

## Science & Society

### Valuing marine restoration beyond the 'too small and too expensive'

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**Restoration is criticized as ineffectively small scale, a smoke screen against global-scale action. Yet, large-scale solutions arise from small-scale successes, which inject social values and optimism needed for global investment. Human values are central to achieving socio-ecological sustainability; understanding human behavior is now arguably more important than understanding the ecological processes.**

#### Human security in an uncertain future

The world is waking up to the reality that global-scale problems can crash economies and strain national security. The impacts of catastrophic events fueled by climate change (e.g., bushfires) and environmental mismanagement (e.g., epidemics) are challenging concepts of human security, such as access to food, income, and social and political security. To provide human security in the face of an uncertain future, society's sustainable well-being relies on the sustainable management of ecosystems [1]. Whilst this requires a coordinated approach from local to global scales, local actions can reduce the effects of global stressors not under our governance [2]. Ecosystem restoration represents a particularly engaging local solution. Among the tools for managing ecosystems, restoration holds genuine promise that can inspire

society's engagement [3,4]. Restoration demonstrably boosts the natural life support systems that underpin the human-centered benefits of food production, economic livelihoods, and mental well-being [1,4,5], helping attain our social goals of sustainability and economic development.

Inspiration for restoration has built on optimism that humans can reverse past management failures and turn ecological losses into gains that provide hope for a sustainable future [4,6]. Ecological restoration can secure local access to the ecosystem goods and services on which economies depend whilst fostering collaboration, community bonding, and human well-being [4,5]. However, restoration is often undervalued by society and science. It is criticized for being too small and expensive to be effective, operating at scales mismatched to the scale of damage [7]. Critics fear such cosmetic conservation provides false hope and is subject to political manipulation that distracts from the real challenge of avoiding catastrophic environmental change. This criticism has merit for many current practices of restoration (Box 1), but small-scale restoration can boost local ecologies and provide stepping stones to broader recovery [4,8]. It is these small-scale successes that provide the necessary models, confidence, political will, and mechanistic understanding to scale up to meet global problems (Figure 1), but a step change is now required.

We now need to learn from bold attempts to restore at larger scales, embrace new technologies that facilitate success, and assess whether economies of scale will follow. Critically, it will be human values that drive a sustainable socio-ecological future [5,9], and understanding human behavior and the socioeconomics of restoration is now arguably as important to restoration as understanding the ecological processes that enable it. People enable restoration; restoration projects are a reflection of common social values

and beliefs, where value-laden goals inform restoration goals [9]. Whilst environmentalists are motivated by ecological goals [10], the critical support from the public, government, and industry for restoration is motivated by human-centered goals. Consequently, human values are central for restoration. Enabling public interest and participation injects the cultural meaning needed to legitimize restoration policies [11], including practitioners that increasingly seek to resolve social license issues before restoration activities [12]. This realization has prompted calls to redefine the science of restoration ecology to capture why we restore habitats, which is to improve social well-being [9].

#### The promise of marine restoration

Marine restoration is relatively new to Western science but has demonstrated the capacity to revive lost habitats, prompting optimism for repairing the seas over the coming decades [3]. This focus for resuscitating marine ecosystems is gaining appeal as it becomes clear that conservation initiatives to date have failed to reverse ecological decline. Whether to restore or conserve, such decision-making represents a key challenge for sustaining humanity given our disproportionately large reliance on marine ecosystems for food and regulation of nutrients and climate [13].

Unlike the lengthy timescales required for a forest to grow on land, which can take many decades, restoring marine forests can be relatively rapid, taking several years to a decade (e.g., macroalgae, oysters, seagrass). Coastal waters are fertile with propagules actively responding to settlement opportunities and targeted interventions (e.g., providing settlement substratum). Even in biologically barren seascapes, restoration can rapidly revive the foundations of productive ecosystems, augmenting ecological goods and services that extend beyond the restored footprint [4]. Rapid transitions from barren to productive seascapes mean that the

### Box 1. Major challenges for restoration

Global commitments and large-scale successes provide optimism that restoration can realize its potential. However, current action lags behind our ambition [9]. To ensure the major challenges of restoration do not stifle its expansion, we must solve three major issues:

- Scale: practical knowledge for expansion beyond small scales is lacking for some systems (e.g., coral reefs), while timescales over which socio-ecological outcomes are measured remain insufficient.
- Limited social support: a widespread restoration culture is needed to motivate political and industry buy-in.
- Economic inertia: transitioning to a market economy that is a better arbitrator of the value of the environment (i.e., moves from incentives to destroy the environment to one where landowners benefit from prioritizing restoration).

