

### Distinct Biogeographic Phenomena Require a Specific Terminology: A reply to Wilson and Sagoff

In a recent publication (Essl et al. 2019), we proposed that the increasing number of range-expanding species that track human-induced environmental change warrant specific recognition in science and biodiversity management, and we proposed the term “neonative” for these taxa. In the present letter, we reply to two letters (Wilson 2020, Sagoff 2020) that criticized specific but different aspects presented in our publication. Although we disagree on several points with both authors, we agree that a broader discourse is needed for developing robust and widely accepted definitions and terms for the ever more important phenomenon of neonative species.

Our recent publication on range-expanding species tracking human-induced environmental change (Essl et al. 2019) has led to questions regarding the validity of the concept we have put forward. Wilson (2019) raises several important issues about the usefulness of the term “neonative”, which we proposed as a shorthand to describe range-expanding native species that track human-induced environmental change. In another letter, Sagoff (2020) argues that species’ origin does not matter, because it is not associated with biologically or ecologically relevant differences.

We disagree with Wilson (2019) that the inherent difficulties and uncertainties in identifying neonatives invalidate the concept. If we consider a phenomenon distinct (and important), we should denote it by a distinct term. This is not only prerequisite to classifying real cases, however difficult this may be, but also clarifies thinking and fosters inclusion of such phenomena into the development of hypotheses and theory. In fact, making current uncertainties and knowledge gaps in delineating neonatives explicit will promote research on these topics and will ultimately lead to better science and also support more focused decision making. Giving up the development of standardized protocols (e.g., for assessing

the impacts of alien species) in the face of large uncertainties has been suggested several times in invasion science (e.g., Ojaveer et al. 2015), but giving up studying such challenges would hinder the advancement of knowledge (Blackburn et al. 2014). The need to name such species is also evident in other studies, especially when dealing with the predicted massive range shifts or altered abundances caused by climate change (Carey et al. 2012, Scheffers and Pecl 2019) and the need to manage their impacts (Latombe et al. 2019). For example, for many people, native invaders are species that become abundant within their natural range after an anthropogenic disturbance (e.g., Simberloff et al. 2012), whereas neonatives expand to a range where they have not been present, at least not in the current interglacial. Having a clear terminology to distinguish both phenomena will promote efforts to monitor species redistribution from local to global scales, will help managers in developing strategies for dealing with these newly arriving species, and will permit to develop focused policies in the future.

Wilson (2019) also suggests that we should focus on impacts instead of biogeographical origin of species when prioritizing interventions. This argument echoes long-standing disputes in invasion science (e.g., Gilroy et al. 2017; but see Simberloff et al. 2011). However, there is clear evidence that species of different biogeographic origin—that is, alien, neonative, and native species—differ in many crucial characteristics (Engelkes et al. 2008, Essl et al. 2019) and that the rapidly increasing number of alien (Seebens et al. 2017) and neonative species (Scheffers and Pecl 2019) makes this distinction ever more important. Furthermore, waiting until impacts become apparent is unwise, because species management might then come too late to be efficient or even feasible (Pluess et al. 2012). We reemphasize here that our term, “neonative”, does not come with any negative connotations; it therefore does not a priori call for active management actions to

control these species or to stop their spread. Decisions on which species to manage will be context dependent and will require ecological, social, and economic considerations.

Wilson (2019) also questions the usefulness of defining specific thresholds for applying the concept of neonative species because, he argues, it is pointless to “[draw] a line through a continuous process.” We agree (and explicitly state this in our publication) that the processes involved in range-expansions of native species tracking human-induced environmental change are continuous. However, this is also the case for many other phenomena in ecology and other disciplines, such as endemism (What is the maximum area of occurrence to qualify a species as endemic?), alien species (What is the level of human assistance to qualify a species as alien?), or the Anthropocene (At which point in time has the human impact on Earth systems become so pervasive that a new geological epoch should be denoted?). Therefore, the fact that underlying processes are continuous does not mean that it is not useful to define different categories along this continuum. Such definitions come with thresholds and are the basis for investigating separate phenomena on the continuum. Otherwise, these differences would be ignored.

Finally, Wilson (2019) states that the term “neonative” has been used previously in different contexts, and therefore argues that applying it may cause confusion. We explained that the term “neonative” has indeed been used in other contexts but that it has not gained widespread usage in other fields. There are many essential terms in ecology (e.g., invasive, endemic) that have other meanings in other fields (e.g., in these cases, medicine and epidemiology) and that were used well before they were taken up in invasion science; there is little evidence that this caused confusion among scholars.

Sagoff (2020) raises the question of whether the native–alien distinction, however refined, correlates with any biological or ecological difference.

We believe that his interpretation is unhelpful in resolving the debate. Of course, the mode of relocation and subsequent range expansion (directly or indirectly assisted by humans or naturally—i.e., on their own means) may differ and this can also result in evolutionary change of the properties of individuals (postinvasion niche shift; see e.g., Colautti and Lau 2015). Furthermore, the non-randomness of transport leads to propagules with certain characteristics being more likely picked up and relocated than others. Accordingly, species of different biogeographical origin and modes of introduction do differ in their characteristics from species that originated at a location. This has been clearly elucidated in many studies and for many taxa (Engelkes et al. 2008, Simberloff et al. 2013), although this might not be true in every case, such as in Sagoff's example. In addition, ecological novelty—more specifically, the lack of coevolutionary experience of resident species (Saul and Jeschke 2015)—has been shown to cause increased impacts on resident biota (Ricciardi and Atkinson 2004, Richardson and Ricciardi 2013).

Given the high and increasing relevance of species tracking human-induced environmental change, we are pleased that our publication has initiated this debate. The question of how to define, identify, and possibly manage neonatives where appropriate in our human-dominated world will be crucial. In our view, an explicit recognition of this phenomenon in science, conservation management, and policymaking is urgently needed. Our publication has laid the foundation for this discourse. Importantly, we believe that this debate should become a broad one, involving scholars from different disciplines and environmental managers and decision-makers, so that arguments from different perspectives will be put forward. We also believe that this process should finally lead to the development of widely accepted standards and definitions—ideally overseen by relevant international bodies

such as the IUCN, CBD, and IPBES. We see this debate as a contribution to this goal.

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