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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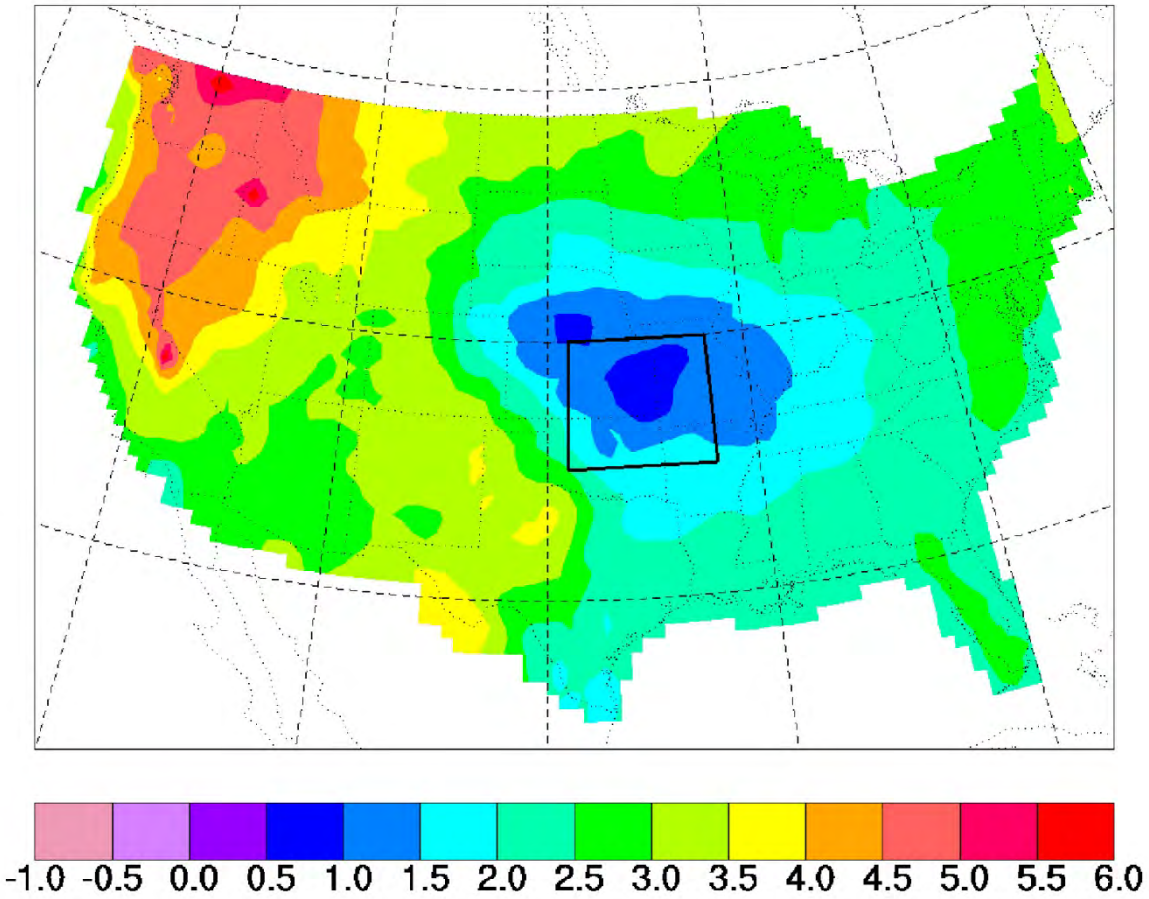
Questions

- 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?


