25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

A partially observed approach to invasive species management: To monitor or control?

T.K. Waring [a,b], V. Somers [c], M. McCarthy [d] and C.M. Baker [a,b,e]

[a] *School of Mathematics and Statistics, The University of Melbourne, Australia*
[b] *Melbourne Centre for Data Science, The University of Melbourne, Australia*
[c] *OPTIMA, The University of Melbourne, Australia*
[d] *School of Ecosystem and Forest Sciences, The University of Melbourne, Australia*
[e] *Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Australia*
Email: tom.waring@unimelb.edu.au

Abstract: One of the challenges involved in managing invasive species is uncertainty about the size of the population. To reduce uncertainty, we can expend effort to monitor the species, but monitoring typically doesn't reduce the size of the population. Instead, monitoring gives us information. Hence, environmental managers are often faced with the question of how to divide effort between monitoring and control. Building on techniques from Partially Observed Markov Decision Processes (POMDPs), we define a general framework for determining whether it is best to monitor or control. Given an estimate (with uncertainty) of the species' abundance, we compute the optimal action, accounting for multiple control interventions, monitoring with varying uncertainty, and interventions which combine the two. The key advance in our work is the generality and broad applicability of the problem framing.

Environmental managers must balance the cost of controlling an invasive species — say by a program of baiting or trapping — with the potential costs of allowing the infestation to continue. With knowledge of how abundant the species is, and of how quickly it is growing, researchers or managers can use dynamic programming to decide whether a given intervention is cost effective. However, traditional approaches to this problem assume that the size of the population is precisely known, which in practice requires investment in monitoring the growth of the infestation.

Partially Observed Markov Decision Processes are ideally suited to this problem. In general, framing a problem like this allows the manager to account for actions which reduce uncertainty, as well as those which reduce the size of the population. However, existing applications of POMDPs to ecological management are limited by computational resources to very simplistic models of the ecosystem in question. In particular, the dimensionality of the calculation is reduced by limiting the possible states of the system. To facilitate easy interpretation, we propose instead that the distribution over possible population sizes is parametrised by a central estimate of the population, and an estimate of the uncertainty. With this change in perspective, we develop a framework for applying POMDPs to the problem of ecological management and produce intuitive visualisations of the results.

Keywords: *Invasive species, Partially Observed Markov Decision Processes, decision making, uncertainty*