

RESEARCH ARTICLE

Unraveling the dynamics of a ground-dwelling beetle population exposed to quarry exploitation and restoration practices

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Quarry exploitation and restoration practices are expected to have overarching and contrasting impacts on animal communities. Although many studies describe these impacts, they generally overlook the effects on population dynamics and individual movements. We assessed the impacts of quarry exploitation and restoration activity on population dynamics, individual movement, and habitat use of a sand-dwelling specialist beetle (*Scarites cyclops*). The study was performed on three plots: one adjacent to the margin of quarry exploitation, another subjected to restoration practices, and a control plot with no disturbance. A capture-mark-recapture approach was undertaken to estimate population parameters, movement, and habitat use. In the exploitation plot *S. cyclops* exhibited lower probability of recapture and lower apparent survival, as well as many movements fleeing away from quarry limits. Habitat suitability modeling showed that the exploitation plot provided better habitat conditions for the species than the restoration plot. It exhibited higher bare ground cover with scattered clumps of vegetation and higher proportions of fine sand (<0.4 mm). In the restoration plot, *S. cyclops* population showed a lower abundance, with a higher rate of recaptures, and a more limited dispersal ability of the individuals. There is an apparent early stage of colonization by *S. cyclops* in the restoration plot, but movements may already be hampered by unsuitable habitat restoration (higher herbaceous cover and different soil texture). We suggest preserving suitable habitat patches in the vicinity of the impacted areas and providing dispersal routes. Beyond vegetation, soil texture must be considered to allow local animal communities to establish in restored areas.

Key words: animal movement, indicator species, open sand habitats, revegetation practices, sand-dwelling beetle, *Scarites cyclops*

Implications for Practice

- Linking species' population parameters, movements, and abundance to vegetation structure and soil texture provides a comprehensive assessment of responses to quarrying activities.
- In the areas under exploitation, it is important to promote routes of dispersal linking impacted areas to suitable habitat patches in the vicinity that provide refuge and a future source of colonization of newly restored areas.
- Species benefit from bare ground cover with scattered clumps of dense vegetation at ground level, allied to higher proportions of fine sand, which is not consistent with the restored plot characteristics.
- Beyond vegetation, soil texture must also comply with local characteristics, allowing for ground-dwelling communities to re-establish in the restored areas.

Introduction

Quarrying activities have strong environmental and ecological impacts creating highly degraded sites (Clemente et al. 2004; Lei et al. 2016). Most of these impacts can persist for a long

time over large areas (Lei et al. 2016). Quarried areas generally require a widely active restoration approach (technical reclamation), although other authors argue that leaving disturbed areas unaided, or with low intervention, may help preserve rare or conservation concern species (Prach & Hobbs 2008; Tropek et al. 2010; Baasch et al. 2012; Hodecek et al. 2016). Following McDonald et al. (2016), ecological restoration is still a challenging task since many aspects of the impacts of quarrying activities and restoration practices remain overlooked.

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