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Do We Practice What We Preach? Goal Setting for Ecological Restoration

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Abstract

Over the last decade, several research and opinion pieces have challenged the tenets of restoration ecology but a lack of centralized data has impeded assessment of how scientific developments relate to on-the-ground restoration. In response, the Society for Ecological Restoration (SER) launched the Global Restoration Network (GRN) to catalog worldwide restoration efforts. We reviewed over 200 GRN projects to identify the goals governing restoration and the frequency with which they are measured. We used the SER Primer on Ecological Restoration to frame our analysis, categorizing goals by SER's attributes of restored ecosystems. We developed additional attributes to characterize goals not encompassed by the SER-defined attributes. Nearly all projects included goals related to ecosystem form, namely similarity to reference conditions and the presence of indigenous species, and these goals were frequently measured. Most projects included goals related to ecosystem function, and many highlighted interactions between abiotic and biotic factors by either modifying abiotic conditions to support focal species or manipulating species to achieve desired ecosystem functions. Few projects had goals related to ecosystem stability, whereas the majority of projects had goals related to social values. Although less frequently measured, social goals were described as important for long-term project success. In conclusion, science and practice frequently aligned on goals related to ecosystem composition and function, but scientific guidelines on resilience and self-sustainability appear insufficient to guide practice. In contrast, the common inclusion of goals for human well-being indicates that, if intended to advise practice, restoration guidelines should give direction on social goals.

Key words: **ecosystem function, Global Restoration Network, historical reference, human well-being, measurement, resilience, social–ecological systems, Society for Ecological Restoration Primer.**

Introduction

In 1935, Arthur Tansley introduced the term "ecosystem" in a paper entitled "The use and abuse of vegetational concepts and terms" (Tansley 1935). With that beginning, the ecosystem concept was destined to be controversial. Seventy years later, when leaders from the Society for Ecological Restoration (SER) sat down to describe how to *restore* ecosystems, active debate was inevitable. The product of that meeting, the SER Primer on Ecological Restoration, defines its subject as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004). To clarify the term "ecosystem recovery," the SER Primer includes nine attributes of restored ecosystems that relate to ecosystem form, function, and stability (SER 2004; Table 1). Considering the legacy they inherited, the authors described the goals and intent of ecological restoration admirably well—over the past 8 years, at least 40 NGOs, academic institutions, and government agencies have adopted the SER Primer's definition of ecological restoration (www.ser.org).

Since 2004, further debate and research in restoration ecology have challenged certain principles of ecological restoration (reviewed in Shackelford et al. 2013). Greater appreciation of environmental change has given rise to the perspective that the restoration of historical conditions is often unrealistic (Suding et al. 2004; Choi 2007; Choi et al. 2008; Hobbs & Cramer 2008; Hobbs et al. 2011). Increased interest in ecosystem services has also led some to argue that species should be valued for their roles in ecosystems over their origins (Davis et al. 2011). Research on linked social–ecological systems has convinced many that the explicit inclusion of social goals is critical to the success and value of ecological restoration (Davis & Slobodkin 2004; Higgs 2005; Burke & Mitchell 2007; Temperton 2007). Some of these new directives may become fundamental to ecological restoration, whereas others may be lost or rejected in the transition from theory to practice. Comparing the goals set across restoration projects should be

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Table 1. Attributes of a restored ecosystem as defined in the Society for Ecological Restoration Primer on Ecological Restoration (2004), their identifying tags used in Figure 2, and categories we used to group them.

Tag	*Abbreviated Attribute*	*Full Attribute*	*Category*
1Ref	Similarity to reference conditions	The restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure	Form
2Spp	Presence of indigenous species	The restored ecosystem consists of indigenous species to the greatest practicable extent. In restored cultural ecosystems, allowances can be made for exotic domesticated species and for non-invasive ruderal and segetal species that presumably co-evolved with them. Ruderals are plants that colonize disturbed sites, whereas segetals typically grow intermixed with crop species	Form
3FGr	Presence of functional groups for development and stability	All functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means	Function
4Phy	Capacity of the physical environment to sustain populations	The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory	Function
5Fun	Normal functioning	The restored ecosystem apparently functions normally for its ecological stage of development, and signs of dysfunction are absent	Function
6Lan	Landscape integration	The restored ecosystem is suitably integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges	Function
7Thr	Elimination of threats	Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as possible	Stability
8Res	Resilience	The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem	Stability
9Sus	Self-sustainability	The restored ecosystem is self-sustaining to the same degree as its reference ecosystem and has the potential to persist indefinitely under existing environmental conditions. Nevertheless, aspects of its biodiversity, structure, and functioning may change as part of normal ecosystem development and may fluctuate in response to normal periodic stress and occasional disturbance events of greater consequence. As in any intact ecosystem, the species composition and other attributes of a restored ecosystem may evolve as environmental conditions change	Stability

a powerful way to distinguish which scientific viewpoints do, in practice, define "ecological restoration."

