Exotic plant prevention: Assessing the invasion risk associated with refrigerated shipping containers entering the Port of Savannah, GA

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The relationship between international trade and non-native species

Hulme, 2009; Levine and D’Antonio 2003
90% of Global Trade uses Sea Transportation
The Gates: Sea Ports of Entry
United States
The Port of Savannah

- Key Location
- 4th Largest-2nd Busiest in US
- “Largest Single Container Terminal in North America”
- Over 3.5 million containers moved annually
- Major agricultural trade hub
Projected 10%+ per annum growth
What is the invasive plant establishment risk at the Port of Savannah?

Question 1: What is the invasive plant propagule (seed) pressure associated with refrigerated shipping containers?

- Quantity
- Frequency

Propagule pressure (PP) = 
# of propagules * number of entry events

[Diagram: Graph showing the relationship between propagule pressure and probability of establishment, with thresholds and benefits marked.]
Question 1: Seed survey of hitchhikers on refrigerated containers
Invasive plants of interest

Federal Noxious Weeds

- **Cogongrass IMCY**
  - Established, highly invasive
  - “introduced” in 9 states

- **Coatbuttons TRPR5**
  - Naturalized in FL
  - Habitat suitability model suggest widespread invasion

- **Wild sugarcane SASP**
  - No reported presence in US
  - Impacts > cogongrass
  - Rice & sugarcane production
Question 1: What is the propagule pressure associated with shipping containers?

Seed Survey
- Single commodity
  - Peru
- Biweekly sampling
- 2 year survey
# of Entry Events (Frequency)

Total containers arriving
- Year 1: 1858
- Year 2: 1889

Date

# of containers arriving

- Hurricane Matthew
Year 1: 331 containers sampled, 15 sampling timepoints

Year 2: 297 containers sampled, 14 sampling timepoints
Sorting & Counting: *Propagule #* (Quantity)
Does propagule number vary across month?

**Propagule #**

5,582 Total Seed 2015-16
5,962 Seed so far 2016-17

**Avg # of seeds/container = month + # of containers sampled**

Year 1 (n=15): No!
(F=0.9149, p=0.5351, $R^2=0.4408$)

Year 2 (n=8): Yes!
significant variation across month
(F=29.719, p=0.0328, $R^2=0.992$)
Does propagule number vary across month?

Avg # of seeds/container = month + year + # of containers sampled

Both Years (n=21): Yes! Significant variation across month (F=3.9164, p=0.0245, R²=0.6035)
**Propagule Pressure**

\[ \text{# of propagules} \times \text{number of entry events} \times \text{germination rate (Quality)} \]

<table>
<thead>
<tr>
<th>Month</th>
<th>Year 1: # of prop/cont.</th>
<th>Year 2: # of prop/cont.</th>
<th>Year 1: # of entry events</th>
<th>Year 2: # of entry events</th>
<th>Year 1: Prop Pressure</th>
<th>Year 2: Prop Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug</td>
<td>14.400</td>
<td>25.625</td>
<td>261</td>
<td>237</td>
<td>3,758</td>
<td>6,073</td>
</tr>
<tr>
<td>Sept</td>
<td>6.525</td>
<td>12.833</td>
<td>214</td>
<td>311</td>
<td>1,396</td>
<td>3,991</td>
</tr>
<tr>
<td>Oct</td>
<td>25.173</td>
<td>15.567</td>
<td>418</td>
<td>280</td>
<td>10,522</td>
<td>4,359</td>
</tr>
<tr>
<td>Nov</td>
<td>55.825</td>
<td>91.103</td>
<td>256</td>
<td>316</td>
<td>14,291</td>
<td>28,789</td>
</tr>
<tr>
<td>Dec</td>
<td>9.127</td>
<td>33.433</td>
<td>303</td>
<td>177</td>
<td>2,766</td>
<td>5,918</td>
</tr>
<tr>
<td>Jan</td>
<td>10.480</td>
<td>-</td>
<td>347</td>
<td>396</td>
<td>3,637</td>
<td>-</td>
</tr>
<tr>
<td>Feb</td>
<td>8.364</td>
<td>-</td>
<td>59</td>
<td>178</td>
<td>493</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36,863</td>
<td>49,130</td>
</tr>
</tbody>
</table>

Overall Propagule Pressure will be adjusted using Seed Quality
Germination rate (Quality)
**Germination rate**

**Year 1:**

\[
\frac{49 \text{ individual germinants}}{5582 \text{ seeds planted}} \times 100 = 0.8778\% \text{ germination rate}
\]

Low germ. in Year 1, due to methodology

**Year 2:**

\[
\frac{167 \text{ individual germinants}}{610 \text{ seeds planted}} \times 100 = 27.38\% \text{ germination rate}
\]

Germ. rate Year 2, in progress......
Species specific propagule pressure?

Plant Identification

Seed and mature plant

Morphological ID

- Arkansas State Herbarium
  - Vouchered and accessioned
  - Digitally accessible

Genetic ID

- Burgess Lab, Columbus State
  - DNA barcoding
  - Digitally accessible
Seed Types

41 Total Seed Types

Does the number of “species” vary across month?

Avg # of seeds/container = month + # of containers sampled

Year 1 (n=15): No!
(F=0.5223, p=0.7767, R²=0.3154)

Year 2 (n=8): No!
(F=3.9217, p=0.2134, R²=0.9266)
Seed Types

Does the number of “species” vary across month?

Avg # of seeds/container = month + year + # of containers sampled

Both Years (n=21): No! (F=1.9783, p=0.1533, R^2=0.5813)

BUT, Year was significant (F=12.6178, p=0.0032, R^2=0.5813)
Conclusion: What is the invasive plant propagule (seed) pressure associated with refrigerated shipping containers?

Seed survey:
- Large number and variety of seeds coming in on refrigerated containers
  - Quantity of seeds varies across month
- Estimate Propagule Pressure
  - Germination trials
  - Seed and plant identification
    - Are these species risky?
    - Species specific prop. pressure
What is the invasive plant establishment risk at the Port of Savannah?

Question 1: What is the invasive plant propagule (seed) pressure associated with refrigerated shipping containers?

Question 2: Are shipping ports exotic species hotspots?
   • High propagule pressure
   • High disturbance
Question 2: Is the shipping port an exotic species hotspot?

Floristic Survey
• Sampling
  • 6 green spaces
  • 4 sampling trips: Aug, May, Nov, Feb
  • Collected all fruiting and flowering vegetation
• Voucheried and Identified at ASU, CSU
Floristic Survey:
Is the port and exotic hotspot?  
**YES!**

- Compared with other floristic surveys in GA and SC (Floras of North America database)

Exotic Species
- 32% of species on Port
- Avg 12.5% of species in GA/SC region
On-going work

- Floristic survey
  - Morphological ID
  - Vouchered & accessioned
  - DNA barcoded

- Seed survey
  - Germination trials
  - Seed and plant
    - Morphological ID
    - Vouchered & accessioned
    - DNA barcoded
Acknowledgements

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