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Perspective essay

Managing invasive species in cities: A framework from Cape Town, South Africa

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HIGHLIGHTS

- Existing invasive species management frameworks are inadequate in urban areas.
- Urban stakeholders often hold conflicting views and are critical of management.
- Divergent stakeholder perceptions need to be considered explicitly and transparently.
- Urban management frameworks should allow for acceptance of some invasive species.

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ABSTRACT

Invasive non-native species are often more prevalent in cities than in rural areas because of numerous environmental disturbances and higher propagule pressure. Attempts to manage invasive species in cities are often controversial because of the diversity of stakeholder views. Until now, however, environmental managers in cities have managed invasive species using approaches and paradigms developed for a rural context, despite the radically different socio-environmental conditions that prevail in cities. We examine the case of Cape Town, South Africa, a rapidly growing metropolitan centre within a global biodiversity hotspot and a developing country, to underline the considerable challenges and complexities of managing invasive species in cities. We argue that traditional management approaches need to be supplemented by consideration of stakeholder views and the social consequences of management actions. We present a framework for selecting appropriate goals for the management of invasive species, ranging from eradication to acceptance.

1. Introduction

Invasive non-native species (*sensu* Richardson, Pyšek, & Carlton, 2011; hereafter 'invasive species') are often abundant in cities (Kowarik, 2011). Cities contain a high density of people and they are hubs of human-mediated movement of commodities. Transport linkages (e.g., airports and harbours) facilitate the introduction and dissemination of non-native species through dispersal pathways such as trade, tourism, and horticulture (Dehnen-Schmutz, Touza, Perrings, & Williamson, 2007); such activities release high numbers of individuals into a region (high 'propagule pressure,' see Lockwood, Cassey, & Blackburn, 2005). In cities these non-native species encounter habitats, soils, climatic conditions and hydrology that have been profoundly changed by human activity and that can promote their spread if they are pre-adapted to similar conditions in their region of origin (Pickett et al., 2001; Kowarik, 2011). Urban heat-island effects, for example, may facilitate the spread of invasive species (Nobis, Jaeger, & Zimmermann, 2009). Also, typical urban conditions such as fragmented habitats and altered disturbance regimes often favour non-native species (Cilliers, Williams, & Barnard, 2008; Zisenis, 2015). In Central Europe, most urbanophilic non-native plant species can be found in inner city areas, which

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provide suitable conditions for plant species that tolerate or even thrive when temperatures are warmer and disturbances more frequent (Klotz & Kühn, 2010). In short, many non-native species are more prolific in cities because long histories of human dispersal, disturbance and habitat modification enhance their opportunities for establishment, proliferation and spread.

Invasions pose well-documented risks in both natural and semi-natural habitats and in both protected areas and public open spaces. Invasive species may displace native species and contribute to homogenization of habitats within cities (Burton, Samuelson, & Pan, 2005; Kühn & Klotz, 2006; McKinney, 2006; Trentanovi et al., 2013). Ornamental invasive plant species in gardens act as significant sources of non-native propagules (Alston & Richardson, 2006; Bowers, Bean, & Turner, 2006), and non-native animals kept as pets can establish and become invasive (van Wilgen & Richardson, 2012). Invasive species in cities may also disrupt important ecosystem services such as water filtration, flood attenuation and coastal protection. Invasive plants can clog streams and canals, resulting in flooding, and they may also increase fire severity and soil erosion risk (van Wilgen & Scott, 2001). Although some invasive species were introduced to provide particular ecosystem services, such as trees for timber production or erosion control, their subsequent spread and proliferation may ultimately have a net detrimental effect (e.g. van Wilgen, Reyers, Le Maitre, Richardson, & Schonegevel, 2008; Vilà et al., 2009). Invasive species may also affect urban biodiversity in ways that reduce human well-being more directly, for example by changing the aesthetics of the environment (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007; Kowarik, 2011). For all of these reasons, policies are in place in many parts of the world to manage invasive species in parks, public areas and other urban zones. Despite growing concerns about invasive species, some authors argue that we may, in some instances, have to learn to "cohabitate" with them in cities (e.g., Foster & Sandberg, 2004). Even if an invasive species disrupts an ecosystem service, it may also be beneficial. Studies in urban forests in Florida, for example, have shown that invasive trees were most successful in sequestering CO_2 (Escobedo, Varela, Zhao, Wagner, & Zipperer, 2010).

