TITLE: Rocketing restoration: Enabling the upscaling of ecological restoration in the Anthropocene

RUNNING HEAD: Upscaling ecological restoration in the Anthropocene

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ABSTRACT

In the 25 years during which the *Society for Ecological Restoration* (SER) has overseen the publication of *Restoration Ecology*, the field has witnessed conceptual and practical advances. These have become necessary due to the scale of environmental change wrought by the increasing global human population, and associated demands for food, fibre, energy and water. As we look to the future, and attempt to fulfil global restoration commitments and meet sustainable development goals, there is a need to reverse land degradation and biodiversity loss through upscaling ecological restoration. Here, we argue that this upscaling requires an expanded vision for restoration that explicitly accounts for people and nature. This expansion can assess success in a future-focussed way and as improvements relative to a degraded socio-

ecological system. We suggest that upscaling requires addressing governance, legal and ethical challenges, investing in technological and educational capacity building, bolstering the practical science necessary for restoration, encouraging adoptable packages to ensure livelihoods of local stakeholders, and promoting investment opportunities for local actors and industry. Providing SER embraces this socio-ecological vision, it is ideally placed to aid the achievement of goals and remain globally relevant. SER needs to harness and co-ordinate three sources of potential energy (global political commitments, the green economy and local community engagement) to rocket restoration in to the Anthropocene. With principles that can embrace flexibility and context-dependency in minimum restoration standards, SER has the potential to guide socio-ecological restoration and help realise the ultimate goal of a sustainable Earth.

KEYWORDS

Capacity building, Coupled human and natural systems, Governance, Landscape-scale rehabilitation, Socio-ecological restoration, Sustainable development goals

IMPLICATIONS

- A planet under multiple environmental pressures requires upscaling of restoration to meet sustainable development goals. This requires an expanded vision of ecological restoration that simultaneously values benefits to people and nature, and that restores desired socio-ecological systems
- Restoration success needs to be measured relative to degraded socio-ecological systems and requires a future focus that allows for sometimes rapid socio-economic and environmental change but that remains grounded in principles
- The *Society for Ecological Restoration* can enable this expansion and upscaling through a number of avenues: addressing governance challenges, investing in capacity building, promoting policy that supports the practical science necessary for restoration, and raising awareness of livelihood and investment opportunities from local to global scales

INTRODUCTION

In the 25 years since *Restoration Ecology* was first published, the field of restoration ecology has grown and developed conceptually (Perring et al. 2015). From rare forays in the pages of *Restoration Ecology*'s early volumes (e.g. Naveh 1994), to the more recent acknowledgement of ecological restoration's growing ambitions (Suding 2011; Suding et al. 2015), complexity (Miller et al. 2017), and knowledge gaps (e.g. Merritt & Dixon 2011; Breed et al. 2018), the discipline is now positioned to attempt considerable upscaling. Restoration at scale is necessary because of extremely high rates and increasing extent of environmental degradation, the loss of unique elements of biodiversity, the inability of conservation reserves alone to halt this loss (Mora & Sale 2011; Brancalion et al. 2013) and because environmental degradation negatively affects people's quality of life (Millennium Ecosystem Assessment 2005). The promise of traditional restoration is to mitigate and reverse such environmental degradation, and put ecosystems on sustainable trajectories of ecological change that ultimately reinstates system resilience to future changes and capacities for ongoing evolutionary development (SERI 2004; McDonald et al. 2016).

Most recently, the ambition to scale up restoration has been translated into global policy initiatives such as the Bonn Challenge and New York Declaration on Forests, which pledged to restore 350 million hectares of forest landscape by 2030 (Chazdon et al. 2017; Holl 2017; Verdone & Seidl 2017). In conjunction with the older Convention on Biological Diversity's Aichi Target 15 to restore 15% of degraded lands (Jørgensen 2015), governments across the globe have pledged, and are still pledging, to commit to ecological restoration (Suding et al. 2015). Although such pledges are ratified at the national level, cumulative local, regional, and potentially cross-border, actions will be needed to achieve these targets (Menz et al. 2013; Meli et al. 2017). Crucially, actions to improve the ecological condition of systems do not take place in a vacuum; in different parts of the globe they are perceived to be more or less strongly interconnected with livelihoods, social empowerment, food security and poverty alleviation (Guariguata & Brancalion 2014).

