



Invasive reed canary grass (photo: Rojas-Viada)/Uninvaded tussock sedge meadow (Photo: Zedler)

## ARBORETUM RESEARCH HELPS RESOLVE THE “INVASIVE SPECIES DEBATE”

### What is under debate?

Do invasive plants reduce native species or do they add diversity, given favorable conditions? Some researchers have shown that non-native species are diverse in the same places that native plant species are diverse, leading them to conclude that introduced/invasive species have no negative impact on natives. At the same time, others report the reverse relationship or no pattern, suggesting that it is best to be cautious and to attempt to control invaders. Do invaders affect resident natives or not?

Isabel Rojas-Viada set out to resolve this debate for her M.S. degree. Contributing to confusion were the terms being used to describe invaders, the metrics used to assess effects on native species, and the spatial scale under consideration. While testing the hypothesis that effects of Wisconsin’s “worst wetland weed” (reed canary grass; RCG; *Phalaris arundinacea*) depend on the scale (total area or size of plots) being studied, two more factors emerged, namely the type of invader studied and the type of ecosystem being invaded. Here, we explain how these five factors fuel the debate.

**1. Terms.** Arguments are partly attributable to equating invasive plants with non-native species. Dan Simberloff and other authors recognize that many non-native plants can become invasive and decrease diversity, so they give high priority to controlling non-natives. Mark Davis and others claim that non-native species add diversity at the regional scale and urge conservationists to spend less money eradicating species just because they are exotic. To manage our “model invader” based on its geographical origin, we would need to know its genotype and be able to identify them in the field, since both native and European strains are present in North America. In Wisconsin, RCG appears in early herbarium records, but it was likely displaced by introduced European strains. While a species’ geographical origin needs to be known to predict its future behavior, actual effects of invasive species are best assessed regardless of origin.

**2. Metrics.** Responses to an invader can differ with the way that effects are measured. Some researchers use the ratio of natives:non-natives, also called the “native-exotic richness relationship” (NERR). This ratio equates exotic (non-native) species with invasive species, adding unnecessary confusion, since native species can become aggressive invaders (e.g., the native gray dogwood,

*Cornus racemosa*, in Curtis Prairie). Also, NERR breaks down when the invasive species’ origin is uncertain, as for RCG.

In our study of seven sedge meadows, native and non-native species were not correlated. NERR would thus suggest no effect of invaders, even though RCG consistently reduced diversity. In general, NERR does not account for the effects of plants that invade aggressively, become dominant, and shade out natives. Such invasions not only degrade native vegetation but are very difficult to reverse. Mike Healy tried for three years to control RCG in Curtis Prairie and elsewhere. Using the grass-specific herbicide sethoxydim, he kept RCG from flowering, but the RCG rebounded the following year. NERR is insensitive to different behaviors among species.

Two alternative metrics are more useful; these are direct counts of species and species-area curves. Rojas-Viada (2013) found 83 species in uninvaded areas of seven sedge meadows, compared to 50 species in RCG-invaded areas (40% fewer species). In a more robust analysis using species-area curves (Fig. 1), she showed that the number of species encountered (log-transformed data) was significantly lower for invaded than uninvaded stands, and the pattern was the same for each of four plot sizes (0.25, 1, 4 and 16 m<sup>2</sup>). The different intercepts on the y axis represent differences in species richness at the small scale. Each of the seven wetlands had fewer species where RCG was dominant (Fig. 2).

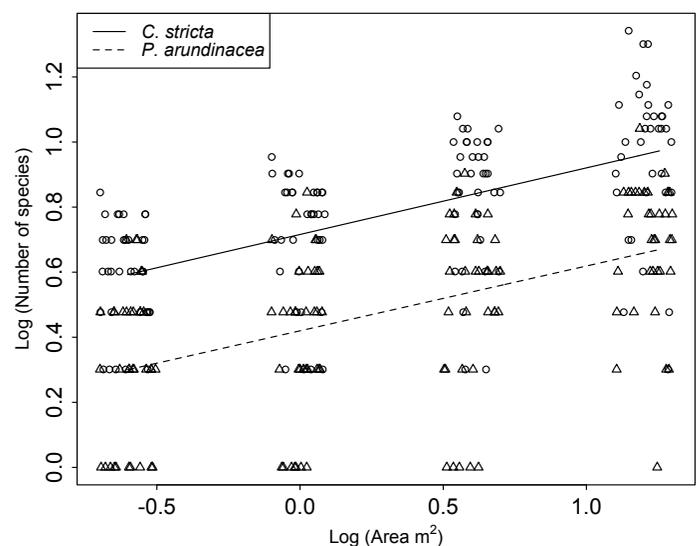


Fig 1. The species-area curve for all sites combined for plots without RCG (solid line) and with RCG (dashed line); data for both axes are log transformations.

