Propagule Pressure and the Establishment Success of Problem Species

Renata Poulton Kamakura[1,2], Adrienne Ernst[1,3], Andrea Kramer[1]

[1]Chicago Botanic Garden, [2]University of Chicago, [3]Northwestern University

Introduction

Problem species, or unwanted species that can cause ecosystem damage, are a threat to conservation efforts in the US and across the globe [5]. In order to reduce the incidence of harmful plant introductions in tallgrass prairies, we have to understand the factors that make problem species successful. One factor is propagule pressure, defined as the number of seeds that attempt invasion over a period of time [2].

For each problem species, releasing more seeds increases the likelihood that viable seeds will fall into favorable growing conditions, survive, and reproduce. A larger population of established problem species will also be more likely to persist over time [3]. Propagule pressure also affects the number of species that establish: only as many species as attempt invasion can possibly invade [2]. The phylogenetic diversity (a measure of species relatedness) of species attempting invasion may also have positive effects. Assuming all the species invading are relatively well suited to the environment, the more phylogenetic diverse they are, the less likely they are to compete [4].

Objective

Examine the effect of propagule pressure on invasion success in terms of:

1. the number of individuals of a species that attempt invasion
2. the number of species that attempt invasion
3. the phylogenetic diversity of the species attempting invasion.

Hypotheses

1. There will be a positive relationship between propagule pressure (number of seeds) and invasion success (invasive biomass) for each individual species.
2. There will be a positive relationship between the number of species attempting invasion and the number of species that successfully invade.
3. A more phylogenetically diverse group of problem species will allow for more species to successfully invade.

Methods

We worked in an experimental tallgrass prairie at the Morton Arboretum with 127 total species of Midwestern plants. We used 30 plots and all species not intentionally seeded in were considered problem species.

