Are invasive plants a threat to native biodiversity? It depends on the spatial scale

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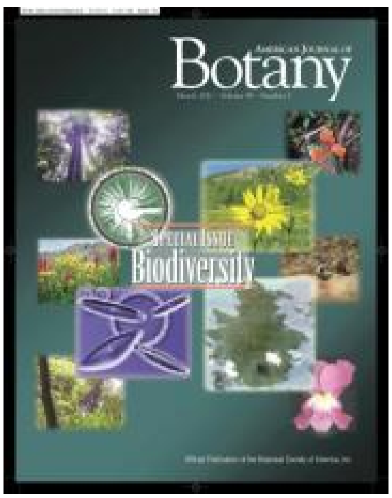

The study of biodiversity is fundamental to our understanding of life on Earth and to confronting some of the problems caused by our own species. Further, we increasingly count on biodiversity for a wide variety of ecosystem functions and services amidst a gauntlet of anthropogenic changes. In fact, biodiversity is disappearing at a rate even faster than the last mass extinction at the end of the Cretaceous Period, 65 million years ago, with possibly two thirds of existing terrestrial species likely to become extinct by the end of this century. This Biodiversity Special Issue looks at taxonomy and systematics, evolutionary biology and biogeography, ecology, and conservation/restoration, and the images on the cover represent these areas of focus. Credit: Various contributors to the Special Issue

The phrase "invasive plant species" typically evokes negative images such as broad swaths of kudzu smothered trees along the highway or purple loosestrife taking over wetlands and clogging waterways—and as such, invasive plants are largely viewed as major threats to native biodiversity. However, research has shown both that invasive species may be one of the most important threats to biodiversity and that plant invasions are rarely the cause for native species extinctions. How can these conflicting pieces of evidence be reconciled?

Kristin Powell, from Washington University, MO, was interested in determining whether some of the differences in the effects that invasive plant species had on biodiversity was in fact due to the spatial scales at which they were studied.

"Biological invasions are often thought to be one of the leading threats to global biodiversity," Powell comments. "However, recent studies and popular literature have begun to question this view, especially in the context of invasive plants, asking 'Are invasive species really that bad?' For example, invasive plants have never been implicated as the sole cause in driving a native plant extinct."

To tackle this apparent conundrum, Powell and her co-authors took a two-prong approach; first, they conducted a meta-analysis to synthesize results from as many previous studies on the subject as they could find, and then they developed a model to investigate mechanisms that might explain their results. They published their findings in the recent Biodiversity Special Issue of the *American Journal of Botany*.

Powell and her colleagues found 57 studies containing information on average species richness with and without invaders. They used a meta-analysis because it is a powerful tool that allows each study to be used as a separate data set, to some degree. By comparing the difference in species richness between plots with and without invasive plant species and regressing that against the studies' plot sizes the authors were able to see if a meaningful relationship existed between spatial scale and the effect of invaders.

Indeed, they found a negative relationship between area and species richness. While invasive plant species at small spatial scales (plots ^{2}) severely decreased native species richness, the impact of the invasive species decreased as the size of the study plot increased.

"Our meta-analysis reconciles the opposing views on invaders by finding that invasive plants cause a large loss in biodiversity at small scales, but this effect essentially disappears at broader scales," explains Powell. "That is, invasive plants are much more likely to cause extinctions at local but not regional or island-level spatial scales." Furthermore, while invasive species may lead to native plant extinctions at the local-level, it may take decades, centuries, or even longer for these plant species to become extirpated at the regional or global level.

How can this disparate effect of invasive plants at small versus large spatial scales possibly be explained?

To explore a potential mechanism for this effect, Powell and her colleagues developed a model based on the idea that invasive plants might change the abundance and structural pattern of native plants—depending on how many rare and common species are present—which in turn might explain these differences.

In the model the authors randomly assigned 150 native species to occupy a certain number of patches within a simulated area. Then an invading species took over 90% of the patches, causing almost half of the native species in each patch to decline to extinction. In some simulations the invader negatively impacted common species more than rare ones, and vice versa.

The authors found some very interesting results. At the local scale invading species always resulted in a loss of native species. However, the outcomes differed at the regional (larger) scale. When the invader impacted the common species more, diversity at the regional level was unaffected (it was the same in plots with or without invaders). But when rarer species were disproportionally affected, diversity at the regional level was much lower in invaded than uninvaded plots. Thus, as the effect of the invader changed from having proportionally greater effects on common to rare species, the potential for extinctions at the regional level increased, as long as there was a large number of rare species in the community.

In other words, in order for invasive species to drive native species extinct at the regional (or broader scale) level the model indicated that the system must have many rare species which are strongly and disproportionally influenced by invasive species relative to the more widespread, common species. In all other scenarios, invasive species would have bigger or similar impacts at the local rather than the regional scale – which is what the meta-analysis, based on the literature, also showed.

"It is not surprising that invasive plants cause larger declines in diversity at smaller spatial scales, as plant competition is a local, ecological process," Powell notes.

"One process that can lead to fewer native plant extinctions at broader scales is if invasive plants generally affect common species proportionately more than rare species" Powell states. "We are currently investigating if there are commonalities across several plant invasions in how strongly common versus rare plant species are affected by invasive plants."

Powell emphasizes that it is important to understand the local-scale processes that contribute to the loss of biodiversity from plant invasions and that future research should examine the impacts of invasives across local and regional spatial scales. "The local-scale reduction of diversity by invasives is also the scale at which ecosystem services can be altered by invasive species." Interestingly, one of the invasive species she and her colleagues have been studying, Amur honeysuckle, has been shown to decrease bird nesting success, decrease survivorship of frog tadpoles in nearby ponds, and increase the risk of tick-borne illness in humans. "Through local-scale effects, invasive plants can also alter population and meta-population dynamics of native species, which may lead to broad-scale extinctions in the future," Powell concludes.

More information: Powell, Kristin I., Jonathan M. Chase, and Tiffany M. Knight (2011). A synthesis of plant invasion effects on biodiversity across spatial scales. American Journal of Botany 98(3): 539-548. DOI: 10.3732/ajb.1000402

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