

# Who's invading what? Systems thinking about invasive species

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Larson, B. M. H. 2007. **Who's invading what? Systems thinking about invasive species.** *Can. J. Plant Sci.* **87**: 993–999. While invasive plant species have dramatic and varied effects, this paper examines the focus of this symposium on their “threat to native biodiversity and ecosystems”. This claim implies that there is (i) an enduring something, (ii) it is native, and (iii) it is under threat from invasive species. I examine these implications in turn, first considering the role of the observer in invasion biology, particularly in preferring a nature characterized by stability rather than flux. Second, I examine the concept of “native” given that humans are thoroughly embedded within ecological systems. Third, I demonstrate how our exclusion of humans conditions us to consider invasive species a primary threat rather than one among many interacting causal agents of global change; in particular, recent evidence indicates that these agents, which include human-caused disturbances and global warming (not to mention human population growth and global trade), may overwhelm the effects of invasive species per se. For these and other reasons, some ecologists have argued that ecological change is inevitable and that our concerns about invasive species are unjustified. I discuss these issues and suggest ways for ecologists to conduct engaged research through appropriate advocacy and engagement with stakeholders dealing with local invasive species.

**Key words:** Advocacy, culture, philosophy of nature, sociology of science

Larson, B. M. H. 2007. **Qui envahit quoi? Les espèces envahissantes sous l'angle systémique.** *Can. J. Plant Sci.* **87**: 993–999. Bien que les espèces végétales envahissantes aient des répercussions aussi désastreuses que variées, l'article insiste sur leur « menace pour la biodiversité et les écosystèmes indigènes », thème du colloque. Ce dernier présume (i) que quelque chose est en difficulté, (ii) que ce quelque chose est de nature indigène et (iii) que les espèces envahissantes le menacent. Je me penche tour à tour sur ces trois implications, prenant d'abord le rôle de celui qui observe la biologie de l'envahisseur, surtout en privilégiant une nature que caractériserait la stabilité plutôt que le changement. Ensuite, j'examine le concept d'« indigène », sachant que l'être humain est totalement immergé dans les systèmes naturels (écologiques). Enfin, je montre comment l'exclusion de l'espèce humaine nous amène à envisager les espèces envahissantes comme une menace plutôt qu'un des nombreux agents qui s'entremêlent pour engendrer un changement global. Des données récentes indiquent notamment que ces agents, qui incluent les effets des perturbations attribuables à la main de l'homme et au réchauffement planétaire (sans parler de la croissance démographique et du commerce mondial), surpasseraient ceux des espèces envahissantes en soi. Pour ces raisons et d'autres motifs, quelques écologistes soutiennent que le changement écologique est inévitable et que nous n'avons pas à nous inquiéter des plantes envahissantes. J'aborde ces différents aspects et suggère aux écologistes comment éviter le cynisme dans leurs travaux en prenant la défense d'une cause de la manière appropriée et en gardant contact avec ceux qui doivent composer avec des espèces envahissantes localement.

**Mots clés:** Défense d'une cause, culture, philosophie naturelle, sociologie de la science

Ecologists have taken a lead role in speaking out about invasive species, recognizing that they represent one of the most significant forms of contemporary ecological change. The most highly cited paper in invasion biology, “Biotic invasions: Causes, epidemiology, global consequences, and control” (Mack et al. 2000a), for example, was reformulated for the Ecological Society of America's (ESA) Issues in Ecology series (Mack et al. 2000b). This series is designed “to report, in language understandable by non-scientists, the consensus of a panel of scientific experts on issues relevant to the environment.” The report on invasive species concluded that they are “altering the world's natural communities and their ecological character at an unprecedented rate. If we fail to implement effective strategies to curb the most damaging impacts of invaders, we risk impoverishing and homogenizing the very ecosystems on which we rely to sus-

tain our agriculture, forestry, fisheries and other resources and to supply us with irreplaceable natural services.” More recently, the ESA issued a position paper on biological invasions written by a dozen prominent ecologists and invasion biologists (Lodge et al. 2006). Their paper underscored the accelerating impacts of invasive species and recommended six actions by which the US government can oversee more effective responses. Similar recommendations have been highlighted in the Invasive Alien Species Strategy for Canada that was introduced by the Government of Canada in September 2004.

