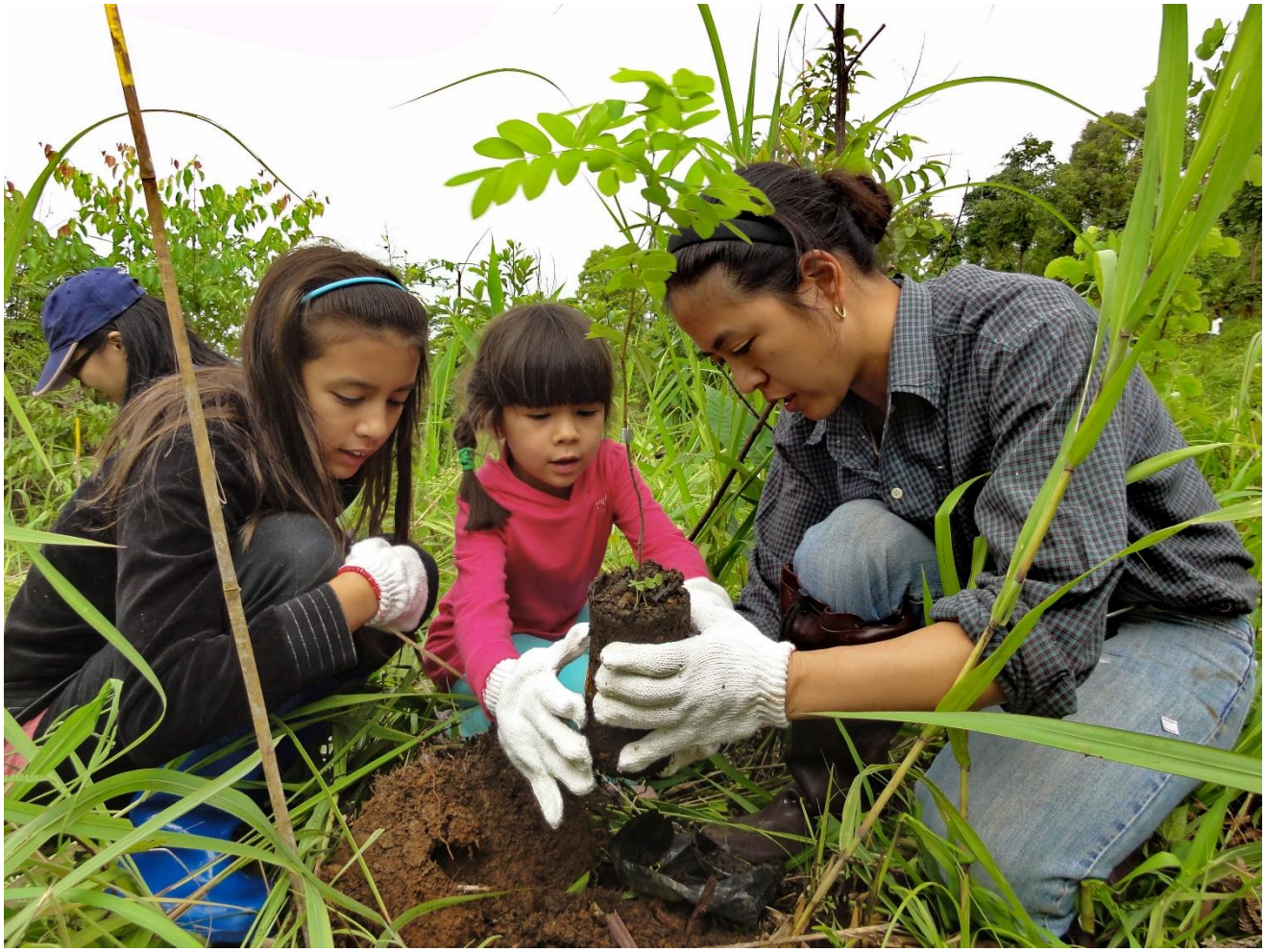

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SUMMARY REPORT

2022

UNDERSTANDING FOREST LANDSCAPE RESTORATION: REINFORCING SCIENTIFIC FOUNDATIONS FOR THE UN DECADE ON ECOSYSTEM RESTORATION

