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Opinion

Making the UN Decade on Ecosystem Restoration a Social-Ecological Endeavour

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The United Nations (UN) recently declared 2021 to 2030 the Decade on Ecosystem Restoration. Against this background, we review recent social-ecological systems research and summarize key themes that could help to improve ecosystem restoration in dynamic social contexts. The themes relate to resilience and adaptability, ecosystem stewardship and navigation of change, relational values, the coevolution of human and ecological systems, long-range social-ecological connections, and leverage points for transformation. We recommend two cross-cutting new research foci; namely: (i) *post hoc* cross-sectional assessments of social-ecological restoration projects; and (ii) transdisciplinary social-ecological 'living labs' that accompany new restoration projects as they unfold. With global agendas increasingly taking a social-ecological perspective, the recasting of ecosystem restoration as a social-ecological endeavor offers exciting new opportunities for both research and practice.

Highlights

The UN declared 2021–2030 the Decade on Ecosystem Restoration, and this opens new opportunities for restoration ecologists.

We argue that ecosystem restoration will be most effective if approached from a social-ecological perspective.

We synthesize key insights from the field of social-ecological systems research that are particularly relevant for ecosystem restoration.

Restoration in an Era of Global Change

In response to human-induced ecosystem degradation, biodiversity loss, and climate change, the science and practice of restoration are rapidly expanding [1,2]. With the United Nations (UN) having declared 2021–2030 the Decade on Ecosystem Restoration [3], it is timely to reflect on the future of restoration as a science and practice.

In this opinion article, we consider ecosystem restoration as 'the process of assisting the recovery of a degraded, damaged, or destroyed ecosystem to reflect values regarded as inherent in the ecosystem and to provide goods and services that people value' [4]. Such a focus implies an interest in species composition as well as in ecosystem functioning and services [5,6]: asking, for example, how different combinations of species help to facilitate certain types of ecosystem functions or which management actions are needed to enhance especially valued ecosystem services (see the Society for Ecological Restoration Standards [7]). Like many other ecologists, we support a pluralist approach to restoration that encompasses both species composition and ecosystem functions and services [1,8], while cautioning that a narrow focus on single or a few ecosystem services to the detriment of biodiversity is not desirable (e.g., tree plantation monocultures for carbon storage [9]).

Global social-ecological change has brought many new challenges for restoration. Shifting environmental and social baselines call for restoration goals to not only include ecological criteria for success but also consider the effects on human benefits, landscape multifunctionality [10–12], and **resilience** (see Glossary) [1]. Ultimately, all types of ecosystem restoration are normative undertakings [13] in that they seek to improve the world, be it in terms of biodiversity or ecosystem functioning [14], or to improve human well-being [15]. However, what roles do various social benefits of restoration play? Which particular reference state should be used for which location when there are uncertain trajectories; for example, of climate change and nitrogen deposition

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[13]? When are unprecedented combinations of species, including introduced species, acceptable in a restoration context? Who gets to decide which species, functions, or services should be prioritized? Should restoration be guided by rational self-interest, social responsibility, or an ethic of care?

Pressing questions such as these cannot be answered from within the ecological sciences alone. Instead, they require inter- and **transdisciplinary** approaches that facilitate collaboration between ecologists, social scientists, and diverse groups of actors. Here, we suggest that a **social-ecological systems** perspective on restoration can provide entry points for to improve restoration in terms of process and outcomes and can help to better connect ecologists, social scientists, and practitioners. We give an overview of key insights from social-ecological **systems thinking** and show how these insights can inform ecosystem restoration.

Social-Ecological Systems Thinking for Restoration

Social-ecological systems thinking applies complex adaptive **systems** theory to interlinked social and environmental phenomena [16] and is recognized to be useful in the pursuit of sustainability in general [17] as well as for biodiversity conservation in particular [18]. We highlight six social-ecological themes of particular relevance for restoration.

Resilience and Adaptability of Social-Ecological Systems

Restoration can directly benefit from the adoption of key principles for social-ecological resilience relating to diversity and **redundancy**, **connectivity**, slow variables and feedbacks, systems thinking, learning, participation, and polycentric governance [19,20]. Some of the principles have direct parallels in the science of restoration ecology, while other principles are uniquely social-ecological but still have immediate relevance for restoration.

Restoration ecology routinely works with the notion of alternative stable states and regime shifts or transitions between such states [21–23]. Combinations of abiotic and biotic drivers cause transitions between ecosystem states and a given ecosystem state is reinforced and stabilized through internal feedback mechanisms [24].

