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Research article

A framework for engaging stakeholders on the management of alien species

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ABSTRACT

Alien species can have major ecological and socioeconomic impacts in their novel ranges and so effective management actions are needed. However, management can be contentious and create conflicts, especially when stakeholders who benefit from alien species are different from those who incur costs. Such conflicts of interests mean that management strategies can often not be implemented. There is, therefore, increasing interest in engaging stakeholders affected by alien species or by their management. Through a facilitated workshop and consultation process including academics and managers working on a variety of organisms and in different areas (urban and rural) and ecosystems (terrestrial and aquatic), we developed a framework for engaging stakeholders in the management of alien species. The proposed framework for stakeholder engagement consists of 12 steps: (1) identify stakeholders; (2) select key stakeholders for engagement; (3) explore key stakeholders' perceptions and develop initial aims for management; (4) engage key stakeholders in the development of a draft management strategy; (5) re-explore key stakeholders' perceptions and revise the aims of the strategy; (6) co-design general aims, management objectives and time frames with key stakeholders; (7) co-design a management strategy; (8) facilitate stakeholders' ownership of the strategy and adapt as required; and (9) implement the strategy and monitor management actions to evaluate the need for additional or future actions. In case additional management is needed after these actions take place, some extra steps should be taken: (10) identify any new stakeholders, benefits, and costs; (11) monitor engagement; and (12) revise management strategy. Overall, we believe that our framework provides an effective approach to minimize the impact of conflicts created by alien species management.

1. Introduction

Over the past centuries, humans have moved species to regions

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outside their native ranges. This has been done for a range of reasons including purposefully for agriculture, aquaculture, forestry, ornamental horticulture, the pet trade, and recreation; and accidentally through ballast water, fouling or concealment in transported goods (Mack, 2003). Many of these introductions were, and remain, desirable (indeed indispensable) for humans, and include the staple food crops in most countries. These can be called "desirable species" due to the benefits they provide and the low or no costs they have (Ewel et al., 1999). Other introduced species provide few or no benefits (Shackleton et al., 2007; van Wilgen and Richardson, 2014) and are environmentally inconsequential – e.g. insects that are transported by boats between continents and which do not survive in the introduced area.

However, a small proportion of all alien species become invasive (i.e. reproduce and spread over substantial distances from introduction sites; Blackburn et al., 2011). Such growth and spread sometimes results in negative impacts, but even if there is no spread, alien species can be "undesirable" (Fig. 1). Impacts caused by invasive species (and occasionally alien species which are not invasive) include changes to ecosystem services (such as water or grazing supply), changes to ecosystem processes (such as fire and nutrient cycling), reductions in biodiversity, and negative effects on local economies and livelihoods (Levine et al., 2003; Le Maitre et al., 2011; Jeschke et al., 2014; Shackleton et al., 2014). For example, the perennial herb *Chromolaena odorata* in South Africa prevents the establishment of native plants, reduces grazing ground for native animals, alters natural ecosystem processes, alters features of fire regimes, causes negative impacts on forestry and crop plantations, reduces pasture carrying capacities, and is toxic to humans and animals (Goodall and Erasmus, 1996; te Beest et al., 2015). In New Zealand, the black rat (*Rattus rattus*) causes substantial declines in native plant and animal populations (Caut et al., 2008), damages agricultural crops and carries human-threatening diseases (Russell et al., 2008). Effective management of such undesirable species often requires the engagement of all stakeholders, to ensure that all relevant ecological and socioeconomic dimensions influencing the management are addressed (Liu and Cook, 2016). A management strategy designed and implemented without engaging all stakeholders can be controversial and might be challenged, ultimately reducing the efficiency of management efforts (Crowley et al., 2017a). For example, an aerial spraying program aimed at eradicating the light brown apple moth (*Epiphyas postvittana*), a major threat to agriculture in northern California, was challenged by a popular opposition movement which was concerned that the spray might pose a risk to human health (Lindeman, 2013). In this case, the strategy adopted for the management of the alien species created a conflict.

