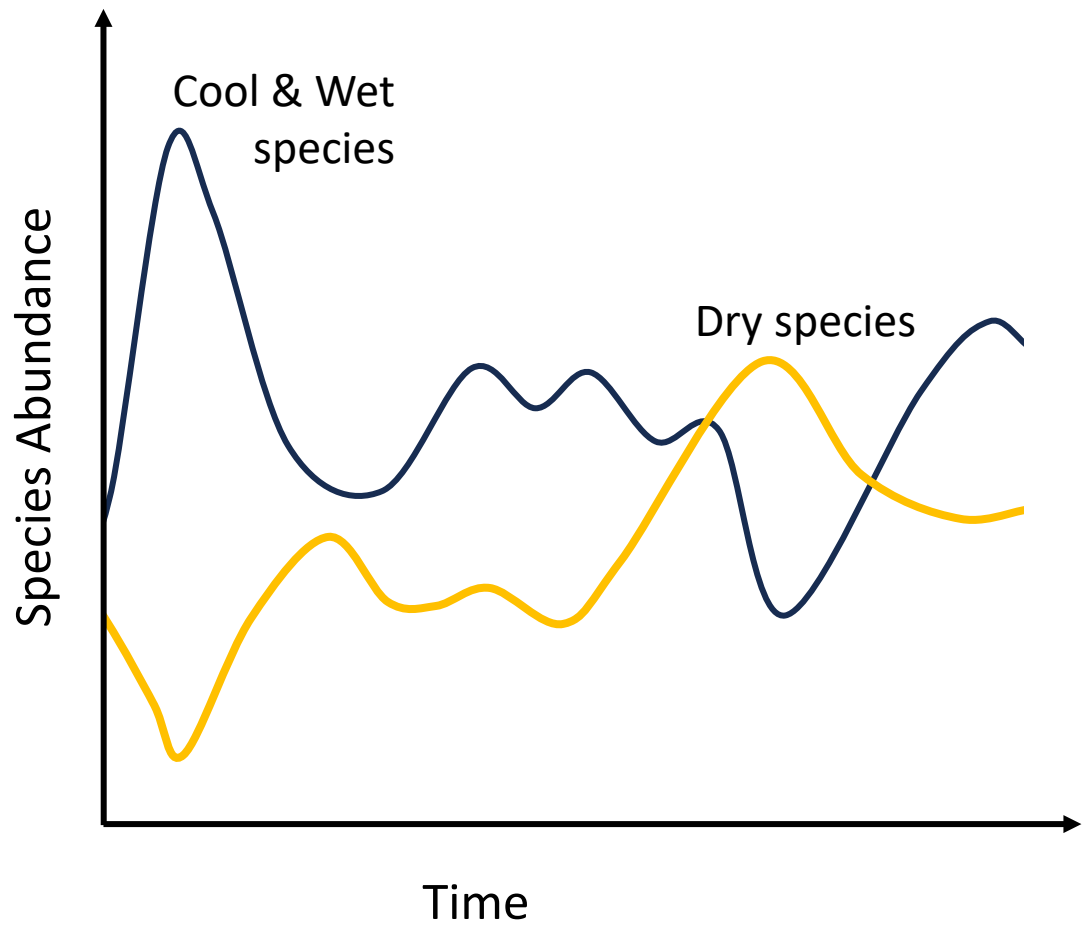




# What's an alternate metric for a dynamic system?

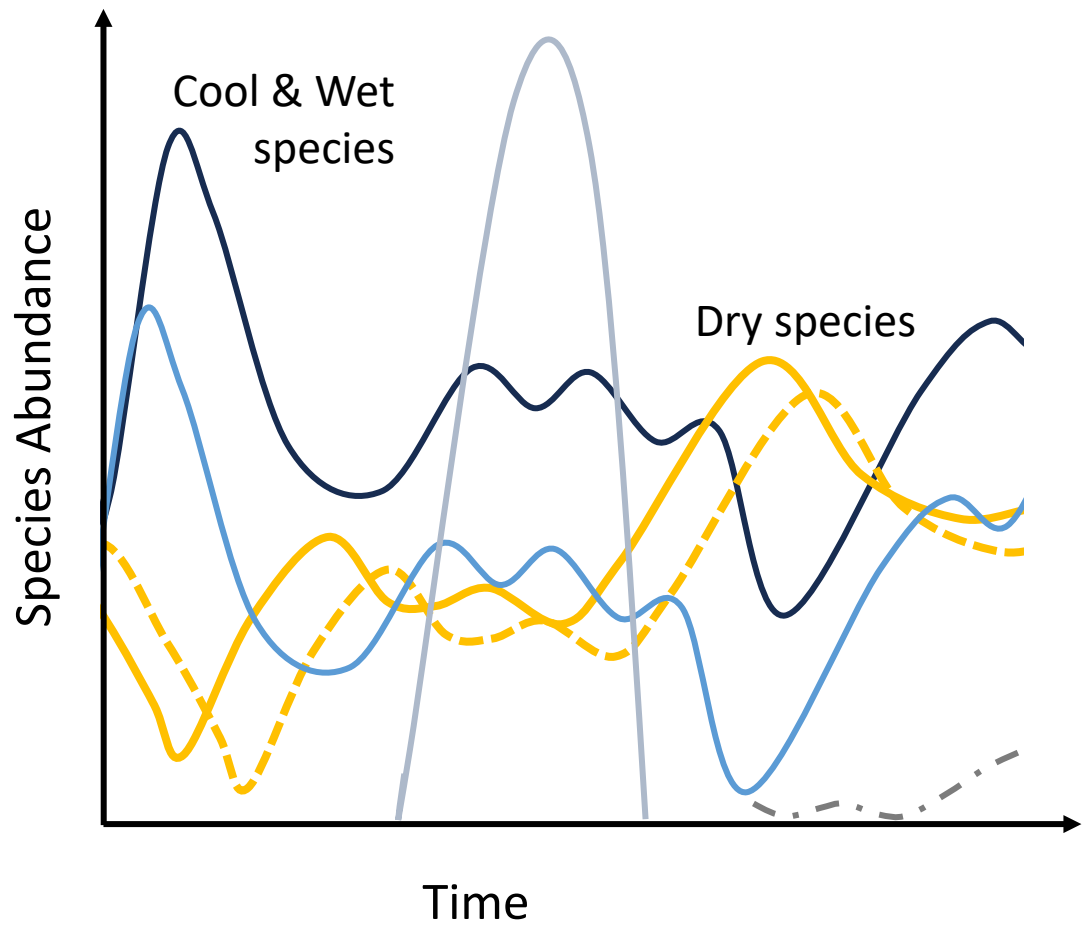
# Species trade off over time

- Species vary in their environmental tolerances:
  - Germination cues
  - Minimum temperatures