Social-ecological systems thinking also recognizes alternative stable states and transitions between these [25–27]. Social-ecological systems researchers have synthesized seven key principles that typically enhance the resilience and adaptability of systems [19,20]. Their relevance for social-ecological restoration was recently reviewed in depth by Krievins *et al.* [28] and Aslan *et al.* [29]. Given these in-depth reviews, we provide only a short overview here, highlighting parallels between a more disciplinary ecological focus and a more interdisciplinary social-ecological perspective.

First, diversity and redundancy are important in a context of the functional responses of species to disturbance [30]. They also matter in a social context; for example, restoration will be more successful in terms of both process and outcomes if it accounts for diverse social preferences. Second, connectivity needs careful management, because it may entail ecological benefits (e.g., dispersal of native species) as well as risks (e.g., dispersal of invasive species) [31–33]. Similarly, in a social context, without any connectivity, the restoration activities of multiple actors might be uncoordinated; by contrast, in overly bureaucratic situations actors might be so tightly connected that any one actor may be unable to work without the approval of all others, such that too much connectivity can cause rigidity. Third, slow variables and feedbacks need to be managed in ecological and social-ecological contexts alike. In an ecological context, for example, gradual accumulation of phosphorus in a lake can lead to its ecological state flipping into an

Glossary

Connectivity: the degree of connectedness among different elements in a system. Ecological elements can be connected (e.g., via corridors) and social actors can be connected (e.g., via collaboration).

Leverage point: a place to intervene in a system. Intervening at the level of system design or intent is thought to be more difficult than intervening at the level of parameters or feedback but is more likely to bring about fundamental system change.

Living lab: a transdisciplinary collaboration focusing on interventions in real-world contexts that aims to understand and contribute to social change.

Redundancy: a situation in which multiple elements in a system fulfil the same ecosystem function, such that one or multiple elements can compensate for changes in others' contributions to that function.

Relational values: the preferences, principles, and virtues associated with relationships to nature; encompassing human–nature connections and human–human connections in nature, both interpersonal and as articulated by policies and social norms.

Resilience: the ability of a system to absorb shocks but continue to function in the same overall way.

Social-ecological system: a set of connected social and ecological elements that interact to produce certain outcomes.

System: a set of connected elements generating outcomes that arise from the interactions of the elements; examples include ecosystems and social-ecological systems.

Systems thinking: viewing the world as a system, and using that perspective to solve problems.

Telecoupling: long-range connections of social and ecological phenomena; for example, high demand for soy or palm oil in some countries influences ecosystems in distant locations.

Transdisciplinarity: the collaboration of actors from multiple academic disciplines together with actors from outside academia, such as government agencies or citizen groups. The perspectives of those involved mutually inform one another, which facilitates co-creation of knowledge.

undesired turbid state [25]. Similarly, social-ecological restoration needs to watch for underlying dynamics playing out in a given location. For example, gradual human population growth could put restoration efforts at risk or gradual climate change could alter fire regimes.

In addition to these first three principles, for which there are direct parallels between ecosystems and social-ecological systems, social-ecological researchers have proposed four additional resilience principles, which can also help to improve restoration activities [28]. Systems thinking runs as a theme throughout this opinion article and thus its utility does not require specific explanation here. Ongoing learning is deemed important, and any restoration practitioner knows of the importance of learning from both successes and failures; similarly, community participation is a critical hallmark of good ecological restoration [7,34,35]. Finally, polycentric governance denotes the dispersion of decision-making across multiple actors and governance levels [36]. It suggests that coordination among actors is important to reach a specific goal, but that it is also beneficial for different actors to retain some autonomy in their ecosystem management decisions.

People as Stewards Who Navigate Complexity

Restoration and social-ecological systems thinking both recognize the interdependence between people and the rest of the biosphere, and have similar moral concerns, but restoration can learn from social-ecological systems thinking about how to navigate complexity and unpredictable change.

Social-ecological systems thinking has emphasized that human actions shape the environment and that the environment, in turn, provides the biophysical basis for human well-being [17]. Not least because of the fundamental dependence of human survival on functioning ecosystems (and their associated services), social-ecological systems thinkers have highlighted the important moral responsibility of taking care of the environment, advocating a stewardship ethic [37–39]. Notably, this view has been criticized because some scholars see it as having religious roots [40]. Here, we take a broader perspective, and define stewardship as an ethic of caring about all living beings while recognizing their interconnectedness.

To facilitate stewardship, social-ecological systems scholars have advocated the reconnection of humans and the environment [41,42]. Social-ecological research suggests that increasing experiential, emotional, and even spiritual disconnection of people from the biosphere is one of the most significant latent threats to global sustainability [43]. Restoration could help to reinstate meaningful and tangible connections between people and ecosystems [44]. Arguably, the goal should not be to fix any particular kind of human–nature relation, but rather to facilitate dynamic ways of 'interbeing' with one another and the natural world [45], analogous to the fluid change of ecosystems [46], to facilitate a kind of social-ecological fluidity.

