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In everybody's backyard? Examining the intersection of invasive alien species and environmental justice

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ABSTRACT
This paper explores the development of scholarship examining invasive alien species and their impacts from an environmental justice perspective. As the scope of the environmental justice field grows to encompass considerations of ecological integrity, invasive alien species should be part and parcel of this discourse, because they have the potential to harm human health directly and interfere with ecosystem services upon which vulnerable groups sometimes rely. Further, invasive alien species might cause environmental justice issues at the international level, as developing countries are likely at greater risk from their impacts. We propose that research should investigate the distribution of direct impacts from invasive alien species, as well as those via changes of ecosystem functioning and services, across different socioeconomic populations. We highlight the need for a holistic approach to understanding these impacts that includes environmental justice concerns and recommend the development of a framework that would enable consideration of cultural, ecological, economic, and social issues involved in the management of invasive alien species.

KEY WORDS
developed countries, developing countries, ecological integrity, ecosystem services, environmental justice, invasive alien species

As the field of environmental justice continues to grow and expand, there is increasing interest in examining how anthropogenic changes to the environment are playing out across human communities typically affected by environmental justice concerns. Recent papers by Neimanis et al. (2012) and Schlosberg (2012) have sought to expand the scholarship of the environmental justice discourse by integrating the concept of "ecological integrity". Within the context of a recent workshop entitled, *Environmental Justice, 'Collapse' and the Question of Evidence*, we examine the possible intersections between the fields of invasion science and environmental justice. Invasive alien species (IAS) represent complex problems in the field of conservation biology and are often seen as a threat to ecological integrity. The term IAS reflects the potential threat these species pose to biodiversity and human well-being, but their impacts are not always negative (e.g., Gozlan et al. 2010; Schlaepfer et al. 2011). The Neimanis et al. (2012) paper performed a review of the environmental justice literature and found that ecological considerations in general are rarely used to define environmental justice**.** As that study did not specifically examine IAS, we performed an informal survey of the literature using the keywords "invasive species" and "environmental justice" using Google Scholar and our institution's EBSCO[1] subscription and found very few studies that discuss IAS within an environmental justice perspective (or vice versa), indicating that these two fields have yet to be linked in a significant way.

This paper is intended to be an initial exploration of the potential overlaps between the fields of invasion science and environmnental justice. After a brief explanation of the various terms used in the fields, we draw on existing studies to examine how the direct impacts of IAS could affect vulnerable populations. We then explore how IAS affect ecological integrity and what that can (could) mean for environmental justice. Lastly, we consider the positive effects IAS may sometimes have and the role these could play in future scholarship. In so doing, we strive to identify possible areas of research which could enrich both fields and help us better understand and manage the challenges related to IAS in a manner that is cognizant of environmental justice issues.

EXPLAINING TERMINOLOGY

As a first step in this exploration, we provide some background on the various terminologies often encountered in the two literatures. In invasion science, different terms are used to describe species in various stages of establishing themselves in new environments. For the most part, the terms *non-native*, *introduced*, *alien*, *exotic* refer to organisms introduced via human activity to areas not considered part of their native habitat or dispersal range (Falk-Petersen, Bøhn, & Sandlund, 2006; Humair, Edwards, Siegrist, & Kueffer, 2014; Sax, Stachowicz, & Gaines, 2005). Once a group of non-native organisms has begun to reproduce and create a self-sustaining population, it is considered *established* or *naturalized* (Falk-Petersen et al., 2006; Sax et al., 2005; Walther et al., 2009). *Invasive* species are a sub-group of those established organisms that are spreading rapidly in new habitats and causing some type of damage to ecosystems, economic infrastructures, or human health (Humair et al., 2014; Info Flora, 2015; Sax et al., 2005). This aspect of causing harm makes biological invasions arguably relevant for environmental justice as impacts are likely not distributed equally across different social groups. The term *invasive alien species* highlights those species that are both non-native and invasive, to differentiate such species from native species that display invasive characteristics after other changes in their local environments (Valery, Fritz, Lefeuvre, & Simberloff, 2009). We will use the term invasive alien species (IAS) in this paper.