An early and lasting tenet of ecological restoration is that goals should be explicitly stated and measurable (Hobbs & Norton 1996; Clewell & Aronson 2007). Previous attempts to assess commonalities among restoration goals, however, have been impeded by inadequate communication between restoration ecologists and practitioners (Cabin et al. 2010) and a lack of available data (Suding 2011, but see Bernhardt & Palmer 2011). In 2007, SER responded to these barriers by launching the Global Restoration Network (GRN), a database of worldwide restoration efforts (LeFevour et al. 2007). With over 200 cataloged projects across the six populated continents, the GRN database is an unprecedented repository of information about restoration. We reviewed projects in the GRN, focusing on goal setting and assessment. We used the SER-defined attributes as a starting point to categorize goals, and used the content of GRN projects to modify or develop additional attribute categories. We asked three questions: (1) Which SER-defined attributes of restored ecosystems are most often reflected in restoration goals? (2) Are there common goals that are not reflected in the SER-defined attributes? (3) Is the success of some goals more frequently measured than others?

Methods

General Approach

SER maintains the GRN database to allow restoration practitioners to catalog their projects (LeFevour et al. 2007). We

Table 2. Additional attributes that fit project goals in the Global Restoration Network database, their identifying tags used in Figure 2, and the category we used to group them.

Tag	Abbreviated Goal	Full Goal	Category
Com	Community engagement	The restoration builds support and connections among the local community (e.g. provides a gathering for local families, creates community groups to protect and manage shared open space areas)	Social
Cult	Cultural values	Cultural values are promoted or revitalized through the restoration (e.g. restores culturally important species, provides recreational opportunities, enhances landscape aesthetics, increases public safety)	Social
Econ	Economic benefits	Economic benefits enhanced through ecosystem restoration (e.g. entices clients to local businesses, enhances ecosystem services, restores resources important for local livelihoods)	Social
Ed	Education	Educational opportunities are incorporated in restoration planning (e.g. creates environmental or cultural education sites, demonstrates best practices)	Social
Gov	Governance	Institution with governance capacity either fund, mandate or maintain the restoration effort (e.g. complies with legal mandates, partners non-profit organizations with federal agencies)	Social

examined all 203 GRN projects listed as of May 2012 to distill a list of goals that guided each effort. Project descriptions in the GRN follow a standardized format, with sections for the executive summary; biome and ecosystem type; prior ecosystem and type of degradation; project description; project goals; project activities; stakeholder involvement; human well-being; recovery to date; long-term management; and project evaluation (LeFevour et al. 2007). We included goals stated in the executive summary and project goals sections as well as goals described throughout the full record.

Classification of Restoration Goals

We categorized each goal by its correspondence to an SER-defined attribute (Table 1). One project goal could involve more than one attribute. For example, a goal to "restore native species characteristic of British heathlands" would be listed under both similarity to reference conditions and the presence of indigenous species. We noted when an SER-defined attribute encompassed a goal but a more specific attribute might be appropriate. For example, restoring indigenous species was considered in different contexts, such as conserving endangered species or removing non-native species. Each attribute was listed at most once per case study.

For goals that did not correspond to any SER-defined attribute, we developed additional attribute categories through literature review and discussions from an interdisciplinary focus group (representing natural resource management policy, environmental planning, geography, and social and ecological sciences; Eitzel et al. 2012). We iteratively modified these attributes by adding ones that emerged from the project descriptions and modifying or removing purported attributes that were rarely reflected in the GRN projects (Table 2). In addition, we grouped SER-defined attributes into three overarching categories: ecosystem form, ecosystem function, and ecosystem stability (Table 1). We used ecosystem form to refer to attributes that described either the structure or composition of the system, and used ecosystem function to denote attributes focused on functional biotic and abiotic interactions and ecosystem effects. While the idea of ecosystem stability has been widely debated in scientific literature (Holling 1973; Connell & Sousa 1983), we used stability to characterize attributes that help in maintaining the form and function of a restored ecosystem in the long term.

