

misleading. This mixes up two different concepts that might superficially appear similar. The authors do not provide a formal definition of social responsiveness, but from the evolutionary scenarios they present, 'social responsiveness' seems to refer to the degree to which individuals respond to social information. In these scenarios, individuals can adopt one of two strategies, responding to social stimuli or ignoring them (e.g., [4,5]). Thus, variation in social responsiveness exists along a single dimension; social information is used to a higher or lesser degree. If individuals are responsive and use external information, they do so by following fixed rules. This includes showing the best possible response to the last move of an opponent (scenario 1), copying the most recent choice of another group member (scenario 2), or choosing the most profitable patch by using social information revealing the state of available patches (scenario 3). By contrast, 'social competence' refers to the ability of an individual to optimise its social behaviour depending on social information [1]. The concept of social competence not only describes the extent to which external information is used, but also incorporates the ability to respond adequately to social information. Individuals with low social competence can arise from either (i) not taking social information into account (in which case, they are similar to individuals with low social responsiveness), or (ii) showing a high but wrong response (in which case, an individual with high social responsiveness can have low social competence). Thus, variation in social competence can arise from variation in the weight given to social information (i.e., social responsiveness) and/or from variation in the ability to express an appropriate response to social information. Therefore, in contrast to social responsiveness, which represents a behavioural strategy, social competence refers to an ability. It is difficult to imagine how a lack of an ability, which may lead to poor performance in a particular social context, should become evolutionary stable through fitness payoffs obtained in that particular context.

Finally, because of the general differences between a behavioural strategy and the ability of an animal to conduct an ecologically relevant task (performance trait [3]), the eco-evolutionary framework leading to variation in social competence is unlikely to be based on frequency-dependent decisions within the same behavioural context, as it does in the case of social responsiveness. Individuals performing poorly in the social domain should always be outperformed by individuals performing well in the same domain. However, the environment and the selective forces usually differ between individuals of a population. For example, in cooperatively breeding species, a high ability to cope with social challenges (social competence) may be important for members of large social groups, whereas the ability to evade predation may be more important in small groups, which provide less protection against predator attacks. Given that the acquisition of different abilities can be assumed to be costly, trade-offs are likely to exist between the acquisition of different abilities. Thus, decisions across different ecological and behavioural contexts can lead to adaptive variation in social competence.

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## Managing invasive species amidst high uncertainty and novelty

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Most conservation biologists would agree that the spread of non-native species is undesirable and should be prevented whenever possible. This view was recently criticized by Davis *et al.*, who argued that organisms should be

assessed on their negative environmental effects rather than on whether they are native or not [1]. In a recent article in *TREE*, Simberloff *et al.* take issue with their critique, demonstrating that great progress has been made in understanding and managing the negative effects of biological invasions, and proposing that the proper role of scientists is to educate people about these negative effects and thereby to inform societal debate [2]. As an

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interdisciplinary group of ecologists and social scientists, we agree that invasion biologists should interact with society, yet we wish to point out some of the difficulties of this interaction in situations in which our understanding remains highly uncertain [3–5].

Simberloff *et al.* emphasize the role of scientists in ‘transferring knowledge’ to the public, arguing that they should inform the public about the right decision to be taken [2]. This might be practicable when the effects of biological invasions are well documented, so that experts and the public can agree about what form of preventive action is needed. However, when uncertainties are high, it will be unclear whether action – or inaction – will have net positive or negative consequences. Indeed, as Simberloff *et al.* acknowledge [2], the effects of invasive species are often difficult to detect or occur after long time lags, and the accuracy of our present weed risk-assessment systems is ‘usually insufficient’ [6]. Furthermore, there is often little agreement about what sort of management would be appropriate, with options ranging ‘from complete eradication to tolerance and even consideration of the “new” species as an enrichment of local biodiversity and key elements to maintain ecosystem services’ [7].

For these reasons, scientists will often be unable to fulfill the role advocated by Simberloff *et al.* [2]. Not only might they be unable to separate ‘good’ from ‘bad’ decisions, but definitive recommendations based on incomplete information can aggravate rather than alleviate policy conflicts [4,8,9]. A more effective role for scientists, therefore, would be to portray the range of possible outcomes associated with prevention, early detection, and management, and – to the extent possible – to indicate the associated uncertainties. This requires earlier engagement with diverse stakeholders, and could stimulate more creative and locally generated conservation solutions [10].

Scientists must also be careful in the language they use to describe biological invasions. In our view, Simberloff *et al.* create confusion by defining impact neutrally as ‘any significant change (increase or decrease) ... regardless of perceived value to humans’, yet then use it normatively, for instance when they state that ‘by the time impacts are noted, irreversible changes might have occurred or palliative measures might be too costly or impossible’ [2]. The word ‘impact’, which occurs nearly 50 times in their paper, usually harbors negative connotations and thus communicates a judgment that is not supported by scientific evidence. It could simply be replaced by ‘change’ or ‘effect’. Even more problematic is the description of the spread of invasive species as ‘reminiscent of armies moving’ [2]. Such

a vivid metaphor might be effective in prompting people to take action when negative effects of a particular invasion are obvious, but can hardly be justified in other cases in which the ecological evidence is at best weak.

By documenting cases in which invasive species have had severe negative effects, invasion biologists have helped to build awareness and institutions for preventing and mitigating their costs. However, the effects of many invasive species are less certain, so invasion biology will only serve the interests of society by embracing the actual complexities. In such cases, biological facts alone cannot clarify how to act, which has implications for interpreting and implementing both prevention and the precautionary principle [3]. Like other risks, such as genetically modified organisms (GMOs) and new technologies, precautionary action against biological invasions must be balanced with opportunity costs, and world views on nature and human intervention might be just as important as scientific facts in reaching a decision. Therefore, more biological facts about invasions will sometimes not suffice to convince the public about the importance of a precautionary approach; rather, we require more social scientific insights into why some people prefer caution whereas others are willing to opt for novelty.

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