Restore the lost ecological functions of people

Recent calls for the reintroduction of functionally important animal species are motivated by a desire to restore ecological function, but overlook the ecological roles performed by humans. Here, we consider humans in ecological context, exploring our roles in the maintenance and restoration of ecosystem function.

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Declining biodiversity has motivated numerous strategies to arrest ecological degradation and restore ecosystems. Rewilding is among the most recent and ambitious, aiming to introduce keystone species that can reinstate ecological functions lost to extinction — such as herbivory, predation, seed dispersal and bioturbation — in order to restore ecosystems. Given that humans are the major cause of the global biodiversity crisis and affect even the most remote parts of the Earth, it is perhaps unsurprising that discussions about ecological restoration rarely acknowledge the missing ecological functions once performed by people. Yet this absence belies the reality that people have been functionally vital to many ecosystems across the globe for millennia, and that in many parts of the world, ecological degradation has arisen through the loss of people[1,2].

Scale and scope

One of the challenges in considering the role of people in ecosystem functioning is the enormous variation in the scale and scope of human ecological interactions — from hunter-gatherers interacting largely with local plant and animal communities, to post-industrial societies in which resource use and production is remotely coupled across thousands of kilometres. The intensity of interaction — the footprint of human disturbance — varies from low-intensity disturbances scattered in small patches across landscapes (such as the harvesting of plant underground storage organs), to mass mortality events causing significant declines in biodiversity (such as forest clear-cutting).

Yet, on evolutionary timescales, this variation emerged quite recently. For the majority of our existence as a species, all human societies were organized around hunting and gathering, with the addition, over the past 10,000 years, of nomadic pastoralism, horticulture and small-scale agricultural systems. Although diverse, these societies differ from post-industrial society in that they are 'place-based' — individuals live within the landscapes and ecosystems that support their resource extraction and consumption[3]. Place-based societies exhibit strong positive and negative feedbacks with local ecosystems that are felt by individual actors. Their 'place-based' nature provides feedbacks to individual decision-making processes that fine-tune subsistence and social strategies to local environments through learning and cultural evolution (barring abrupt climate change or rapid colonization of a new ecosystem). This process is not a one-way street, and neither does it imply that such societies inevitably become 'natural conservationists'. Ecological interactions are changed by human social, cultural and economic strategies, including by completely unintentional processes (Fig. 1). This change allows organisms to adapt to, as well as better suit, human social and economic strategies. Species evolve and communities assemble in response to the new selective pressures brought about by people, and some require continued human intervention for their persistence[4,5].

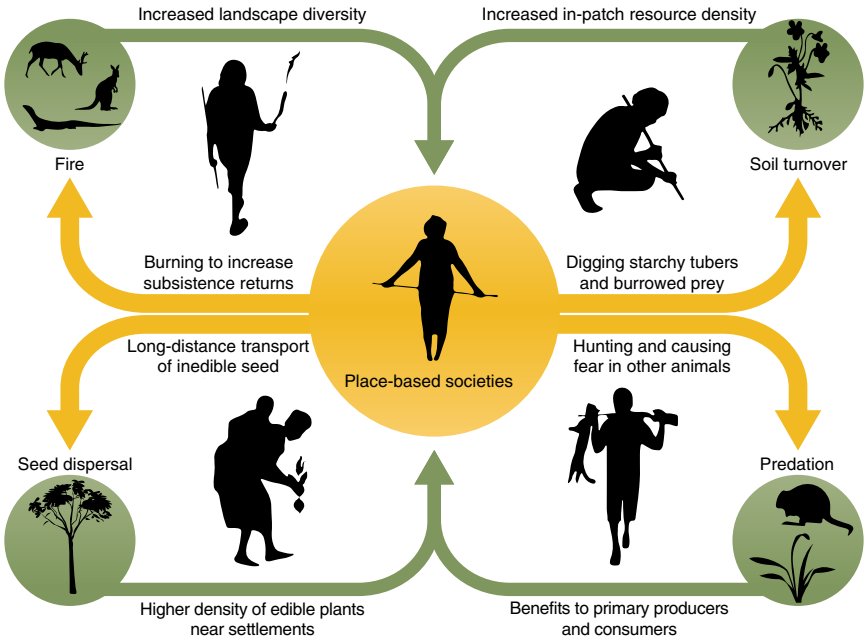

Fig. 1 | The ecological functions and feedbacks of place-based societies.

