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Invasion biology and uncertainty in *native range* definitions: response to Pereyra 2019

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Article impact statement: Uncertainties in the definition of *native range* definition are not as much of a problem for invasion biology as claimed.

Pereyra (2019) discusses several problems -arising from the designation of a species' native range, the definition of which seems straightforward but , as he demonstrates, has limitations. His interesting and thought-provoking argument could point to conceptual or technical

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challenges in ecological theory and help remedy them. Unfortunately, Pereyra inadequately jumps from particular issues in the definition of *native range* to dismissal of the concept itself to questioning an entire research field that uses it, invasion biology.

In essence, Pereyra's essay is articulated along flawed logical reasoning. The definition of *nativeness* is unclear; therefore, the concept of nativeness is also unclear and the concept of non-nativeness is unclear by symmetrical reasoning. Consequently, a discipline based on non-nativeness is open to question. We argue that each of these 4 points and the logical links between them are flawed. Moreover, Pereyra's essay is based on errors in reasoning, a misleading selection of examples, incorrect citations, and sophisms and logic fallacies that are unfortunate in the context of the increase in denial of invasion biology (Russell & Blackburn 2017; Ricciardi & Ryan 2018).

Imperfection of the definition of *native range*

Pereyra's starting point is that it is difficult to define a species' native range because the perfect spatial limit of native range is not always known and ranges shift with time. The former is true, just as the identity of some species is unknown. There are 12,000 documented species of ants, out of an estimated 20,000 extant species (Wilson & Hölldobler 1990). Not knowing the approximately 8,000 undocumented species does not mean the definition of ant species is problematic. Thus, not knowing the boundaries of a species' range does not mean it does not have one. The evolution of such boundaries is no more problematic than the evolution of other species' traits and does not negate the existence of limits to biogeographic

distribution any more than evolution does for other life-history traits. Granted, the quantitative outline of a range is not always known at any point in time, but it still exists and has important implications. Placing quantitative limits to species' native ranges and defining *nativeness* are 2 very different things; one can be unclear without the other being unclear.

Clarity of the definition of *native range*

The definition of *native range* is to some extent contextual and subject to interpretation and therefore likely to be different for different authors, but disagreeing on the value of a parameter or trait because experts use different rules to define it does not mean the concept is invalid, does not exist, or is not useful.

Pereyra claims, “[t]he temporal dimension of native range estimation is as unclear as the spatial dimension.” The examples given are admittedly diverse (1492 for America, 1770 for Australia...), but this reflects the diversity of dates of first possible introductions by humans, not a diversity of concepts. Contending this is a problem is harmful because a potential difference in date of introduction among continents, or even in thresholds among authors, would not mean the concept of native range is problematic. Rabbits are not native to Australia, regardless of the date of discovery of Australia. Moreover, broadly accepted definitions of *non-nativeness* (e.g., Pyšek et al. 2004; Blackburn et al. 2011) do not entail temporal limits. Often, threshold dates simply reflect when knowledge of the first species inventories were obtained and a conservative approach to identification of species as native or non-native.

Pereyra uses the same faulty reasoning to invalidate the idea of geographic barriers. He implies that because it may be difficult to define what they are in all cases, ~~then-so-that~~ defining a species as non-native because it crossed a geographical barrier is incorrect. In general, when a species is considered non-native because it crossed a geographical barrier (e.g., an ocean for terrestrial species, a catchment boundary for freshwater species), it is because the geographical barrier in question is well identified (Essl et al. 2018).

Pereyra's wording provides the impression that species' native ranges are generally poorly known (e.g., "native range is often poorly characterized"), whereas the opposite is true: they are known in most cases. Denying this ignores the entirety of botanical and zoological literature concerned with ranges (phytogeography and zoogeography). It is true that there are many cases where range limits are insufficiently known, but these are a minority. The wealth of information on faunas and floras of the majority of the world, based on work of local experts, provides robust and reliable information for most species. Pereyra's general wording implies this is not the case, which is misleading. This relates to Pereyra's claim that invasion biology has not provided a theoretical definition of *native range*. It has not, indeed, because, as is common in science, this field rests on centuries of research of another discipline, biogeography (e.g., Danserau 1957).

