This is the peer reviewed version of the following article: Cross, S.L., Bateman, P.W. and Cross, A.T. (2020), Restoration goals: Why are fauna still overlooked in the process of recovering functioning ecosystems and what can be done about it?. Ecol Manag Restor, 21: 4-8, which has been published in final form at https://doi.org/10.1111/emr.12393. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions.

Restoration goals: why are fauna overlooked in the process of recovering functioning ecosystems and what can be done about it?

Abstract

Despite the evidence that fauna play complex and critical roles in ecosystems (e.g. pollination and nutrient cycling) and the knowledge that they need to be considered in restoration, fauna often remain poorly represented in restoration goal-setting, monitoring, and assessments of restoration success. Fauna clearly are integral to the aspirations of achieving full ecosystem recovery. However, over-reaching assumptions about their unassisted return to restored sites, minimal consideration of, or requirements for fauna monitoring in regulatory guidance and standards, and low investment appear to have led to the historically vegetation-centric approaches to rehabilitation and ecological restoration. We argue that ecological complexities render assumptions of unassisted fauna return inappropriate in many situations and may represent a missed opportunity to enhance ecological outcomes and improve restoration trajectories. We advocate for greater consideration of fauna as facilitators of ecological restoration, and, particularly for well-funded projects, for monitoring to place greater emphasis on examining the behaviour and resilience of restored fauna communities. There is a clear need for both industry and regulators to recognise that fauna can be crucial facilitators of restoration and appreciate that the return and monitoring of functional faunal communities can be costly, challenging, and may require detailed study across a wide range of taxonomic groups. Failure to advance from business-as-usual models may risk leaving a legacy of ostensibly functional, but biodiversity-depauperate, restored ecosystems.

Keywords: Ecological restoration; ecological monitoring; ecosystem engineers; ecosystem functioning; restoration policy; rehabilitation

Implications for managers:

- Fauna play critical ecological roles in ecosystems, and the complexity of biological systems may render assumptions of unassisted fauna return inappropriate.
- Attitudes to fauna goal setting and monitoring must change if we are to meet the increasing aspirations for ecological restoration to achieve full ecosystem recovery.
- Restoration and rehabilitation monitoring projects should, wherever possible, include assessments of the complex behavioural and ecological interactions of fauna with their environment
- The efficacy of new monitoring technologies must be empirically tested to ensure they offer accurate, as well as cost effective, monitoring solutions for restoration practitioners
- Practitioners need clear and unambiguous, internationally-consistent guidance on how restoration standards and regulatory expectations can be achieved

Introduction

We are entering the age of ecological restoration. The importance of returning disturbed and degraded landscapes to resilient, self-sustaining, and functional ecosystems on a global scale is increasingly being recognised (Standards Reference Group SERA 2017; Gann *et al.* 2019; Miller *et al.* 2017). However, rehabilitation and ecological restoration have historically been flora-centric (McAlpine *et al.* 2016), focussing predominantly on landform stability and examination of vegetation structure and communities (Ruiz-Jaen and Mitchell Aide 2005;

Koch *et al.* 2010). Indeed, both ‘rehabilitation’ and ‘restoration’ have historically been somewhat synonymous with ‘revegetation’ (Cross *et al.* 2017), leading to a focus in the last few decades on returning plant diversity at appropriate densities in degraded landscapes.

There is clear and compelling evidence that fauna from multiple trophic levels play crucial and regionally-variable roles in ecosystem function, and that ecosystem function is tightly linked to fauna diversity (e.g., Gagic *et al.* 2015). For example, earthworms and termites (König 2006; Jouquet *et al.* 2011; Blouin *et al.* 2013), and burrowing mammals (Davidson *et al.* 2012; Coggan *et al.* 2018) act as soil engineers and play critical roles in soil modification, particularly in semi-arid regions (Pate *et al.* 1998; Debruyn and Conacher 1995). Birds aid in the seed dispersal and pollination of many native plants (Carlo *et al.* 2016; Wenny *et al.* 2016), often playing a facilitator role in ecological restoration (Reid *et al.* 2015; Ritchie *et al.* 2017). Even reptiles have recognised roles in pollination (Godínez-Álvarez 2004), seed dispersal (Valido and Olesen 2007), and prey-regulation (Cortés-Gomez *et al.* 2015).

