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Trapping for mink control and water vole survival: Identifying key criteria using a spatially explicit individual based model

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ABSTRACT

Introduced alien species are the second most important threat to global biodiversity after habitat loss. The American mink *Mustela vison* has been introduced to several countries and is threatening a number of native species worldwide. We developed a spatially explicit and individual based model as a planning tool to identify key criteria for the implementation of trapping campaigns as a way to control open American mink populations. We first predicted the minimum effort required to reduce populations of mink below a certain threshold and the best time of year in which to trap mink to minimise their numbers. We then employed this methodology to predict the best trapping strategy to ensure the long-term survival of the water vole *Arvicola terrestris*, one of the species most endangered by the spread of the mink in the UK. We also applied the mink and water vole population models to rationalise a set of observed data in an area of 50×30 km in the Upper Thames (UK). The model predicted that it is necessary to remove mink for at least 3 months every year and that a mixed strategy of trapping during the mating, late dispersal and winter seasons is best for keeping mink at low densities. Concentrating trapping during the late dispersal and winter seasons is instead best for ensuring the long-term survival of water voles. Targeting immigrating juvenile mink as well as reproductive adults is important. The model also showed that trapping efficiency might be an important factor to consider when choosing periods in which to trap.

1. Introduction

Introduced vertebrate predators are an increasingly common, and often unwelcome, addition to native fauna, and they can have significant negative effects on native species (Mack et al., 2000). Whilst the problem is widespread, in Europe only a few control or eradication programs have been implemented probably due to the limited awareness of the public and the decision makers, the inadequacy of the legal framework, and the scarcity of resources (Genovesi, 2005). Control and eradication campaigns may incur large costs in terms of animal welfare, human effort and funding (e.g. Gosling and Baker, 1989; Moore et al., 2003) and experience has shown that the success of such efforts varies widely, ranging from satisfactory to disappointing (Mack et al., 2000). Therefore, before undertaking such a campaign, a preliminary assessment of the likelihood of success and careful planning are vitally important. Indeed, a preliminary modelling exercise

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contributed crucially to the success of a coypu *Myocastor coypus* eradication campaign (Gosling and Baker, 1987), but there is, in general, a shortage of projects that employ this kind of approach for invasive species management. In this paper, we develop a modelling approach as a planning tool to evaluate the feasibility and to identify key issues determining the success of trapping as a way to control open populations of American mink *Mustela vison*.

The American mink is native of North America and is now established as an invasive species in South America, Europe, Russia and Asia (Dunstone, 1993). Several studies have demonstrated that mink can have serious impacts on native species, in particular ground-nesting birds (Craik, 1997; Nordström et al., 2003), rodents (Woodroffe et al., 1990; Banks et al., 2005), and mustelids of similar size (Maran et al., 1998; Sidorovich and Macdonald, 2001). In Europe, trapping campaigns have been or are being carried out to remove mink from certain areas, mostly islands (e.g. Macdonald et al., 2002b; Moore et al., 2003). Parts of the benefits of carrying out eradications on islands derive from the fact that immigration of mink from the mainland and hence re-establishment of populations is prevented or restricted (Nordström and Korpimäki, 2004). On the mainland, control or eradication campaigns require greater effort and a long-term commitment because immigration of mink from nearby areas can occur continuously (Sidorovich and Polozov, 2002). However, in spite of these problems there are cases when local control of mink on the mainland has been attempted to protect species and populations that are particularly endangered, such as in the case of the water vole *Arvicola terrestris* in Britain (Anon., 1995). Our work is aimed at developing a trapping strategy for locally controlling mink on the mainland in relatively small areas of less than 1000 km^2, where immigration is often an important factor in their population dynamics.

There are two main ways of reducing mink numbers, live-trapping and killing any American mink trapped or using lethal traps designed to kill instantly (Macdonald and Harrington, 2003). In the UK and most of Europe, mustelids and other animals of similar size are sympatric with mink hence live-trapping is more appropriate because it allows the selective removal of mink. With live-trapping, traps can be set on the ground, usually along water bodies, or on rafts floating on the water (Macdonald and Harrington, 2003; Reynolds et al., 2004). The use of floating rafts is relatively new, hence there are few data on the seasonal patterns of capture with this method. However, there are numerous data on the seasonal patterns of capture when using traps set on the ground. Our model is therefore based on the latter method of trapping.

To provide a framework for assessing the efficacy of mink trapping as a way to control mink, we developed a spatially explicit, stochastic, and individual-based model. The success of control programs is likely to be profoundly influenced by the life-history traits and space-use patterns of the target species (Conner et al., 1998) and spatially explicit and individual-based models allow ecologists to explore management scenarios in a spatial context by varying life history and management parameters. The analysis of the outputs of these models can help identify the most promising management approaches and thus design the most effective experiments so that time and funding are used efficiently. We first worked with a system that incorporated a two-level interaction between trappers and mink to explore what is the minimum effort required to reduce populations of mink below a certain threshold, and to establish what is the best time of year in which to trap mink to minimise their numbers. In addition we investigated two further issues: (1) How does immigration from nearby areas affect the choice of the trapping periods? and (2) how does systematic trapping compare to occasional trapping? The optimal time of year for trapping can, however, depend on the life-history traits of the prey species that one wishes to protect, as well as those of the predator. We therefore introduced a third variable in the system in the form of a prey of mink, to investigate whether the best time of year in which to trap mink would change depending on the interaction between the life-history traits of mink and those of its prey. We choose water voles as a model prey. Agricultural changes in Britain in the last century have destroyed water vole habitat, and the arrival of the mink as a predator has further aggravated the situation to the point that water voles are now in danger of extinction having declined by 88% since the beginning of the XXth century (Woodroffe et al., 1990; Jefferies, 2003).

2. Methods

2.1. *Model structure*

The model consisted of two components: (1) a GIS that stored habitat and animal population information; and (2) an individual-based population dynamics module that simulated individual life histories and dispersal within the GIS-held landscape. The GIS stored and retrieved habitat information and we used Geographic Resources Analysis Support System (GRASS) for map output (Westervelt et al., 1990). The population dynamics module was written in the programming language C and integrated with the GIS component through a UNIX-shell environment.

2.2. *GIS: properties of the spatial component of the model*

As a study area for our simulations we chose part of the Upper Thames catchment (UK) and its immediate surroundings (Ordnance Survey: N 230000 S 180000 E 456000 W 387000 – e.g. Fig. 8a for an outline of the study area) because a control operation was planned for this area and the model informed the planning of the control strategy. The total length of the rivers in the whole area was 1052 km. Of these, 127 km were selected for trapping in the model. A buffer of at least 15 km where the mink population was left undisturbed was left around the trapped area. The undisturbed population provided immigrants to the trapped area ensuring that the controlled population was open rather than closed.

2.2.1. *Mink model*

The land surface was partitioned into two categories: (1) areas of habitat that could be used by the mink for foraging, breeding and dispersing, namely rivers, streams and brooks and their immediate surroundings; (2) areas through which animals could move when dispersing but in which they could