Invading the territory of invasives: the dangers of biotic disturbance

New York City, 1908: different colors of skin swirl in the great melting pot to produce a cultural medley. Now imagine such a metropolis spreading to cover every last crevice on Earth. Over time, people will weave to produce an unprecedented uniformity; once discrete identities would be lost. Our heritages will be remembered only by the history texts in the hands of our progeny. A similar effect can be observed in environmental systems: we are in danger of losing our global biodiversity to a monotonous fate. The threat of invasive species is now greater than the world has ever witnessed. The number of introductions caused by international commerce is enormous (Mooney and Cleland, 2001). Although only a small portion of emigrants survive, those survivors have aggregated to form a giant global problem of bioinvasions (Mack et al., 2000). Extensive studies have been done on many exotics, such as the zebra mussel *Dreissena polymorpha*, and their biological and ecological threats prompt human interest and intervention (Facon et al., 2006). Environmentalists advocate the awareness of invasive species and governments spend millions to purge them. However, species removal is not as simple as it seems; we must be aware that the removal of an invasive causes ecosystem disturbance, just like its introduction, and hasty action can cause irreparable damage to our global asset of biodiversity. Extensive and specific studies of the risks and rewards of invasive species removal should be done before any actions to control a bioinvasion.

The greatest danger in dealing with invasive species involves risks in disturbing an ecosystem, especially one that's already threatened by an exotic. There are many studies being done on the effects of these unwanted immigrants, but precise mechanisms for these ecological disturbances are still unclear (Mack et al., 2000). Even less understood are the consequences of their removal. A study on the effects of introduced trout on frogs showed that native populations can dramatically rebound upon extirpation of the invasive predator (Vredenburg 2004). However, studies like this may not have strong implications on the majority of bioinvasions. This study was carried out in isolated mountain pools. With the exception of the introduced trout, these ecosystems have had minimal disturbance and human contact. This is quite different from many other bioinvasions that happen in peoples' backyards.

Insufficient understanding of invasive mechanisms can have catastrophic ramifications. In French Polynesia, the predatory land snail *Euglandina rosea* was deemed a fix to the economical threats of the giant African land snail *Achatina fulica*. Convinced by experiences with *A. fulica* in Hawaii, a hasty French Polynesian government set this invasive control project into action (O'Foighil 2006). The resultant extinction of nearly all endemic Partulid species is a painful lesson today (Coote and Loeve, 2003). Hawaii and French Polynesia are both pacific archipelagos, but their differing ecosystems led to the tragedy of the Partulids. Thus historical precedence cannot always be generalized and applied to foreign problems. Specific studies of any target invasive and ecosystem must be done before drastic actions are carried out.

The removal process itself is extremely tedious and in some cases near impossible. The removal of trout from five isolated lakes in Sixty Lake Basin of California took six years (Vredenburg 2004). Similar cleansing of downstream lakes that could receive upstream fish would require even greater efforts. In the case of *E. rosea* in French Polynesia, removal is thought to be impossible. The carnivorous snail has infested every corner of numerous French Polynesian islands, eliminating any possibility of Partulid reintroduction (Coote and Loeve 2006).

The ability of bioinvaders to hybridize with native species to produce a spectrum of pseudo-exotics exacerbates difficulties faced. This is most common among plants, which can also undergo extremely rapid evolution (Callaway and Maron, 2006): in England native species of the genus *Senecio* have readily hybridized with exotics to produce offspring that have taken over the country (Facon et al. 2006). In such cases, total extirpation of non-natives would require the elimination of more than one species and looms as a truly daunting task. As can be seen, removal projects are not always pragmatic or even possible. Studies like the English *Senecio* project help elicit the mechanisms for bioinvasion and gauge the practicality of control projects so we do not waste effort on an impossible task. Similar research should be done on all exotics before invasive removal projects.

The economic costs of invasive species total over one hundred billion dollars a year in the United States alone, and millions more are spent to control or eliminate them (Mack et al., 2006). However, the benefits of such projects aren't always clear even upon completion. We assume the noble goal of restoring a native ecosystem, yet actual outcomes can be less-than-equitable compromises. In the mid 20th century the United States government extirpated arctic foxes that had been introduced to the Aleutian archipelago fifty years earlier (Croll et al., 2005). Now half a century later, once fox-infested islands still bear the scars of the bioinvasion despite the 'success' of the fox removal project. Seabirds are slow to recolonize the once dangerous islands, and the lack of guano leaves them under blankets of tundra. Again, research to understand the mechanisms of bioinvasions could have helped predict this outcome and prevent implementation of such wasted efforts.

We launch invasive removal projects to 'save the natives'; however, are we actually helping them by removing an invasive? Environments that have been exposed to an exotic for sufficiently long periods have reestablished equilibrium: species have developed adaptations to cope with their new neighbors. Off the coast of New England, mussels exposed to predatory crabs develop thicker shells as protection (Freeman and Byers, 2006). In Australia, snakes evolved smaller relative head sizes to cope with the introduced toxic cane toads (Phillips and Shine, 2004). These morphological changes represent investments to increase fitness in altered habitats. The energy cost of these features is balanced by an increased ability to survive. By removing invaders, we are eliminating the benefits of their adaptations. These disturbances would leave the native species with just the adverse costs of thickened shells and smaller heads. In dealing with bioinvasions, we must consider not only the native species, but also the dynamic ecosystems. Disturbances can draw out unforeseen effects; like the fox removal project in Alaska, a disturbance with the noblest of purposes can fall short of recovery.

Invasive species are a threat to the world's biodiversity, but their removal can be just as hazardous. Even with the right goal, without proper planning and sufficient studies to understand target ecosystems, projects in invasive removal can prove futile or even produce dire consequences. Fortunately for Partulids in French Polynesia, at least one extant member of each endangered clade has been discovered and some hope of recovery still exists (O'Foighil 2006). Yet many organisms have no immediate relatives:

the "dead clades walking" are survivors of past mass-extinction events and their loss would be irreparable (Jablonski 2001).

When controlling the global problem of invasive species, prevention outshines restoration. Most modern invasives are spread by artificially, either as unwitting stowaways or intentional imports. However for the average citizen, the awareness of biodiversity is often masked by personal, political, and economic concern. The threat of bioinvasions must be publicized and personalized. Only thru the aggregation of countless personal efforts can a global threat be contained. In New Zealand, invasive trout are a publicly supported economic boon (Townsend 2003). Any extensive lobbying for the continued existence of a species is admirable. If people were just as aware of the value in their endemic biodiversity, curbing the spread of exotic species would take an easier turn.

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