  - Maximum temperatures



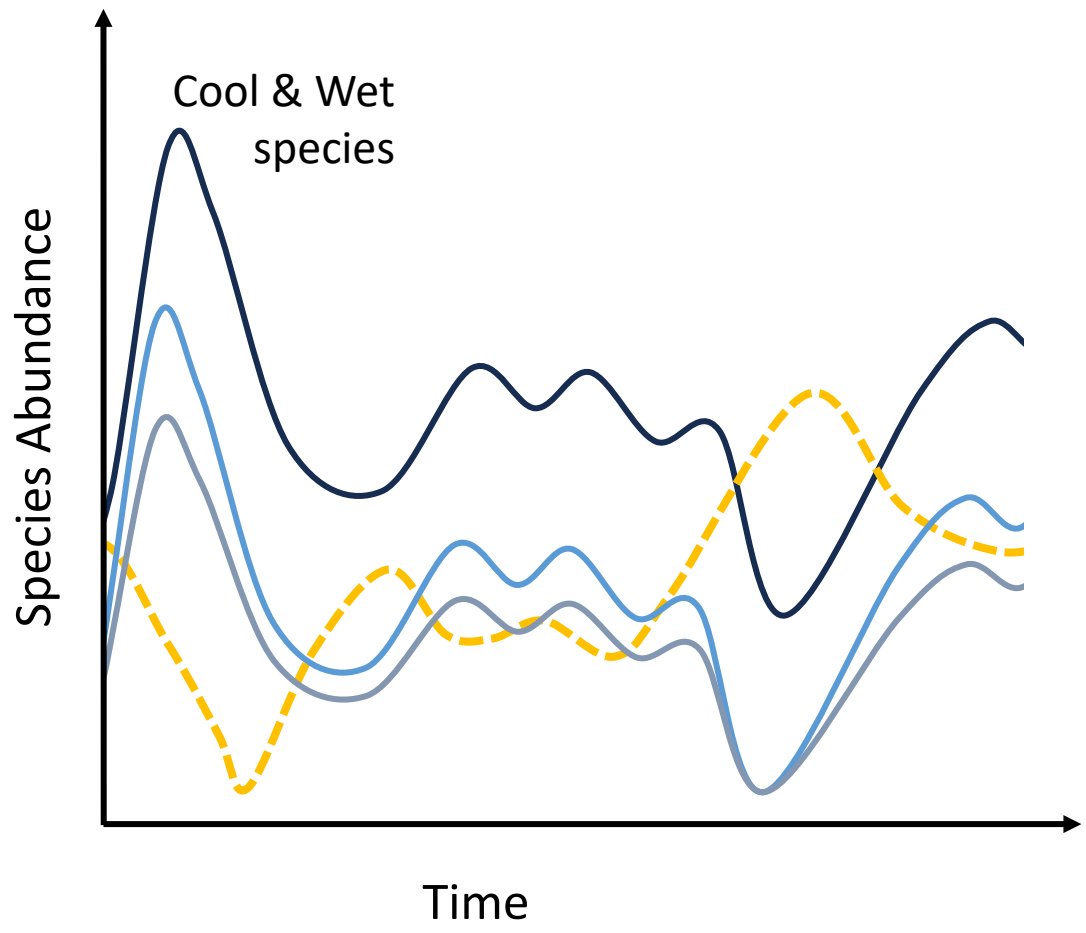
# Species trade off over time

- Species vary in their environmental tolerances:
  - Germination cues
  - Minimum temperatures
  - Maximum temperatures
- Results in **asynchrony** in species abundances