There have been numerous calls for fauna to receive greater consideration in restoration projects (Majer 1989; Majer 2009; Lindell 2008; Cross *et al.* 2019). While some studies report on the responses of fauna to landscape revegetation, for example in agricultural areas of Australia (Munro *et al.* 2007), the poor representation of fauna in studies of ecosystem recovery continues to be reported across numerous landscape degradation processes, including broadacre agriculture (Catterall 2018; McAlpine *et al.* 2016), forestry (Jansen 2005; Rodrigues *et al.* 2009), mining (Cross *et al.* 2019), and the creation of novel ecosystems, for example, through climate change (Kennedy *et al.* 2013).

Fauna are clearly integral to the aspirations of achieving ~~full~~ ecosystem recovery (i.e., the state whereby all ecosystem attributes closely resemble those of the reference ecosystem) (Standards Reference Group SERA 2017; Gann *et al.* 2019). So, we ask i) why are fauna often overlooked in the monitoring of rehabilitation and restoration projects, particularly monitoring beyond assessments of only presence or absence, such as behavioural responses and habitat use, and ii) how might this oversight be addressed by future projects, such that fauna are adequately considered in projects of all scales from small community conservation initiatives to large mining rehabilitation and restoration programs?

A four-fold problem: *assumptions, a lack of innovation, misdirected investment, and ambiguous guidance*

Assumptions. Approaches to ecological recovery and restoration are often built around the theory that animals will return to pre-disturbance abundance, diversity, and community dynamics once the ecosystem's vegetation has been established (Frick *et al.* 2014; Hale *et al.* 2015; McAlpine *et al.* 2016). Summarised as the Field of Dreams Hypothesis, or 'build it and they will come' (Palmer *et al.* 1997; Cristescu *et al.* 2012), this assumption is appealing in theory and seems to be entrenched in the attitudes of practitioners to ecosystem recovery. However, this theory fails to recognise critical plant-animal interactions that are integral to ecosystem function (Tomlinson *et al.* 2017), and few studies have rigorously tested whether fauna from different functional groups do return to restored ecosystems (Hale *et al.* 2015; Cross *et al.* 2019). While some studies assess faunal responses to variation in habitat conditions (e.g., Riffel *et al.* 2001; Poulsen 2002; Cross et al. 2016), these are predominantly assessments of presence or absence, and in a limited selection of anthropogenic landscape impacts (e.g., forest management and agriculture) (Tews *et al.* 2004; Cahall *et al.* 2013). Returning physical habitat structure was considered by Hilderbrand *et al.* (2005) to be unlikely to facilitate natural recolonisation by fauna [t1]or the return of ecological function to a state comparable to that of the reference, pre-disturbance system.

While it is possible that the Field of Dreams Hypothesis holds true for some faunal assemblages and ecosystems, recovering diverse animal communities to pre-disturbance biodiversity and abundances can be exceptionally difficult~~, both to achieve~~ [t2]~~and to monitor~~ (Cross *et al*. 2019; Cristescu *et al.* 2012; Perring *et al.* 2015). For example, presence/absence studies are useful tools in monitoring populations and identifying critical habitats and resources for population support (Mackenzie 2005) but provide little evidence of the ability of communities to reproduce at self-sustaining rates (Aldridge and Boyce 2007; Lindell 2008). In contrast, behavioural studies can address these critical knowledge gaps, and aid in understanding movement ecology, habitat use, and critical resource requirements that facilitate the long-term support and functionality of fauna populations (Lindell 2008). The inherent complexity in natural ecosystems means it is probably inappropriate to rely upon assumptions, such as the Field of Dreams hypothesis, when undertaking restoration (Palmer *et al.* 1997). It is vital to our pursuit of knowledge that every opportunity is taken to include assessments of the complex behavioural and ecological interactions of fauna with their environments in restoration and rehabilitation monitoring projects. While this is not affordable in all projects, it is our view that investment in such research should be carried out in all mitigation projects (e.g. mining and other commercial developments), with the development of partnerships between non-profit restoration organisations and research organisations to be highly encouraged. Such research will substantially aid in understanding the mechanistic processes facilitating fauna return to altered and disturbed landscapes.

