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# Resolving the issues of translocated native species in freshwater invasions

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## Abstract

Biological invasions, driven by human-mediated species movements, pose significant threats to global ecosystems and economies. The classification of non-native species is a complex issue intertwining ecological considerations and ethical concerns. The need for nuanced and less ambiguous terminology is emphasised, considering biogeographic, evolutionary, and ecological principles. In-country translocations of native species into ecosystems they do not naturally occur, are often overlooked and are the least regulated among species movements, despite being increasingly common in conservation. Our case studies, spanning various ecosystems and taxa, illustrate the diverse impacts of translocations on native species and ecosystems. The challenges associated with translocated species underscore the urgency for robust risk management strategies and rigorous monitoring. A comprehensive and adaptable management framework that considers translocated species for evidence-based management decisions is critical for navigating the complexities of translocations effectively, ensuring the conservation of biodiversity and ecosystem sustainability.


**Keywords:** biological invasions, conservation, translocations, invasive species management

## Introduction

Biological invasions are where species are moved by human activities from their native range to new areas where they have no evolutionary history and are a major global economic and ecological concern (Simberloff et al. 2005). Biological invasions are recognized as a pervasive threat to biodiversity and human well-being, especially in aquatic ecosystems (Cuthbert et al. 2021; Haubrock et al. 2021). Numerous pathways facilitate the spread of aquatic non-native species (Ruiz et al. 2011), with human-mediated pathways involving global trade and transportation (Avila et al. 2020). Once established in new habitats, aquatic non-native species can disrupt local ecosystems by competing with native species for resources, modifying habitats, and altering nutrient cycles, often with severe consequences for human well-being (Piria et al. 2021; Hald-Mortensen 2023). Economically, these species can damage sectors including fisheries and, among others, public welfare, leading to substantial financial costs (Cuthbert et al. 2021; Warziniack et al. 2021).

### Terminology of non-native species

The classification of non-native species is a complex issue intertwined with both ecological considerations and ethical concerns (Richardson et al. 2011) and was recently reviewed and discussed by Soto et al. (2024). Ethically, the language used in invasion science to describe non-native species often mirrors societal views on foreignness, with terms for non-native species such as “alien” reflecting and even reinforcing xenophobic attitudes (Soto et al. 2024), paralleling language used against human immigrants. From an ecological perspective, the current classification systems used for ‘invasiveness’ can differ substantially, where the focus is the ecological impact of the species or its ability to establish and spread, but rarely both (Soto et al. 2024).

In general, policies and management of non-native species rely strongly on national boundaries (Piria et al. 2021), which can be highly problematic as these boundaries fail to consider biogeographic principles on the evolutionary history and intricate ecological interactions of the species being moved (Soto et al. 2024). This is especially true for freshwater ecosystems, where nativeness and non-nativeness may even differ between adjacent river basins within the same biogeographic realm (e.g Warren et al. 2024). This is then exacerbated by ambiguous terminology with, for example, the EU Invasive Alien Species Regulation (Regulation (EU) 1143/2014) definition of an "invasive alien species" being '*animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment*', with the aim of the associated legislation to '*prevent, minimise and mitigate the adverse impacts posed by these species on native biodiversity and ecosystem services*'. Accordingly, there remains considerable ambiguity as to what constitutes the '*natural environment*' and '*native biodiversity*' (Chew and Hamilton 2011). We thus argue the requirement for a more nuanced and less ambiguous terminology for native species translocated within their native region that combines the issues of the species' biogeographic region of origin and ecosystems it naturally occurs in, as well as its evolutionary history and ecological role(s), rather than just relying on geo-political (often national) boundaries. More explicitly, we suggest that current terminology, such as "native biodiversity" and "non-native species" when considered in the assessment of biological invasions is too associated with national boundaries and their use must instead be based on sound biogeographical, evolutionary and ecological principles (Nehring and Klingenstein 2008; Wolter and Röhr 2010).

The abuse of terminology in this regard is well illustrated by native species that can become pests in their native region (previously named "native invasive", Simberloff and Rejmánek 2011; see also Soto et al. 2024) through human activities. This can occur through anthropogenic driven environmental changes that result in the abundance of native species rapidly increasing through shifts in life history traits, and through human-induced habitat changes that create novel environments where some native species can form highly abundant populations to the detriment of others (e.g. the transformation of lotic to lentic environments through impoundment; Šmejkal et al. 2023). It can also occur as a direct result of human actions, including intentional stocking, where a species considered native (according to national boundaries) is moved into a new area within either their original biogeographical range or into a new biogeographic range within the country (Carey et al. 2012). We argue this activity, despite often practised by conservationists to e.g. protect a highly endangered species (Ricciardi and Simberloff 2009; Olden et al. 2011; Bradley et al. 2022), represents the release of a non-native species and potentially results in a biological invasion whose harm on the receiving ecosystem is likely to be underestimated (Gilroy et al. 2017). It is these releases of species within national boundaries, but between biogeographic areas that ignore evolutionary histories and ecological roles, which we consider as being highly problematic for invasion management (Usher 2000; 2020; Soto et al. 2024).