Some alien species, in addition to incurring costs, provide benefits and are, therefore, embraced by certain stakeholders (e.g. Dickie et al., 2014; Kull et al., 2011; Novoa et al., 2015a; Shackleton et al., 2007, 2014; van Wilgen and Richardson, 2012). Alien species with both benefits and costs ("conflict species", Fig. 1) usually lead to conflicts around both their use and management (Dickie et al., 2014; Novoa et al., 2015b; Shackleton et al., 2014; Stanley and Fowler, 2004; van Wilgen and Richardson, 2012, 2014; Woodford et al., 2016). For example, several tree species in the genera *Acacia*, *Pinus* and *Prosopis*, which are highly invasive in many areas of the world, are extensively used in the forestry industry and for agroforestry and silviculture by farmers and rural communities (Kull et al., 2011; Moran et al., 2000; Shackleton et al., 2014). Furthermore, many alien plant invasions that have arisen from 'escaped' horticultural introductions (e.g. the jacaranda tree *Jacaranda mimosifolia* in South Africa, the African tulip tree *Spathodea campanulata* in Fiji and the saltcedar *Tamarix ramosissima* in the USA), have substantial intrinsic and aesthetic value for some stakeholders (Dehnen-Schmutz and Williamson, 2006; Dickie et al., 2014). Several invasive animals [e.g. the Mediterranean mussel (*Mytilus galloprovincialis*) in South Africa and feral pigs (*Sus scrofa*) in the USA] and plants [e.g. prickly pear (*Opuntia* spp.) in Australia and Spain, guava (*Psidium* spp.) in Mauritius and brambles (*Rubus* spp.) in Australia, New Zealand and the USA] are used for food (Cole et al., 2012; Naylor et al., 2001; Novoa et al., 2015a; Robinson et al., 2005; Stanley and Fowler, 2004) and numerous invasive fish species [e.g. the rainbow trout (*Oncorhynchus mykiss*) in Australia, Europe or South Africa] are popular both for food and for sport fishing (Cambray, 2003).

The categorisation of species as inconsequential, desirable, undesirable, or conflict can also change over time (Shackleton et al., 2007). For example, the following species have all become undesirable over time as they have started to spread and caused negative impacts: (1) inconsequential species [e.g. parthenium (*Parthenium hysterophorus*) in eastern and southern Africa (McConnachie et al., 2011) and the red imported fire ant (*Solenopsis invicta*) in the USA (LeBrun et al., 2012)], (2) desirable species [e.g. boneseed (*Chrysanthemoides monilifera*) in Australia (Downey, 2010) and the erect prickly pear (*Opuntia stricta*) in South Africa (Foxcroft et al., 2004)], and (3) conflict species [e.g. mesquite (*Prosopis* spp.) in South Africa (Shackleton et al., 2014) and the silver wattle (*Acacia dealbata*) in Spain (Lorenzo et al., 2010)]. Similarly, a desirable species might become a conflict species [e.g. the prickly pear (*Opuntia ficus-*

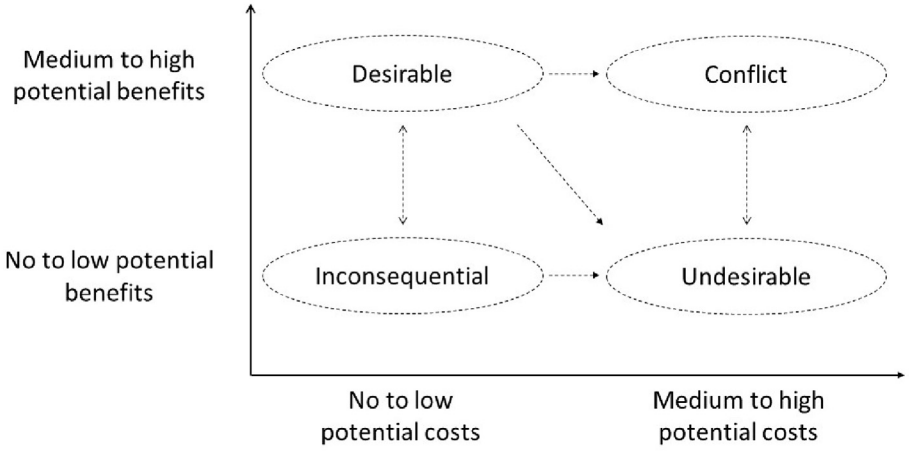

Fig. 1. Classification of alien species based on their potential benefits and costs for society. Arrows indicate potential category changes for a particular species over time.