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Managing Invasive Aliens through Habitat Restoration and Biomanipulation: the Case of American Bullfrog Lithobates Catesbeianus in Belgium

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It has been shown that invaded ecosystems are often complex and composed of multiple networks and feedback loops, which can lead to unexpected effects of management actions. Removal of one species can then result in unanticipated changes to other ecosystem components. Under such circumstances, managing the whole biotic community to reduce invasion impacts may be more effective for achieving the desired conservation goals.In (semi-)natural ecosystems, we consider every form of ecologically-based interference aimed at enhancing the biological interest of an area or habitat as habitat management. On the other end of the control spectrum, restoration, unlike eradication, focuses on restoring a healthy ecosystem instead of on removal of organisms. The case of the control program for invasive American bullfrog *Lithobates catesbeianus* management in Flanders (Northern Belgium) illustrates the approach of combining several objectives and methods for invasive species control. American bullfrog isone of the top 100 of the world's worst invasive and damaging species. It is not clear if the poor water quality is due to its abundance or it is its consequence; regardless, control of bullfrog populations is extremely difficult due to the species' flexible life history and population biology. We investigated two contrasting approaches to control the species. Isolated populations in permanent, small (< 4000 m²) and shallow water bodies were actively managed through trapping. In large interconnected meta-populations we explored passive management through general habitat restoration. We investigated the effect of predation by introduction of native northern pike *Esox Lucius* on bullfrogs which lead to a strong decline in tadpoles. Also, communities receiving pike harboured less other invasive alien species that facilitate bullfrog larvae through predation on macro-invertebrates and increases in phytoplankton. Thus, using a native predatory fish species can effectivelylead to a change in food web interactions to the detriment of bullfrog. At the same time the ecosystem at hand is rendered more resilient to future invader problems. Bio-manipulation may be more cost-effective for controlling or sustainably mitigating bullfrog impact in permanent water bodies. The method can also be used as after-care on actively managed sites. Similar examples are the use of pike or perch *Perca fluviatilis* for the biological control of invasive topmouth gugeon.Thus, invasion biology could entangle more with the field of restoration ecology. This requires consideration of exotic species in the greater context of community structure, knowledge of their impact in time and impact on succession. These elements can be essential in conservation triage, removal prioritisation and the setting of realistic management targets.

Keywords: biomanipulation; habitat restoration; pike; American bullfrog; fyke netting.