**The issue of in-country translocations: case studies from freshwater ecosystems**

Efforts to conserve biodiversity and the aim of invasion scientists to understand and mitigate biological invasions are often perceived as a philosophical paradox due to synergistic overlaps concomitant to differing priorities (i.e. species native in one region but invasive in another; Pérez et al. 2006; Marchetti and Engstrom 2016). In recent years, the importance of in-country translocations of native species have increased in conservation worldwide (Vitule et al. 2019), yet are still largely overlooked by invasion scientists (see Glamuzina et al. 2017), despite being particularly common in certain countries (Tarkan et al. 2017). However, while conservation related translocations are often pre-planned and strictly regulated, movements of species for use in fisheries, aquaculture and the ornamental trade are less regulated, leading to widespread secondary spread (Vander Zanden and Olden 2008). Translocated native and non-native species (*sensu stricto*) thus can pose a considerable threat to native species and ecosystems, especially where the translocation has been poorly regulated (e.g. Hodder and Bullock 1997; Glamuzina et al. 2017), which we demonstrate in the following case studies.

## Translocated fishes

Translocations of freshwater fishes are commonplace, as this easily completed exercise can be used to enhance aquaculture production, and catches in commercial, artisanal and recreational fisheries. It has been used extensively in East Africa, with species such as Nile tilapia *Oreochromis niloticus* moved extensively between lakes in Kenya to enhance fish catches and improve food security (Geletu and Zhao 2023). These translocations have contributed to fish diversity loss in recent years, including through their hybridisation with native congeners, with the interaction of their translocation dynamics with aquaculture escapes also driving artificial gene flow between different Nile tilapia stocks, impacting the integrity of local gene pools (such as through outbreeding depression), impacting the sustainability of the species as a resource for fisheries (Tibihika et al. 2022).

In England, fish species richness is naturally higher in eastern flowing rivers than those flowing west. This resulted from a now drowned land-bridge with mainland Europe at the end of the last glacial period that connected these eastern flowing rivers with the Rhine and Danube systems, providing a route for fish recolonisation from glacial refuges further south (Wheeler 1977). In the last 100 years, there has been the frequent translocation of species, such as European barbel *Barbus barbus*, from these eastern flowing rivers where they are indigenous (usually in the Thames basin in southeastern England) to the western flowing rivers, where they are non-indigenous (e.g. Wheeler and Jordan 1990). A prominent example of this was the translocation of 509 adult fish from the River Kennet into the middle reaches of the River Severn in 1956, and completed by the fishery regulator of that time with the aim to enhance angling (Wheeler and Jordan 1990; Antognazza et al. 2016). These fish rapidly established a sustainable population which dispersed throughout the Severn basin and also resulted in further translocations in western Britain, with anglers moving these fish to neighbouring basins, such as the River Wye (Antognazza et al. 2016). In addition, translocations in the indigenous range involve the movement of hatchery reared barbel reared using broodstock from one basin (often the Thames again) and releasing them in different basins, with this already identified as impacting barbel genetic integrity in northeast England (Antognazza et al. 2016). Accordingly, barbel are now widespread through Great Britain, with populations in England, Scotland and Wales due to translocations, despite their native range being restricted to a small number of basins in eastern England (Wheeler and Jordan 1990; Antognazza et al. 2016).

European perch (*Perca fluviatilis*), known for its aggressive feeding behaviour that often results in the extirpation of native fish species, has been extensively translocated between different bodies of water within its native range by anglers from Thrace (European part of Turkey) to newly established water reservoirs in the Anatolian part (Tarkan et al. 2023b). The translocated perch exhibit higher aggression levels than native populations, impacting native fish communities (Tarkan et al. 2023a), and potentially lead to cascading effects throughout the food web, altering community structure and ecosystem dynamics, with implications for both ecosystem functioning and human well-being (Tarkan et al. 2023a). Similarly, the extirpation of two endemic fish species in lakes Egirdir and Beysehir (southern Anatolia) has been linked to the introduction of translocated piscivorous pikeperch *Sander lucioperca* (Tarkan et al. 2014).

A unique example in support of our argument relates to the existence of two distinctive populations of racer goby (*Babka gymnotrachelus*) in Poland. In the mid-1990s, the species was recorded in the Vistula drainage system, likely reaching it from the Dnieper through Pripyat-Bug canals (Semenchenko et al. 2011). It has since been listed among other spreading non-native species in Polish rivers (Grabowska et al. 2010). However, monitoring studies in 2009 in the Strwiąż River, a tributary of the upper Dniester River, identified an abundant population of racer goby, suggesting its native status in Poland. As genetic analyses confirmed the dual origin of the species (Grabowski et al. 2015), this creates an ambiguous situation where, considering administrative borders, the species is simultaneously native to one and invasive to another tributary within the same country, posing challenges from a legislative and regulatory perspective.