Currently, restoration pledges far outweigh areas actually under restoration management (e.g. Latawiec et al. 2015; Toledo et al. 2018): in other words, action lags behind aspiration. Further, within the ultimate goals of restoration, and the actions undertaken by local and regional stakeholders, there is much scope for competing and contrasting visions of what constitutes restoration management (Stanturf et al. 2014). Such contrasts have most recently been highlighted by discussions on standards and principles for restoration (McDonald et al. 2016; Gann et al. 2018; Higgs et al. 2018b; Higgs et al. 2018a), notwithstanding efforts to indicate what commitment to ecological restoration is best represented by (Suding et al. 2015; Brancalion & Chazdon 2017). Despite these debates, it appears that restoration could be on the cusp of a revolution as efforts to achieve global targets efficiently and effectively gather pace. At the same time, however, there may be conceptual and practical impediments to progress (Ghazoul & Chazdon 2017). For instance, the financial benefits landowners obtain from restoration are not yet enough to offset restoration implementation and land opportunity costs (Brancalion et al. 2012). Further, competition for land is high, and getting more intense, given attempts to feed and provide energy for a global population rapidly approaching nine billion (Godfray et al. 2010; Rulli et al. 2013). Social conflicts worldwide constrain the adoption of sustainable management practices, and the global economy still rewards degradation of ecosystems, without providing enough incentives to revert the trend of natural capital loss (Fairhead et al. 2012).

Here, aligning our thinking with Martin (2017b), we provide an expanded vision for restoration, and outline a framework for what is needed for restoration to truly take off at the scales demanded by global commitments, environmental degradation and socio-ecological imperatives. A continued focus on what constitutes restoration could mean we lose sight of a common goal, and scientific viewpoint, to repair vast areas of damaged land globally using an array of techniques, approaches and desired species assemblages to achieve ecosystem sustainability. Nevertheless, we do not believe “business-as-usual” local-scale restoration actions will achieve the necessary changes in the biosphere, at a fast enough pace, to sustain human, or ecological, well-being in a time of rapid environmental change. We thus provide a revised definition of ecological restoration to clarify our expanded vision. We briefly suggest concrete actions to overcome potential impediments to progress, illustrated by examples, which will enable large-scale restoration to achieve ecological *and* societal goals. We suggest that the *Society for Ecological Restoration* (SER) is in an ideal position to promote and enable this achievement.

AN EXPANDED VISION OF ECOLOGICAL RESTORATION TO ENABLE UPSCALING

"Business-as-usual" ecological restoration, as defined by the SER Primer (SERI 2004) and further interpreted in the recent Standards (McDonald et al. 2016), tends to focus on the recovery of ecological ecosystems and lacks an explicit human component, akin to "Nature despite humans" or "Nature for itself" (Mace 2014). We perceive that such a continued focus ignores the socio-ecological realities of a globe rapidly approaching nine billion people, who demand ever-increasing amounts of food, fibre, shelter and goods in changing socio-economic, technological, political and environmental circumstances. Although capacity exists to reduce the human ecological footprint (e.g. via reducing food waste and demand for goods, curbing emissions), figures do not suggest this is happening at the global scale (e.g. Ripple et al. 2017). Clearly, ecological restoration is going to need to continue to happen, and degradation will have to be reversed, to safeguard a good quality of life (Cooke et al. 2018; Díaz et al. 2018). What though, could (or should) be the vision for this ecological restoration in the Anthropocene?

The changing circumstances that ecological restoration finds itself in suggests that for it to be globally relevant (and by implication the *Society for Ecological Restoration*), an expanded vision for restoration is required. We contend this vision needs to focus on the recovery of beneficial social-ecological systems (also known as coupled human and natural systems (Yin & Zhao 2012)), thus being reflective of a "People and Nature" framing (Mace 2014). We believe, as recently outlined by Martin (2017b), this vision needs to focus on *why* restoration is done (i.e. the appeal), and not just *what* it does (i.e. the promise). In so doing, we can potentially achieve a more robust goal-setting structure (Martin 2017b) that can take account of rapidly changing environments. We suggest, as has Martin (2017b), that such a vision necessitates reframing the SER Primer and Standards definition of ecological restoration, and in that spirit, we offer a suggestion here:

"Ecological restoration is the process of assisting the recovery of damaged, degraded or destroyed socio-ecological systems in changing environments, for the benefit of people and nature across scales".