Measurement of Restoration Goals

We reviewed project descriptions to determine which goals were measured. We applied a liberal approach in which we categorized a goal as "measured" if any of the following criteria were met: (1) past monitoring actions were described; (2) a monitoring plan was included for future goal measurement; and (3) the success achieving the goal was reported.

Results

Restoration projects in the GRN spanned 54 countries, although one-third of the entries were based in the United States (Table S1, Supporting Information). Coastal and marine habitats were the most frequently represented biome (30%), followed by freshwater (16%), temperate forests (15%), and tropical forests (12%). The majority of entries summarized full restoration projects (68%) and the remaining entries described scientific studies (32%) (Table S1).

General Restoration Goals

Almost all projects in the GRN had goals related to ecosystem form, and most projects had goals related to ecosystem function and social values (Fig. 1). Less than a quarter of projects had goals related to ecosystem stability (Fig. 1).

Ecosystem Form

Goals related to similarity to reference conditions and the presence of indigenous species were each represented in a majority

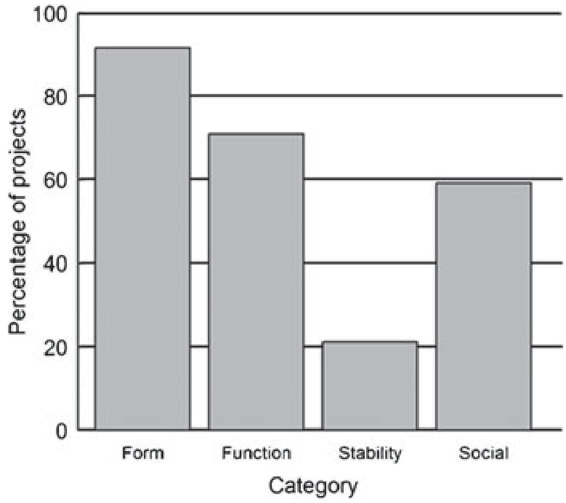

Figure 1. Percentage of projects in the Global Restoration Network database that had goals related to the broad categories of ecosystem form, ecosystem function, ecosystem stability, and social values.

of the GRN projects (Fig. 2). Although we considered the presence of indigenous species as a single attribute, it encompassed three aspects of species identity: characteristic native assemblages (69% of projects with this attribute), rare species conservation (24%), and non-native species removal (23%).

Ecosystem Function

Functional group representation and the capacity of the physical environment to sustain populations were also the common attributes represented in the GRN project goals (Fig. 2), whereas normal functioning was represented in a quarter of projects (Fig. 2). Landscape integration was cited infrequently (Fig. 2). The presence of functional groups could be further distinguished by biotic interactions, such as habitat provisioning (75% of projects with this attribute), and biotic effects on abiotic factors, such as soil stabilization (33%). We had difficulty in interpreting the fifth SER-defined attribute, normal functioning, but chose to list this attribute for goals that altered abiotic functions and did not consider biotic–abiotic interactions. Of these, many aimed to alter hydrology (48% of projects with this attribute).

Ecosystem Stability

Elimination of threats was cited by less than a quarter of projects, and goals related to resilience and self-sustainability were rarely cited (Fig. 2).

Social Values

Educational outreach, economic potential, and community engagement were each represented in a quarter of GRN projects (Fig. 2). A smaller number of projects had goals related to governance and cultural values (Fig. 2).

Measurement of Goal Success

Goals related to the SER-defined attributes were frequently measured (69% of all goals related to the SER-defined attributes were measured). Of these, species identity was the most commonly measured (79% of projects with this goal measured it) and self-sustainability was the least (29%) (Fig. 2). Social goals were infrequently measured (27% of all social goals were measured). Of these, goals related to governance were the most often measured (42% of all projects with this goal) and goals related to community engagement were the least (20%) (Fig. 2).

Discussion

Restoration projects in the GRN included a diverse range of goals that incorporated both ecological and social considerations. The SER-defined attributes describing ecosystem form—similarity to reference conditions and presence of indigenous species—were frequently cited and often measured. Attributes related to biotic and abiotic functional interactions—presence of functional groups and the capacity of the physical environment to support populations—were also common, although these interactions were rarely considered at the landscape scale. Fewer projects had goals