Notwithstanding this apparent consensus, a number of philosophers and social scientists (e.g., Botkin 2001; Chew and Laubichler 2003; Sagoff 2005) have questioned whether our concerns about invasive species are justified and whether it is appropriate for biologists to advocate for native

species. Other authors have reviewed the detrimental effects of entrenched antipathy toward them (Gobster 2005; Larson 2005; Clergeau and Nuñez 2006). Scientists studying invasive species have also re-examined some pillars of invasion biology, including whether invasive species really out-compete native ones (Davis 2003), whether they cause extinctions as often as we think (Gurevitch and Padilla 2004), whether gains in richness due to non-native species outweigh any losses (Sax et al. 2002; Fridley et al. 2007), and whether the current rate of change is actually greater than past biotic interchanges (Brown and Sax 2004). Consequently, some biologists have questioned whether invasive species are really so bad (Slobodkin 2001; Brown and Sax 2004, 2005). On the other side, it has been claimed that papers such as these comprise a “rearguard action to convince biologists and the lay public that the ecological threat from invasive species is overblown (Simberloff 2006, and see Simberloff 2005).” While we might expect such debate in any field where the ecological stakes are potentially so high, these arguments point to philosophical tensions that have tremendous implications for our conception of and response to these species.

Invasive species certainly present challenges for humans, but this paper will focus on the ESA’s desire “to protect still uninvaded ecosystems” and this symposium’s focus on “threats to native species and ecosystems (Clements and Catling 2007)”. While these claims may seem intuitive to us as ecologists, they are not without their problems, as shown by extensive philosophical discussion (Peretti 1998; Rolston 2001; Hettinger 2001; Woods and Moriarty 2001; Lodge and Shrader-Frechette 2003). I wish to review some of these issues here to enrich our perception of invasive species. I will argue that we can no longer isolate invasive species as merely a scientific issue, and that we need to explicitly consider their larger socio-ecological context (Bradshaw and Bekoff 2001). While invasion biology has increasingly recognized this context (Regan et al. 2006; Keller et al. 2007), it often relies on analyses that treat the issue as ecological rather than socio-ecological, which derives at least in part from the emphases and training of the scientists who have become the champions of invasion biology. Invasive species serve as a stark reminder that we cannot study environmental issues as if they are divorced from human perception and human values.

This paper will examine three fundamental limitations of a narrowly ecological focus through the lense of systems-thinking (e.g., Walker and Salt 2006). First, I will draw attention to the observer, those of us who are observing invasive species, thereby acknowledging both the values and particular view of nature that we harbor. We still tend to think of nature in archaic terms of balance and stability—even if implicitly—rather than flux and change. Second, I will examine the boundaries we draw around the system under study to question whether a dichotomy between native and non-native is satisfactory. This dichotomy speaks to an underlying distinction between nature and culture, one that has been the focus of extensive discussion in literature concerning invasive species. Last, after breaking down the human-nature boundary we can better understand that inva-

sive species result from the interactions of diverse causal agents, which necessitates questions about whether they are really so blameworthy or such a “threat.” After discussing these points, I will return to the broader question of whether ecologists can still demonstrate concern about invasive species even if these foundational assumptions have been shaken, and if so, how they might do so.

### THE OBSERVER IN INVASION BIOLOGY

Systems-thinking first asks us to acknowledge the role of the observer in conceptualizing nature, including invasive species. As the ESA position paper acknowledges, the harm caused by invasive species is a function of human values (see also Woods and Moriarty 2001; Maguire 2004). As ecologists, we have been raised or trained to value biodiversity, in general, and certain species rather than others, more specifically. Many people do not prioritize these same values (see Foster and Sandberg 2004; Head and Muir 2004; Bardsley and Edwards-Jones 2006; Fischer and van der Wal 2007). In fact, most people are able to recognize very few of the organisms around them, let alone differentiate which are native and which non-native. That said, some would argue that ecologists have a moral duty to raise their concerns about invasive species given the possibility that they might someday undermine the ecological services and functions on which human survival depends (Hooper et al. 2005). Nonetheless, ecologists do not possess a God’s-eye view of the phenomenon of invasive species. There are many alternative views of the natural world and of invasive species (Hull 2006; Larson 2007b). Yet, if we act as if our particular perception is the only possibility then we will run into grave difficulties in communicating with the public (Weber and Word 2001). We also depend on diverse stakeholders for their support of eradication and/or restoration projects.