Such a definition will help enable the upscaling of restoration to achieve current global political commitments, and thus aid the realisation of a vision (hopefully shared by many) of a sustainable, equitable and just Earth (Martin (2017a) has an interesting presentation on the need for justice, and not only equitability, for effective conservation). The revised definition has parallels with original and amended conceptions of forest (and) landscape restoration (Sabogal et al. 2015; Mansourian 2017) (see also https://infoflr.org/what-flr), and acknowledges the changing environmental circumstances under which ecological restoration is currently practised, as well as the need to consider local, regional and global outcomes over space and time ('benefit … across scales'). Crucially, the definition enables a broadening of what constitutes restoration success. Typically, success has been measured in terms of how far an ecosystem undergoing restoration is from its reference condition, using ecological metrics that are not necessarily linked to human well-being (Ruiz-Jaen & Aide 2005; Wortley et al. 2013). The application of an expanded vision of restoration broadens this perspective. Restoration success can be based, instead, on the improvement in socio-ecological conditions in relation to some initial degradation state, or a reference condition when available. Success must be related to metrics that clearly address nature's contribution to people, whether that be materially or intrinsically. This necessitates the addition of a socio-ecological reference, which relies on combining biophysical conditions with people's interests and needs (Yin & Zhao 2012).

ROCKETING RESTORATION: THE ROLE OF SER IN ENCOURAGING UPSCALING

Accepting an expanded vision of ecological restoration would explicitly acknowledge the human agency involved in the process. This human agency is currently providing potential energy for restoration from three inter-related sources: global political commitments, the green economy (BenDor et al. 2015), and the increasing engagement of local communities and concerned citizens. Ecological restoration, through the auspices of SER, could change this potential energy to further action on the ground. We argue that with appropriate synergies, harnessing these energy boosters provides the fuel for the rocket of ecological restoration to take off, travel towards a target of a recovered Earth, and thus close the gap between pledged and realised restoration and its expected benefits (Figure 1). Without synergy and collaboration, the rocket may not reach the desired destination – for instance, the impetus provided by political commitments will fizzle out if not matched by participation from, and engagement with, local communities e.g. by highlighting projects that demonstrate the benefits of restorative interventions.

SER is ideally placed to oversee integration of multiple disciplines to allow the rocket to take off on the desired trajectory. First, it has the opportunity to formalize, through dialogue and participation, principles to guide restoration efforts across scales that take account of local, regional and global needs and the landscape context. Without such agreed principles, there is a risk of projects being classified as ecological restoration when they do not provide benefits to people and nature. It may be tempting for SER to act as a judge of what constitutes ecological restoration or not, and this is promoted by providing a definition however composed. We believe an expanded vision allows the society to be open to novel restoration perspectives and work collaboratively with different stakeholder groups, with different expectations regarding the means and goals of restoration. Despite this, we believe, as others have intimated, that principles that embrace flexibility still need to be accompanied by minimum standards that can be related to the landscape socio-ecological context (e.g. Suding et al. 2015). Such a framing allows the differentiation of restorative actions from other landscape interventions in a suitably nuanced manner: successful ecological restoration need not have the same absolute bar everywhere. However, without guidance (preferably provided by SER), undesired trajectories may occur (Brancalion & Chazdon 2017). Hubris and a lack of guidance may lead the rocket to follow Icarus' path, falling to an untimely end (Figure 1) to the detriment of the global environment.

Second, as *the* international body for ecological restoration, SER can integrate practitioners, scientists, and policy makers. As such, it can help provide the operational framework to enable achievement of global political commitments, making sure to involve stakeholders across scales. In our view, this operational framework requires (see also Table 1):

i) Addressing legal and ethical challenges of <u>governance</u> and ownership in different contexts (Guariguata & Brancalion 2014; Mansourian 2017);

ii) Investing in <u>capacity building</u>, through both technology and sustained education opportunities / networks (e.g. Aguilar et al. 2015). This capacity building entails the capacity to achieve the areas demanded by global targets, and the ability to monitor and verify the socio-ecological values of the areas being restored;

iii) Bolstering the practical science necessary to guide restoration (Miller et al. 2017) including through deliberately embedding scientific research experiments into global restoration programs (Gellie et al. 2018);

iv) Considering ways to make enough land available for restoration without compromising livelihoods i.e. developing adoptable packages for farmers and landowners that do not constitute 'green land grabbing' (Latawiec et al. 2015);

v) Highlighting suitable investment opportunities for local actors and industry players (e.g. Brancalion et al. 2012; Faruqi et al. 2018).