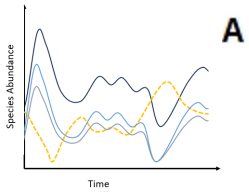


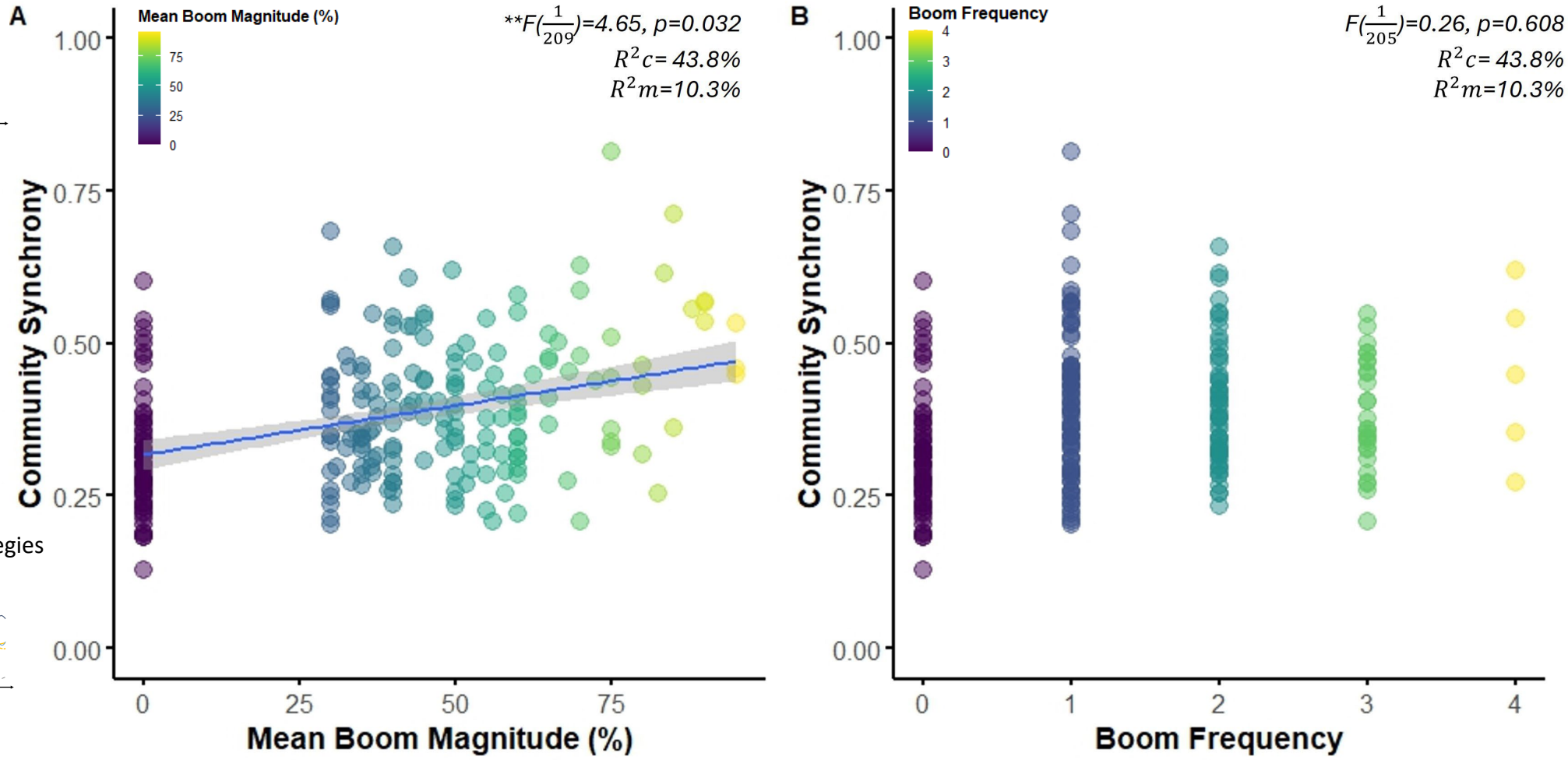
# Invasions may change this asynchrony

- If only species with a similar strategy to the invader are present => higher synchrony
- May not result in changes in average annual richness or diversity observed in a plot