Change requires greater investment and innovation, and the efficacy of restoration monitoring is constrained by cost. Significant innovation is required in the monitoring of fauna, as current approaches are clearly insufficient to determine and quantify the capacity of restored systems to support self-sustaining and functional animal assemblages. It is critical that assessments adopt methods that not only facilitate the survey of a wider range of taxa, but that monitoring also provides tangible information on behavioural and ecological responses, such as habitat utilisation, population structure and the resilience of communities to change. Effective projection of the trajectory of ecological restoration requires extensive and continuous monitoring over a wide suite of ecological parameters (Standards Reference Group SERA, 2017, Gann *et al.* 2019), not just assessment of bioindicator species or only one ecosystem metric (e.g., plant species composition; Herrick *et al.* 2006).

Returning biodiverse and representative animal communities to restored ecosystems can be costly, both in terms of its execution and monitoring (Cristescu *et al.* 2012; Perring *et al.* 2015). For example, the release of only 55 juvenile individuals of a threatened waterbird as part of an ecological recovery program in the Mediterranean was estimated to cost nearly US$200,000 per annum (Martínez-Abraín *et al.* 2011); recovery efforts to restore Caribou (*Rangifer tarandus*) populations in Alberta reached nearly US$9 million per km^2 (Schneider *et al.* 2010); and the cost of translocating and tracking large carnivores in Namibia averaged US$2000 per individual (with a maximum cost of US$8000). Costs are a major influence upon social and corporate responsibility in industry (e.g., Laurence 2011; Govindan *et al.* 2014).

Although the costs of comprehensive ecological monitoring remain high, a suite of new technologies offering novel methods for biodiversity monitoring, such as the detection of environmental DNA (eDNA; e.g., Fernandes *et al.* 2018; Kamoroff and Goldberg 2018), and the application of drones (e.g., Pirrotta *et al.* 2017; Buters *et al.* 2019), are likely to result in more rapid, accurate and affordable techniques into the future. While these technologies present excellent opportunities to increase the speed, scale and replicability of restoration monitoring, they remain in their experimental infancy, or are limited in their applicability at broad scale. For example, eDNA is constrained by similar factors as traditional measures of biodiversity assessment in that it provides information only on species presence or absence rather than selective habitat use or key ecological interactions by fauna, it fails to distinguish between living or dead specimens, it provides little information on habitat occupancy of wide-ranging or itinerant taxa (e.g., peripatetic species), and is unlikely to provide accurate measures of the ability for populations to persist in restored landscapes (Kamoroff and Goldberg 2018). Significant future investment is required before these technologies can be accurately and reliably applied to restoration monitoring at broad scales.

Vague legislative frameworks and slow uptake by practitioners. Rehabilitation or restoration of landscapes to functional, self-sustaining and resilient ecosystems following degradation is increasingly a legislative requirement in regions such as Australia (e.g. Wardell-Johnson *et al.* 2015; Stevens *et al.* 2016), China (e.g., Ran *et al.* 2013; Lei *et al.* 2016), Europe (e.g. Balaguer *et al.* 2014; Šebelíková *et al.* 2016), and South America (e.g. Aronson *et al.* 2011; Balaguer *et al.* 2014). However, policy guidelines in these regions are often vague in their reference to fauna or divest the responsibility of setting restoration targets and monitoring goals to practitioners. For example, mine closure policies in major mineral extraction provinces such as North America, South America, and Australia, largely focus on waste management and landform stability and often make only ambiguous reference to flora and fauna ‘management’ (e.g., Garcia 2008; DMP-EPA 2015; DMIRS 2018). While guidance on mine closure in some Australian states includes statements about requiring rehabilitated and restored areas to '*provide appropriate habitat for fauna*', and suggest that practitioners should ensure '*fauna utilisation, abundance, and diversity are present in appropriate proportions*' and '*maintain representation, diversity, viability, and ecological function at the species, population, and community levels*' (DEHP 2014; DMP-EPA 2015; DMIRS 2018), little direction is provided on how these targets should be achieved or monitored. The underpinning principles of the International Principles and Standards for the Practice of Ecological Restoration (Gann *et al.* 2019) clearly articulate the importance of considering fauna in the restoration equation and highlight the need for adaptive management and ongoing monitoring in restoration. However, the Standards also provide limited advice on the methodology required to monitor these interactions and complexity. If practitioners around the world are to meet, and exceed, the growing societal and regulatory expectations for ecological recovery placed upon them (Stevens and Dixon 2016; Cross et al. 2017), they need strong leadership that provides unambiguous and internationally-consistent guidance on how these expectations can be attained (Silveira *et al.* 2019). Where the political environment is such that governments are permitting habitat clearance but are unwilling or unable to provide this leadership to ensure fauna losses do not ensue, the scientific community must take on this mantle not only to advocate for change on their behalf, but also to provide clear, evidence-based and effective standards and solutions.

