Impacts of Exotic Plants in Natural Systems: Methods and Findings of Experimental Research

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Does exotic species ‘X’ have an impact?

Yes [ ] No [ ]
Native species decline vs. Exotic species dominance.
Multiple environmental stressors

Photos: fs.fed.us, taluswindranch.com, invasive.org, planetware.com
Drivers or passengers of change?

Native species decline

Exotic species dominance
Ecological significance

Wardle et al. Science, 2004
Variability

- Exotic species
- Exotic density
- Site
- Resident community
- Abiotic conditions
- Disturbance
Recap: considerations when quantifying impacts

- Source of impacts
- Significance (biological) of impacts
- Context-dependence of impacts

Relative assessments

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Review of experimental impacts research 2001-2010

111 studies worldwide
75 in USA & Canada
Exotic growth forms

- Perennial forb: 24%
- Annual C3 grass: 20%
- Annual forb: 14%
- Shrub: 12%
- Perennial C3 grass: 11%
- Annual C4 grass: 9%
- Deciduous tree: 3%
- Perennial C4 grass: 3%
- Evergreen tree: 2%
- Vine: 1%

Photo: Forest & Kim Starr
Exotic species

73 total
51 species in 1 study each

<table>
<thead>
<tr>
<th>Exotic species in multiple studies</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Microstegium vimineum</em></td>
<td>7</td>
</tr>
<tr>
<td><em>Alliaria petiolata</em></td>
<td>6</td>
</tr>
<tr>
<td><em>Centaurea maculosa, Lonicera maackii</em></td>
<td>5</td>
</tr>
<tr>
<td><em>Avena barbata, Bromus diandrus, Lythrum salicaria</em></td>
<td>4</td>
</tr>
<tr>
<td><em>Bromus inermis, Bromus madritensis ssp. rubens, Euphorbia esula</em></td>
<td>3</td>
</tr>
<tr>
<td><em>Acer platanoides, Bromus hordeaceus, Medicago polymorpha, Phalaris arundinacea, Rhamnus frangula</em></td>
<td>2</td>
</tr>
</tbody>
</table>

6 N-fixers (4 forbs, 1 shrub, 1 evergreen tree)
Study locations

Photo: Chris Evans, River to River CWMA, Bugwood.org

Photo: Stan Spencer, CalPhotos

75 Studies
Experimental systems

- **CC: Field**: 24%
- **CC: Greenhouse**: 21%
- **Grassland**: 14%
- **Hardwood forest**: 13%
- **Riparian/Wetland**: 9%
- **Hawaiian forest**: 7%
- **Desert**: 4%
- **Dune**: 4%
- **Old ag. field**: 1%
- **Coastal scrub**: 1%
- **Conifer forest**: 1%

CC = constructed community
Analyses by experiment

Experiment = exotic species + response variable

\[ n = 469 \text{ experiments} \]
Ecological level of impact \((n = 469)\)

- Individual species: 57%
- Community structure: 30%
- Abiotic conditions: 10%
- Ecosystem processes: 4%
<table>
<thead>
<tr>
<th>Response variables</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Plant performance</td>
<td>52%</td>
</tr>
<tr>
<td>Plant richness, diversity, &amp; composition</td>
<td>22%</td>
</tr>
<tr>
<td>Soil nutrients</td>
<td>9%</td>
</tr>
<tr>
<td>Arthropod abundance &amp; composition</td>
<td>7%</td>
</tr>
<tr>
<td>Abiotic conditions</td>
<td>5%</td>
</tr>
<tr>
<td>Soil community</td>
<td>2%</td>
</tr>
<tr>
<td>Animal behavior</td>
<td>2%</td>
</tr>
<tr>
<td>Animal abundance</td>
<td>1%</td>
</tr>
<tr>
<td>Decomposition</td>
<td>1%</td>
</tr>
</tbody>
</table>
A few impacts findings
<table>
<thead>
<tr>
<th>Impact</th>
<th>Increase</th>
<th>Decrease</th>
<th>No effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Species</td>
<td>8%</td>
<td>37%</td>
<td>54%</td>
</tr>
<tr>
<td>Community Structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant abundance &amp; richness &amp; arthropod abundance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abiotic Properties</td>
<td>30%</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>Ecosystem Processes</td>
<td>32%</td>
<td>11%</td>
<td>58%</td>
</tr>
</tbody>
</table>
Impacts by growth form & species

- $C_3$ annual grasses < expected
- Annual forbs > expected
- No strong growth form signal

- Species in multiple studies
  - Findings varied among studies
  - *Microstegium*
    - 7 studies
    - 3 found some evidence of ↓ plant richness & diversity
  - Generally mix of ↑, ↓, & no effect
Variability of impacts
Summary

• Relative assessments
• Variability
• Multiple drivers of change
Understanding impacts is a cumulative process

- Multi-factor, multi-site in natural system
- Single-factor/ site in natural system
- Single-factor in controlled environment
- Observational study
Conclusions

Future impact studies:

• Multiple sites
• Interactions
• Discriminatory power