AN INCONVENIENT TRUTH
A REASSURING LIE
THE CHRISTIAN SCIENCE MONITOR
Bennett

Average 3.6 – 8.1º F increase over 1980-1999, likely 5.4º (IPCC 2007)



Possible Summer Temperature Increase from 1990s to 2040

Image from Iowa State University

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

Reichard, S., H. Liu, and C. Huseby. 2012. Is Managed Relocation Another Pathway for Biological Invasion? Pages 243-261, In Maschinski, J. And K. Haskins, eds, Plant Reintroduction in a Changing Climate: Promises and Perils. Island Press

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

		Predicted Group Membership		
Actual Group	# Species	Accept	Reject	Further analysis
Invader	110	18	85	7
		16%	**77%**	**6%**
Not invader	46	35	4	9
		73%	**9%**	**20%**

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

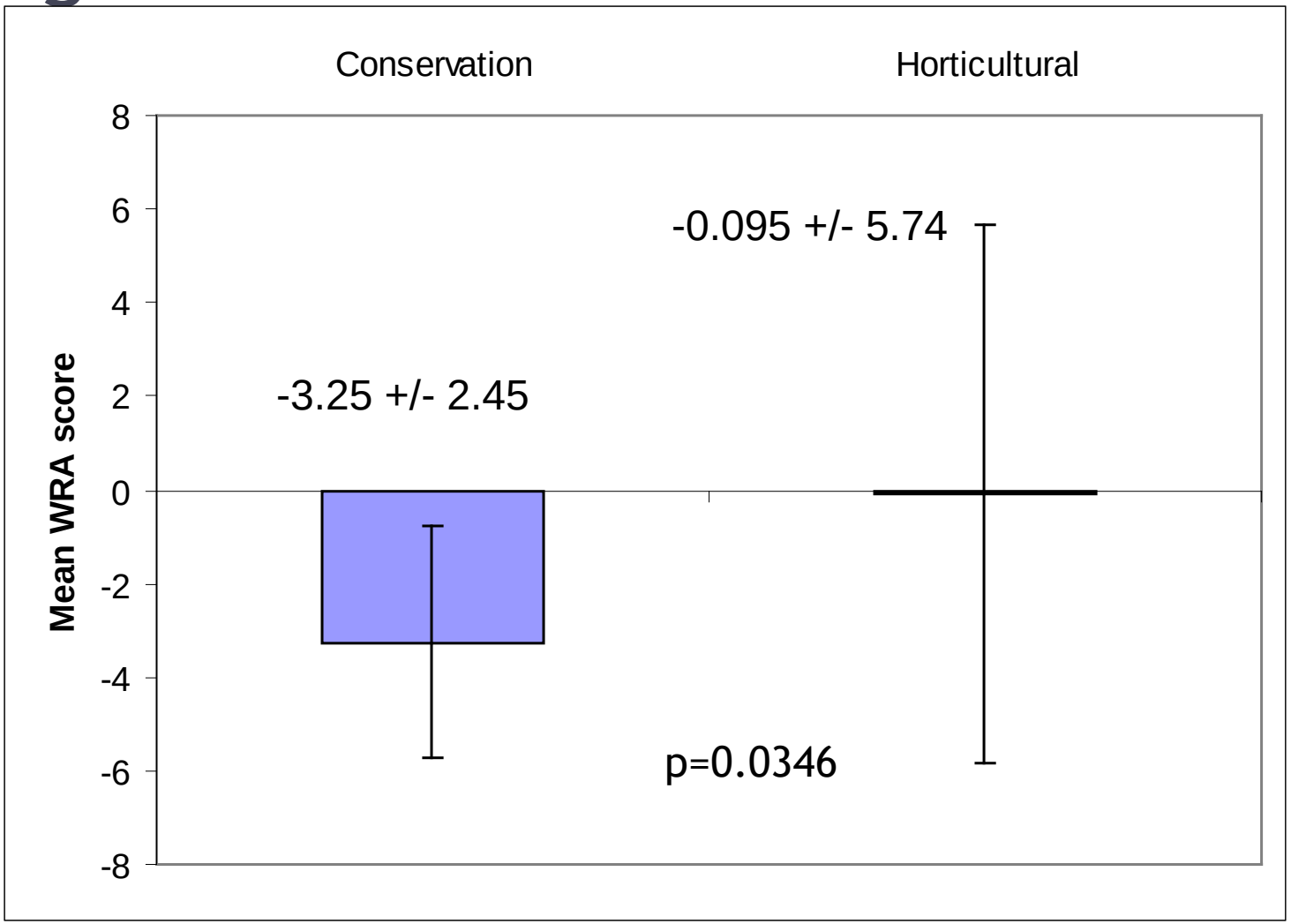
- Species evaluated using Florida WRA, risk scores calculated (1<not a problem, 1-6 evaluate further, >6 a problem)
- Data from FTBG/MBC records, internet and published sources, and field observations
- 3 evaluators, then checked for consistency