Concluding remarks

The goal of ecological restoration (Gann *et al.* 2019) is, ideally, full ecosystem recovery (particularly in compensatory cases, such as mining, involving degradation of intact ecosystems). This remains the case even if outcomes take long time-frames, as attaining full recovery is a challenging prospect (Gann *et al.* 2019). We acknowledge that the ecological study required to fully understand complex biological systems is not always possible, or, indeed, justifiable, for every restoration project. However, this limitation emphasises the importance of undertaking detailed ecological research in the context of ecological restoration wherever logistics and funding allow. In such cases research should focus increasingly upon examining the nexus between the practice and science of ecological restoration, utilising restoration projects as field laboratories to empirically test whether the assumptions of restoration hold true for different ecosystems in different regions in response to different types, scales and severities of disturbance. Aspirations for ecological recovery are positively shifting, and practitioners are increasingly recognising the need for further research to ensure restoration standards are met even if they remain flora-centric (e.g., Rokich 2016). Both practitioners and regulators must increasingly consider the value of, and the role played by, fauna in ecosystem recovery if a goal of full ecosystem recovery (or even substantial partial recovery) is to be achieved. It is not appropriate to simply assume that restored habitats will attract and sustain functional and representative faunal assemblages. Attitudes to fauna monitoring must change if we as a community are to meet the increasing aspirations of ecological restoration to full ecosystem recovery.

Literature cited

Aldridge C.L., and Boyce M.S. (2007) Linking occurrence and fitness to persistence: Habitat-based approach for endangered greater sage-grouse. Ecological Applications 17, 508-526.

Aronson J., Brancalion P.H., Durigan G., Rodrigues R.R., Engel V.L., Tabarelli M., Torezan J.M., Gandolfi S., De Melo A.C., and Kageyama P.Y. (2011) What role should government regulation play in ecological restoration? Ongoing debate in São Paulo State, Brazil. Restoration Ecology 19, 690-695.

Balaguer L., Escudero A., Martin-Duque J.F., Mola I., and Aronson J. (2014) The historical reference in restoration ecology: re-defining a cornerstone concept. Biological Conservation 176, 12-20.

Blouin M., Hodson M.E., Delgado E.A., Baker G., Brussaard L., Butt K.R., Dai J., Dendooven L., Pérès G., and Tondoh J. (2013). A review of earthworm impact on soil function and ecosystem services. European Journal of Soil Science 64, 161-182.

Buters T.M., Bateman P.W., Robinson T., Belton D., Dixon K.W. and Cross A.T. (2019) Methodological ambiguity and inconsistency constrain unmanned aerial vehicles as a silver bullet for monitoring ecological restoration. Remote Sensing 11, 1180.

Catterall C.P. (2018) Fauna as passengers and drivers in vegetation restoration: a synthesis of processes and evidence. Ecological management and restoration 19, 54-62.

Cahall R.E., Hayes J.P, and Betts M.G. (2013) Will they come? Long-term response by forest birds to experimental thinning supports the “Field of Dreams” hypothesis. Forest Ecology and Management 304, 137-149.