Despite the potential for coupled evolutionary dynamics between place-based societies and their ecosystems[6], ecological research on human–environment interactions has (understandably) focused on the negative impacts of industrial and post-industrial societies through large-scale land clearing, pollution and climate change. The focus on the ecological catastrophes occurring in urban-industrialized society inevitably shapes the lenses through which we approach studies of other societies, past and present. The ecological consequences of prehistoric or indigenous human environmental interactions are often presented as a litany of environmental disasters, from habitat destruction to megafaunal extinction[7]. While negative interactions undoubtedly occur, it is vital to recognize that, for the vast majority of our history as a species, those interactions occurred as part of a much wider repertoire of interactions with local ecosystems. Many of these interactions have provided vital

Fig. 2 | Ecological functions provided by people of the Western Desert, Australia. a, Seed dispersal. A Martu woman cleans *wamurla* fruit (*Solanum diversiflorum*), discarding the inedible, bitter black seeds near the campfire. Such dispersal may have contributed to the spread of this important food plant throughout the region, and the lack of people to its decline. **b**, Fire. Lighting a winter fire for hunting *parnajarlpa*, monitor lizards (*Varanus gouldii*). Mosaic hunting fires increase vegetation diversity across the landscape, providing greater access to patches of unburnt vegetation and supporting populations of many endemic animals. In the absence of people, lightning fires reduce biodiversity and threaten species persistence[17,18]. **c**, Bioturbation. Three women turn over the soil in a floodplain to harvest *minyarra*, the underground corms of the sedge *Cyperus bulbosus*. Soil turnover may be critical to the continued persistence of such plants, especially with the spread of invasive grasses. **d**, Predation. The hunting of feral cats is common throughout the Western Desert and may contribute a measure of control to an invasive species that threatens numerous endemic mammals and birds.

ecological functions, as our work with indigenous communities in Australia's Western Desert demonstrates (Fig. 2). Some of these functions, such as herbivory, predation, seed dispersal and bioturbation (Box 1), closely parallel those played by the non-human keystone species on which the rewilding debate has focused.

Role for people in restoration

Rewilding has brought into focus the importance of recognizing and restoring lost ecological function. However, without appreciation of the long histories of human interaction in such systems — or worse, with active discouragement of such interactions — we risk omitting a key functional player in ecosystems past and present. Place-based societies interacted — and continue to interact — with their ecosystems in a myriad of ways. Just as with the loss of other keystone species, these co-evolutionary relationships can unravel when such societies are displaced via colonialism, or their interactions substantially and rapidly altered by radically changing political and economic circumstances. As just one example, landscapes in the Amazon basin that supported swidden cultivation sustainably for millennia are now the source of coffee and hamburgers for consumers far and wide[8], leading to substantial biodiversity losses[9]. We must recognize that these losses are a function not just of what industrialized societies do when they displace indigenous peoples, but also of what ecological functions are no longer being supplied by the people that 'belong' to that country.

Greater recognition of the ecological function of place-based societies is important for a number of reasons. First, considering the potential functional role of humans and the history of human interactions affects our estimation of ecological baselines — the ecological state we seek to restore. The question of baselines has been central to the rewilding debate since its inception[10]. If we take the view that the baseline should be prior to the emergence of modern humans, then we are ignoring tens to hundreds of thousands of years of co-occurrence and co-evolution between behaviourally modern people and the ecosystems within which they became deeply embedded across vast portions of the globe. If the baseline incorporates those times in which people have been actively shaping landscapes, then ignoring the function performed by those people risks retaining ecosystems in an artificial and functionally impoverished state.

Second, ignoring the functional roles of people in ecosystems hampers our ability to understand past ecological change. In many regions of the globe, the loss of place-based societies coincided with their replacement by other societies with fundamentally different human–environment interactions. Subsequent changes in ecosystems are often attributed to the changes brought about by the new societies, overlooking the lost functions of the displaced.

Third, ignoring the ecological functions of placed-based societies can spur approaches to conservation that impinge upon local people's livelihoods (for example, 'fortress conservation'[11]), while overlooking opportunities to improve modern-day ecosystem management. Improved access to customary lands and payment schemes for ecosystem services are avenues for supporting indigenous efforts for economic autonomy and cultural sovereignty while restoring ecological function. For example, traditional fire management by indigenous Australians has been supported by market-based greenhouse gas abatement schemes[12], indigenous hunting as a way to control invasive species[13] and indigenous farming practices as a way to prevent deforestation, a major cause of biodiversity loss[14]. Recognizing other forms of traditional land use linked with important ecological functions and incorporating these into similar schemes could further enable place-based societies to maintain or return

Box 1 | Ecological functions provided by place-based societies

Fire. Large grazing mammals shape plant communities; their loss changes vegetation composition and causes fire regime shifts. In using fire, place-based societies act as generalized herbivores by consuming plant biomass and converting it to organic and mineral product[19]. The loss of indigenous burning, much like the loss of large grazing mammals, has precipitated changes to vegetation communities and fire regimes worldwide.