Finally, SER, in conjunction with other learned societies, can promote arguments for the necessity of ecological restoration to achieve sustainable development goals. They can continue to be a valuable voice for lobbying governments and other decision makers. With an expanded vision of ecological restoration, this voice may be able to reach powerful actors (e.g. multinational corporations, certain government departments) that currently tend not to be approached, and thus help engender change at the necessary scale.

FINAL REMARKS

Rapid environmental changes and ongoing widespread degradation necessitate socio-ecological restoration at scale. Achieving this at the rates demanded by global commitments will not be straightforward, but is it rocket science? Fundamentally, it requires a change in mind-set, from older views and the locked-in inertia of 'we have always done it this way' in particular locations, to a more structured approach. This structured approach can utilize the many tools and learnings from 25 years of active research and practice in ecological restoration across the globe, as well as reaching out across different perspectives from varied cultures, continents and disciplines (see also Table 1). Providing an expanded vision for ecological restoration may help towards altering mind-sets, change perceptions of a culture of constraint (e.g. green tape) to a culture of opportunity, and allow successful upscaling of restoration endeavours in space and time.

Historically, even supposedly rapid land cover changes took time – for instance, 50 years was needed for the planting of seven million hectares of *Eucalyptus* species in Brazil (Gonçalves et al. 2013) yet national restoration targets necessitate 12 million hectares of restoration in a fifth of that time. Achieving the New York Declaration requires 17.5 million hectares of ecological restoration at the global scale, every year for twenty years, and even that would be a delay in success, given the Declaration's current timeframe. Future work thus needs to concentrate on how SER and other invested parties can operationalize an expanded vision of ecological restoration at scale, and meet the rapidity of restoration demanded by global political commitments. Examples of rapid restoration at scale do exist e.g. China's Grain for Green (Sloping Land Conversion) program (Bennett 2008; Cao et al. 2009), although its socio-ecological credentials can be questioned (Martin 2017a). We suggest that rapid upscaling requires, *inter alia* and see Table 1 for further examples, concerted investment in seed sourcing technologies that do not harm extant native populations while ensuring genetic diversity of ecological restoration (Tischew et al. 2011); developing means to efficiently prioritize restoration sites at scale, including from natural regeneration, while not compromising local participation and involvement; the enhancement of nursery production methods and technological seed planting/reintroduction skills to upscale survival outcomes (e.g. Erickson et al. 2017; Muñoz-Rojas et al. 2018a); investment in certification and monitoring techniques to assess the socio-economic and ecological trajectories engendered by restoration; and, raising awareness of investment opportunities to aid upscaling.

Our aim here was to encourage readers, particularly those engaged in restoration science and practice, to reflect on the ecological restoration paradigm as *Restoration Ecology* celebrates a significant milestone. Is the current restoration paradigm, as reflected by the definition in the SER Primer and Standards, sufficient to meet global restoration commitments? We would contend 'no'. Five years ago, we were exhorted to 'roll up our sleeves' (Aronson & Alexander 2013); it is now time, metaphorically at least, to reach for the stars. Up until a few decades ago, humanity could only imagine setting foot on the Moon and now we actively plan for reaching Mars. Arguably, a more pressing rocket mission is to provide and maintain a sustainable Earth. A co-ordinated global restoration effort that encourages local participation, embraces a plurality of views, and where many parties work together to put all the pieces of the rocket together, will allow a global restoration journey to be realised. In our view, this requires an expanded vision of ecological restoration. With such a vision, the *Society for Ecological Restoration*, and its flagship journal *Restoration Ecology*, has the potential to contribute to and guide the mission across scales over the next 25 years and beyond, for the benefit of people and nature.

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413 **TABLES**

414 **Table 1:** Five pillars of an operational framework for upscaling ecological restoration for the benefit of
415 people and nature. Currently, these pillars can provide challenges to upscaling e.g. notions of land
416 ownership, and ownership of organisms on this land, can vary, compromising sustainability of restoration
417 interventions (Mansourian 2017). Where possible, we provide examples from across the globe and in
418 different contexts, of innovative approaches that may help address these challenges, and thereby assist
419 upscaling endeavours. As explained in the main text, SER and its constituent expertise can guide progress in
420 these areas, in collaboration with other organisations.