Carlo T.A., and Morales J.M. (2016) Generalist birds promote tropical forest regeneration and increase plant diversity via rare-biased seed dispersal. Ecology 97, 1819-1831.

Coggan N.V., Hayward M.W., and Gibb H. (2018) A global database and “state of the field” review of research into ecosystem engineering by land animals. Journal of Animal Ecology 87, 974-994.

Cortés-Gomez A., Ruiz-Agudelo C.A., Valencia-Aguilar A., and Ladle R.J. (2015) Ecological functions of neotropical amphibians and reptiles: a review. Universitas Scientiarum 20, 229-245.

Cristescu R.H., Frère C., and Banks P.B. (2012) A review of fauna in mine rehabilitation in Australia: current state and future directions. Biological Conservation 149, 60-72.

Cross A.T., Stevens J.C., and Dixon K.W. (2017) One giant leap for mankind: can ecopoiesis avert mine tailings disasters? Plant and Soil 421, 1-5.

Cross A.T., Young R., Nevill P., Mcdonald T., Prach K., Aronson J., Wardell-Johnson G.W., and Dixon K.W. (2018) Appropriate aspirations for effective post-mining restoration and rehabilitation: a response to Kaźmierczak *et al*. Environmental Earth Sciences 77, 256.

Cross S.L., Cross A.T., Merritt D.J., Dixon K.W., and Andersen A.N. (2016) Biodiversity responses to vegetation structure in a fragmented landscape: ant communities in a peri-urban coastal dune system. Journal of Insect Conservation 20, 485-495.

Cross S.L., Tomlinson S., Craig M.D., Dixon K.W., and Bateman P.W. (2019) Overlooked and undervalued: the neglected role of fauna and a global bias in ecological restoration assessments. Pacific Conservation Biology doi: 10.1071/PC18079.

Davidson A.D., Detling J.K., and Brown J.H. (2012) Ecological roles and conservation challenges of social, burrowing, herbivorous mammals in the world's grasslands. Frontiers in Ecology and the Environment 10, 477-486.

Debruyn L.L., and Conacher A.J. (1995) Soil modification by termites in the central wheat-belt of Western-Australia. Soil Research 33, 179-193.

DEHP (2014) Rehabilitation requirements for mining resource activities. Department of Environment and Heritage Protection, Queensland Government. Brisbane, Australia.

DMP, and EPA (2015) Guidelines for preparing mine closure plans. Department of Mines and Petroleum, Environmental Protection Authority.

DMIRS (2018) Guidance note – environmental outcomes for mining proposals. Government of Western Australia, Department of Mines, Industry Regulation and Safety. Perth, Australia.

Fernandes K., Van Der Heyde M., Bunce M., Dixon K., Harris R.J., Wardell-Johnson G., and Nevill P.G. (2018) DNA Metabarcoding-a new approach to fauna monitoring in mine site restoration. Restoration Ecology doi: 10.1111/rec.12868

Frick K.M., Ritchie A.L., and Krauss S.L. (2014) Field of Dreams: Restitution of Pollinator Services in Restored Bird-Pollinated Plant Populations. Restoration Ecology 22, 832-840.

Gagic V., Bartomeus I., Jonsson T., Taylor A., Winqvist C., Fischer C., Slade E.M., Steffan-Dewenter I., Emmerson M., Potts S.G., and Tscharntke T. (2015) Functional identity and diversity of animals predict ecosystem functioning better than species-based indices. Proceedings of the Royal Society B: Biological Sciences. Feb 22, 282(1801):20142620.

Gann G.D., McDonald T., Walder B., Aronson J., Nelson C.R., Jonson J., Hallett J.G., Eisenberg C., Guariguata M.R., Liu J., Hua F., Echeverría C., Gonzales E., Shaw N., Decleer K., Dixon K.W. (2019) International principles and standards for the practice of ecological restoration. Second edition. Restoration Ecology DOI:10.1111/rec.13035

Garcia D. (2008) Overview of international mine closure guidelines. Pages 20-24 Proceedings of the 2008 Meeting of the American Institute of Professional Geologists, Arizona Hydrological Society, and 3rd International Professional Geology Conference. Flagstaff, Arizona. September.