The term *environmental justice* describes a field of inquiry that developed out of the realization that certain groups in society often bear a disproportionate burden of environmental problems, such

[1] EBSCO is a subscription-based search engine for scholarly articles commonly used by research libraries and is run by EBSCO Industries (www.ebsco.com).

as pollution (Mohai, Pellow, & Roberts, 2009). These groups are neither responsible for the problems they have to deal with nor do they have the political capital to fight against the groups responsible for the problems. Even though environmental justice issues existed long beforehand, the field itself developed out of a controversy caused by a planned hazardous waste landfill in a predominately African-American county in the rural United States. The outcry over the landfill in Warren County, North Carolina inspired studies that found that poor minority communities were shouldering a large share of America´s hazardous waste (e.g. USGAO 1983; United Church of Christ Commission for Racial Justice 1987; Lee 1992). Scholarship in the field grew rapidly and environmental justice scholarship uncovered issues affecting other types of vulnerable groups, such as children, the elderly, and indigenous communities, in other regions of the world, and involving other environmental issues, such as climate change (Mohai et al., 2009; Schlosberg, 2013).

HUMAN HEALTH IMPACTS

The early environmental justice scholarship examined the direct impact of certain environmental problems (primarily exposure to toxic waste) on vulnerable communities. Similarly, we start our exploration with an examination of the direct human health impacts of IAS and how they (could) appear through an environmental justice lens. IAS can directly affect human health in a variety of ways, such as by transmitting disease, causing physical harm, triggering allergies, and creating toxins (Pyšek & Richardson, 2010). Thus, it can be insightful to examine the potential impacts of IAS on local vulnerable communities. In Switzerland, 15 of the 40 plant species listed as invasive in 2015 have the potential to harm human health (Info Flora, 2015). These include the common ragweed (*Ambrosia artemisiifolia*), whose pollen is a potent allergen, and the giant hogweed (*Heracleum mantegazzianum*), which contains a compound that can cause severe skin irritations. The effects from these plants do not discriminate per se: allergenic pollen floats through the air and toxic plants can affect all who come into contact. Nonetheless, there are likely environmental justice issues embedded in these effects. First, many of the listed plants are ornamental and have been intentionally brought into the country to decorate public and private spaces. Specific groups are likely responsible for their introduction but may not be the same groups bearing the impacts from the introductions. Further, as previous research has found that economically disadvantaged populations in Switzerland experience health inequalities, including higher risks for respiratory disorders (Reich, Wolffers, Signorell, & Blozik, 2014), there is arguably a need to assess if the health impacts from IAS represent an unfair burden to the already disadvantaged populations. Important aspects that assessments need to consider include what access different groups have to (a) information about the risks associated with these invasive species, particularly with respect to education level, and (b) medical care to deal with health impacts resulting from exposure.

ECOLOGICAL IMPACTS

Invasive alien species are perhaps more known for their ecological impacts. They can affect local ecological communities in various ways, such as via direct predation on, or competition and hybridization with native species, by introducing new diseases, and altering nutrient availability (Halverson, 2010; Rhymer & Simberloff, 1996; Simberloff et al., 2013). These interactions can lead to the disruption of or loss of members from the native community and can eventually change the affected ecosystem. For example, invasive lake trout (*Salvelinus namaycush*) prey heavily on native Yellowstone cutthroat trout (*Oncorhynchus clarkii bouveri*) in Yellowstone Lake in Yellowstone National Park (Gresswell, 2009). Besides being the major cause of the decline of cutthroat trout in the lake, lake trout has interrupted the energy flow between the lake and its surroundings habitats. Cutthroat trout represented an important food source for several species in the Park such as the grizzly bear (*Ursus arctos horribilis*), the bald eagle (*Haliaeetus leucocephalus*),

and the American white pelican (*Pelecanus erythrorhynchos*), all of which have now moved to other areas to find other food sources. The brown tree snake (*Boiga irregularis*) is another well-known example of ecological impacts. The snake's introduction to the island of Guam led to the extinction of the majority of the island's original species and greatly simplified its food webs (Fritts & Rodda, 1998).