As another example, studies from northern parts of South Africa show that invasive *Eucalyptus* trees are used extensively as roosting sites for the vulnerable Lesser kestrel (*Falco naumannii*) and as breeding sites for the African fish eagle *(Haliaeetus vocifer*) (Cilliers & Siebert, 2012). Managing invasive species in urban areas is sometimes further complicated by the cultural connections that people have forged with them. Just like native species, invasive species can become associated with a place and be regarded as culturally important by some city inhabitants (Warren, 2007).

Stakeholders in cities often have strongly divergent views about the impacts and benefits of particular invasive species, so conflicts over the management of invasive species are emerging (e.g., trees, Dickie et al., 2014). In particular, invasive species may provide provisioning ecosystem services, but at the expense of various elements of biodiversity, which can lead to conflicts over whether to manage for the former or the latter. Such conflicts exemplify the extent to which invasive species management, especially in human-dominated areas, is increasingly viewed as a "wicked problem" (Rittel & Webber, 1973) because sometimes there are no straightforward "win-win" solutions. A particular problem is that even if an invasive species is "accepted" (i.e., not regulated or targeted for containment or control) within a city environment, such acceptance may pave the way for its spread into adjacent rural landscapes where it may have substantial negative impacts (Botham et al., 2009; Moreira-Arce, de la Barrera, & Bustamante, 2014).

In this paper, we explore the challenges and complexities of managing invasive species in cities by examining the exemplary case of Cape Town, South Africa. Cape Town is a rich case study for elucidating the complexity of managing invasive species in cities because it highlights several interwoven social and ecological dimensions.

We use this city to highlight challenges that will be faced by an increasing number of cities given ongoing urbanization and growing human populations.

Our objectives are to utilize this case study: (1) to review the challenges faced by managers who seek to control invasive species in an urban environment; and (2) to develop a framework to assist environmental managers globally as they seek to integrate a range of management options for invasive species in urban systems to deal with diverse and often conflicting views of what is appropriate.

2. The case of Cape Town, South Africa

Cape Town's conservation significance derives from its location in the Cape Floristic Region, a global centre of plant endemism (Cowling, Rundel, Lamont, Arroyo, & Arianoutsou, 1996). The city (2445 km^2) includes Table Mountain National Park (221 km^2), as well as 17 smaller nature reserves and 500 biodiversity network sites that together cover 270 km^2. It has a population of 3.8 million people and is growing more rapidly than any other southern African metropolis on a per capita basis (Boraine et al., 2006), especially within its poorer suburbs ("townships") which have experienced an influx of mainly Black citizens following the collapse of apartheid. At present, 26% of Cape Town is urban, 35% is agricultural, and 39% is natural and semi-natural vegetation concentrated in mountainous areas (mainly within Table Mountain National Park) (Fig. 1). Many lowland areas have been transformed, with remnants being highly threatened and thus having become a priority for conservation (Rebelo, Holmes, Dorse, & Wood, 2011). Cape Town remains a focal point of the national economy and international tourism, and thus faces ever-growing needs for housing, transport networks and trade. The fact that Cape Town has high levels of human population growth, unemployment and crime adds dimensions of complexity.

Nonetheless, many of Cape Town's citizens are involved in conservation initiatives, such as "Friends" groups for nature reserves and various conservation stewardship and citizen science initiatives (e.g., spotter networks for emerging invasive species, see http://www.capetowninvasives.org.za). Cape Town has a long history of European colonization and the associated introductions of non-native species present a significant challenge to people and landscapes (van Wilgen, 2012) (Fig. 2). For example, invasive tree species such as pines (*Pinus* species), grown in plantations, and Australian wattles (*Acacia* species), planted mainly along the coast for dune stabilization, have spread widely into natural vegetation. Aquatic invasive species such as Water hyacinth (*Eichhornia crassipes*) block waterways and affect water quality (Richardson & van Wilgen, 2004).

The trade in ornamental plants and pets, and other enterprises that rely on non-native taxa, continue to introduce new species into the city; many of these remain undetected and/or unregulated. Some invasive plant species pose serious risks to humans; for example, invasive pines and wattles increase the severity of wild fires near residential areas (Fig. 1) (van Wilgen & Scott, 2001).

The Department of Environmental Affairs is responsible for the overall administration of the National Environmental Management: Biodiversity Act (NEMBA), which places obligations on all landowners and all organs of state, including the City of Cape Town, with regard to the management of invasive species. Invasive species control programs date back to the 1940s (Macdonald, Clark, & Taylor, 1989), and in 2008 the city established an Invasive Species Management Unit, with an annual budget of about 84,000 USD and one semi-skilled team. Since then the program has grown to include areas managed by multiple departments within the city.