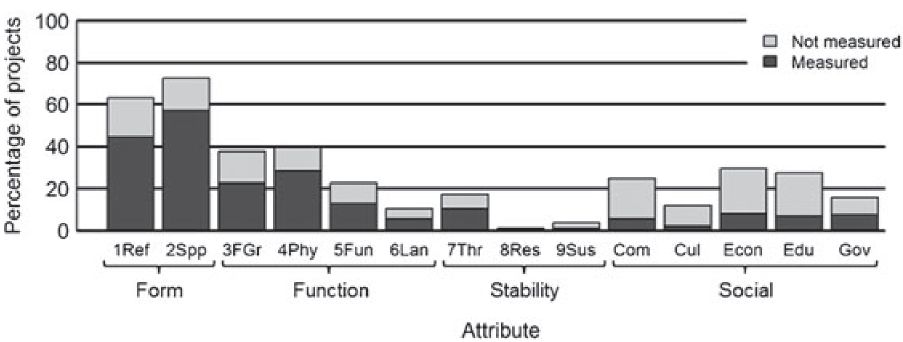

Figure 2. Percentage of projects in the Global Restoration Network database that had goals related to the nine Society for Ecological Restoration attributes of a restored system (Table 1) and five additional social attributes (Table 2). These attributes are grouped by category and partitioned by the frequency with which each goal was measured.

for ecosystem function unrelated to abiotic–biotic interactions. Attributes describing ecosystem stability—elimination of threats, resilience, and self-sustainability—were rarely reflected in project goals.

The SER-defined attributes focus exclusively on ecological patterns and processes. Restoration goal setting, however, is a human-defined process based on human values (Higgs 2003). We found that the majority of projects in the GRN also had goals related to social values and human well-being. These are most commonly related to economic benefits, education, and community engagement. Although less frequently measured than goals related to the SER-defined attributes, social goals were noted to be both intrinsically valuable and important for the long-term success of the restoration project.

Evaluating how the SER-defined attributes apply to a wide range of restoration projects provides an opportunity to see how restoration theory relates to on-the-ground practice. The GRN is an extensive database and is the first that compiles descriptions of projects without restricting them to specific systems (such as most mitigation databases) or locations (such as state or country-run databases). It is, however, dependent on voluntary submissions that are not peer reviewed and can be highly variable in detail and expression. We describe the theoretical and practical insights that emerged from our GRN assessment below, but emphasize that further development and additions to the GRN and similar databases are critical to better understand the links between restoration science and practice.

Ecosystem Form: Use of a Reference

Establishing a target ecosystem based on ecological form (composition, structure) is almost universal among restoration projects. A common way to develop a target is to select a reference ecosystem as a point of comparison (Aronson et al. 1995). The use of a reference ecosystem was one of the most ubiquitous characteristics of projects in the GRN; over half of projects described a goal in relation to reference conditions, and these goals were commonly measured. Many projects aimed to return the ecosystem to a historical reference state and some used reference comparisons to monitor success. Others chose reference sites based on specific functional attributes.

The idea of a reference ecosystem as a useful restoration goal has been debated and modified in academic literature for two main reasons. First, ecosystems are always in flux and snapshot measures of a reference ecosystem may miss important dynamics. Different approaches have been suggested to deal with this dynamism, from aggregating data from multiple reference sites (White & Walker 1997; SER 2004; Ruiz-Jaen & Aide 2005) to departing from the concept of a reference altogether (Pickett & Parker 1994). We rarely encountered projects that modified their reference to incorporate temporal variability, although we cannot be sure that the absence of these details from the project summaries means they were not incorporated during project implementation.

Second, SER suggests that a historical reference be used as a target, but others have suggested that selecting references for specific characteristics will better achieve restoration values (Davis & Slobodkin 2004). Arguably, this second approach falls within the realm of other "re-" words associated with ecological restoration, such as rehabilitation and reconciliation, that describe attempts to achieve ecological value from land without restoring it to a historical ecosystem per se (Clewell & Aronson 2007). Many projects in the GRN took the first approach and used a reference system as a primary goal, such as projects that tried to recover historical conditions following mining disturbance (e.g. case 113 in Table S1). However, at times projects took the second approach and used a reference as a heuristic for achieving specific ecosystem characteristics, such as projects that aimed to be similar to a reference that provided adequate flood water storage capacity (e.g. case 55) or appropriate habitat for a rare species (e.g. case 180). Projects generally had goals related to multiple attributes and rarely discussed their goals as a trade-off between the two approaches; while many projects focused on restoring a historical ecosystem, few did so without also targeting desired ecosystem characteristics.