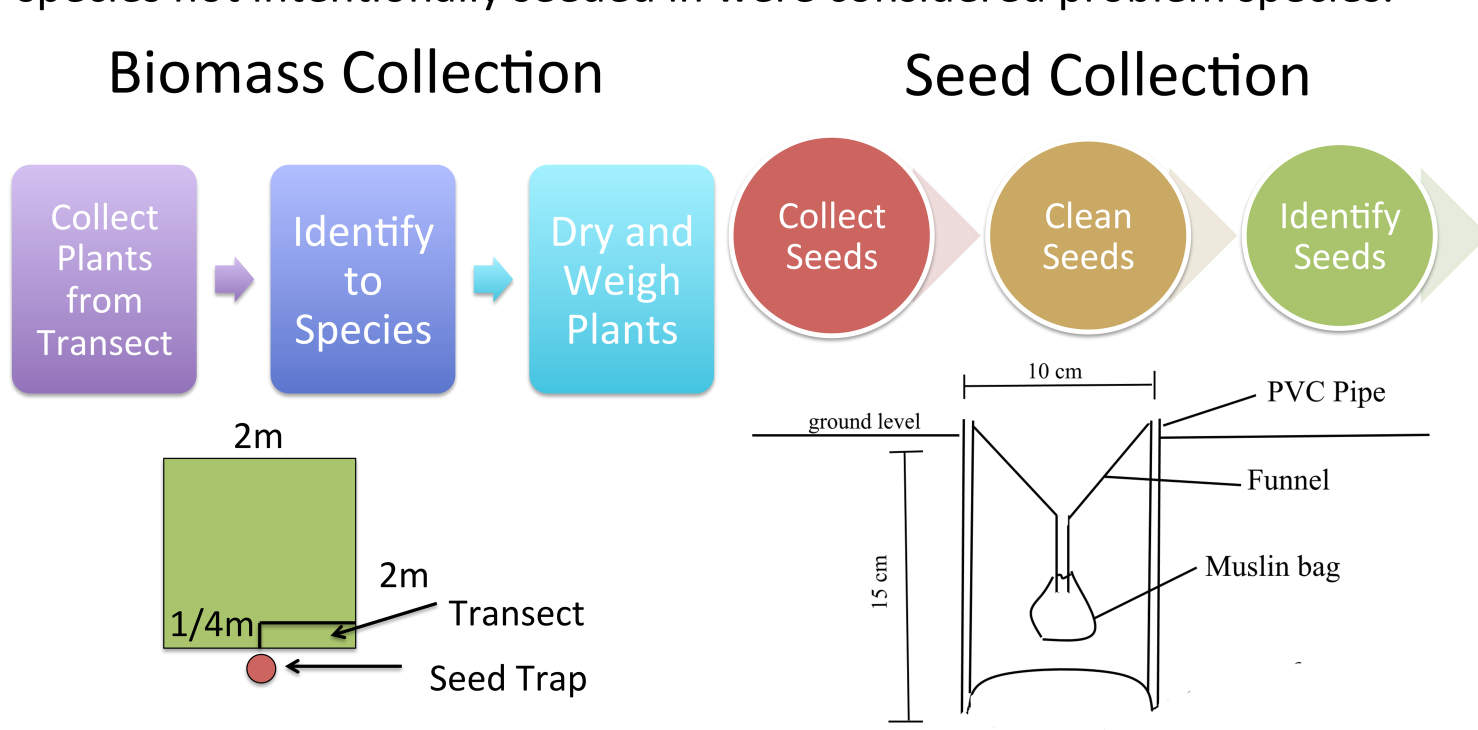
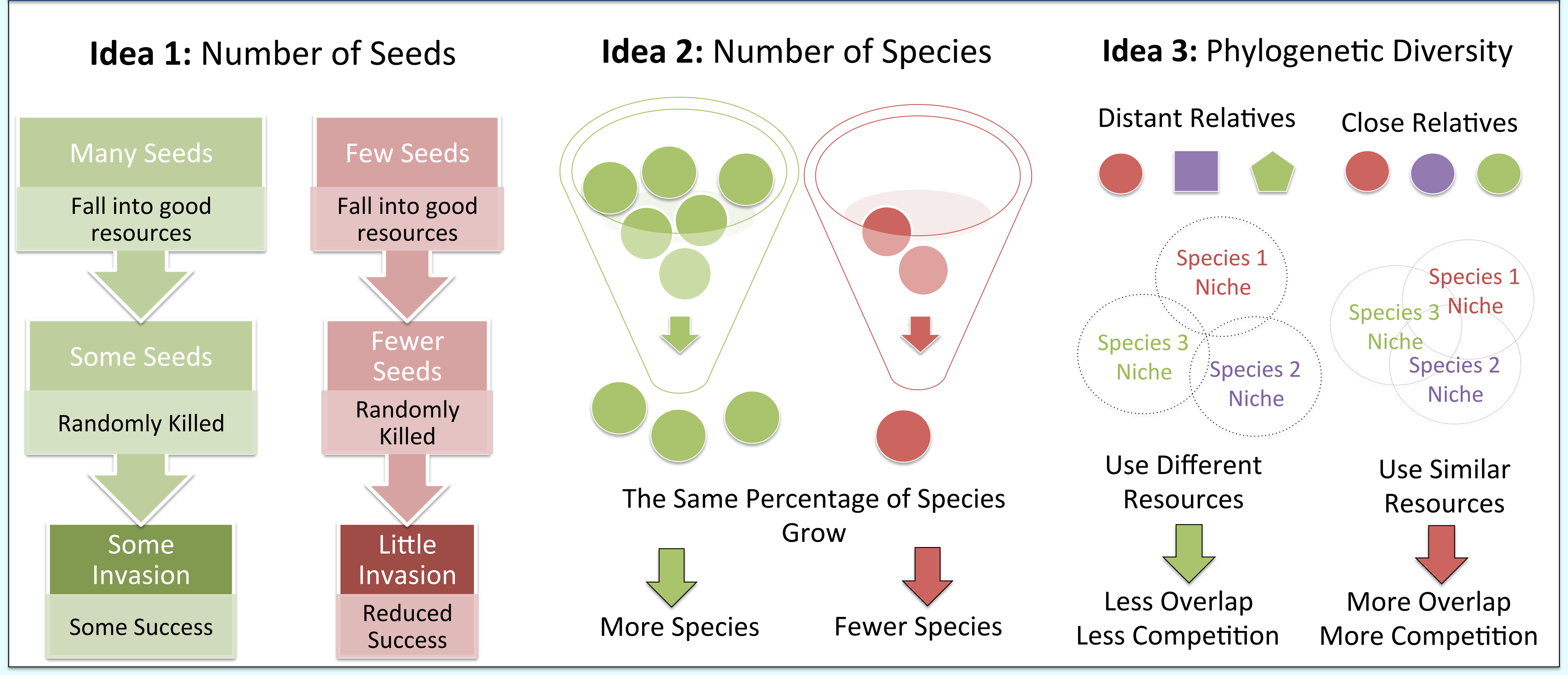