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Executive summary of a theme issue in Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, November 2022 (https://royalsocietypublishing.org/toc/rstb/2023/378/1867)

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HIGHLIGHTS

- The UN Decade on Ecosystem Restoration will need scientific input to ensure success.
- Our thematic issue identifies 15 key priority areas for forest restoration science, and contains 20 articles making scientific advances in these areas. The editorials also highlight the ways that restoration science practice can be improved and be better communicated to practitioners, policy makers and broader stakeholders.
- Science and monitoring are crucial, particularly for understanding long-term outcomes, and yet typically not central to restoration planning.
- Scientific focus is needed at scales relevant to restoration action and decision-making.
- Forest restoration can benefit both nature and people if done correctly, but there are common barriers to achieving these goals simultaneously.
- More research is needed into the costs and benefits of restoration for nature and people, and what constitutes best-practice is context specific.

INTRODUCTION

The United Nations Decade on Ecosystem Restoration, 2021-2030, brings a critical opportunity to restore forests, which are vital for the world's species, people and climate. Delivering forest restoration and tree-planting using evidence-based practices is important for both nature and people: using appropriate species and methods, at appropriate locations, and with full collaboration between practitioners, scientists and local people. Equally, it is essential that implementers of Forest Landscape Restoration (FLR) consider entire regions and all relevant people and organisations, not just individual sites in isolation. Accordingly, FLR is defined as a process aiming to restore both ecological functioning and human wellbeing in degraded forest landscapes. By adopting a holistic approach, FLR efforts can address the multiple reasons for regrowing forests and ensure benefits for all stakeholders, including those that live outside of the landscape. Scientific approaches are required to fully understand and act upon the multiple objectives and challenges of FLR, and yet scientists are infrequently involved in planning FLR strategies and implementing actions.

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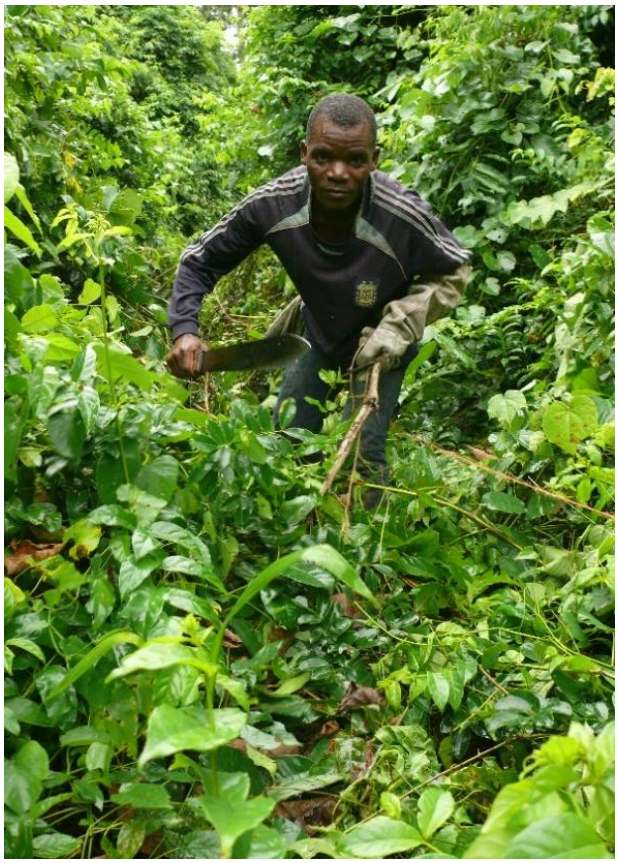
This article summarises findings from a landmark theme issue in a major international journal, uniting scientists from across the world, from diverse scientific disciplines. It comprises 20 articles, with 192 authors from 27 countries, including many from the developing tropics, where most of the featured work is focussed. Most of these scientists, including the 7 guest editors, are working at the frontline of forest restoration, attempting to use evidence from research to inspire action and change. To assist with their endeavours, the theme issue aims to identify how science can help to achieve global FLR priorities during the UN Decade and beyond. Articles in the theme issue test options and offers solutions for planning and executing FLR, to benefit both nature and people. Further articles include approaches to identify, monitor, predict and mitigate the multiple challenges to successful FLR. Several articles also make method and conceptual developments towards growing forests for both biodiversity and carbon sinks, using appropriate methods, and fair and inclusive practice.

