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Viewpoint

Facing the broader dimensions of biological invasions

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ABSTRACT

Invasive species are an excellent opportunity to think about the nature society desires, particularly in the face of global changes. Nature and human views of nature are rapidly evolving; our approach to biological invasions through biosecurity institutions and land management policies must evolve in tandem with these changes. We review three dimensions that are insufficiently addressed. *First*, biological invasions are culturally shaped and interpreted. Humans play a major role in the movement and nurturing of alien life, and esthetics, perception, and emotion are deeply implicated in the management of invasive species. What people fear or regret with invasive species are not their effects on nature per se, but their effects on a particular desired nature, and policymaking must reflect this. *Second*, biological invasions are not restricted to negative impacts. Invasions take place in landscapes where many natural conditions have been altered, so policy tools must recognize that invasive species are a functional, structural, and compositional part of transformed ecosystems. In some cases, native species benefit from changes in resource availability caused by invasions or from protections provided by an invasive plant. *Finally*, invasive species can help ecosystems and people to adapt to global change by maintaining ecosystem processes such as productivity, carbon storage, and nutrient cycling in a context of climate change or land cover transformations. While recognition is growing among ecologists that novel, invaded ecosystems have value, and while the on-the-ground application of biosecurity policies has of necessity adjusted to local contexts and other agendas, invasion biology could aid policymaking by better addressing the three complexities inherent in the three dimensions highlighted above.

Introduction

The emergence of the term 'biosecurity' and its incorporation into legislation, policy instruments, and institutional structures in many countries over the past two decades signaled an intensified focus on invasive species. Threats as diverse as disease epidemics, food safety, agricultural pests, and environmental weeds are lumped together under 'biosecurity' with an associated sense of urgency (Bingham et al., 2008; Dobson et al., 2013; Barker, 2008).

Yet, managing and legislating for the control of biological invasions in the broader landscape are quite different than dealing with the specific, human health and economic threats of H1N1, foot and mouth disease, or fruit flies. The concept of biological invasions evokes a tension between what nature *is* and what nature *ought to be*. Yet nature is changing, and what nature ought to be is changing as well, in response to the evolution of human society and our views of nature. As such, the concept of biological invasions must be considered by policy makers as an unstable, evolving concept requiring place-based deliberations of values and interests as well as global-scale science.

Vigorous debate has engulfed the field of invasion biology since the 50th anniversary of the seminal work of Elton (1958), with tensions between those who consider that the spread of alien species is categorically undesirable, and others who think that invasive organisms should instead be assessed on their environmental effects (Davis, 2009). While the majority of arguments are restricted to the terrain of neutral scientific language, some suggest that invasion biologists need to more explicitly recognize the value systems that influence their work (Rozzi, 1999; Larson, 2005; Kueffer, 2013; Humair et al., 2014). Furthermore, it is increasingly pointed out that invasive species must be investigated in the context of rapid change, ecological novelty, and global transformations to climate and land cover (Larson et al., 2013; Thomas, 2011). From such perspectives, invasive species and the new ecosystems to which they contribute may potentially be considered as 'good'.

The aim of this short review is to argue that to adapt to our changing world, and as such to promote more pertinent policies on

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biosecurity and environmental management of living species, we should reevaluate invasive species. We address three new facets of biological invasions: their cultural dimension, their potentially positive environmental effects, and the benefits they can provide in a context of global change (i.e. climate and land cover change), before concluding with some policy recommendations.

Recognizing the cultural dimension of biological invasions

Biological invasions are both biological phenomena (movements, distributions, and community dynamics of species) and cultural phenomena (how people – including scientists – in different places facilitate, are affected by, interpret, react to, label, and judge invasions and the landscape changes they induce or represent). This is quite different from saying that biological invasions have a cultural impact: this is to say that they *are* cultural. Reducing such hybrid phenomena to purely biological aspects is appealing for strictly focused research on species redistribution or ecological interactions, but useless for policy makers. Decisions on funding, management and research topics regarding invasive species are made by people, who as social beings, necessarily mobilize cultural references (Rozzi, 1999; Hall, 2003; Larson, 2005; Rotherham and Lambert, 2011). Cultural considerations – which are dynamic in themselves (Starfinger et al., 2003; Stromberg et al., 2009) – are inextricable from the science and management of invasions in at least three ways.

First, perceptions and esthetics play a major role in the treatment of particular species. Some are highlighted as invaders primarily because they are ugly, annoying, noxious, or highly visible. For instance, the decision to manage purple loosestrife (*Lythrum salicaria*) in North America was mainly based on esthetic considerations (Hager and McCoy, 1998), or Europe's efforts to control ragweed (*Ambrosia artemisifolia*) are justified through its strong allergic impact (Fried, 2012). Other actions to control invasive plants are based on the perception that they cause extinctions, despite the fact that such extinctions do not appear to be occurring (Powell et al., 2013).

