Calling time on alien plantscapes

Running title: Alien plantscapes

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This manuscript is under review in Global Change Biology and is a non-peer reviewed preprint submitted to EarthArXiv. Therefore, the final version of this paper may differ.

Key words: alien plants, biotic homogeneity, invasion debt, non-invasive, sense of place

Abstract

Both urban and rural environments around the globe have become dominated by alien plant species to the extent that plantscapes from one region or country have become difficult to distinguish from many others. This process of plant community homogenisation comes at a cost to cultural identity and undermines people's sense of place. Although invasive alien plant species have received considerable attention in recent decades, issues with non-invasive alien plant species have largely been ignored, and yet they contribute significantly to biotic homogeneity and impose an ever accumulating invasion debt: a debt that increases in proportion with their population sizes. By contrast, an abundance of native species in the places where people live is important for strengthening commitment to biodiversity conservation. Is there therefore sufficient evidence of harm from increasing numbers of non-invasive alien plants to justify local and central governments introducing measures to substantially reduce the proportion of non-invasive aliens in both urban and rural environments?

Main

Alien plant species are those that have crossed a biogeographic barrier with the help of humans. They are a driver of plant community homogenisation that is occurring across nearly all biomes and spatial scales (Daru et al. 2021). Alien species, both invasive and non-invasive, are so widespread and abundant they have led to the notion of the homogocene (Olden et al. 2018) where the loss of unique biotic character among regions and nations defines the age in which we live. In many parts of the world, they now greatly out-number indigenous species (Brandt et al. 2021).

People bestow important symbolic, aesthetic and cultural values on native species, and natural ecosystems contribute to a sense of place (Horwitz et al. 2001, Forristal et al. 2014). Biodiversity and its spatial distinctiveness have been regarded as essential if ecosystems are to provoke attachment and stimulate people's identification with particular landscapes (Horwitz et al. 2001). The outward expression of how native species are woven into society and a sense of place can be seen by the large number of logos, sport team mascots, and symbols of national identity that make use of them (Gascon et al. 2015). These symbols would not succeed if the species they depict did not resonate with people. Importantly, an abundance of native species in the areas where people live is important for expanding the public's understanding of biodiversity and strengthening societal licence and commitment to biodiversity conservation (Segar et al. 2022). The corollary is that because increasing urbanisation is driving declines in native biodiversity (Larson et al. 2022) and the majority of species within lived-in environments are often alien imports, people are becoming increasingly disconnected from natural ecosystems (McKinney 2006).

Some argue that biotic homogeneity is unimportant because alien species can possess functional traits that fulfil similar ecosystem services as native species (Leuzinger and Rewald 2021). However, alien plant species can alter trophic interactions, functional balances and whole ecosystem process (Badenhausser et al. 2022), and because all resources in an ecosystem are metabolised in some way, "every introduced species must affect at least the topology of energy flow and nutrient cycling" (Simberloff 1990). Moreover, the motivation for biodiversity conservation for most people is likely to be the aesthetic nature of distinctive communities rather than functionality.

Alien plant species that are also invasive can precipitate irreversible changes to ecosystems both above- and below-ground (Wardle et al. 2011), degrade community structures, alter soil properties and nutrient cycling, and cause fire and hydrology regimes to change (Weidlich et al. 2020). They continue to spread rapidly worldwide with no sign of abatement (van Kleunen et al. 2018b), threatening protected areas almost everywhere (Pyšek et al. 2020). In some cases fundamental ecosystem services, such as primary productivity, can be at risk from them (Wang et al. 2021).