To most of us trained as ecologists, concepts such as “native,” “nature” and “wilderness” seem self-explanatory. We know them when we see them or experience them. It is this view, however, that has been drawn into question by those who have examined the extent to which our views of nature reflect the times. In a classic contribution, for example, Cronon (1995) provided historical evidence showing the extent to which wilderness is “quite profoundly a human creation—indeed, the creation of very particular human cultures at very particular moments in human history.” While he was addressing wilderness, his argument can easily be extended to how we think about native spaces (and their species) as areas that are at least relatively untouched by what he referred to as “civilization, that all too human disease.” Cronon emphasizes that wilderness is not *merely* a human creation, yet documents the historical progression in how our views of it reflect our ideals, from the days when it was viewed as wasteland followed by its transition into something sacred and even sublime in the romantic era. He considers revealing ironies such as the shocking absence of aboriginal peoples from our conception of wilderness and the elitism of our contemporary wilderness experiences. He insightfully observes that “Those who have no difficulty seeing God as the expression of our human dreams and desires nonetheless have trouble recognizing that in a secu-

lar age Nature can offer precisely the same sort of mirror.” He concludes that the greatest threat of the notion of wilderness is that there is a realm of “pristine” nature separate from humans, a dangerous quasi-religious myth that gives us “permission to evade responsibility for the lives we actually lead.”

Not surprisingly, critics have considered this viewpoint pernicious (Soulé and Lease 1995; Crist 2004). It seems to deny that there is actually something there in nature that we can value, when in fact Cronon explicitly denies this allegation. More worryingly, his view seems to condone the continued colonization of true nature by claiming that it is inevitable, thus stealing the thunder of those who oppose development, overfishing, and the loss of biodiversity.

While these are valid concerns, I think that both sides of this debate have their merits. They both contain vital elements for those of us who wish to think deeply about how humans might relate more fully to the world in which we live in all its complexity. Unfortunately, it is too easy to brush off the arguments of the other side, once again reinforcing the divide between the cultures of humanities and science at a time when many conservation biologists have recognized that we must better integrate them in the interests of biodiversity (Lubchenco 1998; Robinson 2006). Neither holds the entire truth; instead, we require the insights of both perspectives in our struggle with intractable environmental issues (Proctor 2001). For example, Hayles (1995) argues that most science is not objective *enough* since it fails to acknowledge its own presuppositions, a shortcoming that can be overcome by including marginalized perspectives in order to weaken the dogma of a shared outlook (e.g., one that is predominately white, upper-class and male).

For a prime example of the effect of our view of nature on scientific thinking, we need only turn to invasion biology. Specifically, our concerns about invasive species to some extent reflect an image of an enduring and timeless “nature.” They imply that nature is static, or even that it should continue on a trajectory present before modern humans arrived. It is difficult to escape this romantic “balance of nature” ideal since it reflects a Christian metaphysic that is part of our everyday worldview: there is a fall from grace, we are in error, and we have a nostalgic wish to return. In contrast to this view of the natural world, ecologists now emphasize the prevalence of change and flux, which requires a new vision of environmental responsibility (Worster 1990; Lodge and Hamlin 2006). As White (2006) explains, “The flux of nature paradigm suggests that we cannot find the basis for conservation management and environmental ethics in an eternal, equilibrium, unchanging, and prehuman natural condition.” We cannot simply turn to the flux paradigm for a simple replacement ethic (Fleming 2006), but we are instead in the midst of searching out a new way of relating to the natural world, a new view of the relation between culture and nature.