**3. Spatial scale.** Samples from small plots might show more impact of invaders than samples from large plots, especially when simply counting species. However, few studies have tested scale-dependent effects of invaders that achieve dominance. Because Rojas-Viada (2013) sampled seven sedge meadows using plots of four sizes (0.25, 1, 4, and 16 m<sup>2</sup>), she could determine whether spatial scale made a difference. Four of her sites were located within the Arboretum: Curtis Prairie, Southeast Marsh, Wingra Marsh, and Lower Green Prairie. Others were in Cherokee Marsh and Waubesa Wetland. Rojas-Viada sampled on each side of the RCG boundary with as many plots as she could fit in each site (6 to 14, for a total of 35 in stands of tussock sedge [TS, *Carex stricta*] and 35 in RCG). Comparing all plots in all seven sites (Fig. 1), the average reduction was 48%. Plotted individually (Fig. 2), we learned that three sites had significantly lower species richness with RCG invasion, but species-area curves for Curtis Prairie

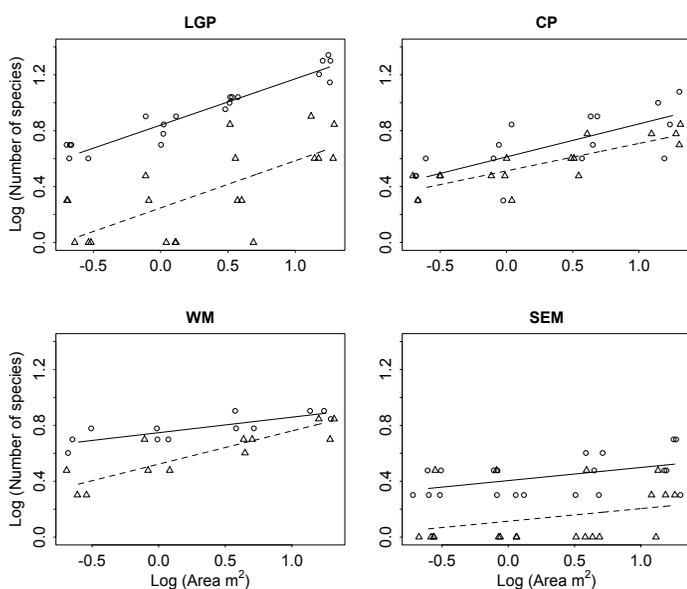


Figure 2. Species-area curves (log-transformed) for sedge meadow vegetation without RCG (solid line) and with RCG (dashed line) for four Arboretum sites (Lower Greene Prairie, Curtis Prairie, Wingra Marsh and Southeast Marsh).

did not differ statistically. Also, six sites had similar increases in resident species with plot size, whether RCG or TS was dominant. One site (Wingra Marsh) had a slightly steeper slope for plots with RCG. Consistent reduction in species richness with RCG invasion across 4 plot sizes led us to conclude that effects of RCG on plant diversity are not scale-dependent. All these plot sizes are small and that impacts might still differ for plots <16 m<sup>2</sup> and much larger areas.

**4. The type of invader.** Species that tend to form monotypes differ from those that dominate along with other species (Leaflet 3). RCG is a monotype dominant, being abundant wherever it occurs. Dominant plants like RCG are known to have negative effects on ecosystem structure and functions, such as canopy structure, productivity, nutrient cycling, and soil properties, due to their differences in height, shade, root and rhizome biomass, or chemistry.

Such species need to be included in the assessment of invader effects. In contrast, our native tussock sedge is a matrix dominant that allows other species to co-exist. Its tussocks facilitate growth of a variety of species with greater and lesser tolerance of waterlogging (Leaflet 22). RCG has invaded many urban sedge meadows that were formerly dominated by TS. RCG is known to displace native vegetation and form a monotype under conditions of augmented water, nutrients and sediments (Leaflet 3). Such species need to be included in general assessments of invader effects on native plants.

**5. The type of ecosystem being invaded.** Wetlands that are the sinks of watersheds are especially vulnerable to invasions because they accumulate water, nutrients and sediments, as well propagules of potential invaders. However, wetland invasions are less well studied than those in uplands. Of 1,637 papers reviewed by Lowry et al. (2013), ~1,200 addressed terrestrial ecosystems, while fewer than 100 focused on wetlands. In our region's urban wetlands, which receive excess nutrient-laden stormwater, we know that RCG readily invades wetlands, forms monotypes, becomes dominant, and displaces resident native species.

## Conclusion

A debate over the impacts of invasive plants is fueled by conflicting terms, various metrics, small vs. large spatial scales, and types of invaders, and ecosystems being invaded. Recent research at the Arboretum suggests that debaters should *generalize* invader effects *only after* they differentiate the terms exotic and invasive, assess outcomes using species richness and species-area curves (not ratios of natives:non-natives), note the spatial scale being considered, and include aggressive invaders and wetlands in the range of outcomes.

## References cited:

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- Rojas-Viada, I. 2013. No scale-dependent effect of *Phalaris arundinacea* L. on plant diversity of sedge meadows. M.S. Thesis, UW-Madison.

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