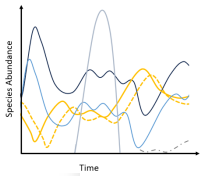


Similar strategies

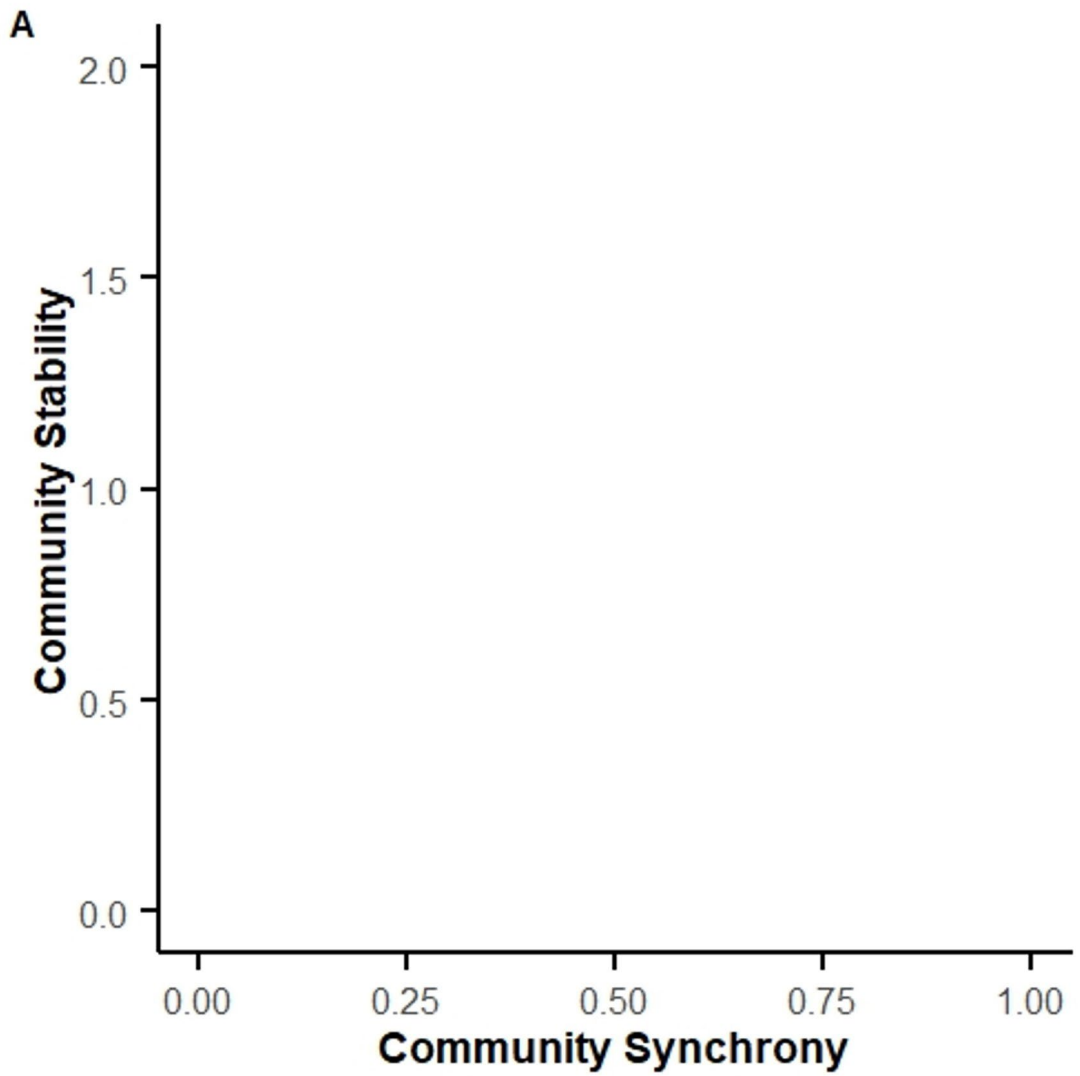



Different strategies



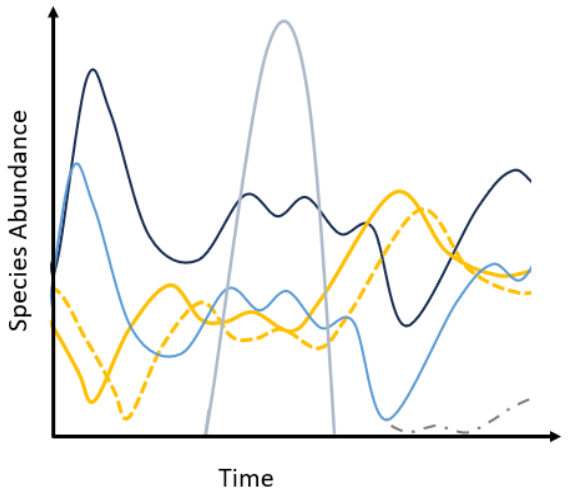

# Mean Boom Magnitude was a better indicator