#### NATURE AND CULTURE IN INVASION BIOLOGY

We typically define nature in opposition to human beings: there is nature-without-humans and nature-with-humans. Philosophers and social theorists have shown, however, that

this dichotomy between nature and culture is deeply problematic. In fact, they would turn our usual conception on its head by demonstrating that we continue to hold onto this dichotomy between nature and culture even though the actual evidence is that “hybrids” between them surround us on all sides (Latour 1993). Ecologist and environmental policy scholar Haila (2000) describes the general problem as follows: “We want to know what nature allows us. To reach an ultimate certainty we would like to distinguish between ‘nature by herself as a standard’ and ‘nature modified and polluted by humans.’ This, however, cannot be done. Humans are creatures of nature; consequently, discriminating between phenomena of nature as ‘natural’ and phenomena of culture as ‘unnatural’ does not make sense at all.” Unfortunately, there is no definitive answer to the question of how nature and culture relate since it is one of the most contentious questions in all of academia (Callicott et al. 1999). Like it or not, this hybrid world is the one in which we live.

Our conception of invasive species demonstrates our denial of the entanglement of nature and culture (Milton 2000; Robbins 2004). Invasion biology relies upon an underlying dichotomy between nature/non-human/native and culture/human/non-native that exemplifies the exclusion of human beings from ecological systems. Invasion biologists thus focus on species that we have introduced and which cause harm, rather than native ones that have similar effects. Their “naturalness” thus becomes the focus of ecological debates. In a recent exchange about the significance of invasive species, for example, Cassey et al. (2005) emphasized the distinctiveness of recent human-induced changes, whereas Brown and Sax (2005) decried those who claim they are unnatural. To resolve this question, we might turn to paleoecological records (Willis and Birks 2006), but this merely reinstates the illusion that we can return to some state that existed before human-induced changes. Instead, it may be more sensible to accept that we are now part of the way the world is and that phenomena such as invasive species are not independent of us.

We are not simply seeing non-native invasive species invade a pre-existing nature, but instead entering a state in which they already exist. The very word “invade,” however, deludes us into thinking there is a pre-existing container there to be invaded. By linguistically framing the situation as an “invader” invading “an uninvaded region,” we have encoded how we think about the situation (Larson 2008). We might instead recognize that the invader and the invaded are not so very different and perhaps even require one another. That is, the “native” place that is invaded already has human elements, especially various forms of anthropogenic disturbance, and these contribute to and even encourage the spread of novel species. “Native” species now occur in largely disturbed landscapes, whether by direct disturbance from humans or from our livestock, or from other effects we have had, including exotic earthworms, reduced fire frequency, acid rain, nitrogen deposition, and global warming. We cannot go back!

A short vignette may help to exemplify the conceptual difficulties with protecting native ecosystems against the

“threat” of invasive species. Consider the recent invasion of emerald ash borer (EAB, *Agrilus planipennis* Fairmaire) in southern Ontario. Undoubtedly, the introduction of this species has aesthetic, ecological and economic impacts. However, can we really make a case that it poses “an enormous threat to native ash [*Fraxinus* spp.] forests in eastern North America (Muirhead et al. 2006, emphasis added)?” In so doing, we simply demonstrate the flexibility of the term “native” and our tendency to adapt its meaning according to context and rhetorical needs. If EAB is invading a “native” ecosystem, then how do we differentiate the forests of 50 yr ago that had American elm (*Ulmus americana* L.) as a dominant species, or the earlier forests typified by American chestnut [*Castanea dentata* (Marshall) Borkh.]? Both of these trees largely succumbed to invasive pathogens. Furthermore, ash was probably over-abundant in these heavily disturbed, early-successional landscapes, which provided the conditions for an outbreak of EAB. We may regret the loss of the “primeval forest,” and we may bemoan continued losses, but we cannot in any case say that we are losing something timeless or “native.”