While the ideas of stewardship and reconnecting people to the environment will intuitively make sense to many restoration ecologists, it is important to think carefully about how these ideas could be enacted best in an era of rapid global change. Social-ecological systems thinking has always been concerned with dynamic complexity; in systems terms, with the 'emergence' of system behavior resulting from complex and partly unpredictable interactions among multiple interlinked system components. Such dynamic complexity, in turn, does not lend itself to (traditional) 'command-and-control' natural resource management [47,48]. Instead, land managers have to embrace uncertainty and navigate complexity, constantly expecting new challenges and remaining responsive to them. Underpinned by a desire to care for life, a paradigm of navigating complexity instead of tightly controlling it is especially useful for restoration: deciding on appropriate restoration targets and motivations thus cannot be a once-off decision. Rather, ongoing deliberation on both restoration theory and practice is the natural and appropriate response to dynamic and unpredictable global change [9,49–51].

Relational Values to Bridge Gaps between Actors

The idea of **relational values** is a relatively new social-ecological framing to conceptualize how people relate to and obtain value from their relationship with nature. Restoration can be more effective if it engages with the relational values of diverse actors.

Ecologists have sometimes been divided about what ought to be conserved and why [52–54]. Such controversy is relevant to restoration; for example, in the context of novel ecosystems [55,56] or of questions about which species, habitats, functions, or services ought to be prioritized [6,13,57].

Recent social-ecological advances open new avenues to navigate such controversy and to incorporate a plurality of values held by different people [58]. While there are many classifications of values [59], the notion of relational values has recently attracted much attention, including by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (https://ipbes.net/) [60]. Relational values encompass the 'preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms' [59]. Relational values acknowledge a plurality of sources of human well-being and emphasize the sum of collective values stemming from interactions within a social-ecological system [61]. Instead of focusing on the impact humans have on nature or the services they receive from it, relational values incorporate the multifaceted links between individuals and their societies, as well as reciprocal individual and collective connections to nature. Such connections include people's experiences, habits, and actions with respect to nature, but also the relationships of people in nature that are associated with a meaningful, ethically responsible, and satisfying life (including restoration or other stewardship activities) [62]. Hence, relational values enable a focus on human–nature connections as well as on human–human connections that are fostered by nature [44,59].

A relational values lens could help to address challenges in restoration related to competing demands on restoration sites, because it facilitates working with diverse values held by multiple actors. A relational values lens could also help to explain how people's preferences influence the implementation and success of projects [63–65]. On the one hand, sense of place and local identity can motivate restoration activities [66]; on the other hand, strong attachment to the *status quo* management of particular landscapes (for economic or other reasons) can hinder ecological restoration [67]. Full accounting for the diverse expressions of relational values for certain places can generate legitimization and support for restoration projects and might help to navigate conflict.

Coevolution of Social and Ecological Systems

Many valued ecosystems have coevolved with social systems. Restoration activities should account for social-ecological coevolution in the past and create opportunities for ongoing social-ecological coevolution in the future. The achievement of these goals requires the honoring of biocultural diversity as well as indigenous and local knowledge.

Social-ecological coevolution is common around the world. For example, highly biodiverse cultural landscapes in Europe have evolved through native species naturally adapted to open environments thriving in low-intensity farmland [68,69]. Biocultural hotspots or refugia are places in which diverse cultural practices have shaped the environment but have also maintained high levels of biodiversity [70,71]. Even places once (incorrectly) thought of as pristine wilderness have typically had a long history of distinct human impact.

In a multidisciplinary review, Hanspach *et al.* [72] found that restoration was one of the most prominent contexts in which scientists drew on the concept of biocultural diversity. Biocultural restoration thus approaches ecosystem restoration through a focus on cultural revitalization and is guided by indigenous and local knowledge [73,74]. Indigenous peoples and local communities are well positioned to contribute to ecological restoration because they often have an intimate relationship with, and holistic knowledge of, their territories [75,76]. The recognition of local and indigenous knowledge, traditions, and institutions thus should be seen as critical for the restoration of diverse social-ecological systems in the future [77].

Long-Range Connections of Social-Ecological Systems

Global connectedness fundamentally shapes our modern world. Interactions among social and ecological phenomena now occur not only locally but also across large distances, and sometimes in surprising ways. Such '**telecoupling**' of social-ecological systems creates opportunities but also challenges for restoration.