Many alien plant populations remain benign for extended periods before crossing a viability threshold to become invasive. This lag phase from introduction to invasive status can vary from a few years to centuries (van Kleunen et al. 2018a). Factors enabling species to cross the viability threshold include rapid phenotypic evolution, changes in interspecific or intraspecific interactions, habitat modification, or shifts in climate regimes (van Kleunen et al. 2018a, Ziska et al. 2019, Pyšek et al. 2020, Brandt et al. 2021). The prevalence of extended lag phases has created considerable invasion debt throughout the world; the non-invasive alien plants currently cultivated will be a source of recruitment of invasive species for decades to come. Cultivation of plants in gardens is associated with increases in their abundance in the wider environment (Segar et al. 2022) and thousands of these species, including many that lack any history of invasiveness, are likely to become as ecologically damaging as the worst invaders are today (Pyšek et al. 2020). Importantly, it is propagule pressure due to the number of individuals and source populations of alien plant species that strongly predict the number becoming invasive (van Kleunen et al. 2018a, Blackburn et al. 2020, Pyšek et al. 2020).

Climate change will exacerbate the problem. Rising temperatures are imposing stresses on ecosystems, facilitating new invasive pathways and increasing the rate at which invasive species establish and spread (van Kleunen et al. 2018a, Pyšek et al. 2020). In the face of the strong adaptive pressure from climate change, alien species are often favoured by both their existing traits and by a greater capacity for rapid adaptive evolution than are native species (Walther et al. 2009, van Kleunen et al. 2018a, van Kleunen et al. 2018b, Ziska et al. 2019, Pyšek et al. 2020). Even among long-lived trees, with long generation times, adaptive evolutionary processes have been intensified within alien populations leading to rapid phenotypic and ecological evolution (Zenni et al. 2017, van Kleunen et al. 2018a).

The unprecedented pace of increase in the number of non-invasive alien plant species and their population sizes throughout the world is swelling the reservoir of invasion debt that will pump ever more invasives into the environment over the coming decades (Blackburn et al. 2020, Pyšek et al. 2020). Lag phases, rapid evolution and climate change are likely to make the identity of these future invasive species difficult to predict. By contrast, policy shifts that lower the proportion of non-invasive alien plant species in the environment would reduce invasion debt and decrease community homogeneity.

Given the importance of the abundance of native species in areas where people live for strengthening commitment to biodiversity conservation, plus the invasion debt and biotic homogeneity imposed by non-invasive alien species, is it incumbent on policy makers to consider introducing a suite of measures aimed at substantially shifting the balance of plants in the environment towards one favouring native species?

Policy and Management

Tools that local and central governments might employ to achieve a shift in the balance between alien and native plants in the environment could include: 1. legislation banning the propagation and sale of all alien plant species that can produce viable propagules; 2. importation bans on all alien species; 3. progressive replacement of alien plants on all public land with native species; 4. rules for developments restricting new planting to native species.

1. Legislation banning the propagation and sale of all alien plant species that can produce viable propagules

Horticulture is the dominant pathway for plant invasions; approximately 94% of naturalised plant species are grown in cultivation (Seebens et al. 2022). Among the alien species traded, those able to produce viable propagules demonstrate a higher risk of becoming invasive. If the sale and propagation of such species can be halted before they become intractably invasive, substantial future costs for control will be avoided. This approach would invoke the precautionary principle and treat alien species with a high risk of invasiveness as ‘guilty until proven innocent’ rather than waiting until it is certain that they have become invasive, by which time it is usually too late to eradicate them (Shrestha and Shrestha 2021).

New Zealand has a National Plant Pest Accord which is a voluntary agreement between the ornamental nursery industry and government that established a mechanism to ban alien plant species from sale or propagation. However, because the horticulture industry must agree to all such prohibitions, only 37% of the invasive alien plants with ornamental origin in New Zealand have been banned under this accord (Hulme 2020). The lack of effectiveness of this accord in even preventing the sale of already proven invasive species, let alone species at risk of becoming invasive, demonstrates the need for local or central governments to consider legislation that automatically bans alien plant species from sale or propagation that have either naturalised or have shown signs of naturalising by successfully producing viable propagules within their introduced range. Exceptions would be needed for plants that are essential for food production or carbon farming.