When we mistake the abstraction “native” for something concrete, we fall victim to the fallacy of misplaced concreteness (Whitehead 1925). While ecologists do not equally denounce all non-native species, there is still an extent to which the classes “exotic” and “native” mislead us. A number of recent ecological studies have shown that they may be more similar than we assume, having classified them as opposing armies in a battle. In coastal prairie of northern California, for example, Thomsen et al. (2006) demonstrated that the competitiveness of exotic and native species “varied continuously” and that the species interacted individually rather than in accord with the classes “native” and “exotic.” In wetlands in southeastern Ontario, Houlahan and Findlay (2004) found that exotic and native species they studied were equally likely to be community dominants and that “the effect of exotic dominants on native species richness was indistinguishable from that of native dominants,” indicating that “exotic plant species are, by and large, a minor threat to native wetland plant diversity.” As a final example, an analysis of 48-yr of permanent plot data from Hutcheson Memorial Forest Center (New Jersey, USA) demonstrated that “exotic species behave in essentially the same way as native taxa within dynamic communities (Meiners 2007).” We cannot yet generalize from studies such as these, but they at least suggest another way of looking at exotic and native species. While it is often useful to differentiate a continuum of human disturbance and naturalness, however we define it (Brunson 2000; Hull and Robertson 2000; Ridder 2007), there is no self-evident point at which it is sensible to say that an ecosystem is “native.” Rather, this classification must occur as part of a larger social discussion as it is not a question that is restricted to the realm of ecological science.

#### INVASIVE SPECIES AND CAUSATION

We can also bring humans back into invasion biology by extending the lines of causation beyond the tendency to prioritize invasive species as a cause of ecological change.

Humans currently impact global ecosystems in diverse ways, yet invasive species have become a scapegoat because of their ecological impacts and perhaps because they are sometimes easier to deal with than overarching causal factors. With reductionist approaches, we focus on invasive species as a “threat” to “native species,” but that presupposes a relatively unitary and independent force, when in fact invasive species cannot easily be parsed from numerous other concurrent changes.

In a study based in Garry oak (*Quercus garryana* Dougl. ex Hook) meadows in British Columbia, MacDougall and Turkington (2005) attempted to empirically tease apart whether invasive species “drive” ecological change or just respond (as “passengers”) to prior and ongoing ecological change. They found that native species did not recover as expected when invasive species were removed, which provided support for the “passenger” model. Didham et al. (2005) highlighted this study not because of its specific results, as the driver model is certain to apply in other contexts, but because it is the first rigorous examination of this question. They also propose a more general “interacting drivers” model that considers how the “relative importance of invasive species and habitat disturbance var[ies] between species and between ecosystems.”

To date, however, there has been no meta-analysis of empirical results pertaining to the model proposed by Didham et al. (2005) and specifically whether eradication of an invasive species leads to recovery of a former system. We need such information to assess whether the removal of an invasive species is likely to recover a desired ecosystem state or whether it will instead lead to colonization by new invasive species (Zavaleta et al. 2001; Hulme and Bremner 2006). In some cases, invasive species may actually facilitate native species (MacDougall and Turkington 2005; Rodriguez 2006). Furthermore, simple small-scale removal experiments overlook complex ecosystem interactions and even if they are successful, this may not translate to larger spatial or temporal scales (Ogden and Rejmanek 2005). Generally, control programs have not thus far been that successful, as reported for an overview of programs in the United Kingdom (Manchester and Bullock 2000). The point is that socio-ecological systems are complex adaptive ones, which do not necessarily change in a “predictable, linear, incremental fashion” (Walker and Salt 2006).

Numerous studies have corroborated that we cannot think of invasive species independent of other anthropogenic disturbances (Farnsworth 2004; Huebner and Tobin 2006; Burgman et al. 2007). Wei and Chow-Fraser (2006) demonstrate that multiple stressors, including changes in water level, human population growth, and the spread of exotic species [including reed meadowgrass [*Glyceria maxima* (Hartm.) F.O. Holmb.] and common reed (*Phragmites australis* (Cav.) (Trin. ex Steud.))] have contributed to the decline of cat-tail (*Typha* spp.) marsh communities around Lake Ontario. While some have projected that declining water levels with global warming may allow restoration of these marshes, their results suggest that exotic species and nutrient levels may prevent such restoration. Similarly, although plot surveys carried out across Britain in 1990 and

1998 confirmed that invasive species were affecting native species, Maskell et al. (2006) concluded that “at the landscape scale in Great Britain they are best considered as symptoms of disturbance and land-use change rather than a direct threat to biodiversity.”