Other translocated taxa

The issue of translocations is not limited to fish but is a cross-taxa issue involving amphibians, reptiles and crustaceans. For crustaceans, the translocation of the freshwater shrimp (*Paratya australiensis*) within the same drainage system in Australia to maintain and even increase genetic diversity led to the extirpation of the resident genotype within seven years due to mating preferences of females with translocated males and the low viability of crosses between resident females and translocated males (Hughes et al. 2003). In Australia, the translocation of three native freshwater crayfish species (*Cherax tenuimanus*, *C. destructor*, and *C. quadricarinatus*) raised concerns due to the subsequent harmful impacts on native freshwater ecosystems (Beatty et al. 2005) While Australia has established controls to manage the import and export of these crayfish, the regulatory approach within the country lacked uniformity and, ultimately, led to numerous impacts, including the introduction of diseases, disruption of local ecosystems through competitive interactions with native species, habitat alterations, and genetic dilution through hybridisation. Similar cases may also be found in North America, where many crayfish species are widespread, but where the native regions and river basins do not overlap with state boundaries (Taylor et al. 2007).

For other taxa, translocations often have negative outcomes for the released individuals rather than resulting in invasions, which can be problematic if the driver of the translocation was to relocate endangered animals (such as amphibians) that are under threat from habitat destruction (Bradley et al. 2022). Such translocations for mitigation effects are a form of assisted colonisation and mirror debates on using this as a climate change adaptation action for protecting vulnerable species (e.g. Lunt et al. 2013). To reduce human-wildlife conflicts reptiles are moved to new locations where they seem to experience elevated mortality rates compared to resident individuals. This is frequently linked to unusual movement patterns, stress, disease, and challenges in surviving winters, particularly for species that prioritise locating suitable hibernation sites (summarised by Sullivan et al. 2015; Cornelis et al. 2021).

## Redefining 'native area': a call for a biogeographic ecosystem approach

These case studies indicate that the translocation of species between river basins may exhibit diverse reactions based on the specific environmental conditions in which they are introduced (Tarkan et al. 2017). This inherent variability emphasises the need for a nuanced understanding of ecological dependencies, as not all translocated species respond uniformly to non-native counterparts (Vitule et al. 2019). The underlying factor driving such varied responses lies in the ecological dependency of species, whereby their behaviour is intricately influenced by the environmental context (Strona et al. 2021).

Accordingly, we argue that the issue of translocated native species within national boundaries demands a re-evaluation of the concept of 'native area' (Guichón et al. 2015) and associated terminology (Soto et al. 2024), particularly in the contexts of fisheries, aquaculture, and the ornamental trade. Traditional classification systems based on national boundaries are insufficient for addressing the ecological complexities of species translocations (Pyšek et al. 2004). A bio-geographically informed approach, recognizing the ecological and evolutionary contexts of species, is imperative. These could, among others, include river basin district (RBD) type approaches as implemented in the Water Framework Directive (Nilsson et al. 2004) and thus, we emphasise that our primary concern lies with the movements for fisheries, aquaculture, and ornamental trade, areas where risk screening and regulatory measures are more strictly adopted. The implementation of such an approach would involve considering the historical distribution, ecological interactions, and evolutionary relationships of species to define their nativity more accurately. This shift in perspective would enable conservationists and policymakers to develop more effective and ecologically sound strategies for managing non-native species and allow a more accurate risk screening and assessment process (Copp et al. 2016; Tarkan et al. 2020). We then suggest the term ‘translocated native species’ is replaced by ‘introduced native species’, bringing it in-line with invasion science terminology and embedding biogeographic principles within policy and regulation.

**Conclusion**

The evident importance of species translocated within their native region in the context of biological invasions, equivalent to that of non-native species, highlights the need for a flexible management framework designed to fully incorporate and address the nuances of species propagated for commercial sale. Such a framework should consider both the native species natural ecosystems, biogeographic distribution, and evolutionary history when outlining its natural occurrences. One such framework could be the Dispersal-Origin-Status-Impact (DOSI) assessment scheme, introduced by (Soto et al. 2024) DOSI classifies populations of non-native species at the population level. For this, it assesses non-native species based on their dispersal methods (assisted or independent), origin (allochthonous or autochthonous), current status (expanding, stationary, or shrinking), and impact (ecological, economic, health, or cultural). DOSI's flexible and comprehensive approach supports objective, data-driven decision-making for managing biological invasions, allowing for prioritisation of interventions at various scales. This method represents an improvement over previous strategies by addressing the needs of managers and stakeholders with limited resources. DOSI could be expanded to include introduced species (i.e., species translocated within their native range to ecosystems where they do not occur naturally) or native pests whose inclusion might refine the management strategies under DOSI. DOSI only considers negative impacts (i.e., potential threats), acknowledging that negative impacts considerably outweigh and are distinct from any potential benefits. However, the aim of DOSI is to prioritise populations of non-native species for management interventions based on local risks, disregarding the feasibility or existence of adequate approaches, and the species' ability to spread beyond current confinements. While this is one possibility, the intricate challenges associated with translocated species however stress the urgency for robust risk management strategies, complemented by meticulous monitoring and centralised databases, to navigate the complexities of translocations in more effective ways.

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