Ecosystem Form: Species Identity

The premise that ecological restoration should attempt to "recover as much historical authenticity as can be reasonably accommodated" underlies the SER-defined attributes (SER 2004). Projects in the GRN most commonly adopted this premise in relation to species selection. Nearly three-quarters of GRN projects aimed to restore indigenous species, and this goal was frequently measured. First and most commonly, projects tried to restore a native species assemblage characteristic of a historical habitat type. These projects reflected an overarching goal of historical fidelity, and they often emphasized dual goals of both diverse and native species assemblages. Second, several projects focused on restoring an iconic or endangered species. These ranged from providing habitat for migratory birds and fish (e.g. cases 41 and 46) to establishing rare native plants (e.g. case 114). The focal species in these projects were generally (but not always) native.

Third, a number of projects focused on non-native species removal. The justification for these projects almost always described non-native species in the context of their effects on ecosystems. For example, one project described removing a non-native plant that reduced the water table (e.g. case 181) and another prioritized removing a non-native grass that excluded focal species (e.g. case 164). Debate has escalated among ecologists as to whether ecosystem restoration and management should favor native species, or whether management actions should be based on species effects rather than origin (Davis et al. 2011; Simberloff et al. 2011). Our GRN assessment suggests that increasing the presence of native species was a common restoration goal, but practitioners only actively removed non-native species after considering both their origin and effect.

Ecosystem Function: Biotic–Abiotic Interactions

Ecosystem functions, as defined by SER, are "the dynamic attributes of ecosystems, including interactions among organisms and interactions between organisms and their environment" (SER 2004). The SER-defined attribute that directly relates to ecosystem function states that "the restored ecosystem apparently functions normally for its ecological stage of development," but gives no guidance on what "normal" means. In contrast, projects in the GRN tend to select goals for specific ecosystem functions. These ranged from restoring hydrological patterns as a flood mitigation strategy (e.g. case 129) to reducing fuel loads for fire management (e.g. case 142). This suggests that practitioners tended to focus on references when considering ecosystem composition, but prioritized desirable services when choosing targets for ecosystem function. The limited number of cases that included a landscape dimension, however, indicates that both form and function are considered primarily at the site level.

Projects in the GRN emphasized dynamic relationships between abiotic and biotic processes. First, many modified the physical environment to enable the establishment and persistence of desired species. Efforts ranged from scarifying compacted soil to enable root growth (e.g. case 198) to altering regional hydrologic patterns in order to reduce soil salinity to levels that support mangrove forests (e.g. cases 37 and 59). Biotic interactions were also commonly cited. Of these, projects frequently seeded plants with functional traits that support wildlife (e.g. cases 152 and 202), but they also manipulated mychorrizal associations (e.g. case 200), introduced ecosystem engineers (e.g. case 185), and increased functional diversity (e.g. case 55), all with the aim of supporting key biotic relationships. Biotic processes can similarly affect abiotic conditions (Tansley 1935; Naeem 2002), but this relationship is not well developed in the SER-defined attributes. In contrast, it was a prominent consideration in several GRN projects. Some projects capitalized on biotic–abiotic interactions, such as using termites to rehabilitate soil (e.g. case 18) and planting deep-rooted species for erosion control (e.g. cases 70 and 131). Other restoration efforts found biotic–abiotic relationships to be significant challenges, e.g. when invasive species altered abiotic functions (e.g. case 142) or the habitat of desired species (e.g. case 39).

Ecosystem Stability: Elimination of Threats, Resilience, and Self-Sustainability

Resilience was almost never noted as a project goal in the GRN database. Likewise, self-sustainability—the degree to which a system can sustain itself without external support—and the elimination of threats were rarely included as goals in GRN projects. Although researchers are in the process of developing metrics to measure resilience in the context of ecosystem management (Resilience Alliance 2010), resilience is still rarely an explicit or measured goal in restoration (Suding 2011). Other more commonly measured SER-defined attributes, such as species diversity, are often assumed to increase resilience and self-sustainability (Elmqvist et al. 2003; Brand & Jax 2007). However, many factors have been associated with resilience (Folke et al. 2004) and the attributes of the species present may matter as much as their numbers (Vinebrooke et al. 2004; Cote & Darling 2010).

This raises a broader question: if resilience and self-sustainability are hard to measure, are they useful to restoration practitioners in other ways? Walker and Salt (2006) argue that resilience is best applied as a conceptual or metaphorical goal, as "resilience thinking." This approach assumes that the concept of resilience may still be useful for encouraging broader thinking about restoration interventions in coupled social and ecological systems. For example, the aspirational goal of resilience might encourage a restoration practitioner to move beyond single species counts to develop comprehensive, context-specific goals, and measurements. Given that resilience and self-sustainability may be best employed metaphorically rather than quantitatively, it is unsurprising that they were rarely explicit or measured goals in the GRN projects.