At a larger scale, human-caused global warming will likely exacerbate the spread and effects of many invasive species (Dukes and Mooney 1999). Some naturalized species may begin to spread and become invasive as the climate warms. And even some native species, such as the mountain pine beetle (*Dendroctonus ponderosae* Hopkins), which is affecting the forests of British Columbia, are becoming “invasive” because of this change. We thus come full circle to the role of humans in the spread of invasive species. Our daily habits contribute to their spread, including seed dispersal because of our heavy reliance on automobiles (von der Lippe and Kowarik 2007). For example, *Phragmites australis* spread less along natural wetland corridors than anthropogenic ones in southern Quebec, unless the former intersected transportation rights-of-way (Maheu-Giroux and de Blois 2007). Once again, humans—each and every one of us—and our actions need to be incorporated into how we think about invasive species.

### PUTTING HUMANS BACK INTO INVASION BIOLOGY

This paper has reviewed a number of reasons why the received view of invasive species as a “threat to native species” is unsatisfactory. If they are not considered a threat, however, do ecologists have any basis for action towards them? As mentioned above, there are still many reasons for concern, but defending “native” systems is not the most salient. I suspect that concerns founded on the native/non-native dichotomy will gradually be replaced by concerns about the spread of “dominant” species. The spread of such species may lead to diversity decline, and whether they are native or non-native species is not the primary issue (Houlahan and Findlay 2004; White 2006; Meiners 2007). The potential decrease in ecological functioning underlies many ecological concerns about invasive species. Furthermore, the spread of dominants may also affect our aesthetic preferences for diverse landscapes. While a preference for diverse systems may be value-laden too, it may be better founded in ecology than excising humans from ecological systems.

Rather than seeking an elusive “native state,” in most instances we will have to make do with what we have, perhaps restoring desired communities on relatively small scales. It is thus all the more important to be proactive in preventing the emergence of new harmful species where this is feasible. This should not be so much to protect native ecosystems, however, as part of a larger discussion over what kinds of ecosystems we prefer as a society and with acknowledgement of the economic cost of many invasive species. Our discussions need to focus on the future, using invasive species as a touchstone for reconceptualizing the way we interact with nature in order to help resolve the quandary of how to live sustainably on the planet (Brunson 2000; Jordan 2003).

Ecological expertise will play a role in these discussions, though not without confronting the issue of advocacy (Larson 2007a). There has been extensive debate about this topic in the conservation literature, ranging from those who argue that scientists must separate their values from their objective results if they are to retain policy credibility (Lackey 2007), to those who argue that these values are inseparable elements and should not be artificially separated (Noss 2007). The former would argue that the claim that invasive species pose a “threat to native ecosystems” is an unscientific statement, whereas the latter might argue that it needs to be made anyway. There is no easy answer to this question, as scientists hold a wide range of opinions on the issue of advocacy (Scott et al. 2007).

Regardless, ecologists who are concerned about invasive species can skirt some of these advocacy issues by defining research projects that engage with local citizens and problems (Lach et al. 2003). A first step might be involvement with multi-stakeholder groups to decide what to do about particular novel species, perhaps in the context of larger decision or risk analyses that explicitly incorporate diverse values (Maguire 2004; Stohlgren and Schnase 2006; Wallace 2006). It will not suffice to simply state that we need to remove a species because it is a threat to native species, and this will particularly hold in urban areas where many people only have experiences of non-native ecosystems. If an invasive species is entering an area, ecologists may be able to help answer questions about the likely consequences of its spread, whether it would simply be replaced by another one if it were removed, and whether this species is really the problem as opposed to other concurrent changes. They may also be able to help design appropriate protocols for removing particular invasive species, if that is the direction that is chosen. Finally, as systems-thinking ecologists we can play a role in helping people to understand the nuances of invasive species as an ecological force, rather than simply being alarmist, by reiterating that the effects of these species must be placed in a broader social context and that they are not always as bad as we fear.

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