As highlighted in the section on relational values seen previously, numerous links between people and local ecosystems have been lost in many social-ecological contexts. Instead of local links, much more diffuse and long-range telecoupling between people and nature has become common [78–80]. Materially, people may consume ecosystem products generated in remote locations (e.g., soy, timber), while in immaterial terms they may feel a sense of connection to nature in an indirect rather than a direct sense (e.g., through watching nature documentaries).

The opportunities of social-ecological telecoupling for restoration are most obvious in the context of carbon sequestration. Restoration projects for carbon sequestration take place around the world, not only to accrue local benefits but to generate benefits for the global climate, financed by people living far from actual restoration sites [8,50,51].

However, there are also negative repercussions of globalization in a restoration context. Even well-intended restoration projects can have negative off-stage impacts [81]. First, telecoupled social-ecological systems not only are characterized by 'sending' and 'receiving' systems, but also can have unintended negative effects on 'spillover' systems elsewhere [80,82]. A decline in agricultural commodity production in one location thus can inadvertently increase the pressure on land elsewhere [83,84]. Second, hidden negative effects of restoration can arise locally due to insufficient recognition of social-ecological connections. An extreme example is that of 'green grabbing', the appropriation of land for environmental purposes by non-local actors [85]. In the worst case, remotely funded restoration projects could displace existing land uses, increase competition for land, spark social conflicts [86], or even lead to the displacement of marginalized communities [87]. With offsetting policies increasing in prevalence [88,89], ecosystem restoration should be especially mindful of potential risks posed by social-ecological telecoupling.

'Deep' Leverage Points

When seeking to change a social-ecological system (or any other complex system), not all interventions are equally powerful. Social-ecological systems thinking has produced insights on different types of **leverage points** to bring about change. Taking such a 'leverage points perspective' could help to make restoration more effective.

The dynamics of social-ecological systems play out at multiple realms of systemic depth. Analogous to an iceberg, engaging with the most visible realm is easiest but may not bring about fundamental changes to the system, while engaging with and altering increasingly deeper realms of a social-ecological system is more difficult but can lead to more fundamental (or even transformative) change

[90,91]. Abson *et al.* [92] classified interventions in complex systems [91] into four increasingly deep realms: namely, parameters, feedbacks, design, and intent. Changing parameters in a system is relatively easy, but may not change the overall system behavior (e.g., planting additional trees), while feedbacks are more difficult to detect and more influential; changing system design and intent is most likely to be truly transformative (e.g., designing land management for resilience instead of for maximum commodity production).

Parameters and feedbacks have received a lot of attention in restoration, not least because feedbacks (in combination with slow variables) fundamentally shape transitions between alternative ecosystem states [24,93]. Social-ecological system design goes beyond such feedbacks and explicitly points to the intertwined nature of social and ecological system components. Ostrom [94] showed that certain social-ecological system properties facilitated more sustainable management of common property systems (one particular kind of social-ecological system). A similar logic is likely to hold in a restoration context. How should restoration practices be designed to be most effective? Which combination of social and ecological system properties will best support restoration activities? Questions of system design include, for example, the structure of information flows, the rules and incentives for restoration activities, and the ability of restoration actors to self-organize [91].

The deepest level at which system change can occur is at the level of intent. This relates to the goals pursued by societies. If restoration truly is a goal taken seriously by decision-makers around the world, this will fundamentally change the actions that follow. Similarly, if restoration is thought of as a complex social-ecological endeavor from the outset (as opposed to a merely resource-intensive act of ecosystem management), this profoundly changes all actions that follow: different types of actors and their interests would be considered from the outset, which is thereby likely to improve the restoration process and its social and ecological benefits.

Restoration practitioners are likely to have experienced the importance of system 'design' and 'intent'. For example, powerful interests, poor information flows, perverse incentives, or a lack of political will have frustrated many practitioners around the world. Themes such as these, according to a leverage points logic, are at the heart of how to effectively intervene in social-ecological systems. While the purely ecological science of restoration remains important, some of the greatest gains in real-world restoration thus may be achieved by approaching restoration as an inherently complex social-ecological endeavor.

Concluding Remarks

Each of the six themes outlined in the previous text translates into new priorities for the UN Decade on Ecosystem Restoration, which we propose ought to be a Decade of Social-Ecological Restoration (Box 1). Based on these reflections, we suggest two cross-cutting research priorities specifically focusing on social-ecological restoration (see Outstanding Questions): first, to conduct *post hoc* comparisons of different restoration projects; and second, to establish '**living labs**' that facilitate social-ecological restoration.