2. Importation bans on alien species

Despite increasing awareness of the issues due to introducing new alien species, alien plant imports will continue to increase throughout the world under current policy frameworks (Seebens et al. 2022). Many jurisdictions have bans on the importation of specific taxa known to be invasive and broader bans, such as for all genera of cacti known to include invasive species, have been proposed (Novoa et al. 2015). However, import bans for specific invasive taxa are problematic and expensive to enforce due to the difficulty in distinguishing many non-invasive species from invasive ones (Damayanti et al. 2021). This approach also does not provide any protection from the plethora of taxa that currently lack any history of invasiveness but are likely to become invasive in the future (Pyšek et al. 2020). The demand for a continuous supply of new and exotic ornamental species by home gardeners and the ornamental horticultural industry is generated by desire, not need, and given that the future costs on the environment due to invasion debt are not covered by end users or the industry, there is good reason to discontinue this trade. New Zealand has led by banning all imports of alien species not already within the country (Hulme 2020). It maintains a list of species, currently within its borders, that are permitted imports. Any species not on this list must undergo a rigorous risk assessment before an import permit is issued. This is a preferable approach to that of maintaining lists of banned taxa that are inevitably incomplete (Hulme 2020). However, risk assessments do not ensure zero risk and they fail to address the problem of increasing biotic homogeneity and of declining biotic identity of place. Given that there is no pressing need for importing alien species, simple outright bans would be preferable and might be considered by jurisdictions throughout the world.

3. Progressive replacement of alien plants on all public land with native species

Alien plant species have dominated urban plantings for many decades, but in parts of the world such as in Europe, North America and Australasia there are movements to encourage representation of native plant species within urban communities (Ignatieva and Stewart 2009). For example, in Wellington, New Zealand, threatened native plants are included in city plantings (Sawyer 2005), and in Canada there is an increasing emphasis in urban management plans for planting native species. However, despite these plans, alien species are often still planted in preference to natives (Ordóñez and Duinker 2013, Almas and Conway 2016).

Governments (local, regional and central) could move well beyond encouraging native planting and actively seek to redress the balance between alien and native plants on both urban and rural public land by introducing polices to progressively replace non-invasive alien plant species with native ones. Exceptions would be needed for plants that are grown for food or carbon farming, or that have significant scientific or historic importance. The cost of removing non-invasive aliens will be far less than invasives because after removal non-invasives will not re-establish and therefore not require ongoing control costs. Substantial future savings will occur due to reduced invasion debt.

4. Rules for private developments restricting new planting to native species.

There is an increasing number of programmes, such as the Gardens for Wildlife in Australia, that encourage higher native plant diversity in home landscaping (Larson et al. 2022). In the United States there are at least 193 voluntary initiatives promoting increases in native species richness (Pham et al. 2022). However, little consideration has been given to mandating conditions on new developments that restrict planting to native species. In New Zealand, several district councils (local government entities) have rules requiring native planting in new housing developments. For example, Dunedin District Council requires a minimum of one planted native tree for every 250 m^2 of land plus "where the site adjoins a road, at least 50% of the land within the road boundary setback must be planted with trees, shrubs or groundcover species that are native to New Zealand" (Rae et al. 2022). However, the rule does not prevent people from also planting alien species. Local governments throughout the world should consider introducing rules for new housing and commercial developments that require the planting of native species and prohibit planting of alien species other than those used for food production.

Conclusion

An abundance of native species in areas where people live is important for enhancing the public's commitment to biodiversity conservation whereas non-invasive alien plant species impose a future invasion debt on natural ecosystems and contribute to biotic homogeneity. If policies that reduce the proportion of non-invasive alien plant species on public and private land, and that turn off the tap for new introductions, were implemented, it might be possible to look forward to reduced invasion debt, and to plantscapes with less homogeneity and greater native diversity.

Declarations

The author declares no competing interests. The author wrote the paper. There are no data associated with this paper.

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