Fig.1: Plot design with transect for biomass collection and seed trap for seed collection.

Fig.2: Seed Trap diagram. Seeds fall though the funnel into the collectable bag.

Conceptual Diagram



Results

Result 1: Number of Seeds

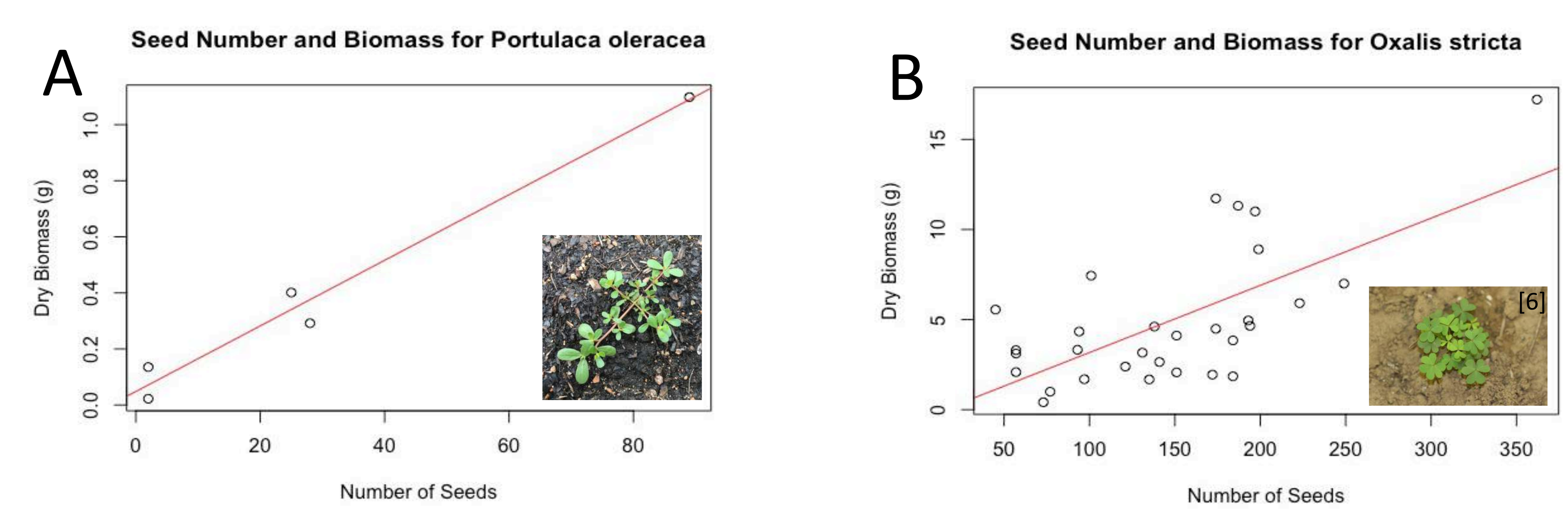


Fig. 3: Positive relationship between the number of seeds and biomass for A: *Portulaca oleracea* (p-value = $5.375 * 10^{-5}$, $r^2 = 0.4471$) and B: *Oxalis stricta* (p-value = 0.001619, $r^2 = 0.9757$)