Godínez-Álvarez H. (2004) Pollination and seed dispersal by lizards: a review. Revista Chilena de Historia Natural 77, 569-577.

Govindan K., Kannan D., and Shankar K.M. (2014) Evaluating the drivers of corporate social responsibility in the mining industry with multi-criteria approach: A multi-stakeholder perspective. Journal of Cleaner Production 84, 214-232.

Hale R., Reich P., Johnson M., Hansen B.D., Lake P.S., Thomson J.R., and Mac Nally R. (2015) Bird responses to riparian management of degraded lowland streams in southeastern Australia. Restoration Ecology 23:104-112.

Herrick J.E., Schuman G.E., and Rango A. (2006) Monitoring ecological processes for restoration projects. Journal for Nature Conservation 14, 161-171.

Hilderbrand R.H., Watts A.C., and Randle A.M. (2005) The myths of restoration ecology. Ecology and Society 10, 19.

Jansen A. (2005) Avian use of restoration plantings along a creek linking rainforest patches on the Atherton Tablelands, North Queensland. Restoration Ecology 13, 275-283.

Jouquet P., Traoré S., Choosai C., Hartmann C., and Bignell D. (2011) Influence of termites on ecosystem functioning. Ecosystem services provided by termites. European Journal of Soil Biology 47, 215-222.

Kamoroff C., and Goldberg C.S. (2018) An issue of life or death: using eDNA to detect viable individuals in wilderness restoration. Freshwater Science 37, 685-696.

Kennedy P.L., Lach L., Lugo A.E., and Hobbs R.J. (2013) Fauna and novel ecosystems. Novel ecosystems intervening in the new ecological world order. West Sussex; UK: Wiley Blackwell, Pp. 127-41.

Koch J.M., Grigg A.H., Gordon R.K., and Majer J.D. (2010) Arthropods in coarse woody debris in jarrah forest and rehabilitated bauxite mines in Western Australia. Annals of forest science 67, 106.

König H.. and Varma A. (2006) Intestinal Microorganisms of Termites and Other Invertebrates. In *Soil Biol., Ser. Edit.*, Köning, H. and Varma, A., Eds., Berlin-Heidelberg: Springer-Verlag, Vol. 6.

Laurence D. (2011) Establishing a sustainable mining operation: an overview. Journal of Cleaner Production 19, 278-284.

Lei K., Pan H., and Lin C. (2016) A landscape approach towards ecological restoration and sustainable development of mining areas. Ecological Engineering 90, 320-325.

Lindell C.A. (2008) The value of animal behavior in evaluations of restoration success. Restoration Ecology 16, 197-203.

Mackenzie D.I. (2005) What are the issues with presence-absence data for wildlife managers? The Journal of Wildlife Management 69, 849-860.

Majer J.D. (1989) Animals in primary succession: the role of fauna in reclaimed lands. Cambridge University Press, Cambridg: New York.

Majer J.D. (2009) Animals in the restoration process—progressing the trends. Restoration Ecology 17, 315-319.

Martínez-Abraín A., Regan H.M., Viedma C., Villuendas E., Bartolomé M.A., Gómez J.A., and Oro D. (2011) Cost-effectiveness of translocation options for a threatened waterbird. Conservation Biology 25, 726-735.

McAlpine C., Catterall C.P., Mac Nally R.M. *et al.* (2016) Integrating plant and animal-based perspectives for more effective restoration of biodiversity. Frontiers in Ecology and the Environment 14, 37-45.

Miller B.P., Sinclair E.A., Menz M.H., Elliott C.P., Bunn E., Commander L.E., Dalziell E., David E., Davis B., and Erickson T.E. (2017) A framework for the practical science necessary to restore sustainable, resilient, and biodiverse ecosystems. Restoration Ecology 25, 605-617.

Munro N.T., Lindenmayer D.B., and Fischer J. (2007). Faunal response to revegetation in agricultural areas of Australia: a review. Ecological Management & Restoration 8, 199-207.