In essence, the author implies that because the concept does not apply clearly in some situations, the entire concept is flawed. Yet, just because scientists do not know how a particular species evolved, does not mean they reject evolution. Similarly, ~~because~~ when it is unclear whether an organism is a species or subspecies, scientists do not reject the species concept. Pereyra is arguing a logical approach: if one disproves the particular, one disproves

the universal. For example, if one finds the law of gravity does not apply somewhere, then one has disproved the entire law. However, biology is not a science like physics, and there are few universal laws that are true in all cases. In addition, the focus here is a concept or definition, rather than a biological law, so the logical approach is even more inappropriate.

Finally, the link between *native range* and *native species* definitions is applied inappropriately. This application is misleading because there are 2 senses to the term *define*: quantitative and conceptual. So, there is confusion between outlining a native range and defining its concept; difficulties in the former do not invalidate the existence of the latter. Second, difficulties in defining a concept do not invalidate the existence or usefulness of the concept. Scientists have problems with the complex concept of biodiversity, but biodiversity exists (Burch-Brown & Archer 2017).

Native range versus non-native range

Invasion biology is less concerned with the precise identity of a species' range than the certainty that the species is non-native in a region and how species' origin may influence ecological interactions (Rejmánek & Simberloff 2017). The exact native range of cats or a some cosmopolitan weeds may be unknown because their precise location of origin is unknown, but certainly some areas (e.g., islands) to which they are non-native are known.

In any case, most of the comments in Pereyra (2019) are about human fallacy (inability to define a native species' range), rather than the veracity of whether a native (or non-native) species' range exists (which it does). That may mean that due to human

limitations every non-native range cannot be perfectly defined (it is of course much clearer on islands), but the concept is still useful and important.

While Pereyra elaborates on definitions of nativeness, his understanding of how non-native species are defined is inaccurate. He states “by definition, [a species is] non-native when it is outside its current or historical range.” This is untrue. They are only defined as such if the reason they are found outside of their native range is due to human agency (Pyšek et al. 2004; Blackburn et al. 2011). For example, New Zealand is still being naturally colonized by species blown across from Australia, and these species are treated as native. A recent case is the Barn Owl (*Tyto alba delicatula*), which is native in Australia and was recently determined to have an established population in New Zealand, where it was celebrated as its newest bird species in 2019. Similarly, Pereyra (2019) claims “[i]f a species is found outside its native range, it is usually considered non-native, potentially invasive, and possibly troublesome,” but this is rarely the case. In general, only a minority of non-native species are seen as economic, environmental, or social problems (Vilà et al. 2010).

From questioning a definition to questioning a discipline

Even if there were problems with definitions of *nativeness* and *non-nativeness*, it would not at all affect the importance of an entire discipline that uses this concept. By cherry picking examples that are marginal and failing to consider the typical state for the majority of species, the demonstration is inadequately overgeneralizing. Yet, even if the outline of the native

range of every species on Earth were undefined, it remains that invasion biology would still be important for fundamental and applied ecology.

Pereyra's statement "the enigma here is that if species are allowed to migrate to another more propitious area and fend for itself, it will be considered not native by invasion scientists" does invasion biology a great disservice. Recently, invasion biologists have addressed this very issue, and contrary to the negative view of Pereyra, invasion biologists have proposed that naturally migrating species be classified as "neonatives," a distinct type of native species (Essl et al. 2019).

Conclusion

The demonstration used by Pereyra is based on a logical succession of 5 claims, none of which are correct. It is based on misleading reasoning that ignores contradictory evidence and creates the impression that invasion biology is responsible for what he presents as a failure. In line with previous, similar essays that deny the importance of this discipline, we warn against such faulty logic and the inappropriate conclusions it leads to. Pereyra does not explicitly deny the validity of the concept of non-native species, but his article could easily be misinterpreted by those who seek to undermine the significance of biological invasions as major agents of global environmental change.

Invasion biology is an important discipline that has led to tremendous progress in understanding ecological functioning and is enabling scientists and biodiversity managers to better conserve affected species and ecosystems, as well as human societies (Genovesi 2005; Simberloff et al. 2011, 2013). Providing a critical appraisal of theoretical concepts and ideas is an essential endeavour in science, but one has to be particularly careful that it is robustly anchored in facts and logic in order to avoid contributing to the current trend in scientific scepticism that damages the very basis of fundamental and applied research.

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