ESSENTIAL SCIENCE ADVANCES IN THE THEME ISSUE

The introduction to the theme issue lists 15 ways that science can help to provide essential new information for better restoration of forest landscapes[1]. In drawing up this list, an international team of scientists considered knowledge gaps throughout the whole cycle of forest restoration, from planning, to implementation, to evaluation and reassessment. The list is used to identify critical areas for future research, and to highlight major advances made by the accompanying articles.

1. ADVANCES FOR OVERCOMING BARRIERS TO FOREST LANDSCAPE RESTORATION



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The theme issue emphasizes that essential science advances are needed to better understand the human wellbeing, economic and management challenges for successful FLR[1]. In developing regions, local communities have often been overlooked in forest restoration and by the management structures that oversee the work. Sustainable financing of FLR is one major economic challenge, with most restoration projects having insufficient funding beyond short-term donor interests and no concrete scientific evidence for how best to achieve long-term funding. Considerable uncertainty also remains regarding how all these challenges compare to and interact with environmental challenges, such as natural and human-induced variation in climate. Consequently, another major challenge is that ongoing disturbances, especially tree-harvesting, herbivory, fire and windstorms, continue to threaten forest restoration, even under good management and favourable climates.

In the theme issue, a literature review and rare case study show that human wellbeing in FLR regions can benefit from fair and equitable practice, e.g. through incentive schemes[2] and forest certification[3], but this remains to be tested across regions differing in biophysical, socio-economic and governance conditions and land use history. Wellbeing can improve with increased crop yields and access to forest resources[2], but there are both benefits and costs associated with biodiversity[4]. While overcoming wellbeing and other human challenges is often difficult in developing regions, a pioneering new theory in the theme issue highlights that a relatively simple assessment of community capacity can predict how best to overcome some challenges with relative ease[5]. New landscape level data presented in the theme issue show that restoring forests within existing protected areas may avoid many of the human

complexities of FLR, thus saving costs[6]. However, this also highlights a temptation to follow the simplest paths for achieving restoration targets, overlooking community restoration needs on public or private land6. Furthermore, where human or management challenges have led to disturbance or poor practice, case studies in the theme issue show that forest recovery becomes more vulnerable to environmental stresses[7,8,9]. Fire remains a significant environmental stress in many parts of the world but approaches to manage it often need more site-specific knowledge regarding its natural role, as observed in the theme issue from landscape planning[6] and emerging new concepts[10].

2. ADVANCES FOR PLANNING AND EVALUATING FOREST LANDSCAPE RESTORATION

Landscape restoration planning rarely considers the many potential reasons for restoring forests, for example, biodiversity and species recovery, carbon sequestration, economic development and livelihood needs[1]. Planning decisions are compounded by the lack of scientific evaluation of alternative procedures for decision-making. As a result, critical scientific information is missing relating to where (and where not) to restore forests. The limited information available has also been controversial, especially for global attempts at mapping restoration priority locations, which have not incorporated several feasibility factors essential for regional decision-making. Scientific evaluation is also seriously limited in terms of identifying the value and supply chains that are crucial for establishing financial benefits from forests and trees for local people. And more broadly, most restoration projects lack sufficient measurement and monitoring to truly evaluate forest landscape restoration success for both nature and people[8,12].