of effects on synchrony




# Community Synchrony influences overall community stability

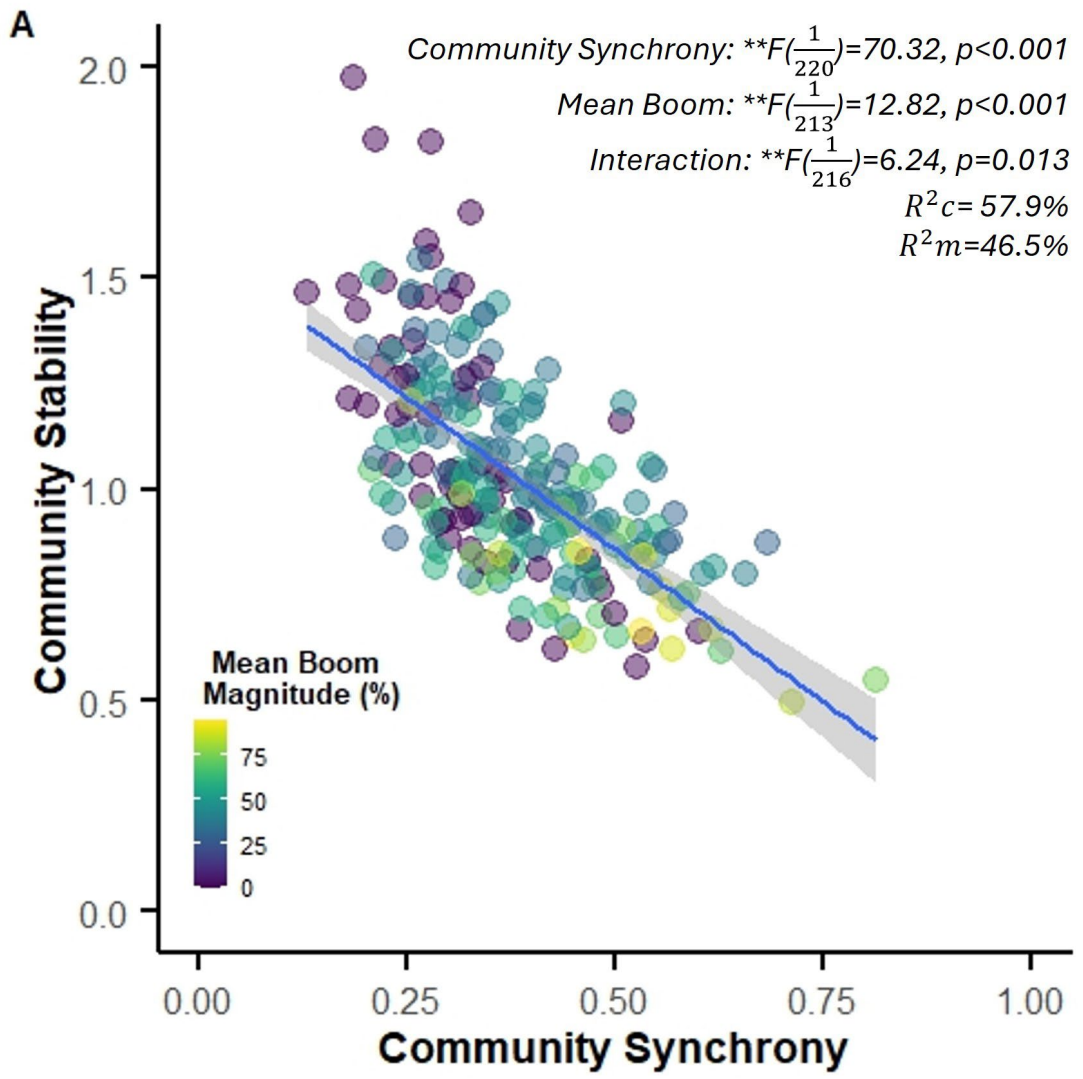
- Community temporal stability = smaller fluctuations in abundance over time

