PUBLISHED: 22 JUNE 2017 | VOLUME: 1 | ARTICLE NUMBER: 0201

editorial

Invasions everywhere

The study of invasive species is burgeoning and involves both the natural and social sciences.

Invasive species — how and why they spread and how we should control them — is a much researched topic in ecology and an issue on many policy agendas. For example, Target 15.8 of the Sustainable Development Goals (https://sustainabledevelopment.un.org/sdg15) calls for alien species introductions to be prevented, the impact of invasives to be reduced, and for key species to be controlled or eradicated. The importance of the topic is reflected in both submissions to this journal and the articles we have published so far, and our July issue provides a good example.

Islands have been particularly susceptible to the effects of invasive species because of their naive flora and fauna before human arrival. In a Perspective, Nogué *et al.* (article no. 0181) argue that palaeoecology is necessary for tackling island invasions as long-term data can provide strong evidence of effects on ecosystems, as well as answering the more basic question of whether a species is actually native or not.

Bertelsmeier *et al.* (article no. 0184) explore in detail the link between human history and the spread of invasives, comparing over 200 ant species. They found that the non-native species clustered into groups that spread in different ways, each group associated with a particular historical period and specific ecological traits. For example, species with a truly global spread tended to be habitat generalists that invaded before the First World War. Applying this understanding to other species groups could help predict the circumstances under which species become a major threat to ecosystems.

Dawson *et al.* (article no. 0186) take a broader taxonomic approach, comparing a wide range of different plant and animal groups of terrestrial invasive species at a global scale. They find that islands and coastal regions are the most strongly affected areas, but that the environmental factors that explain geographical variation differ between taxonomic groups. For example, the richness of established alien species is positively related to mean annual temperature for ants and reptiles, but negatively related for fishes, mammals and plants.

Finally, Ottoni *et al.* (article no. 0139) explore the domestication and early spread of what has become one of the most destructive invasive species known — the equally loved and loathed domestic cat. Domesticated animals as invasives are a double whammy of an anthropogenic problem, with humans responsible for the species' origin and also their non-native spread. A study[1] from 2013 estimated that free-ranging domestic cats in the US cause the deaths of 1.3–4 billion birds and 6.3–22.3 billion mammals per annum.

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As with many themes in conservation science, our approach to invasive species cannot be determined by understanding the biology alone; we need to understand the associated social science. This includes the complex politics of how decisions are made about control programmes; the psychology of how people view different types of invasive species — pathogenic microorganisms versus domesticated vertebrates, for example; and the economic and historical trends that are associated with the spread of invasives.

The iterative Delphi technique is a social science method that has been successfully applied for horizon scanning key issues in conservation. A recent paper[2] applies the technique to invasive species and identifies the areas that experts see as being of most importance. The socio-political issues identified include changes to international trade deals, the globalization of the warming Arctic, and concern about invasive species denialism. On the biological front, key issues are the importance of microorganisms, both as invasive pathogens and as a key part of the soil biota that determines invasiveness, and the use of genomic technologies in attempts to control invasions.

A recent *Nature Ecology & Evolution* Comment[3] examines the risks associated with biocontrol programmes for invasive species. The authors provide a checklist for decision-makers assessing the risks and benefits of control programmes, including issues such as the knock-on effects to other invasive and native species, and the possibility of reversing the action should unexpected problems occur. They focus in particular on the gap between scientific understanding of the risks, and the proper assessment of these risks as part of the decision-making process.

This increasing consideration of the social science complexities of invasion science is not to say that the biological questions are any more straightforward. In 2011, a group of ecologists wrote in *Nature*[4] calling for the scientific community to move away from its automatic hostility to non-native species, arguing that ecological impact rather than biogeographical origin should be the key metric when assessing species. This elicited a strongly worded response from 141 other ecologists[5], who felt such an approach risked underestimating the potential harm a species could cause in the future. Similarly, Chris Thomas argued[6] in 2013 that we should be more welcoming of the evolutionary diversity that can be generated by invasions, treating it as a hallmark of the Anthropocene. While this idea is controversial, it is certainly true that the range shifts seen as a result of environmental change make the distinction between native and non-native species much less clear than it was traditionally. Species can move taking some of their ecological network with them but rewiring it to include some new species as well. The extent to which this can be seen as an invasion is debatable.

Such debate, and such strong interactions between different disciplines, demonstrates the vibrancy and importance of invasion science. This month, the global ecology of invasive species will again be in the spotlight at the British Ecological Society's symposium 'The Macroecology of Alien Species' (http://go.nature.com/2scnat9) in Durham, UK. We shall be there, and are looking forward to furthering this journal's keen interest in understanding the consequences of the global mixing of biota. ❐

References

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