Editorial note for the special collection “Trees and Restoration”

Fabio Rubio Scarano¹

Received: 19 May 2021 / Accepted: 19 May 2021 / Published online: 29 May 2021
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2021

Key message Ecological restoration is an increasingly global concern. Trees are the basic unit for land restoration in forests. Our journal “Trees: Structure and Function” now launches a special collection on structure and functions, including development, ecology and evolution of trees, to support concepts and approaches of restoration. Submission of original research and review essays is invited.

Context

Ecological restoration has been upscaled from science and local practice to global, national and subnational policies. The United Nations (UN) have declared 2021–2030 the UN Decade on Ecosystem Restoration, and the topic is now embedded in goals and objectives of the global conventions on climate change, biodiversity and combat to desertification. Restoration is, therefore, an instrument well placed to foster all 17 Sustainable Development Goals of the UN Agenda 2030 (Herrick et al. 2019). It is a ‘nature-based solution’ to societies, since it can be valuable to mitigate and adapt to climate change, to reduce disaster risk, to combat desertification and land degradation, to ensure food and water security and, last but not least, to halt species extinction driven by human activities (Keesstra et al. 2018). It is also being increasingly used to address human rights issues, particularly in relation to land and cultural rights of indigenous and traditional peoples (Wehi and Lord 2018).

The sense of urgency and opportunity is such that many countries have collectively set ambitious commitments, such as the Bonn Challenge and the New York Declaration on Forests, which aim to restore 350 million hectares worldwide by 2030 (Strassburg et al. 2020). Global agreements percolate to national policies. The pledges for land restoration of Brazil, China and India (12, 40 and 21 million hectares, respectively) exemplify the impetus for large-scale restoration in developing nations (Viña et al. 2016; Scarano

2017; Chaturvedi et al. 2018). Madagascar and Indonesia, two other developing megadiversity countries that contain biodiversity hotspots (Scarano et al. 2021), also have significant land degradation neutrality commitments that include restoration among targeted practices to achieve such goals (UNCCD 2015; Chasek et al. 2019). Developed countries, such as Australia and Italy, follow the same trends (Baumber et al. 2019; Chasek et al. 2019). However, restoration remains a costly enterprise (Brancalion et al. 2019) and various funding sources for large-scale action begin to emerge globally, from multilateral sources—such as the land degradation neutrality fund—to market instruments (Baumber et al. 2019).

Science responds to the challenge of large-scale restoration with a variety of approaches to inform planning, such as by setting priorities based on various criteria, including biodiversity conservation, carbon storage and sequestration, and cost-effectiveness. These efforts are spreading at subnational (Strassburg et al. 2019), national (Tobón et al. 2017) and global levels (Strassburg et al. 2020). Despite the excitement of this challenging scenario, words of caution emerge. What is the evidence-base available for this massive action to be implemented successfully (Cooke et al. 2019; Young and Schwartz 2019)? There are doubts about how successful the restoration enterprise has been so far, but two patterns have already been described based on a meta-analysis of > 400 studies: (1) though restored ecosystems are progressing towards recovery following disturbances, they rarely recover completely; and (2) active restoration did not result in faster or more complete recovery than passive restoration following ecosystem disturbance (Jones et al. 2018).

✉ Fabio Rubio Scarano
fscarano@gmail.com

¹ Ecology Department, CCS, IB, Universidade Federal do Rio de Janeiro, Cidade Universitária, Rio de Janeiro, RJ 21941-970, Brazil

Why trees?

Trees are the basic unit for land restoration in forests and other ecosystems dominated by woody plants. The fact that we do not know enough ecology, physiology and genetics of most of the ~ 60,000 tree species in the world (Beech et al. 2017) may partly explain the existing issues with restoration effectiveness globally and locally. This knowledge gap is particularly true to many tree species in developing countries (Lüttge et al. 2013; Scarano and Garbin 2013), where most of the large-scale restoration is due to take place. For instance, there are gaps on restoration research (and practice) based on plant functional traits (Carlucci et al. 2020), conservation physiology (Madliger et al. 2018), phylogenetic approaches [e.g., adaptive networks, Raimundo et al. (2018)], priority effects [i.e., the implications of the order of timing of species arrival, Weidlich et al. (2021)], to name but a few.

Themes and approaches with overlaps and close links to ecological restoration include ‘novel ecosystems’ and ‘regenerative agriculture’. First, ecological restoration of highly degraded terrestrial ecosystems, such as post-mining sites, often creates novel ecosystems that differ substantially in structure and/or function compared to their historical conditions (Evers et al. 2018). Reference systems and plant trait indicators for novel ecosystems are largely lacking, and defining those for local enterprises consists of an important step to design targets, which are increasingly demanded by public policies and private sector practices (Gwenzi 2021). Second, regenerative agriculture is now recognized as an important tool to restore degraded agroecosystems (Soto et al. 2021) and often leads to the reestablishment of native tree species in agricultural landscapes (Andrade et al. 2020), therefore bearing strong links with ecological restoration (Aronson et al. 2020).