More asynchrony
More ecological strategies




More temporal stability

Linear-mixed effect model

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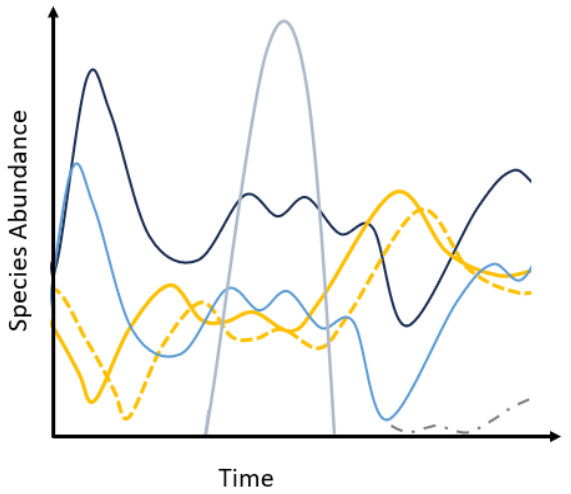


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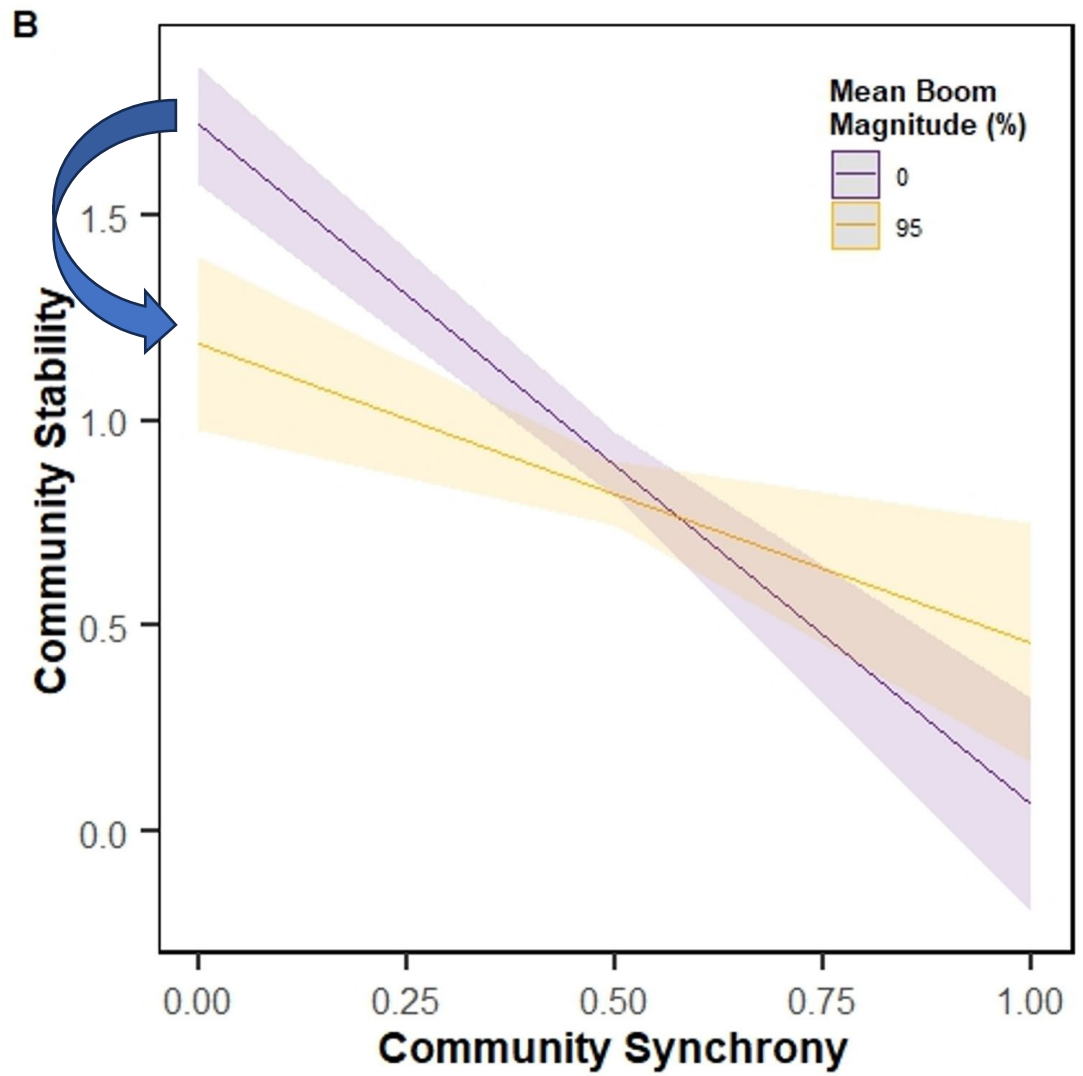
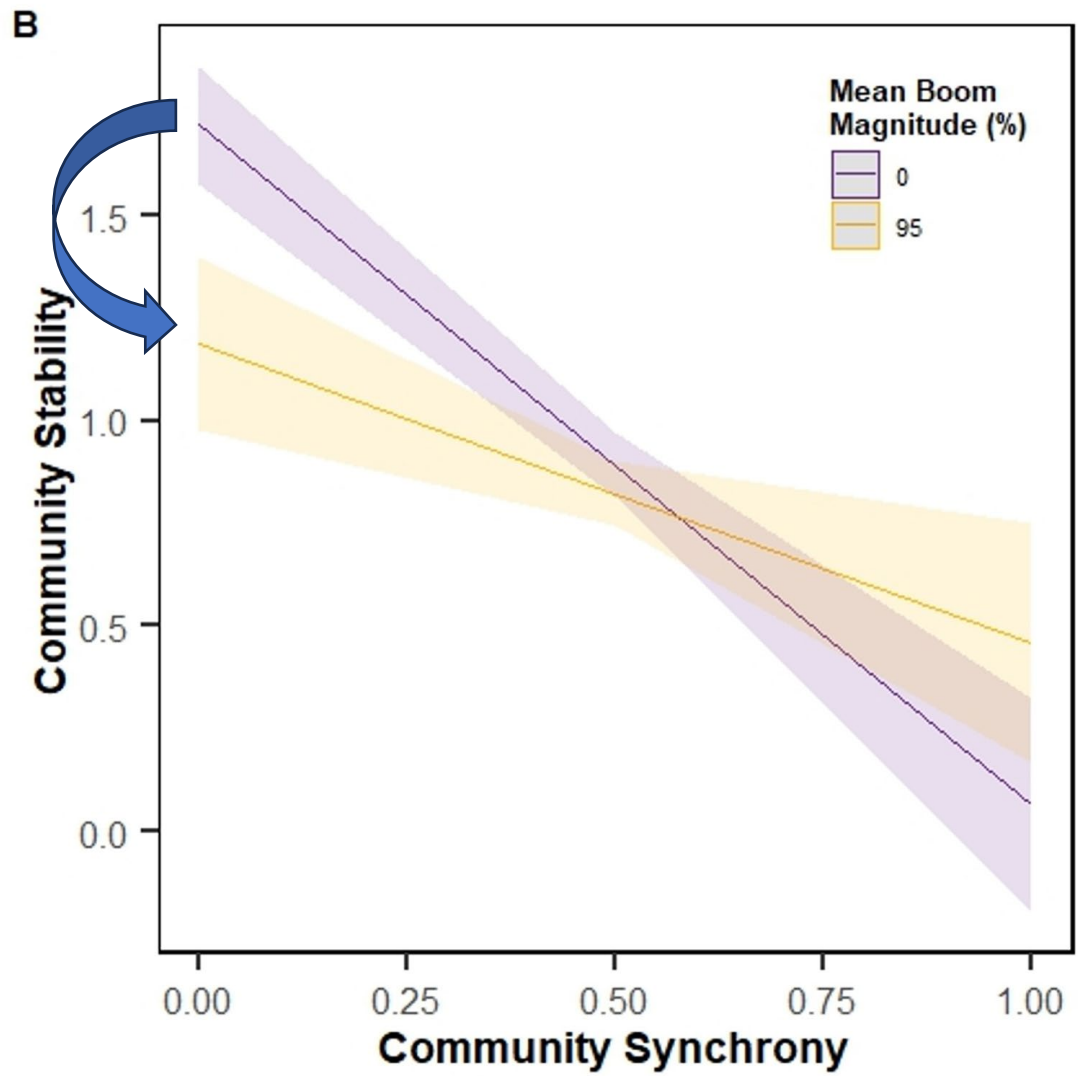



