Management of invasive plants in relation to life history

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Summary   Management of invasive species aims to reduce population growth and invasion speed. Instead of trying to control all individuals in the population, the efficiency of reducing the spread of the invader can be improved by focusing control actions on the life stages (e.g. seedlings, vegetative plants, reproductive plants) or demographic processes with the greatest impact on population growth rate. Demographic processes are here defined broadly referring to plant survival (plants staying alive without growing in size), growth (plants growing in size and transferring to larger life stages) and fecundity (seed and seedling production). So far, general guidelines for management of invasive plants are lacking, necessitating detailed case studies and models to be constructed for each new invader.

Matrix population models, in which the survival, growth and fecundity rates are determined for different life stages, provide a tool for identification of potential control targets for invaders in terms of elasticity values. The greater the elasticity value is for a demographic transition or life stage, the more a perturbation in that transition or stage is expected to affect population growth rate. Studies applying matrix population models to invasive plant species have accumulated, enabling a synthesis of potential life stages and demographic processes to target for reductions in population growth rates. This synthesis will be particularly beneficial where urgent management strategies are needed for new invaders or species lacking detailed demographic data.

Using published matrix population models for 21 invasive plant species with different life histories (list available upon request), we examined responsiveness to survival, growth and fecundity perturbations, and determined which life stages and demographic processes to target for the greatest reductions in population growth rates. To find the best potential targets, we used both an elasticity analysis and a simulation approach.

Although short-lived and long-lived invasive plants had similar population growth rates (λ), elasticities of their growth rates to perturbations in the four life stages (seeds in the seed bank, seedlings, vegetative stages, reproductive stages) differed. Assuming that population dynamics were density independent, elasticities of population growth rates for vegetative stages were greatest for short-lived invaders, and elasticities of population growth rates for reproductive stages were greatest for long-lived invaders. High elasticity values of vegetative and reproductive stages, together with high stage survival, make these life stages better potential control targets than seeds in the seed bank and seedlings.

As the population growth rates of individual species increased, the elasticities for growth and fecundity transitions increased, and the elasticities for survival transitions decreased. According to elasticity analysis, control of growth and fecundity transitions would be the most efficient ways to reduce plant invasion in rapidly growing populations. Simulated reductions in survival, growth and fecundity mainly confirmed the results of the elasticity analysis but revealed that smaller reductions were required for short-lived than long-lived invaders to turn increasing populations into declining populations.

These general guidelines can be applied to rapidly growing new plant invasions where detailed demographic data on invasive species are lacking, and at the invasion front where plant density does not limit population growth. Overall, the results emphasise the importance of population growth rate and the life history of a species in the selection of control targets.

Keywords   Demography, elasticity analysis, management, matrix population models, population dynamics.