Running title: Rewilding with Microcosms
Number of words: ∼xxxx
Number of tables: xxxx
Number of figures: xxxx
Number of references: xxxx

Micromanaging Conservation - how microcosm experiments can inform rewilding campaigns

Adam Kane[1*], **Deirdre McClean**[2,3]

1. *University College Cork, Cooperage Building, School of Biological Earth and Environmental Sciences, Cork, Ireland.*
2. *Trinity College Dublin, Department of Zoology, School of Natural Sciences, Dublin 2, Ireland.*
3. *Trinity Centre for Biodiversity Research, Trinity College Dublin, Dublin 2, Ireland.*

*Correspondence author. `adam.kane@ucc.ie`

Date of submission: 15th June 2016

Summary

Rewilding is a recently heralded approach to conservation that focuses on ecosystem restoration through species reintroductions. Yet, it suffers from disparate definitions and a lack of robust ecological theory. As rewilding typically focuses on large vertebrates, experiments investigating its potential at such scales are unfeasible. Top down effects from these reintroductions also tend to vary across systems, impacting our ability to generalise.

Here, we highlight a hitherto untapped experimental approach in conservation science, in the form of microcosm experiments. These methods have the benefits of short generation times, ease of manipulation and a burgeoning research community. Indeed, they are widely employed in many other facets of ecology such as community ecology and climate change research.

Our review sets out four commonly used definitions of rewilding and describes specific microcosm experiments that could be used to gain a better understanding of each in terms of their ecological and evolutionary impact. The results from this microcosm perspective will put us in a better position to forecast many of the biological consequences of a rewilding campaign at full-scale, ultimately allowing us to evaluate the merit of this controversial strategy.

Keywords: rewilding, microcosms

Introduction

Rewilding – the reintroduction of once native flora and fauna to an area which is then let to recover naturally – is a controversial idea (Monbiot, 2013). It contrasts with the 'protect what we've got' tactic common to conservancy measures (Monbiot, 2013). Leaving aside political barriers to restoring populations and habitats of extinct animals, the scientific obstacles are considerable. For instance, significant perturbations arise when an extinction or reintroduction event occurs, especially when it happens to be the loss of an apex predator (Mittelbach *et al.*, 1995), which are often the target of rewilding projects. Indeed, the reintroduction of grey wolves in the USA had a radical effect on biodiversity as trophic webs re-emerged and repaired which was seen with the increase in the beaver population as wolves preyed on the herbivores that damaged trees essential to the beavers' survival (Hebblewhite *et al.*, 2005). Many other species resurged once the wolves dampened the pressure from their coyote competitors. Investigations into the effects of such events can be carried out at the scale of the ecosystem, as was the case with the Yellowstone wolves, but often take years to complete (Mittelbach *et al.*, 1995). Moreover, taking into account every possible confound is impossible at this scale. These problems diminish at the level of a microcosm. So, in this study we will use microbial microcosms and community ecological theory to explore the dynamics of a rewilded system. This will involve the creation of a complex ecosystem at small scale, using microorganisms, to infer the ecology of large scale systems. The manipulations and multigenerational studies that are possible in microcosm experiments mean we can directly address some of the questions surrounding this new area of conservation which would be impossible at full size.

Fundamental questions in community ecology can be fruitfully addressed through the frame of rewilding. Certainly, we'll need to fill these gaps in our knowledge if we are to improve rewilding campaigns. We can propose three hypotheses which represent open ecological questions that have a significant bearing on rewilding.

1. Habitat size and complexity affects rewilding success Connectivity and core area have been pointed out as being the most important considerations for rewilding campaigns (Soule & Noss, 1998). Because of the large ranges of many species, a suitable habitat core is necessary to contain them. And some measure of connectivity between core sites allows the flow of animals between.

2. The order in which species are reintroduced affects rewilding success Can we identify the best order with which species are reintroduced in order to ensure they successfully re-establish?

3. The time between species extinction and species reintroduction affects rewilding success Time is an essential aspect to consider because rewilding proposals have huge variation with respect to the age of the system or the species that is being considered for reestablishment. Can a species re-establish itself when its habitat has evolved without it?

There has been a credibility gap in the scientific community with respect to microcosm work (Benton *et al.*, 2007). With critics arguing the results obtained at the small scale lose relevance when extrapolated up to larger systems (Carpenter, 1996). However, this criticism has eroded in the face of impressive results derived from microcosm experiments with both an ecological and evolutionary relevance (Jessup *et al.*, 2004; Benton *et al.*, 2007; Buckling *et al.*, 2009; McClean *et al.*, 2015).

Acknowledgments

A lot of people are to thank here.

References

Benton, T.G., Solan, M., Travis, J.M. & Sait, S.M. (2007) Microcosm experiments can inform global ecological problems. *Trends in Ecology & Evolution*, **22**, 516–521.

Buckling, A., Maclean, R.C., Brockhurst, M.A. & Colegrave, N. (2009) The Beagle in a bottle. *Nature*, **457**, 824–829.

Carpenter, S.R. (1996) Microcosm experiments have limited relevance for community and ecosystem ecology. *Ecology*, **77**, 677–680.

Hebblewhite, M., White, C.A., Nietvelt, C.G., McKenzie, J.A., Hurd, T.E., Fryxell, J.M., Bayley, S.E. & Paquet, P.C. (2005) Human activity mediates a trophic cascade caused by wolves. *Ecology*, **86**, 2135–2144.

Jessup, C.M., Kassen, R., Forde, S.E., Kerr, B., Buckling, A., Rainey, P.B. & Bohannan, B.J. (2004) Big questions, small worlds: microbial model systems in ecology. *Trends in Ecology & Evolution*, **19**, 189–197.

McClean, D., McNally, L., Salzberg, L.I., Devine, K.M., Brown, S.P. & Donohue, I. (2015) Single gene locus changes perturb complex microbial communities as much as apex predator loss. *Nature communications*, **6**.

Mittelbach, G.G., Turner, A.M., Hall, D.J., Rettig, J.E. & Osenberg, C.W. (1995) Perturbation and resilience: a long-term, whole-lake study of predator extinction and reintroduction. *Ecology*, **76**, 2347–2360.

Monbiot, G. (2013) *Feral: searching for enchantment on the frontiers of rewilding.* Penguin UK.

Soule, M. & Noss, R. (1998) Rewilding and biodiversity: complementary goals for continental conservation. *Wild Earth*, **8**, 18–28.

Tables

Figures