The specific environmental, socioeconomic, technical, and political challenges to restoration manifest differently for different systems. Coral reef restoration, for example, is particularly challenging because the main threat contributing to decline must be managed. For coral reefs, this is global climate change [7]. Restoration has a future role for saving coral reefs [8], but is doomed to failure if global warming is not curbed. Consequently, opponents warn coral reef restoration is no more than a political distraction for climate inaction, pursued for political gain to the environment's demise [7].

socioeconomic benefits of restoration (e.g., more food and tourism) can be realized within politically meaningful time-scales (e.g., political cycles) to have greater traction on decision-making and restoration investment. These socioeconomic benefits require the ecological science to be communicated with their attendant narrative on the societal benefits. However, few restoration studies measure socioeconomic outcomes [10]. There lies the opportunity of a socio-ecological vision for restoration; public support can be not just an outcome of restoration but a driver that legitimizes investment to restore at larger scales [11].

Ecosystem restoration is really about improving socio-ecological relationships, including societal relationships with the environment and relationships among groups that share marine resources. Although typically viewed through the prism of environmental health [10], the broader motivation and benefits of restoration are industry and community outcomes [5,9]. Marine restoration is a toolkit to repair and sustain the coastal productivity needed to sustain diverse livelihoods and regional economies. Communicated in this way, successful public engagement and enthusiasm can empower governments with the social legitimacy to expand restoration effort (i.e., social license [11,12]) and may also seed society's transition to a culture

that values socio-ecological well-being, material and cultural [1].

### Too small, too expensive

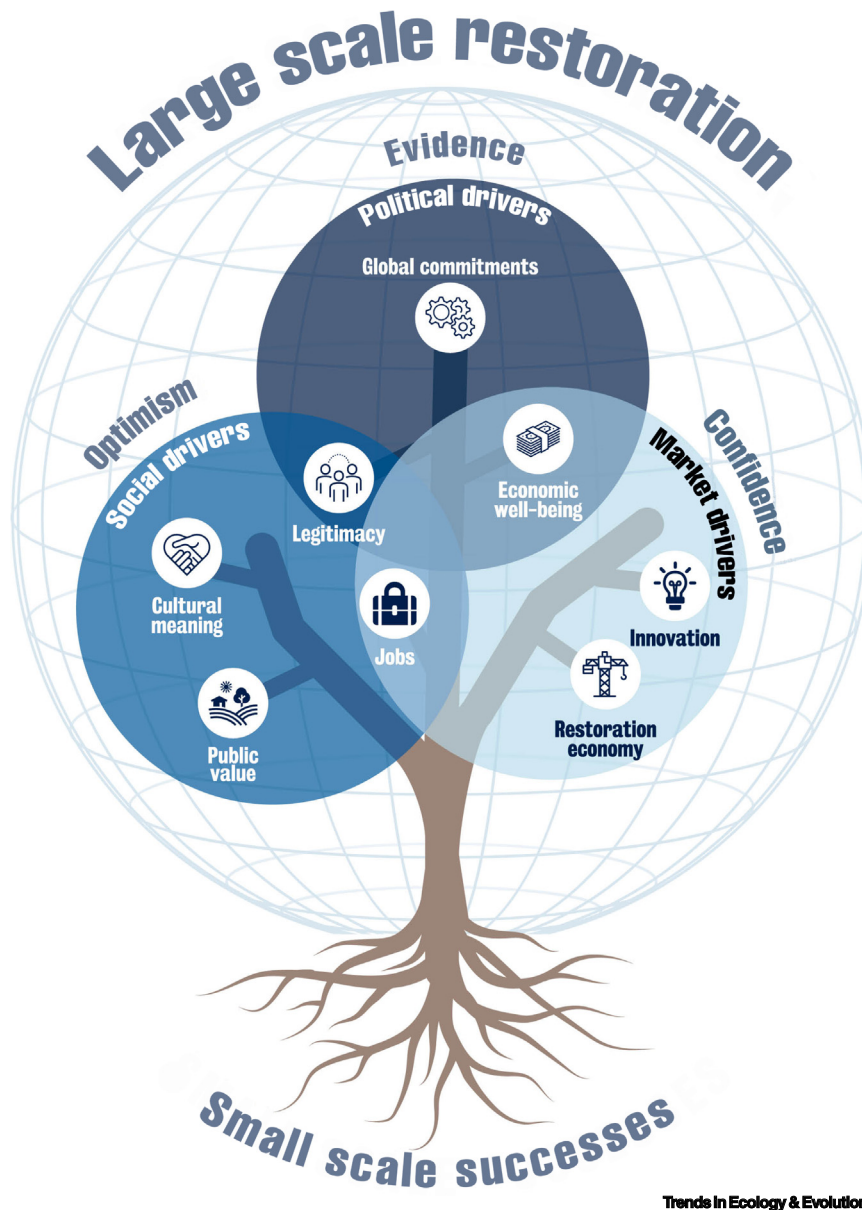
Size matters when building socio-ecological adaptability. To protect communities from a destructive storm surge, for example, the buffering influence of habitats across entire coastlines may need repair. Striking examples show we are restoring at these scales. The restoration of 1500 km<sup>2</sup> of Mekong Delta mangrove forest [3] occurred within decades of its ecological destruction (during the Vietnam War), and the 1950 km<sup>2</sup> restoration of mangroves along Bangladesh's coast has benefited millions of lives and sequestered substantial carbon [4]. On land, our appetite to restore at globally meaningful scales is demonstrated in Africa's 8000-km Great Green Wall, China's Grain-for-Green Program, and the rejuvenation of China's Loess Plateau from eroding deserts to lush green valleys and international commitments to The Bonn Challenge (restoring 350 million ha of forest by 2030). When prepared with the necessary ecological knowledge and technology, the restoration community has the practical know-how to make large-scale restoration successful [4,9] (Box 1).