Methods
Using the WRA for MR

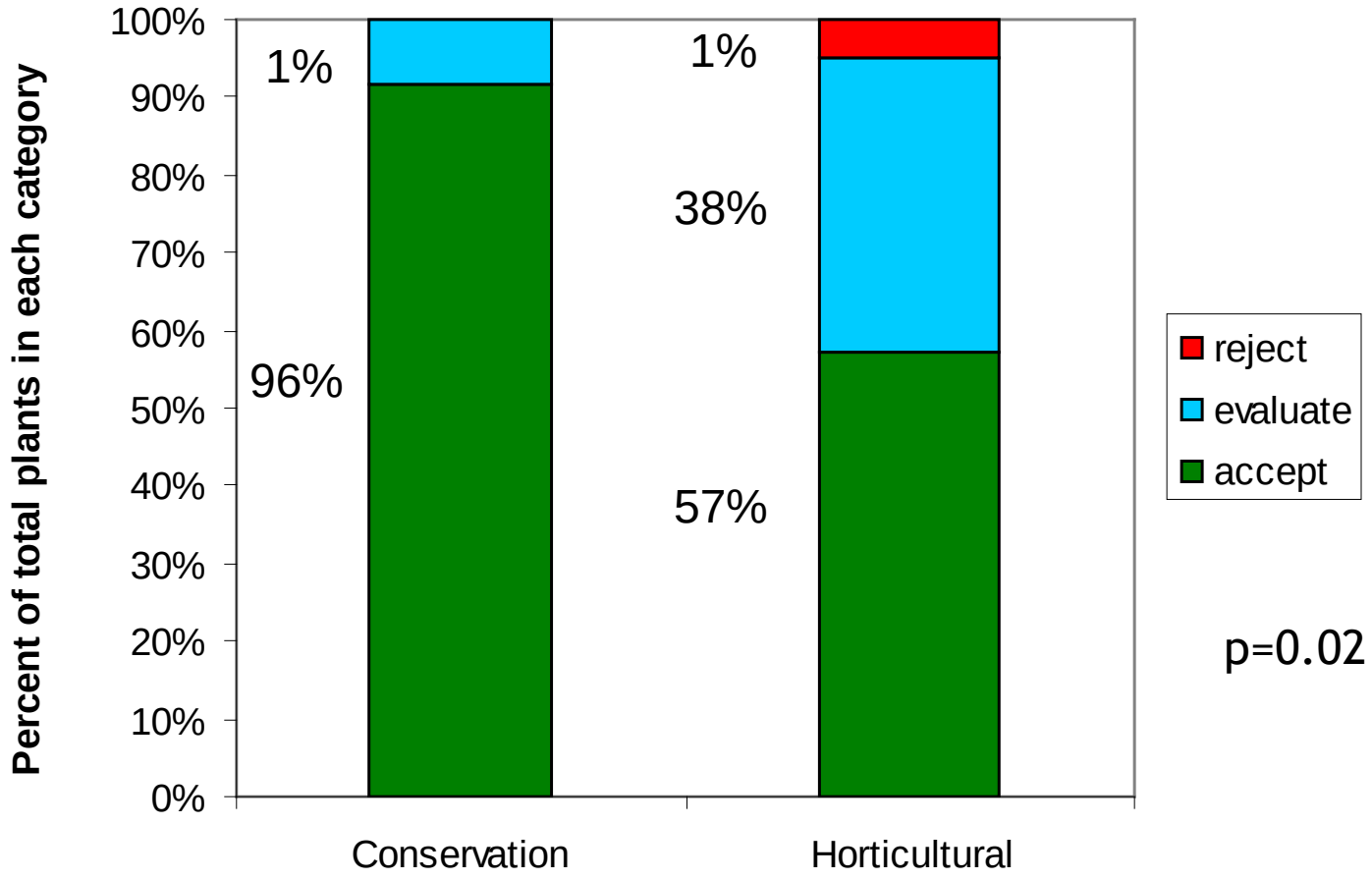
Analyses

- 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



Results
Using the WRA for MR



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

Reichard, S., H. Liu, and C. Huseby. 2012. Is Managed Relocation Another Pathway for Biological Invasion? Pages 243-261, In Maschinski, J. And K. Haskins, eds, Plant Reintroduction in a Changing Climate: Promises and Perils. Island Press.

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"