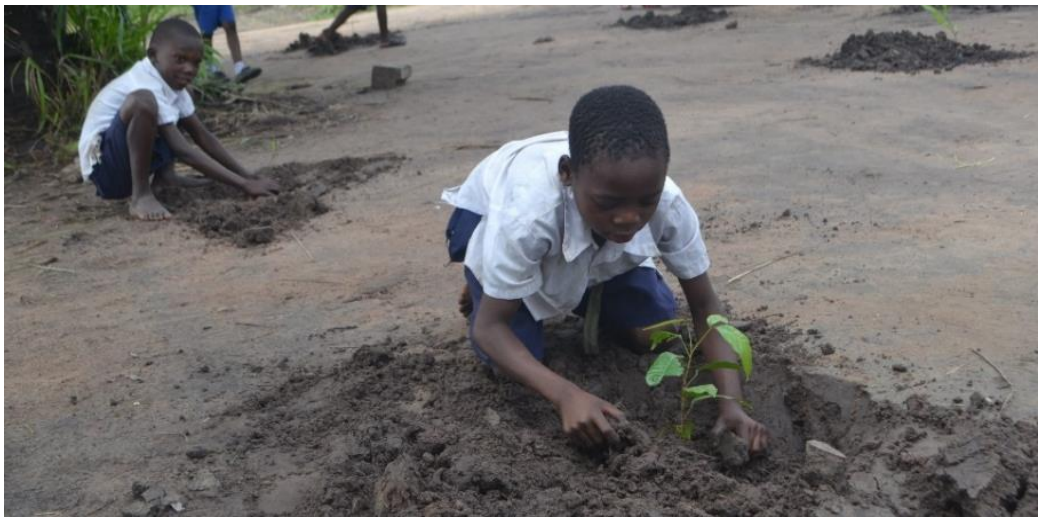
Regional studies in the theme issue show differences in spatial priority-setting when compared to predictions from global assessments, indicating the limitations of global studies, and that the scale of restoration planning has to connect to the decisions being made and to data reliability[6,11]. The theme issue presents innovative new technical approaches for assessing and synthesising the multiple considerations of regional landscape restoration planning, showing that poor planning risks increased conflict between people and wildlife[4] and leads to inefficient use of funding[6]. Assessment of community capacity is used in the theme issue to predict potential for restoration, and also value and supply – communities with greater financial and social capitals need less financial support[5]. However, revenue can take time to accrue, so planning focus on other aspects of wellbeing/livelihoods is also important[3]. Measurement and monitoring of wellbeing, economic and governance outcomes from restoration also have potential to improve FLR objectives[3,4], but socio-economic data are less readily available and methods are less well established in restoration studies, especially for marginalised groups[5]. The theme issue also identifies that biological monitoring data are usually insufficient, lacking comparable controls[1], and require improvements to better consider plant survival and growth[8], species diversity and composition[12], and seed dispersal[13]. And for maximising biological outcomes, case studies in the theme issue emphasise the importance of landcover assessments in forest-savanna mosaic landscapes, to identify which ecosystem is the appropriate restoration target[6,11].

3. ADVANCES FOR IMPROVING FOREST RESTORATION TECHNIQUES

There are many techniques for restoring forest ecosystems and yet there has been a pervasive over-reliance on tree-planting, rather than natural recovery. The consequence of inappropriate tree-planting has been inappropriate species composition, poor survival and growth, and limited benefits for

biodiversity and people. Thus, more scientific information is required to help determine appropriate restoration methods, and how to do a better job at tree-planting if that is the appropriate method. For example, the theme issue identifies that essential scientific advances are needed to determine the impacts of competing plants and how to manage them, which will have significant consequences for improving tree growth and hence also the global carbon sink[1]. Advances are also needed to better understand the importance of soil and below-ground processes, which are crucial for restoration success, yet are rarely managed. Similarly, animals are crucial for seed dispersal and pollination and yet are also often overlooked in restoration planning. Finally, scientific advances are needed to better understand the environmental impacts of restoration, which can be significant. Moreover, conflicting outcomes have been reported, especially with regard to water flow and availability, which can be both positively and negatively impacted by forest restoration[1].

Restoration methods are more cost-effective when they take into account the environmental conditions and degradation levels, and that while tree planting is costly, it becomes cost-effective when used appropriately[6,8,14,15]. However, the theme issue also highlights that methods for selecting tree species are inconsistent and ill-defined[14] and plantings are often species-poor8. And while exotic species can help improve prospects of tree planting by nursing the growth of native trees, they can also reduce overall biodiversity[18]. A further case study in the theme issue shows that cost-effective methods facilitating natural recovery, rather than planting, also improve resistance to wind damage[7]. Spatial assessment in the theme issue shows that restoration best-practice varies across landscapes, and can be predicted using basic biological information[6], but even this information is too limited in many regions[8]. Improved information on soil and disturbance can help to better select restoration methods[9,16] and species[14]. Similarly, research in the theme issue shows how animals are important to consider in selecting species and locations, both for encouraging seed dispersal[13] and minimising human-wildlife conflict[4].



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WHAT NEXT FOR SCIENCE TO HELP RESTORE THE WORLD'S FORESTS?

