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Editor's Choice - The efficacy of ecological restoration

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Tropek, R., Kadlec, T., Karesova, P., Spitzer, L., Kocarek, P., Malenovsky, I., Banar, P., Tuf, I. H., Hejda, M. & Konvicka, M. (2010) Spontaneous succession in limestone quarries as an effective restoration tool for endangered arthropods and plants. *Journal of Applied Ecology*, **47**, 139-148.

One of the greatest challenges facing mankind is maintaining the structure and function of ecological systems as the human population rises ever upwards. How we apportion funding to support and enhance biodiversity in today's landscapes is an important question, especially given that funding for conservation will always be limited. Mitigation measures which spend money on biodiversity enhancement make excellent "show n' tells" to the public and politicians, regardless of whether the treatments are evidence-based or not. As pointed out by the referees who assessed our Editor's Choice paper, this study is a "beautiful wake-up call", which uses simple sampling techniques to provide clear evidence that spontaneous succession can be at least as good an option for biodiversity restoration as technical reclamation.

Quarries, spoil heaps and mining pits are an unavoidable consequence of mining throughout the world. While not intuitively obvious, such sites can be remarkably good for biodiversity; indeed in intensively farmed regions and heavily industrialized areas these sites offer valuable refuges for many organisms. As noted by the authors, limestone quarries are considered to be particularly important for restoration, because they host species-rich natural communities, such as calcareous grasslands, which are among the most endangered habitats in Europe. While the conservation potential of quarry sites has been documented for specific groups such as spiders, plants, butterflies and bees, the conclusions from these studies are subject to the criticism that different taxa respond differently to restoration efforts. This is a limitation of many restoration studies and one solution is a multi-taxa approach. That said, it is unlikely that a one-size-fits-all style of restoration exists for any habitat, but, by considering multiple taxa, the restoration method that suits the majority can be considered as an option.

Tropek *et al*. (2010) report on a survey of plants and eleven arthropod taxa on five limestone quarries that were reclaimed using technical reclamation and five which were left to spontaneous succession. The arthropods sampled by the authors encompass four feeding modes (herbivores, carnivores, omnivores and detritivores) and three mobility guilds (non-fliers, occasional fliers and regular fliers). Besides species richness, Tropek *et al*. (2010) considered the conservation value of the communities resulting from the two restoration approaches, using the Czech Republic red lists. Their results show that technical reclamation is no better than natural succession when considering species richness across the multiple taxa; indeed it is worse when considering rare species.

There are three reasons for selecting this paper as our Editor's Choice. First, it is a high quality data paper which uses robust experimental design to sample multiple taxa. Secondly, it has direct relevance to environmental management and offers clear management advice. Finally, the work provides general lessons. For example, it clearly demonstrates that restoration interventions may not have the expected outcome and it also highlights the conservation value of secondary habitats, a habitat which receives relatively little attention in the ecological literature.

Demonstrating that reclamation efforts can have other than the expected effect is important. Technical reclamation usually involves the addition of topsoil, which reduces microtopographic heterogeneity and imports nutrients and seeds. Problems can arise, though, if mines do not undergo reclamation. These are pointed out by the authors and include erosion, leaching of toxicants and nutrients, and altering water flow. All of these can affect off- and on-site conservation issues and need to be taken into consideration in reclamation efforts. Also, it must be remembered that while current reclamation efforts in this particular part of the world appear to be ineffective, that certainly does not mean that all quarry reclamation efforts are ineffective. Rather it means that more data and more comparisons like the one made here are needed to provide a clear scientific basis for reclamation efforts.

Restoration ecology remains a largely descriptive science. To be able to predict the impact of restoration is a heady goal, but an achievable one perhaps. One explanation for the failure of restoration ecology as a predictive science is a paucity of manipulative experiments on realistic spatial and temporal scales. This is surprising in some ways, as large scale, long term manipulation often comes free via restoration practitioners. That said, it can be difficult to standardize past restoration treatments to fit an experimental design. For example, when working on English heathlands (Forup *et al*. 2008), we found it a challenge to find four restored heathlands, where the restoration treatment had followed the same damage in each case and over the same time period. The number of manipulative experiments could be increased if academics were involved with restoration programmes from the outset so that robust experimental designs can be in place for future use. This involves academics investing in their future as the restoration may take a considerable time to produce publishable data, but the payoff for both restoration ecologists and practitioners could be considerable. For this to happen there needs to be more regular contact between academics and practitioners, something that the Journal of Applied Ecology is working hard to facilitate (Memmott *et al*. 2010).

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