Post hoc comparisons of restoration projects from a social and ecological perspective are now possible and timely, because many restoration activities have been conducted in various contexts. Some restoration sites are multiple decades old, and within a given region or nation, many are similar enough to be compared via natural experiments [95,96]. Already, leading scientists are linking monitoring data with ecological theory to provide increasingly robust guidance for future restoration efforts [97]. Future work should extend such initiatives, and similarly ask whether social benefits are partly predictable from patterns of stakeholder interaction in a given restoration program.

Outstanding Questions

Which social and ecological features of existing restoration projects best explain their success or failure? We recommend conducting social-ecological *post hoc* assessments of restoration activities. Such assessments should collect social-ecological information on a wide range of restoration projects, including consideration of the six themes outlined in the previous text. Projects that worked well from both an ecological and a social perspective then constitute successful examples that offer learning opportunities for newly planned activities. However, unsuccessful projects, too, offer learning opportunities and therefore need to be clearly documented. The upcoming decade thus is an opportunity to learn where, when, and how restoration can be both ecologically and socially successful.

Which transdisciplinary processes are best suited to the design of 'living labs' of social-ecological restoration? In parallel with the aforementioned, we recommend that living labs for ecosystem restoration be set up, to analyze the ecological and social effects of restoration activities as they occur. Such living labs offer an opportunity for diverse local actors to share their insights and participate in decision-making, empowering them to act collectively from an ethos of social-ecological stewardship. Living labs can specifically work with relational values, recognizing diversity, and drawing on indigenous and local knowledge. At the same time, they can be seen as experiments by which we learn how to reinstate meaningful and tangible connections between people and ecosystems, nurture relational values, foster biocultural diversity, and co-design restoration actions.

Box 1. Priorities for Restoration That Can Help to Make the UN Decade on Ecosystem Restoration a Decade of Social-Ecological Restoration

(i) Social-ecological resilience principles: Social-ecological resilience principles have parallels in the science of restoration ecology, but can also help to improve the practice of ecological restoration.
(ii) Stewardship of complex systems: In a context of unpredictable change, social-ecological stewardship will work best if it is approached from the perspective of navigating complexity.
(iii) Relational values: Incorporating a plurality of relational values will help to better engage diverse actors in social-ecological restoration.
(iv) Social-ecological coevolution: Drawing on indigenous and local knowledge will help to facilitate ongoing social-ecological coevolution.
(v) Social-ecological telecoupling: Long-distance social-ecological telecoupling needs to be considered in restoration projects to avoid negative off-stage impacts.
(vi) Leverage points for transformative change: Restoration should engage with deep leverage points for social-ecological system change, which includes challenging rules and societal goals where these are unsustainable.

The idea of living labs is to bring together scientists, practitioners, and other people (including laypersons or even schoolchildren) to work jointly on a real-world problem and learn from each other [98,99]. Living labs thus apply a transdisciplinary approach to improve both science and practice [99]. In a living lab, the role of scientists is not simply to provide the best available evidence to policymakers and practitioners. Rather, scientists work closely with other actors to find solutions to a jointly identified problem, conducting scientific investigations alongside the actions that are being carried out. Living labs are beginning to be used in a restoration context, including, for example, in New Zealand [100] and Canada (https://livinglabproject.ca).

With calls to reconnect to the biosphere [41], social-ecological links recognized in the Sustainable Development Goals (https://sustainabledevelopment.un.org/) and by IPBES and, most recently, the UN Decade on Ecosystem Restoration [3], there are many exciting opportunities to deepen the links between restoration ecology and social-ecological system thinking. Major change is in the air, and the steps outlined here may be only the beginning. In 2013, Raymond *et al.* [101] reviewed multiple conceptions of the links between humans and the natural environment. They highlighted that social-ecological systems thinking was one of the most integrative ways of thinking about the interconnectedness of social and ecological phenomena. However, Raymond *et al.* also highlighted that many indigenous peoples have even more integrative worldviews, seeing everything that is, as part of an interconnected spiritual realm. While this may seem outlandish to many scientists trained in Western cultures, we note that it is precisely these types of arguments that have deeply influenced the globally adopted IPBES conceptual framework [60].

In a restoration context, one might note these trends with curiosity. Modern restoration ecology has parts of its origins in Aldo Leopold's philosophical and moral legacy in the American Midwest. Leopold's famous land ethic [102] is known to and appreciated by many restoration ecologists, and it, too, called for cherishing of the many interconnections around us. Whether through social-ecological framing, indigenous worldviews, or Leopold's land ethic, we argue that it is time to find ways to reintegrate human lives into the rest of the environment. Social-ecological restoration can play a vital role in realizing this goal.

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