Result 2: Number of Species

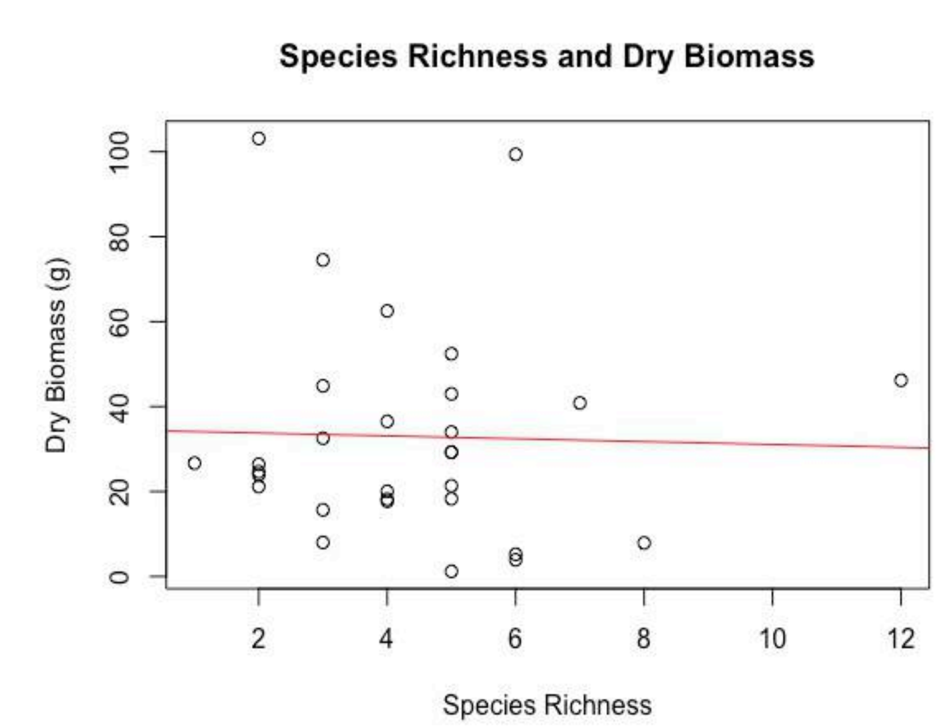


Fig. 4: No statistically significant relationship between species richness and biomass across the 30 plots (p-value = 0.8767, $r^2 = 0.0008752$)