In parallel, there is also plenty of space for more traditional approaches to study plant structure and function in restoration sites, such as functional anatomy, seed germination, ecophysiology, plant–soil, plant–plant, and plant–animal interactions (e.g., Silliman et al. 2015; Lamoureux et al. 2016; Kaiser-Bunbury et al. 2017; van de Bij et al. 2018; Gagnon et al. 2020; Kildisheva et al. 2020). Of course, all landscape settings where restoration takes place can offer a variety of study sites, be they urban, rural or in the wilderness.

The Special Collection “Trees and Restoration”, now launched by *Trees—Structure and Function*, is an attempt to help fill these knowledge gaps. The journal has been addressing restoration in recent years (e.g., Soteris et al. 2014; Albuquerque et al. 2019), but we expect that this special collection will give more visibility to plant

structural and functional biology in restoration systems in the journal, so as to significantly contribute to the science-based evidence in support of ecosystem restoration as a key tool to globally deliver on the Agenda 2030 for sustainable development.

Author contribution statement Fabio Rubio Scarano, as the single author of this paper, has conceived, surveyed the literature and written the paper, incentivised by the Editorial Board of *Trees: Structure and Function*.

References

- Albuquerque RP, Brandes AFN, Lisi CS, De Moraes LFD, Barros CF (2019) Tree-ring formation, radial increment and climate–growth relationship: assessing two potential tree species used in Brazilian Atlantic forest restoration projects. *Trees Struct Funct* 33:877–892
- Andrade D, Pasini F, Scarano FR (2020) Syntropy and innovation in agriculture. *Curr Opin Environ Sustain* 45:20–24
- Aronson J, Goodwin N, Orlando L, Eisenberg C, Cross AT (2020) A world of possibilities: six restoration strategies to support the United Nation’s decade on ecosystem restoration. *Restor Ecol* 28:730–736
- Baumber A, Berry E, Metternicht G (2019) Synergies between land degradation neutrality goals and existing market based instruments. *Environ Sci Policy* 94:171–181
- Beech E, Rivers M, Oldfield S, Smith PP (2017) Globaltresearch: the first complete global database of tree species and country distributions. *J Sustain* for 36:454–489
- Brancalion PHS, Meli P, Tymus JRC, Lenti FEB, Benini RM, Silva APM, Isernhagen I, Holl KD (2019) What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. *Biol Conserv* 140:108274
- Carlucci MB, Brancalion PHS, Rodrigues RR, Loyola R, Cianciaruso MV (2020) Functional traits and ecosystem services in ecological restoration. *Restor Ecol* 28:1372–1383
- Chasek P, Akhtar-Schuster M, Orr BJ, Luise A, Ratsimba HR, Safriel U (2019) Land degradation neutrality: the science-policy interface from the UNCCD to national implementation. *Environ Sci Policy* 92:182–190
- Chaturvedi R, Duraisami M, Jayahari KM, Kanchana CB, Singh R, Segarin S, Rajagopal P (2018) Restoration opportunities Atlas of India. World Resources Institute, Mumbai (**Technical Note**)
- Cooke SJ, Bennett JR, Jones HP (2019) We have a long way to go if we want to realize the promise of the “decade on ecosystem restoration.” *Conserv Sci Pract* 1:e129
- Evers CR, Wardrop CB, Branoff B, Granek EF, Hirsch SL, Link TE, Olivero-Lora S, Wilson C (2018) The ecosystem services and biodiversity of novel ecosystems: a literature review. *Glob Ecol Conserv* 13:e00362
- Gagnon K, Rinde E, Bengil EGT, Carugati L, Christianen MJA, Danovaro R, Gambi C, Govers LL, Kipson S, Meysick L, Pajusalu L, Kızılkaya İT, van de Koppel J, van der Heide T, van Katwijk MM, Boström C (2020) Facilitating foundation species: the potential for plant–bivalve interactions to improve habitat restoration success. *J Appl Ecol* 57:1161–1179