# Invasion effects on community synchrony & community stability

- Sahara mustard invasion lowers overall stability

Linear-mixed effect model



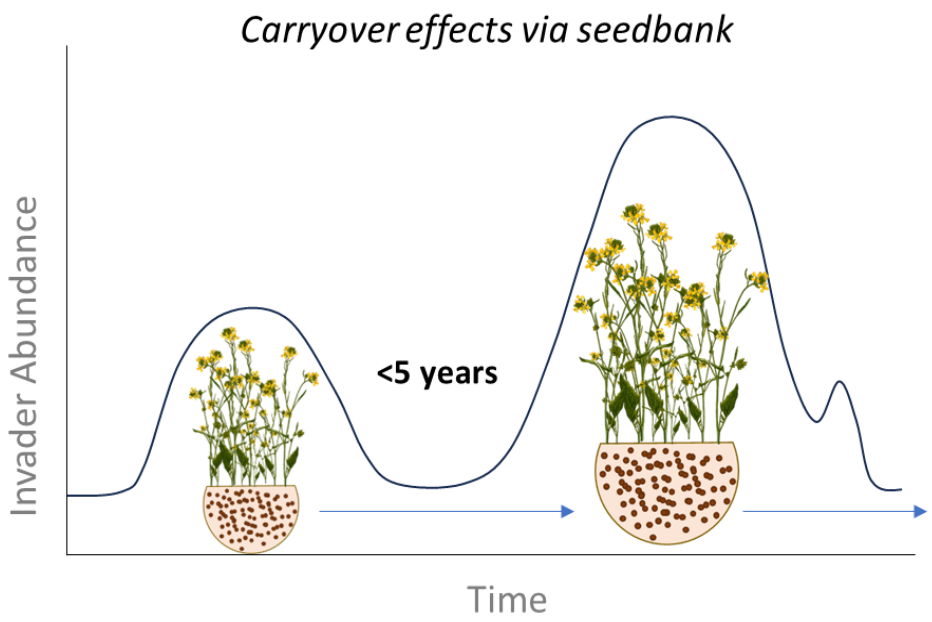

# Invasion effects on community synchrony & community stability

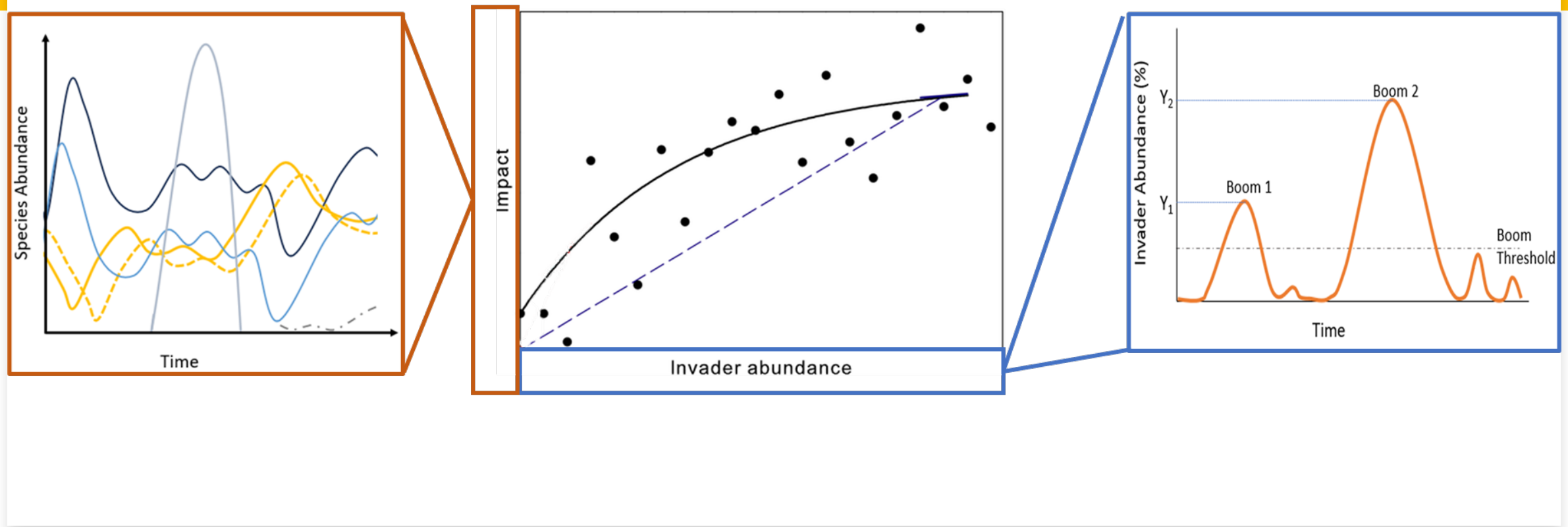
- Sahara mustard invasion lowers overall stability
- Reduces the relationship between synchrony and stability