Large-scale initiatives inevitably begin at small scales. It is lessons learnt here that inform approaches to scaling up.

Understanding how we can build enduring foundations, encourage natural expansion from small-scale interventions, and use technology to catalyze expansion from these footprints will inform where, how, and at what scale restoration is possible [8]. Restored footprints support broader ecological adaptation through seed dispersal for unaided recovery (e.g., 125 ha of eelgrass planting naturally expanded to 1714 ha [3]). And emerging technologies will accelerate this learning process (e.g., unaided drone mapping, selected resilience, and technologies for enhanced seed and larvae recruitment). In time, growth from these footprints [8] may spark a renewal and reimagining of society devoted to a more sustainable socio-ecological future [1].

Achieving social benefits from marine restoration is less contingent on scale. Before any ecological outcomes are realized, significant social (e.g., personal relationships and trust), well-being (e.g., hope, pride, and mental health), and educational benefits (e.g., environmental connectivity and stewardship) can accrue from even small-scale restorations [5]. Communities empowered with optimism and agency for creating positive change tend to experience strengthened social linkages and community well-being [6]. The catalytic role of community support and ambition for restoration is not yet fully realized. Analyzing the changing perspectives and support from the beneficiaries of restoration will help identify the industries, philanthropists, and community groups that can contribute funding to expand beyond the small scale.

While opponents denigrate restoration as 'bad for business' [14], the restoration economy is, in fact, booming. Restoration directly contributes billions to national economies (\$9.5 billion to the United States in 2014) and billions more through indirect socio-economic linkages [14]. For every \$1 million invested, restoration supports over six



**Figure 1.** Success in restoring ecosystems at small scales seeds optimism, confidence, and evidence that we can reverse ecological losses at larger scales. These small foundations of recovery can synergize the sectors needed to up-scale restoration: broad public support to legitimize political investment, a strong restoration economy that supports societal well-being, and bold political commitments to tackle global challenges, including the commitment to take on the challenge of restoring at large scales.

times the jobs of the oil and gas industry. It is also economically transformational, creating jobs across the sectors that construct, plan, administer, and produce materials for restoration [14]. The economic returns of restoration (ten to one invested [3]) should incentivize ongoing investment

as should the future value of ecological services from restored land [1]. But current restoration practices are insufficient to meet global ambitions [9], risking unfulfilled expectations. Close collaboration between government, researchers, industry, community, and indigenous groups is key to

providing the knowledge and confidence for large-scale restoration. The cross-sector restoration economy provides the collaborative stage on which to innovate new technologies to assist scaling up. Only with capacity-building collaboration and technological innovation will we advance restoration practice to achieve the economies of scale that can galvanize large-scale success.

### The importance of socio-ecological connectivity

Restoration is an inherently collaborative process that bridges science, policy, industry, and public sectors. It will take the diverse skills, knowledge, and resources of all these sectors working together for restoration to meet our ambitions [5]. To achieve this, early public participation is needed to inject social values into planning, which serves to strengthen social and industry linkages that bolster the operational capacity (Figure 1) [9]. Broad engagement requires recognizing the psychology of ideological motivations in which environmental solutions can unnecessarily divide communities if the content of messaging is not culturally compatible to their target audiences [6,15].

We argue that because humans enable restoration, the current preoccupation with ecological processes fails to address the more important information gaps in understanding human motivations for restoration. We advocate that restoration research needs a stronger focus on identifying, measuring, and reporting metrics of social well-being and economic benefits as these human-centered values engage people. This human-centered research will not only identify the diverse motivations across society but also reconcile conflicting viewpoints to achieve broad community alignment on shared goals for the future that people want.

A major challenge for society is to maintain, enhance, and balance the beneficial

contributions of ecosystems to the sustainable well-being of humans and the rest of nature. While small-scale responses will not ameliorate global change, they build the evidence base for larger responses; small-scale restoration successes provide knowledge and optimism to embrace larger scales. As local projects expand, the hope is that they will aggregate to form broader networks of action across jurisdictions. Such connections will assist natural regeneration over larger areas. The potential still exists to repair our coastal seas, and small-scale models are needed to guide, motivate, and test our large-scale ambitions. The time is now to pioneer and plan for these large leaps forward that go beyond the incremental small-scale approaches of the past. By bringing people along on this journey as contributors and beneficiaries, we will also change the way society values the rest of nature.

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### Author contributions

D.M., R.C., and S.D.C. contributed to the conceptualization and writing of the paper.

### Declaration of interests

The authors declare no competing interests.

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