- Gwenzi W (2021) Rethinking restoration indicators and end-points for post-mining landscapes in light of novel ecosystems. *Geoderma* 387:114944
- Herrick JE, Abrahamse T, Abhilash PC, Ali SH, Alvarez-Torres P, Barau AS, Branquinho C, Chhatre A, Chotte JL, Cowie AL, Davis KF, Edrisi SA, Fennessy MS, Fletcher S, Flores-Díaz AC, Franco IB, Ganguli AC, Speranza CI, Kamar MJ, Kaudia AA, Kimiti DW, Luz AC, Matos P, Metternicht G, Neff J, Nunes A, Olaniyi AO, Pinho P, Primmer E, Quandt A, Sarkar P, Scherr SJ, Singh A, Sudoi V, von Maltitz GP, Wertz L, Zeleke GIRP (2019) Land restoration for achieving the sustainable development goals: an international resource panel think piece. United Nations Environment Programme, Nairobi
- Jones HP, Jones PC, Barbier EB, Blackburn RC, Benayas JMR, Holl KD, McCrackin M, Meli P, Montoya D, Mateos DM (2018) Restoration and repair of earth's damaged ecosystems. *Proc R Soc B* 285:20172577
- Kaiser-Bunbury CN, Mougil J, Whittington AE, Valentin T, Gabriel R, Olesen JM, Blüthgen N (2017) Ecosystem restoration strengthens pollination network resilience and function. *Nature* 542:223–227
- Keesstra S, Nunes J, Novara A, Finger D, Avelar D, Kalantari Z, Cerdà A (2018) The superior effect of nature based solutions in land management for enhancing ecosystem services. *Sci Total Environ* 610–611:997–1009
- Kildisheva OA, Dixon KW, Silveira FAO, Chapman T, Di Sacco A, Mondoni A, Turner SR, Cross AT (2020) Dormancy and germination: making every seed count in restoration. *Restor Ecol* 28:S256–S265
- Lamoureux SC, Veneklaas EJ, Poo P (2016) Informing arid region mine-site restoration through comparative ecophysiology of *Acacia* species under drought. *J Arid Environ* 133:73–84
- Lüttge U, Garbin M, Scarano FR (2013) Evo–devo–eco and ecological stem species: potential repair systems in the planetary biosphere crisis. In: Lüttge U, Beyschlag W, Francis D, Cushman J (eds) *Progress in Botany*, vol 74. Springer, Berlin, pp 191–212
- Madliger CL, Love OP, Hultine KR, Cooke SJ (2018) The conservation physiology toolbox: status and opportunities. *Conserv Physiol* 6(1):coy029
- Raimundo RLG, Guimarães PR, Evans DM (2018) Adaptive networks for restoration ecology. *Trends Ecol Evol* 33:664–675
- Scarano FR (2017) Ecosystem-based adaptation to climate change: concept, scalability and a role for conservation science. *Perspect Ecol Conserv* 15:65–73
- Scarano FR, Garbin ML (2013) Stem species: plant species that function as regenerating cells of Gaia. *Nova Acta Leopold* 114:317–324
- Scarano FR, Aguiar ACF, Mittermeier RA, Rylands AB (2021) Megadiversity. *Encycl Biodivers* 3 (upcoming)
- Silliman BR, Schrack E, He Q, Cope R, Santoni A, van der Heide T, Jacobi R, Jacobi M, van de Koppel J (2015) Facilitation shifts paradigms and can amplify coastal restoration efforts. *Proc Natl Acad Sci* 112:14295–14300
- Soteras F, Renison D, Becerra AG (2014) Restoration of high altitude forests in an area affected by a wildfire: *Polylepis australis* Bitt. seedlings performance after soil inoculation. *Trees Struct Funct* 28:173–182
- Soto RL, Martínez-Mena M, Padilla MC, de Vente J (2021) Restoring soil quality of woody agroecosystems in Mediterranean drylands through regenerative agriculture. *Agric Ecosyst Environ* 306:107–191
- Strassburg BBN, Beyer HL, Crouzeilles R, Iribarrem A, Barros F, Siqueira MF, Sánchez-Tapia A, Balmford A, Sansevero JBB, Brancalion PHS, Broadbent EN, Chazdon RL, Oliveira Filho A, Gardner T, Gordon A, Latawiec AE, Loyola R, Metzger JP, Mills M, Possingham HP, Rodrigues RR, Scaramuzza CA, Scarano FR, Tambosi L, Uriarte M (2019) Strategic approaches to restoring ecosystems can triple conservation gains and halve costs. *Nat Ecol Evol* 3:62–70
- Strassburg BBN, Iribarrem A, Beyer HL, Cordeiro CL, Crouzeilles R, Jakovac CC, Junqueira AB, Lacerda E, Latawiec AE, Balmford A, Brooks TM, Butchart SHM, Chazdon RL, Erb K-H, Brancalion P, Buchanan G, Cooper D, Díaz S, Donald PF, Kapos V, Leclère D, Miles L, Obersteiner M, Plutzer C, Scaramuzza CA, Scarano FR, Visconti P (2020) Global priority areas for ecosystem restoration. *Nature* 586:724–729
- Tobon W, Urquiza-Haas T, Koleff P (2017) Restoration planning to guide Aichi targets in a megadiverse country. *Conserv Biol* 31(5):1086–1097
- UNCCD (2015) Indonesia—land degradation neutrality national report. United Nations Convention to Combat Desertification, Jakarta
- Van der Bij AU, Weijters MJ, Bobbink R, Harris JA, Pawlett M, Ritz K, Benetková P, Moradi J, Frouz J, van Diggelen R (2018) Facilitating ecosystem assembly: plant–soil interactions as a restoration tool. *Biol Conserv* 220:272–279
- Viña A, McConnell WJ, Yang H, Xu Z, Liu J (2016) Effects of conservation policy on China's forest recovery. *Sci Adv* 2:e1500965
- Wehi PM, Lord JM (2018) Importance of including cultural practices in ecological restoration. *Conserv Biol* 31(5):1109–1118
- Weidlich EWA, Nelson CR, Maron JL, Callaway RM, Delory BM, Temperton VM (2021) Priority effects and ecological restoration. *Restor Ecol* 29:e13317
- Young TP, Schwartz MW (2019) The decade on ecosystem restoration is an impetus to get it right. *Conserv Sci Practice* 1:e145

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.