Linear-mixed effect model

# Likely contributors to Sahara Mustard persistence over time

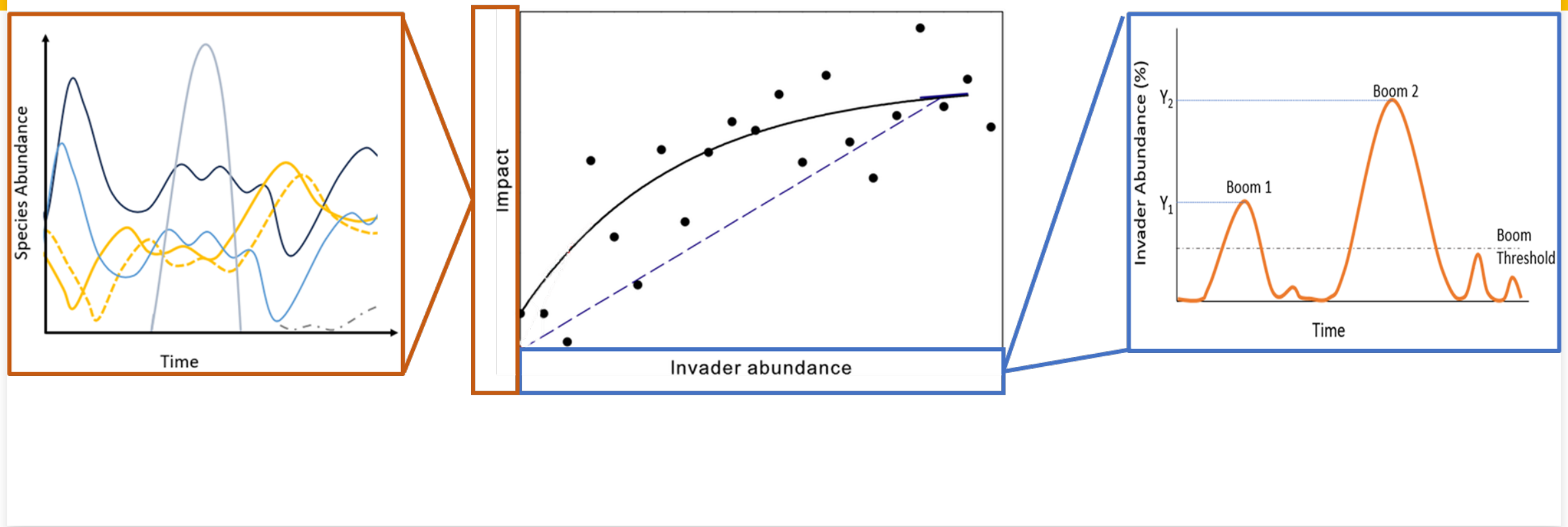
- Intermittent supply of propagules & seedbank longevity <5 years
- Larger magnitude booms
  - ➡ carryover effects via seedbank
- Invader may be “rescued” by dispersal from nearby neighbors





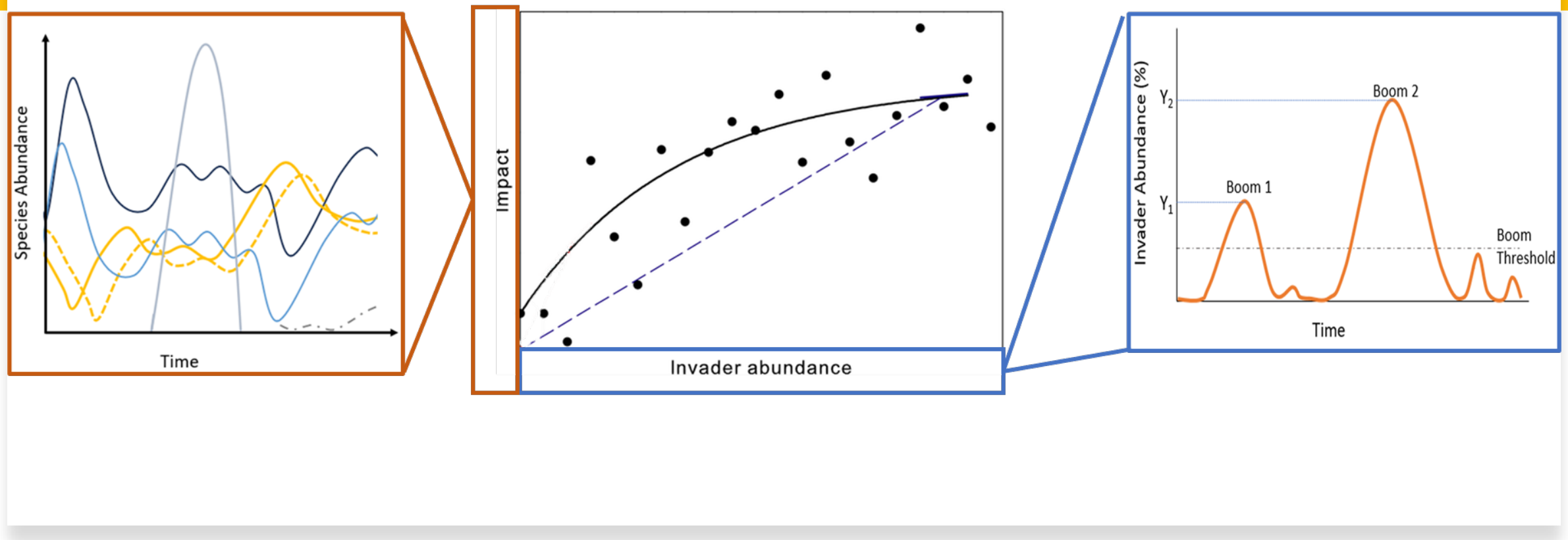

# Conclusions

- Unpacking an invasion regime can help identify mechanisms that contribute to its persistence and impacts
- But these should be classified for the focal system




# Conclusions

- Community measurements done over 1-3 years may underestimate overall diversity of systems and invader impact
- Using integrative metrics like community synchrony can provide insights to changes in underlying community properties




# Thank You, Questions?

- It's key to unpack the dynamics hidden in community metrics like species diversity and overall invader abundance to help identify mechanisms that contribute to a plant invader's persistence and its impacts