Pillar	Examples of upscaling attempts / ideas to enable upscaling	References
Governance and land ownership	Documents interpreting legal text to clarify governance and land ownership arrangements	-
	Developing "Whole-of-Paddock" programs governed by non-profit organisations working on private agricultural land	(Ansell et al. 2016)
Capacity building (Technological)	Methods to prioritize restoration sites in a socio-ecological/multi-objective decision-making manner.	(Bourne et al. 2016) (Hermoso et al. 2015)
	Geographic Information Systems and remote sensing methods to ascertain what type of land is available for restoration and where	(Cordell et al. 2017)
	Enhancing "in-the-ground" outcomes – e.g. operationalising seedbank concepts in restoration (Merritt & Dixon 2011), trialling innovative methods such as seed coating / priming technologies and biological soil crust inoculation	(Erickson et al. 2017) (Gibson-Roy & McDonald 2014) (Muñoz-Rojas et al. 2018b) (Muñoz-Rojas et al. 2018a)
	Machine automation, modification and invention e.g. drones to deliver seeds, seed treatment technologies	(Elliott 2016) (Guzzomi et al. 2016) (Brancalion & van Melis 2017)
	Monitoring and verification e.g.	

Capacity Building (Educational)	alternative use of technology, use of biotic and abiotic indicators extending to socio-economic indicators Regional networking initiatives Training initiatives e.g. Environmental Leadership and Training Initiative, Yale	(Tangney et al. 2018) (Dudley et al. 2018) (Aguilar et al. 2015)
Practical science	Structured applied scientific framework focusing on repeatable outcomes Co-ordinated research approaches and collaborative knowledge exchange between disciplines, including with industry	(Miller et al. 2017) (Breed et al. 2018) (Gellie et al. 2018) (Stevens & Dixon 2017)
Adoptable packages e.g. to sustain livelihoods	Multi-purpose landscapes that benefit humans and nature	(Hobbs et al. 2014) (Ansell et al. 2016) (Keesstra et al. 2018)
Investment opportunities	Payments for Ecosystem Services schemes (but note need for these to be just Martin 2017a) Biodiversity offsets, but note large potential for these to fail in achieving no net loss (Maron et al. 2015) Government funded job creation to aid restorative actions	(Calvet-Mir et al. 2015) (Bull et al. 2013) (van Wilgen & Wannenburgh 2016)

FIGURE LEGENDS

Figure 1: "Business-as-usual" restoration will likely fail to deliver a target of a sustainable Earth for humans and nature. The *Society for Ecological Restoration*, by harnessing the potential energy provided by at least three boosters, can guide a principled trajectory to this target by first providing an expanded vision of restoration that benefits people and nature. A lack of principles, or their misguided use, will likely realise an undesired trajectory. SER can provide an overarching operating system that promotes good governance, capacity building, and encourages innovation. Challenges such as financial viability of restoration interventions and a restricted vision of what constitutes restoration will need to be negotiated to close the gap between pledged and realised restoration in a timely fashion.