Knight, T.M., K. Havens and P. Vitt. 2011. Will the Use of Less Fecund Cultivars Reduce the Invasiveness of Perennial Plants? *BioScience* 61: 816–822.

Sterility in Plants

- Natural or induced mutations may reduce sterility, common and evolved many times

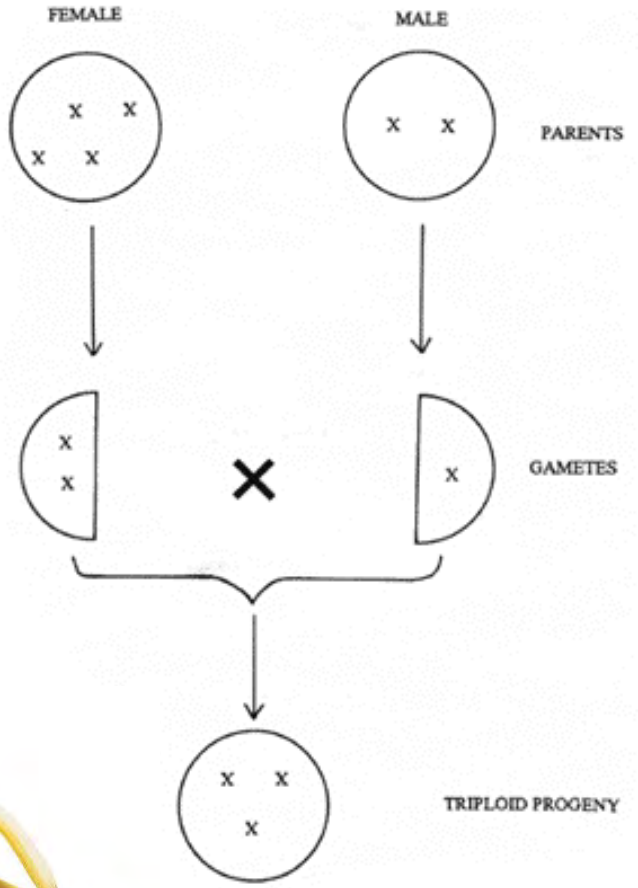
- male sterility – no or reduced pollen
- Can still produce seeds if fertile pollen is available on nearby plants

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)