As IAS disrupt the functioning of an ecosystem, so too do they disrupt the ecosystem services upon which human communities rely. Both Schlosberg (2012) and Neimanis et al. (2012) discuss the concept of "ecological integrity" with respect to environmental justice. Ecological integrity as a term refers to the quality of a given ecosystem and its ability to function effectively. Schlosberg (2012) in examining the application of the capabilities approach to climate justice and ecological integrity reasons that "it is the disruption and increasing vulnerability of the integrity of ecosystems that is at the heart of the injustice of climate change, both in terms of its impact on vulnerable human communities and nonhuman nature (178)." Yet, as mentioned above, Neimanis et al. (2012) found that the term "ecological integrity" was rarely a quality used to define environmental justice and they challenged the field "to create space and a place for the integration of ecological dependencies in environmental justice discourse (360)." Indeed, this call has not gone unheeded, as two recent studies examined environmental justice issues related to ecological integrity in urban (green) spaces (Berland, Schwarz, Herrmann, & Hopton, 2015; Wolch, Byrne, & Newell, 2014).

Research on invasive species and their potential impacts on ecological integrity represents another important addition to the field of the environmental justice scholarship. For example, certain groups depend more heavily on local natural resources for their well-being, such as communities in developing societies that rely upon local food or fuel sources (Nuñez and Pauchard 2010), a dependency that could be threatened by IAS. Further, ecosystem services, such as pollination of subsistence crops or water purification, can be subject to disruption by IAS, which in turn can disrupt the societies that depend on said services. It will be important for research to clarify how vulnerable groups are being affected by IAS, be it on a global or local level, and whether they are bearing an unfair burden of the impacts of species introduced by other, more politically powerful groups.

Environmental justice issues involving IAS also exist at the international level. Drake and Keller (2004) posit that the impacts from marine IAS introduced from ballast water fall much more heavily on developing countries than developed ones. Whereas developed countries benefit most from the international trade, developing countries lack the resources to deal with the unwanted impacts of the introduced species. Their paper also emphasized the need for further research and more data to understand and elucidate the levels of invasion and impacts. Nuñez and Pauchard's (2010) study supports Drake and Keller. It found that developing countries appear to have higher proportions of IAS, are more dependent on natural resources that can be affected by IAS, and have lower levels of education. Further, it discussed cases where projects in developing nations, sponsored by developed nations, employ IAS to achieve development objectives. Such projects may be rooted in good intentions, but could result in serious problems for local human and ecological communities. A related issue is the regulation of the export of potential or known IAS. For instance, a recent study of the international trade of plant IAS found that some developed countries with strong regulations on the import of IAS serve as sources for the export of known IAS to other countries (Humair, Humair, Kuhn, & Kueffer, 2015).

COMPLEXITY OF IMPACTS

Hitherto we have discussed only the negative impacts of IAS. However, there is recognition that IAS can also provide benefits to invaded systems (e.g. Schlaepfer et al., 2011). As Larson (2005)

pointed out, the language surrounding species invasion and management often highlights IAS as the "enemy" while ignoring the fact that many species are introduced to new habitats by humans and that human disruption of said habitats has often enabled the "invasion". Viewing an IAS in purely negative way may prevent the recognition of potential positive values. For example, IAS may be important parts of novel ecosystems that help maintain stability, such as the cinnamon (*Cinnamomum verum*) in the Seychelles, which has helped protect against further invasions (Kueffer & Kaiser-Bunbury, 2014).

The perception of the negative impacts that IAS often cause can also be subjective and vary among different stakeholders (García-Llorente et al. 2008; Simberloff et al 2013; Humair et al 2014). For example, the windmill palm (*Trachycarpus fortunei*) in southern Switzerland is valued as an ornamental tree by locals and is highlighted by the regional tourist industry. Yet, the palm is listed as an invasive species on Switzerland's Black List due to its potential to harm local forest biodiversity (Info Flora, 2015; Vogelaar & Hale, 2013). Additionally, non-native species can be simultaneously harmful and beneficial, even for the same group of stakeholders. Gozlan (2010) argues that the Nile perch (*Lates niloticus*) in Lake Victoria can be seen both as an environmental cataclysm (its introduction might have been responsible for the extinction of hundreds of endemic fish species) as well as an economic boon for the region (fisheries have grown exponentially in Lake Victoria since the establishment of the Nile perch in the lake). Similarly, invasive polychaetes (*Marenzelleria* spp.) are contributing to the displacement of native species in shallow areas of the Baltic Sea, but are also actively contributing to the improvement of the water quality by reducing bottom-water hypoxia (Norkko et al., 2012). Beyond the economic and ecological impacts, Pfeiffer & Voeks (2008) examined how IAS influence local cultural practices and traditions. They conclude that IAS can be classified according to whether their impacts can enrich, facilitate, or impoverish local human cultures, again highlighting the various types of impacts of IAS can have.