Result 3: Phylogenetic Diversity

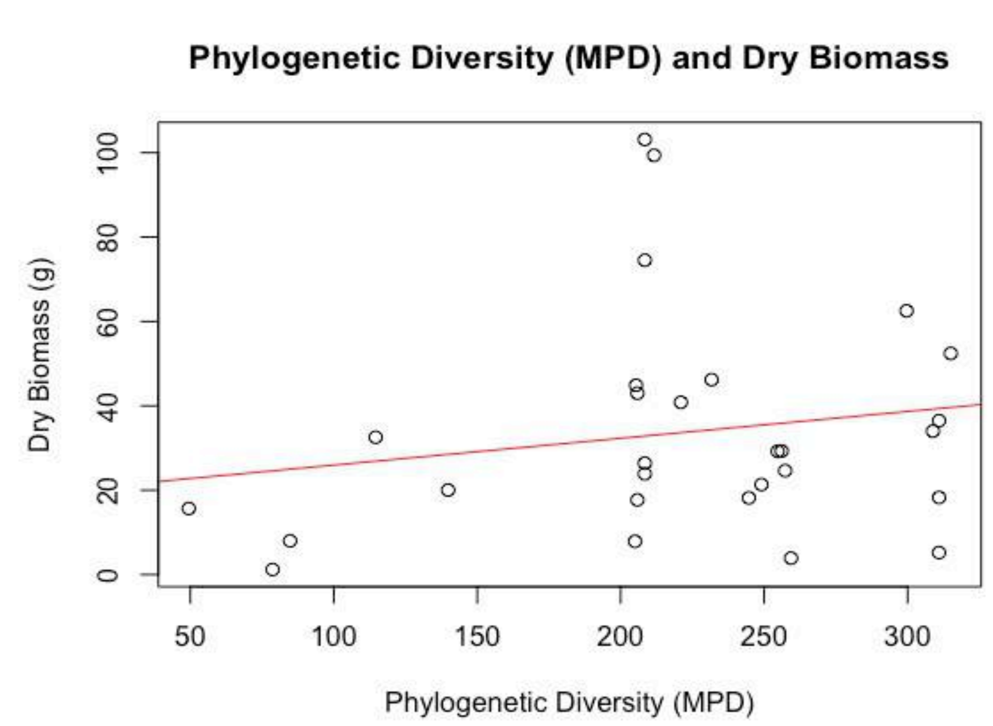


Fig. 5: The relationship between phylogenetic diversity (calculated as mean phylogenetic distance) and dry biomass, which is not statistically significant (p-value = 0.3662, $r^2 = 0.03151$)

Conclusions/Discussion

Conclusion 1: For two problem species, *Oxalis stricta* and *Portulaca oleracea,* there was a positive relationship between the number of seeds that attempt invasion and the dry biomass of that species in the plot (see Fig.3). For three other species, there was no clear relationship.

The positive relationship between the number of seeds and dry biomass is consistent with our hypotheses. It is likely due to an increased likelihood of seeds reaching suitable conditions and surviving.

Conclusion 2: There was no significant correlation between species richness and problem species biomass.

The lack of positive relationship between species richness and problem species biomass is surprising because the relationship is fairly well established [2, 3]. The data used in these analyses are only preliminary and so the relationship may be more clear when more data are collected. However, it is possible that some of the problem species are not suited to the habitat or that there are only enough resources to allow a few species to establish. Then, if too many species try to invade a plot they are either surplus or ill-suited, it would not necessarily grow.

Conclusion 3: There was no significant correlation between phylogenetic diversity and problem species biomass.

Like with species richness, it is possible that we can't see a relationship because of insufficient data. It is also possible that phylogenetic diversity and problem species biomass are not positively related. Perhaps the major traits that determine invasion success in tallgrass prairies are regularly lost or gained across evolutionary time and so phylogenetic diversity would not be as informative and we should instead focus on whether species have certain traits that we know are important.

References

1. C. K. Johnson, N. E. West. Laboratory comparisons of five seed-trap designs for dry, windy environments. *Can. J. Bot.*, *66*(2), 346–348. (1988)
2. J. L. Lockwood, P. Cassey, T. M. Blackburn, The more you introduce the more you get: the role of colonization pressure and propagule pressure in invasion ecology. *Divers. Distrib.*, 15: 904–910, (2009).
3. D. Simberloff, The Role of Propagule Pressure in Biological Invasions. *Annu. Rev. Ecol. Evol. Syst., 40*: 81–82, (2009).
4. J. J. Wiens, D. D. Ackerly, A. P. Allen, B.L. Anacker, L. B. Buckley, H. V. Cornell, … P. R. Stephens, Niche conservatism as an emerging principle in ecology and conservation biology. *Ecol. Lett.*, *13*: 1310–1324, (2010).
5. D. Wilcove, D. Rothstein, J. Dubow, A. Phillips, E. Losos, Quantifying Threats to Imperiled Species in the United States. *BioScience, 48*: 607-615, (1998).
6. *Yellow woodsorrel plant* [Photograph found in Michigan State University]. Retrieved from https://pestid.msu.edu/weeds-and-plant-identification/yellow-woodsorrel-oxalis-stricta/

Acknowledgements

I would like to thank my mentor, Adrienne Ernst, for providing support and guidance, and Raymond Diaz for helping to gather data. I would also like to thank Andrea Kramer, Andrew Hipp, Dan Larkin and Becky Barak. I thank the Chicago Botanic Garden, the Morton Arboretum, and the National Science Foundation for this research opportunity.

REU Site: *Plant Biology & Conservation Research Experiences for Undergraduates - From Genes to Ecosystems* (Supported by NSF award DBI-1461007).