Most of these consistent “traits” are related to biogeography and propagule pressure, not species physiology, morphology or reproduction.
Recap of Traits

**Introduction pressure is extremely important:**

- Traits favored by humans will increase *deliberate* introductions

<table>
<thead>
<tr>
<th>Level</th>
<th>Characteristic</th>
<th>NID</th>
<th>CC</th>
<th>Within</th>
<th>Across</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Climate/habitat match</td>
<td>6</td>
<td>I vs I</td>
<td>B</td>
<td>B, F, I, M, P, R</td>
</tr>
<tr>
<td>Species</td>
<td>History of invasive success</td>
<td>8</td>
<td>I vs I</td>
<td>B, F, P</td>
<td>B, F, M, P, R</td>
</tr>
<tr>
<td>Event</td>
<td>Number of released/arriving individuals</td>
<td>4</td>
<td>I vs I</td>
<td>B</td>
<td>B, F, I</td>
</tr>
<tr>
<td>Event</td>
<td>Number of release/arrival attempts</td>
<td>7</td>
<td>I vs I</td>
<td>F, I, M, R</td>
<td></td>
</tr>
</tbody>
</table>

Crop/Food species

Pet/Garden species
Recap of Traits

**Introduction pressure is extremely important:**
- Traits that help survival or reduce detection will increase *accidental* introductions

---

**Table 3** Characteristics that are significantly associated with establishment success in at least two independent data sets either within or across biological groups

<table>
<thead>
<tr>
<th>Level</th>
<th>Characteristic</th>
<th>NID(^a)</th>
<th>CC(^b)</th>
<th>Within</th>
<th>Across</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Climate/habitat match</td>
<td>6</td>
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</tr>
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</tr>
<tr>
<td>Event</td>
<td>Number of release/arrival attempts</td>
<td>7</td>
<td>I v I</td>
<td></td>
<td>F, I, M, R</td>
</tr>
</tbody>
</table>

---

*Smaller insects may be harder to detect*
Any generalities of species specific traits?
Any generalities of species specific traits?

- Other traits are likely interact with biotic & abiotic factors in the introduced range
- Unique traits (or ‘quirks’) could lead to invasion success

Introduced birds with unique sizes relative to natives were more likely to establish

Quirk: Fish that survive on land

Allen, 2006
Recap of Traits

Biogeography is also extremely important:
• Broad native range means that you can tolerate a lot of environmental conditions
Biogeography

Definition:

• Understanding more about a species by using information from *where* the species is located
  – In what range of temperatures does the species establish? (Physiological tolerance)
  – Is the species located near human activity? (Disturbance responsive)
What affects invasive species spread?
What affects invasive species spread?

Species Traits:

• Dispersal ability
• Fecundity (number of seeds or offspring)
• Wide environmental tolerance
• Fast generation time (early sexual maturity)
• Generalist
What affects invasive species spread?

Environmental Factors:

- Disturbance
- Climatic suitability
- Other environmental suitability (soils, nutrients, prey)
- Dispersal corridors (environmental connectivity)
- Dispersal vectors (e.g., seed carriers)
Climatic Similarity Predicts Invasion

Significant Predictor of **Establishment**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th># Datasets</th>
</tr>
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<tbody>
<tr>
<td>Climate/habitat match</td>
<td>6</td>
</tr>
<tr>
<td>History of invasive success</td>
<td>8</td>
</tr>
<tr>
<td>Number of released/arriving individuals</td>
<td>4</td>
</tr>
<tr>
<td>Number of release/arrival attempts</td>
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</tr>
<tr>
<td>Taxon</td>
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<td>Geographic range size</td>
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</tr>
<tr>
<td>Geographic range size</td>
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</tr>
<tr>
<td>Leaf surface area</td>
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</table>

Significant Predictor of **Invasion**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th># Datasets</th>
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</thead>
<tbody>
<tr>
<td>Climate/habitat match</td>
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<tr>
<td>History of invasive success</td>
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<tr>
<td>Date of introduction</td>
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<tr>
<td>Biogeographic origin</td>
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</tr>
<tr>
<td>Length of juvenile period</td>
<td>2</td>
</tr>
<tr>
<td>Growth form</td>
<td>2</td>
</tr>
<tr>
<td>Asexual/vegetative reproduction</td>
<td>2</td>
</tr>
<tr>
<td>Length of flowering period</td>
<td>2</td>
</tr>
<tr>
<td>Flowering season</td>
<td>2</td>
</tr>
</tbody>
</table>
Similar climatic regions
Similar climatic regions
Biogeographical Modeling of Species Potential Distributions

Relevant to invasive species because it can potentially predict future spread
Climate space is generally conserved between native and invaded ranges.

Only 7 out of 50 invasive plant species tested had invaded ranges that exceeded the climatic conditions of their native ranges by more than 10%.

Petitpierre et al., 2012
Climate matching

*Carpobrotus edulis* (ice plant)
Native to South Africa

Thuiller et al., 2005
Physiological Tolerance
Physiological Tolerance to Extremes

Responses of 7 grass species to a heat wave of +11°C

Milbau et al. 2005
Use physiological characteristics to model potential geographic range.

Buckley, 2008
Use biogeography to empirically determine climatic tolerance
Realized vs. Fundamental Niche

Fundamental Niche:
• All the environmental conditions in which a species can survive.

Realized Niche:
• Fundamental niche *minus* competition with other species.
What causes this pattern?
Biogeographical methods break down because of non-equilibrium

Vaclavik & Meentmeyer, 2011
Suitability through stages of invasion
Non-natives are at lower equilibrium than natives (i.e. they are still spreading)
Use climatic conditions from all native and invaded range to define fundamental niche.

Kriticos et al., 2011
Species of the day: *Caulerpa taxifolia* “Killer Algae”

- Forms dense, monotypic stands
- Crowds out native vegetation
- Toxic to herbivores
- Affects behavior of fish & other organisms
Impacts on (one example) fish

*Mullus surmuletus* activity in the Mediterranean

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*C. taxifolia:*

- Established
- Not Established

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Levi and Francour, 2004
Popular aquarium algae

• Cold-tolerant strain developed in 1980 at an aquarium in Stuttgart
• Cold-tolerant strain shared with aquariums in Nancy, Geneva & Monaco
• Monaco aquarium likely source of release into the Mediterranean

Jousson et al., 1998
Invasive strains are genetically identical to the aquarium strain

Branches of the tree denote genetic difference →

‘Aquarium strain’ also found off the coasts of Australia and Southern California

‘Aquarium strain’ likely tolerant of lower temperatures than species in native range

Jousson et al., 1998
Why is it important to try to predict species ranges in the face of climate change? What are the implications for invasive species?
Why are models based on bioclimate generally more accurate at a larger scale?
What non-climatic reasons (besides human exploitation) could explain inaccuracies in the SPECIES model for the yew?
Fig. 4 Diagram illustrating a hierarchical modelling framework. Different factors affecting the distribution of species are considered to act at different scales. For example, the left-hand section shows species occurring in cells where both large-scale climatic and smaller-scale land-cover requirements are met. The right-hand section shows a downscaled portion from the larger diagram, demonstrating that at a still finer resolution biotic competition becomes significant.
Define a hierarchy (in ecological systems) as defined by several researchers including Kotliar & Wiens and Willish & Whittaker?