MANAGEMENT OF IAS

Preventing introductions in the first place is arguably the best way to manage IAS (Simberloff et al., 2013). Once IAS have been introduced, proper management requires a framework to address the complex issues related to the introduction that can examine and evaluate impacts as well as prioritize actions. Kueffer (2013) provides such a framework that allows the integration and production of information from across disciplines to deal with IAS. Although this framework is very useful, we recommend that it also include an explicit call to examine IAS, their full range of impacts, and possible courses of action from an environmental justice perspective. For example, it goes without saying that the removal or management of IAS is often costly economically (Leung et al., 2002). On the other hand, not managing IAS can be expensive as well, in terms of dealing with impacts to local ecosystems, vulnerable communities, and economic infrastructure. In both cases, the costs associated with the IAS are potentially being borne by third parties, which may include ones vulnerable to environmental injustices. This recognition is vital to reduce the chances of unnecessary impacts on vulnerable groups.

Management actions should also be weighed against other potential needs of a vulnerable or affected community. Sometimes, the goals of IAS control and community improvement might work together. For example, IAS control or removal programs can provide local employment, such as the Working for Water program in South Africa (Nuñez & Pauchard 2010). They can also serve to help develop a better connection of locals to their environment, develop a local sense of community, and assist in greening urban areas (Krasny & Tidball, 2012). However, other removal programs might result in conflicts that involve justice issues. A review of 28 case studies of conflicts involving IAS removal programs discussed several programs where local communities who valued IAS for various reasons were at odds with scientists and resource

managers who desired to remove the species for conservation reasons (Estévez, Anderson, Pizarro, & Burgman, 2015). An examination of the different groups involved in these and other cases that includes an understanding of the power differential across stakeholders, the kinds of impacts being caused by the IAS, and the distribution of impacts across groups would be essential to ensure a management that does not create more problems than it solves.

OTHER POTENTIAL AREAS OF SCHOLARSHIP

An expansion of the environmental justice field along the lines of ecological integrity opens up other possibilities for fields of research. These are generally beyond the scope of this paper, but we mention them here as they represent potentially interesting areas of scholarship. For example, one could move beyond examining humans as the only victims of environmental injustices to include other organisms, which are affected when IAS disrupt ecological communities (Neimanis et al 2012; Schlosberg 2012). One could also argue, following Larson (2005), that IAS are in some sense victims themselves, functioning as a scapegoat for human activities that led to and facilitated the invasions. Thus, scholarship could explore how an alternative perspective with IAS as victims could alter how we perceive and manage them. Lastly, there is the potential to revise the language used in invasion science to use less value-laden terminology. An ongoing debate within the field of invasion science has tackled the field's language use that some claim carries racist or xenophobic connotations (e.g. Davis et al., 2011; Larson, 2005; Simberloff et al., 2013). Indeed, the European designation of a "black" list to describe the list of the most problematic IAS could be viewed by some as problematic in itself. Language and terminology are important because, as Kueffer and Larson (2014) point out, they can drive management actions: extreme language can lead to extreme action, which can be particularly problematic for a field where impacts are likely variable and fall differently across different stakeholder groups.

CONCLUSIONS

As the scope of environmental justice expands to incorporate the integrity of ecosystems, incorporating scholarship on IAS with an environmental justice perspective represents an important area for research. IAS have been designated as such for the harm they cause or are perceived to cause to humans, economic systems, and nature, but the distribution of these effects has rarely been examined through an environmental justice lens. In particular, there is a need to identify instances where vulnerable groups are carrying a greater burden from IAS or where the impacts of the management of IAS falls more heavily on these communities. We encourage the use of a framework that allows consideration of cultural, ecological, environmental, justice, and social perspectives when deciding upon management actions for IAS.

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