Palmer M.A., Ambrose R.F., and Poff N.L. (1997) Ecological theory and community restoration ecology. Restoration Ecology 5, 291-300.

Pate J.S., Unkovich M.J., Erskine P.D., and Stewart G.R. (1998) Australian mulga ecosystems–13C and 15N natural abundances of biota components and their ecophysiological significance. Plant, Cell & Environment 21, 1231-1242.

Perring M.P., Standish R.J., Price J.N., Craig M.D., Erickson T.E., Ruthrof K.X., Whiteley A.S., Valentine L.E., and Hobbs R.J. (2015) Advances in restoration ecology: rising to the challenges of the coming decades. Ecosphere 6, 1-25.

Poulsen B.O. (2002) Avian richness and abundance in temperate Danish forests: tree variables important to birds and their conservation. Biodiversity & Conservation 11, 1551-1566.

Ran L., Lu X., and Xu J. (2013) Effects of vegetation restoration on soil conservation and sediment loads in China: A critical review. Critical reviews in environmental science and technology 43, 1384-1415.

Reid, J.L., Holl, K.D. and Zahawi, R.A., 2015. Seed dispersal limitations shift over time in tropical forest restoration. *Ecological Applications*, *25*(4), pp.1072-1082.

Ritchie A.L., Nevill P.G., Sinclair E.A., and Krauss S.L. (2017) Does restored plant diversity play a role in the reproductive functionality of Banksia populations? Restoration Ecology 25, 414-423.

Rodrigues R.R., Lima R.A., Gandolfi S., and Nave A.G. (2009) On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest. Biological Conservation 142, 1242-1251.

Rokich D.P. (2016) Melding of research and practice to improve restoration of Banksia woodlands after sand extraction, Perth, Western Australia. Ecological Management & Restoration 17, 112-123.

Ruiz-Jaen M.C., and Mitchell Aide T. (2005) Restoration success: how is it being measured? Restoration Ecology 13, 569-577.

Schneider R.R., Hauer G., and Boutin S. (2010) Triage for conserving populations of threatened species: the case of woodland caribou in Alberta. Biological Conservation 143, 1603-1611.

Šebelíková L., Řehounková K., and Prach K. (2016) Spontaneous revegetation vs. forestry reclamation in post-mining sand pits. Environmental Science and Pollution Research 23, 13598-13605.

Silveira F.A.O., Gama E.M., Dixon K.W., and Cross A.T. (2019) Avoiding tailings dam collapses requires governance, partnership and responsibility. Biodiversity and Conservation. Doi:10.1007/s10531-019-01752-5

Standards Reference Group SERA (2017). National Standards for the Practice of Ecological Restoration in Australia. Second Edition. Society for Ecological Restoration Australasia. Available from URL: www.seraustralasia.com

Stevens J.C., Rokich D.P., Newton V.J., Barrett R..L, and Dixon K.W. (2016) Banksia woodlands: a restoration guide for the Swan Coastal Plain. UWA Publishing, Perth.

Tews J., Brose U., Grimm V., Tielbörger K., Wichmann M., Schwager M., and Jeltsch F. (2004) Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of Biogeography 31, 79-92.

Tomlinson S., Arnall S.G., Munn A., Bradshaw S.D., Maloney S.K., Dixon K.W., and Didham R.K. (2014) Applications and implications of ecological energetics. Trends in Ecology & Evolution 29, 280–290.

Valido A., and Olesen J.M. (2007) The importance of lizards as frugivores and seed dispersers. Seed dispersal: theory and its application in a changing world. Wallingford, UK: CAB International, 124-147.

Wardell-Johnson G.W., Calver M., Burrows N., and Di Virgilio G. (2015) Integrating rehabilitation, restoration and conservation for a sustainable jarrah forest future during climate disruption. Pacific Conservation Biology 21, 175-185.

Wenny D.G., Sekercioglu C., Cordeiro N.J., Rogers H.S., and Kelly, D. (2016) Seed dispersal by fruit-eating birds. In: Why birds matter: avian ecological function and ecosystem services (eds C.H. Sekercioglu, D.G. Wenny, and C.J. Whelan), pp.107-145. The University of Chicago Press: Chicago and London.