FIGURES

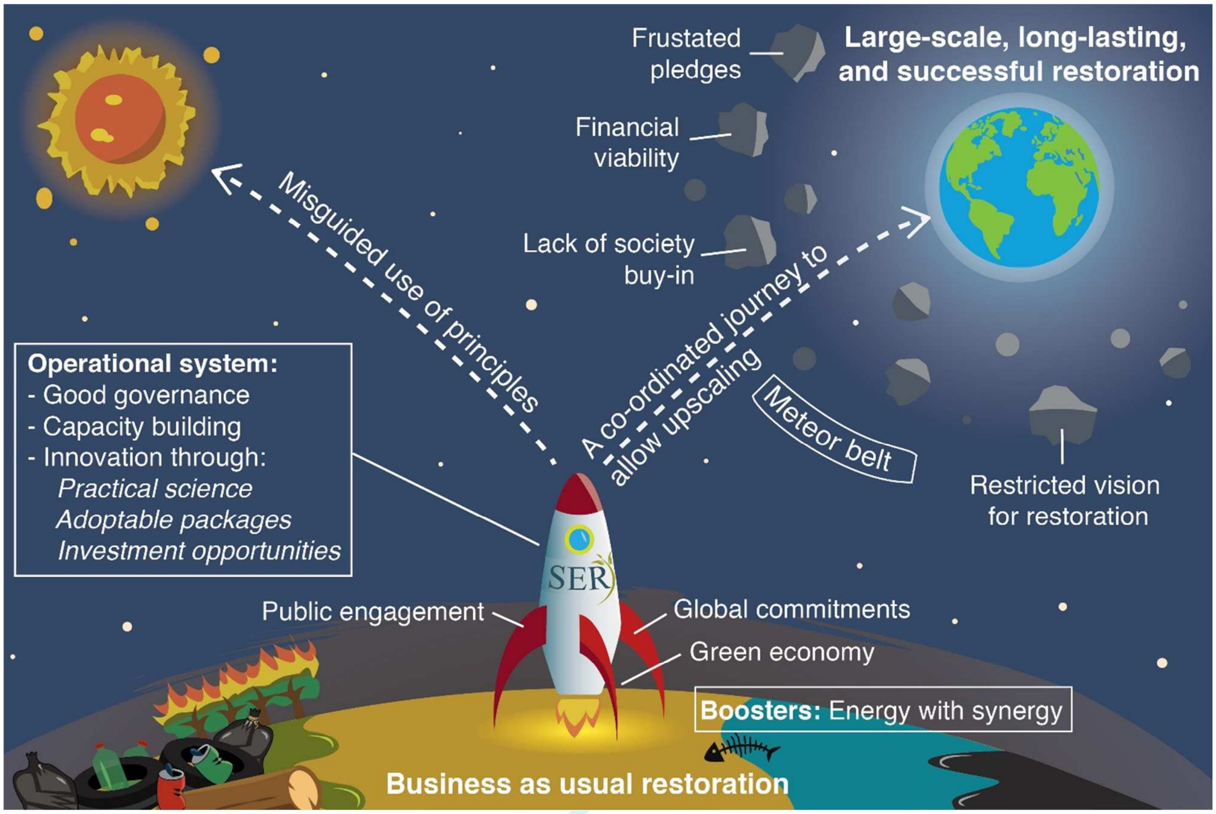
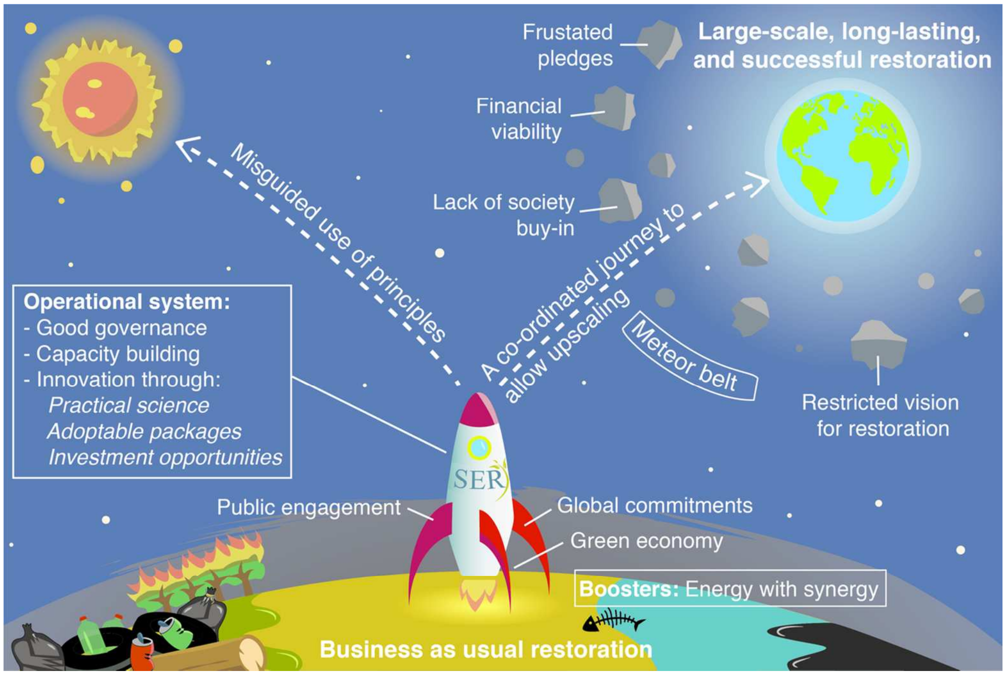


Figure 1



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