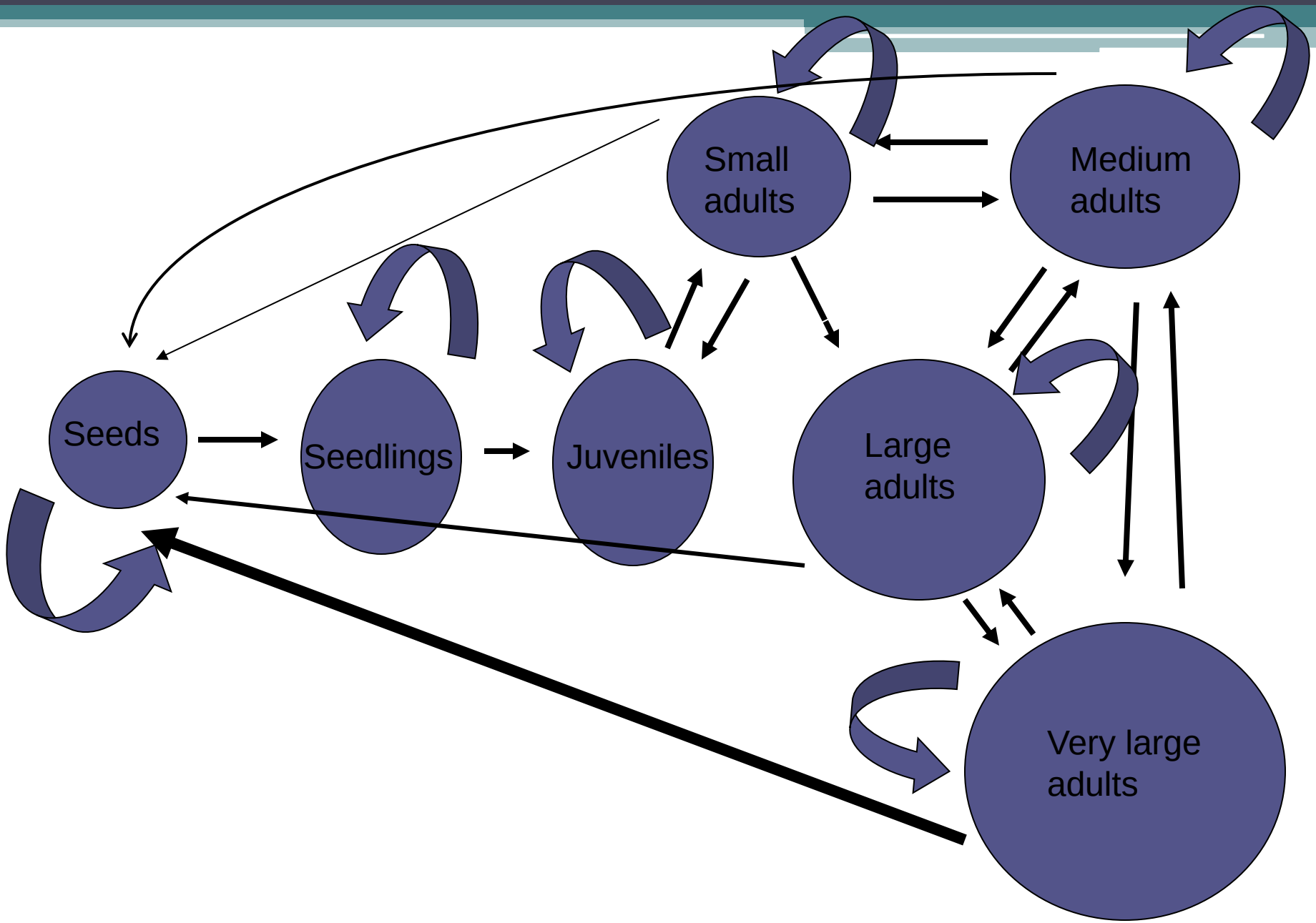


Knight et al. Main Points

- 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


Small adults
Medium adults
Seeds
Seedlings
Juveniles
Large adults
Very large adults

Matrix Population Models

- Look at ALL life stages, not just seeds
- λ greater than 1 = growing population
- All of the trees and shrubs studied needed a 95-100% reduction in seeds to achieve λ 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 transgenic 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