

# Ecological traps in changing environments: Ecological and evolutionary consequences of a behaviourally mediated Allee effect

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## ABSTRACT

Species usually have to use indirect cues when assessing habitat quality. This means that it is possible for humans to alter habitats in a way that causes a discrepancy between the cues and the true quality of different habitats. This phenomenon is called an ‘ecological trap’. Here we show that the trap may lead to a behaviourally mediated Allee effect, where population growth is reduced because of non-ideal choices of individuals. The reduction is greatest at low densities because more individuals can choose their preferred habitat when competition for breeding sites is reduced. An ecological trap may lead to multiple equilibria in population dynamics and cause deterministic extinction in habitats that are capable of sustaining a viable population. We also study the efficiency of three mechanisms that may rescue a population from this extinction trap: natural selection acting on habitat preferences and two forms of phenotypic plasticity, experience-based learning and a philopatric preference for the natal habitat. Selection is most efficient in short-lived species with large heritable variation in habitat preferences, whereas in long-lived species, plastic traits outperform genetically determined preferences. The simple philopatric strategy generally produces the most favourable outcome. It hardly differs from the optimal strategy that assumes perfect and immediate knowledge of habitat change, and is very robust to non-ideal variation in the strength of habitat preferences. We conclude that conservation biologists need to ensure that cues for habitat choice correlate with habitat quality.

*Keywords:* ecological trap, extinction, habitat selection, ideal despotic distribution, philopatry, social learning, source–sink dynamics.

## INTRODUCTION

The Allee effect is defined as a decrease in individual survival or breeding output at low population sizes. It is critical to many issues in population ecology (Dennis, 1989), including extinctions (Reed, 1999; Berec *et al.*, 2001), exploitation (Greene *et al.*, 1998; Petersen and Levitan, in press), social behaviour (Courchamp *et al.*, 1999; Stephens and Sutherland,

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