Soil turnover. Digging mammals (such as rabbits and bilby) maintain soil quality and boost plant recruitment. Humans also exploit below-ground resources such as roots and tubers, providing regular soil turnover. The displacement of place-based societies over the past 500 years has been implicated in the decline of flowering geophytes (plants with starchy underground storage organs) in both southeast Australia[20] and California[21].

Predation. Top predators suppress other, smaller predators and mitigate against plant community losses due to herbivory. In addition to mortality-related suppression[6], humans create landscapes of fear akin to those of other large predators, influencing predator and herbivorous prey behaviour[22–24]. Such behavioural suppression of smaller predators and herbivores can result in trophic cascades[25], but the role of place-based societies in triggering them is rarely considered other than in the context of megafaunal decline.

Seed dispersal. Given high rates of plant use and the residential mobility of hunter-gatherers, there is substantial potential for long-distance, human-assisted plant dispersal extending well into the pre-agricultural past, as recent work on the distribution of Australian baobabs[26] and cabbage palms[27] has suggested.

important ecological functions to their lands. This is especially critical considering that indigenous societies tend to inhabit global biodiversity hotspots[15].

Given that our arguments about the ecological role of place-based societies were well-articulated more than 20 years ago in the debate over wilderness[16], it is surprising that the rewilding movement, and the ecological sciences in general, have so far largely failed to recognize the long evolutionary history of people in ecosystems. When we think about the functions lost from ecosystems we must consider those performed by people, and the extirpation of place-based societies operating within those landscapes as comparable to the extinction of species. The scale of dispossession and displacement of placed-based societies, and the subsequent modification of those landscapes by industrialized agriculture, land clearing and urbanization, has made it difficult to observe the ecological consequences of their loss. But they may have been profound indeed. ❐

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References

1. Bliege Bird, R., Bird, D. W., Codding, B. F., Parker, C. H. & Jones, J. H. *Proc. Natl Acad. Sci. USA* **105**, 14796–14801 (2008).
2. Dunne, J. A. et al. *Sci. Rep.* **6**, 21179 (2016).
3. Norton, B. G. *Ethics Environ.* **5**, 23–45 (2000).
4. Auffret, A. G. *Appl. Veg. Sci.* **14**, 291–303 (2011).
5. Auffret, A. G. & Cousins, S. A. O. *PLoS ONE* **8**, e62763 (2013).
6. Kay, C. E. *Hum. Nat.* **5**, 359–398 (1994).
7. Bird, M. I. et al. *J. Quat. Sci.* **28**, 439–452 (2013).
8. Austin, K. *Rural Sociol.* **75**, 270–299 (2010).
9. Zimbres, B., Peres, C. A. & Machado, R. B. *Biol. Conserv.* **206**, 283–292 (2017).
10. Alagona, P. S., Sandlos, J. & Wiersma, Y. F. *Environ. Philos.* **9**, 49–70 (2012).
11. Brockington, D. *Fortress Conservation: The Preservation of the Mkomazi Game Reserve, Tanzania* (Indiana Univ. Press, Bloomington, 2002).
12. Russell-Smith, J. et al. *Front. Ecol. Environ.* **11**, e55–e63 (2013).
13. Taylor, P. Pintupi cat hunters to take skills across Australia. *The Australian* (26 October 2015).
14. Nepstad, D. et al. *Conserv. Biol.* **20**, 65–73 (2006).
15. Juffe-Bignoli, D. et al. *Protected Planet Report 2014* (UNEP-WCMC, Cambridge, 2014).
16. Cronon, W. *Uncommon Ground: Rethinking the Human Place in Nature* (WW Norton & Company, New York, 1996).
17. Bliege Bird, R. et al. *Biol. Conserv.* **219**, 110–118 (2018).
18. Bliege Bird, R., Tayor, N., Codding, B. F. & Bird, D. W. *Proc. R. Soc. B* **280**, 20132297 (2013).
19. Bond, W. J. & Keeley, J. E. *Trends Ecol. Evol.* **20**, 387–394 (2005).
20. Gott, B. *Archaeol. Ocean.* **17**, 59–67 (1982).
21. Anderson, M. K. *J. Ethnobiol.* **17**, 149–169 (1997).
22. Clinchy, M. et al. *Behav. Ecol.* **27**, 1826–1832 (2016).
23. Smith, J. A. et al. *Proc. R. Soc. B* **284**, 20170433 (2017).
24. Zbyryt, A. et al. *Behav. Ecol.* **29**, 19–30 (2018).
25. Suraci, J. P., Clinchy, M., Dill, L. M., Roberts, D. & Zanette, L. Y. *Nat. Commun.* **7**, 10698 (2016).
26. Rangan, H. et al. *PLoS ONE* **10**, e0119758 (2015).
27. Kondo, T. et al. *Proc. R. Soc. B* **279**, 2652–2661 (2012).

Competing interests

The authors declare no competing interests.