Twenty-first Century Issues for Invasion Biology: Managed Relocations of Rare Species and the Use of Non-invasive Cultivars of Invasive Species

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Questions

- Will managed relocations of rare plants because of climate change lead to a new source of invasive plants?
- Are sterile cultivars the answer to the issue of garden plants becoming invasive species?
Average 3.6 – 8.1° F increase over 1980-1999, likely 5.4° (IPCC 2007)
Why Managed Relocations (MR)?

• Desire to conserve biological diversity
• Inherent limited dispersal ability
• Fragmentation of the landscape
• Limited suitable habitat
Why Not MR?

• Ecological risk of behaving as an introduced invasive species or introducing pathogens (Ricciardi and Simberloff 2008)
Methods

• Applied invasion theory to managed relocations
• Applied Weed Risk Assessment methods to test species introduced into Florida

Methods
Australian WRA

49 Questions
- Climate/distribution
- Domestication
- Weed elsewhere
- Undesirable traits
- Plant type
- Reproduction
- Dispersal
- Persistence attributes

<1 = not a pest
1-6 evaluate further
> 6 = a pest
General Applicability

- Tested in New Zealand, Hawaii, Pacific Islands, Czech Republic, Bonin Islands, Florida
- Grouped, found to be 90% accurate in predicting invaders, 70% accurate with non-invaders
- 80% accurate overall

Gordon et al. 2008, Diversity and Distribution
Florida WRA

- Tested the Australian WRA, slightly modified
- 158 species, 52 families (35 non-invader, 27 minor, 36 major invader, 21% overlap)

Gordon et al. 2008, Invasive Plant Science and Management
Florida WRA Cross-validation

<table>
<thead>
<tr>
<th>Actual Group</th>
<th># Species</th>
<th>Accept</th>
<th>Reject</th>
<th>Further analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invader</td>
<td>110</td>
<td>18</td>
<td>85</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16%</td>
<td>77%</td>
<td>6%</td>
</tr>
<tr>
<td>Not invader</td>
<td>46</td>
<td>35</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>73%</td>
<td>9%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Gordon et al. 2008, Invasive Plant Science and Management
Methods
Using the WRA for MR

- Data about intercontinental introduced species in the collections of Fairchild Tropical Botanic Garden (FTBG) and Montgomery Botanic Center (MBC)
Methods
Using the WRA for MR

Species groups

- **Conservation** from Caribbean, tropical America, Asia, etc. (22)

- **Horticultural** species promoted by FTBG to the general gardening public from 1955-1979, matched with conservation by habit, e.g., tree/shrub, palm, etc. (22)
Methods
Using the WRA for MR

Analyses
• Species evaluated using Florida WRA, risk scores calculated (1<not a problem, 1-6 evaluate further, >6 a problem)
• Data from FTBG/MBC records, internet and published sources, and field observations
• 3 evaluators, then checked for consistency
Methods
Using the WRA for MR

Analyses

• Welch ANOVA to determine significance of scores due to high variation
• Tukey’s HSD test to make pairwise comparisons between means
• Distribution of scores compared using Chi-square (2 X 3 contingency table)
Results
Using the WRA for MR

- Mean WRA score for Conservation: -3.25 +/- 2.45
- Mean WRA score for Horticultural: -0.095 +/- 5.74
- p-value: 0.0346
Results
Using the WRA for MR

- Conservation: 96% accept, 1% evaluate, 1% reject
- Horticultural: 57% accept, 38% evaluate, 5% reject

p = 0.02
Results Recap
Using the WRA for MR

- Scores of conservation species varied significantly less than horticulture
- Scores for both groups were low
- The conservation scores were substantially lower than the cut off point determining non-invasiveness
Bottom Line - Managed Relocations

• All MRs should receive strict supervision from agencies
• All MRs should be carefully considered for many factors, including invasion theory
• For greater distances, WRAs may be useful in evaluating invasive potential
• Manage adaptively to respond to uncertainty

Sterility in Introduced and Cultivated Plants

• Cultivar - natural or bred variation that is maintained mostly by asexual propagation

• “Cultivars per se do not invade: their offspring invade”

Sterility in Plants

- Natural or induced mutations may reduce sterility, common and evolved many times
- Male sterility - no or reduced pollen
- Can still produce seeds if fertile pollen is available on nearby plants
Sterility in Plants

- Female sterility - no or reduced ovules, death of pistil tissue prior to pollination
- Relatively rare - Oleaceae, *Saxifraga*, *Ulmus*
Sterility from Hybridization - Triploids

- Chromosomes must find a corresponding chromosome in both parents to produce offspring
- Triploids mostly sterile
- Can still produce fruit
- Can still reproduce asexually (many dandelions are triploid)
Knight et al. Main Points

• Claims of fecundity are often not well substantiated
• Offspring of cultivars may behave differently
• When crossed with other cultivars, could become fertile
• Matrix models show even large reductions in fecundity can result in population increases in long-lived species
Matrix Population Models

- Look at ALL life stages, not just seeds
Matrix Population Models

- Look at ALL life stages, not just seeds
- $\lambda$ greater than 1 = growing population
- All of the trees and shrubs studied needed a 95-100% reduction in seeds to achieve $\lambda$ of 1 or less
- Most species required well over 50% seed reduction
Other Cultivar Considerations

• Slowed growth rate - variegation, reduced leaf surface
• Production of non-flowering plants or elimination of pollinator rewards
• Biotechnology and transgenetic methods
Bottom Line - Sterile Cultivars

- Some cultivars may be less invasive
- Sterility is often reversible
- Reduced seed set needs to nearly total for long-lived species
- Selecting for slower growth rate may be more effective than selecting male sterility
Conclusions

- We are facing new challenges in the 21st Century
- If managed relocations are necessary, theory and risk assessment could predict invasive potential
- Skepticism is essential in evaluating cultivar invasive potential, but some cultivars may grow or reproduce less than wild types