The first over-arching message from the theme issue is that more scientific research is needed, with focus across the cycle of forest restoration management[1]. From the above summary, we see that scientific focus is needed on spatial planning and projection of FLR outcomes at realistic scales to ensure data reliability and relevance to practitioners and decision-makers. Identifying where and when best to restore will require improved understanding of governance, social and land tenure considerations, and of the biotic, abiotic, and human benefits and costs of restoration action. Once restoration sites have been selected, scientific research is needed to better assist method selection, to better harness and assist natural succession, for more resilient, naturally recovering forests. Monoculture or species poor tree plantations are not healthy, resilient, fully functional forests, and have limited ecosystem services, constraining the benefits available to local people. Scientists are also well-placed to help find ways to fund sustainable restoration, both through investigation, and through their international contacts and funding channels, that may not be accessible or apparent to practitioners working on the ground. Collaborative funding proposals between scientists and practitioners may also broaden the funding pool accessible to both sectors, and permit science to proceed concurrently with management action.

The second over-arching message is that improved science is needed. Recent controversies show that scientists themselves can improve on their work, with a scientific preface to the theme issue highlighting six ways to improve restoration science to ensure transparency, realism, strong focus on data, and attention to financial costs/benefits[19]. FLR also needs to be underpinned by improved methods for measurement and monitoring of both biological and non-biological outcomes, especially those relating to local capacity and wellbeing, that can be easily used by others. Measurements are important for retrospective monitoring of success, i.e. "lagging" indicators, but indicators can also be "leading" in that they can be used to predict imminent threats, future trends, opportunities or suitability of alternative management decisions. Funders and donors need to recognise the importance of longer-term monitoring as a critical component of restoration project cycles.

The third over-arching message is that FLR science, and scientific expertise, need to be communicated and applied more effectively. Scientific findings need to successfully reach decision makers and implementing organizations that will be most able to use the information to leverage action. Accordingly, a practitioner preface to the theme issue by leaders of the Science Task Force of the UN Decade, presents three pathways to help FLR scientists improve the usefulness of their work, emphasising a need for science to better target information of practical relevance, and to better collaborate and communicate with partners outside of academia so that the outcomes are understood[20]. Overall, scientists need to make themselves and their work more accessible, building effective working relationships and dialogue with practitioners and decision-makers.

The main conclusions from the theme issue of relevance to policy and practice are also summarised in twelve consensus statements (see Appendix).

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APPENDIX 1 – CONSENSUS STATEMENTS

CONSENSUS STATEMENTS FOR REINFORCING SCIENTIFIC FOUNDATIONS FOR FOREST RESTORATION UNDER THE UN DECADE ON ECOSYSTEM RESTORATION

The following consensus statements are intended to help communicate scientific findings from the above theme issue, and are intended for development into an article aimed at practitioners and policymakers:

1. Practitioners, biologists, social scientists and economists should work collaboratively to plan, implement and evaluate forest restoration.
2. Locations vary widely in their potential for restoring forests, requiring initial assessments of social and environmental conditions, and spatial planning of activities.
3. Forest restoration methods should be tailored to site conditions, natural processes, and the needs of local communities.
4. Scientific information can be used to improve tree species selection and planting approaches, for facilitating natural recovery, saving costs and improving outcomes.
5. Disturbances and highly-competitive plants are causing problems for recovering forests worldwide, but may be managed using collaborative approaches.
6. Forest restoration is complex, and must consider multiple objectives, outcomes, drivers, stakeholders, land-uses, trade-offs and pathways to success.
7. The costs and benefits of restoration are poorly understood and can extend beyond the boundaries of restoration projects, including to broader communities and watersheds.
8. Local livelihood and management challenges are often poorly understood and thus hard to address, requiring strategies that target human wellbeing and land tenure as priorities.
9. Local people are more likely to implement, support and benefit from forest restoration if they are involved in the whole process and have minimum levels of capacity.
10. Financial incentive and certification schemes benefit both nature and people, if managed correctly.
11. Financial systems for forest restoration require development, to improve cost-effectiveness, sustainability, and longer-term commitments from project partners.
12. Monitoring of ecosystem, social and governance outcomes from forest restoration projects requires adequate controls and appropriate methods.