

Response to Ricciardi. Assessing species invasions as a cause of extinction

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In our recent article in *TREE* [1], we considered the evidence for the common assumption that invaders are a major cause of species extinction. Ricciardi [2] criticized the focus of our paper, and challenged our statement that the role of zebra mussels *Dreissena polymorpha* in unionid mussel extinctions is unclear.

Like Ricciardi [2], we recognize and appreciate the importance of local population losses (extirpation). Risks to evolutionarily significant units (ESUs) rather than species have been the basis for managing endangered Pacific salmonids, and threatened populations are the focus for Endangered Species Act listing in the USA. However, our paper focused on the role of invasives in extinction, rather than in local losses, for several reasons. First, we believe strongly that better determination of the factors implicated in the decline of species threatened with global extinction is crucially important. Local losses might or might not be reparable, but, as the saying goes, 'extinction is forever'. Second, Ricciardi argues that we should examine species that have undergone significant range contractions and population losses; we relied in part upon data from the IUCN Red List (<http://www.redlist.org/>) in making our argument, and many species suffering such contractions and local losses are on that list. Finally, as a practical matter, equivalent extensive validated lists for local populations are unavailable, even though they would be of great value if anyone was able to compile them.

We questioned the role of zebra mussels in the extinction of unionids. Ricciardi argues that empirical modeling has suggested that zebra mussels have greatly accelerated the local extirpation of unionid species. The rapid rate of extinction of these bivalves was recognized long before zebra mussels invaded North America [3]. For these bivalves, the primary extinction threats are habitat loss and degradation (including construction of dams, development, pollution and toxic sediments [4–7]), harvest for the cultured pearl industry, and loss of native

fishes necessary for completion of their lifecycle [3,4]. The hotspots of both unionid diversity and impending losses are in the middle reaches of the Tennessee River and the Coosa watershed in Tennessee, Georgia and Alabama, not in lakes where zebra mussels have the largest impacts. Recent work suggests that even if zebra mussels and other stressors were removed, these long-lived species would not recover because of the legacy of toxic sediments left from decades of pollution [6].

We feel that it is essential to determine the most important factors impacting declining species; failing this, our efforts to save or conserve endangered species will be for nothing. If unionid populations were not already depressed, would invaders have the same impact? We argued [1] that many threatened taxa are affected by multiple stressors, making assessment of the nature of the threats posed by invaders extremely challenging. Correctly assessing the crucial factors responsible for and threatening species or ESUs with extinction is ultimately vital for the preservation of biodiversity.

References

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