Conversely, other invaders are downplayed because they are attractive, useful, or scarcely noticed. Plans to kill feral mammals (e.g. camels in Australia, deer in New Caledonia, gray squirrels in Europe, mountain goats in America's Olympic National Park), or to remove alien trees (e.g. eucalypts in the San Francisco bay area) encounter opposition from the public (Stokes, 2007). Australian Aborigines have been known to resist eradication programs of feral species, believing that the worth of a species lies in its ability to flourish in an environment, not in its claim to being an original inhabitant (Warren, 2007).

Second, different parts of the world have different 'environmental imaginaries', or cultural ways of understanding their interactions with the environment, shaped by history, politics, and geography (Peet and Watts, 1996). As a result, different discourses about invasive species are current in different places. South Americans, for instance, tend to be less concerned about biological invasions than people from Anglophone settler colonies (Speziale et al., 2012). Environmental imaginaries also influence the use of arbitrary thresholds like national borders and historical dates to separate natives from exotics (Head, 2012). Such thresholds can result in perceptions of national or regional ecological integrity that shape whether species are treated as exotic or not. One can also imagine alternative discourses that are compatible with incorporating new species (Kueffer and Kaiser-Bunbury, 2013), metaphors such as 'melting pot' landscapes (Kull et al., 2013) or 'novel ecosystems' (Hobbs et al., 2006; Hobbs et al., 2013).

Third, reliance on words and labels inevitably makes invasion biology cultural. The discursive impacts of categories like 'invasive' and 'alien' are profound, stirring up emotions via anxiogenic metaphors. Discourses on invasive species commonly use military, medical or xenophobic references that are not neutral and cannot be discounted as simply scientific terminology (Larson, 2011; Tassin and Kull, 2012). They represent values that are rarely explained, inspired by certain moral imperatives about what nature ought to be. Unsurprisingly, there are numerous stories about indigenous peoples who take offense of the way language about invasive species shifts attention away from the colonizing people who have brought much greater ecological impacts to their lands and lives (Larson, 2005).

Environmental managers and policy makers working in specific landscapes already recognize many of these cultural aspects, as their work necessarily confronts different interests and viewpoints on the ground (Atchison and Head, 2013). However, much higher scale policy and science confront these cultural issues only with the suggestion that 'awareness' be increased, presuming that people will come around to the dominant scientific point of view (Rotherham and Lambert, 2011). What is necessary instead is recognition that other politics, interests, and agendas in each particular national and local context will re-shape the categories, debates, and policy possibilities (Forsyth, 2005; Barker, 2008; Fall, 2013).

Recognizing the positive effects of biological invasions

Invasive species can endanger native species through predation, herbivory, disease transmission, hybridization and competition, and they can alter the functioning of ecosystems, affect human health, and result in great economic losses (Vitousek et al., 1997; Pimentel et al., 2000). These kinds of impacts have led scientists and managers to focus on the negative aspects of invader-driven catastrophes. Indeed, many studies on invasive species appear biased toward negative impacts (Pysek et al., 2008). Yet a holistic view of the ecological consequences of biological invasions would also include positive impacts. As biological invasions become ever more common in a world where many natural conditions have been altered, any assessment must recognize that invasive species are a functional, structural and compositional part of the invaded or restored ecosystems (Van Riel et al., 2000; Marris, 2009; Ewel and Putz, 2004). For instance, the potential benefits of plant invaders on native species have been largely under-appreciated (Lugo, 2004; Goodenough, 2010; Schlaepfer et al., 2011; Eviner et al., 2012; Lugo et al., 2012; Rodewald, 2012). We briefly review some of these positive impacts here.

In numerous cases, native species benefit from an increase in resource availability after an invasion due to the diversification, enhancement, or replacement of food sources. Native phytophagous insects are increasingly colonizing non-native plants, demonstrating rapid adaptations and becoming model systems for evolutionary biology (Jahner et al., 2011). Waterfowl communities along the mid-Atlantic coast of United States thrive due to the exotic aquatic plants *Hydrilla verticillata* and *Myriophyllum spicatum* (Rybicki and Landwehr, 2007). In Africa, the invasive tree tobacco (*Nicotiana glauca*) greatly increases the local abundance of sunbirds compared with un-invaded areas (Geerts and Pauw, 2009).

Another kind of positive impact is when populations of an endangered species depend on invasive plants providing food sources (Schlaepfer et al., 2011). In subtropical Australia, the vulnerable rose-crowned fruit dove (*Ptilinopus regina*) eats winter fruit from invasive stands of camphor laurel (*Cinnamomum camphora*) and may have been rescued from extinction thanks to this resource (Neilan et al., 2006). Due to their phenology, plant invaders may also extend the seasonal availability of food resources. In the foothills of California's Sierra Nevada, introduced horticultural plant species