Toward a Concept of Socio-Ecological Restoration Through GRN Projects

Half of the projects in the GRN database had goals that were not encompassed by the SER-defined attributes, and all these goals were related directly to human well-being. The inclusion of social goals in GRN projects suggests that restoration practitioners appreciate that social and ecological systems are interlinked. In a salient example, the Chocó forest restoration project in Colombia took a long-term view of post-mining forest restoration in which it aimed to reduce economic dependence on mining by providing alternative income from forestry products (case 35). This approach highlights that ideas of separate "natural" or "wild" ecosystems are a poor match for reality (Ellis & Ramankutty 2008). Rather, humans live near, interact with and may continually alter "restored" ecosystems. Consequently, societal support and long-term human stewardship of restoration sites are often critical aspects of their success.

The preferences and needs of human communities vary widely; correspondingly, projects in the GRN had numerous approaches to social goals. First, many GRN projects attempted to provide economic benefits for local communities. These goals included incorporating food crops into planting palettes (e.g. case 55), restoring commercially important fish and wildlife species (e.g. cases 58 and 190), and providing farmers and ranchers access to agricultural and grazing lands (e.g. case 156). In addition, some restoration projects aimed to enhance market access for sustainably produced forest products (e.g. case 99). At times, conflict between local livelihoods and traditional restoration goals were described as threatening restoration success (e.g. cases 66 and 99). Often project organizers responded by shifting their emphasis from species and habitat conservation to social engagement in order to strengthen the project's long-term potential.

Second, a quarter of projects incorporated education in their objectives. Examples ranged from establishing public demonstration areas (e.g. case 32) and creating environmental education opportunities for school children (e.g. case 5) to increasing the knowledge of agencies implementing restoration projects (e.g. case 133). Third, a similar number of projects endeavored to engage the community directly in the implementation of the restoration project. Community initiatives often involved the creation of new organizations, ranging from Audubon Society volunteer groups (e.g. case 140) to local resident boards responsible for new water supply infrastructures (e.g. case 62). Community involvement through such organizations often supplied essential labor and maintenance for a project (e.g. cases 99 and 140). Cultural values were often identified and mediated by these community organizations. Finally, community-level institutions were described as being highly important for governance purposes, especially when projects involved multiple land owners or when legal compliance was required.

Restoration practitioners' consideration of interactions between social and ecological processes, therefore, emerged as an important step toward anticipating realistic outcomes from restoration initiatives. The contexts in which social goals were discussed in the GRN—both as having intrinsic value and as important factors for the long-term success of the project—highlight that for many projects success required ongoing engagement with human communities through time. In this light, it is perhaps even less surprising that the final two SER-defined attributes, resilience and self-sustainability, were rarely cited in the GRN project goals. The mandate of self-sustainability, that an ecosystem "has the potential to persist indefinitely under existing environmental conditions" (SER 2004), is unrealistic if ongoing anthropogenic influences are not considered and incorporated. Rather, the essence of these attributes—that the benefits of the restoration project persist into the future—is reflected in the explicit consideration of social values in many of the GRN projects.

The idea that ecological restoration can enhance human well-being is not new (Rey Benayas et al. 2009), nor is the notion that engaging with human communities is key to sustaining ecological restoration (Higgs 2003). However, a recent synthesis of peer-reviewed restoration efforts concluded that current restoration paradigms continually fail to quantify the social values of restoration action (Aronson et al. 2010). Addressing this gap arguably could increase public support for restoration efforts, and research in conservation biology suggests that increasing funding for ecosystem services does not divert funding from traditional biodiversity conservation (Goldman et al. 2008). At the same time, there is a risk that modifying traditional restoration to incorporate social goals may justify an "anything goes" approach. However, the fact that many projects included social goals indicates that, whether or not they are described by scientific guidelines, these considerations will shape restoration practice. Given this, perhaps the best way to guard against an "anything goes" approach is to draw upon existing social science literature to develop guidelines and attributes to help practitioners achieve social goals without sacrificing traditional restoration values.

Implications for Practice

- Documenting the specifics of project goals, actions, and outcomes (including monitoring data) is a key way to link research with practice and to determine restoration success. Publicly accessible resources such as the GRN can be utilized for this purpose.
- The SER-defined attributes could be used as a checklist for practitioners when developing project goals and restoration plans. Below are some modifications that would help the SER-defined attributes speak to the concerns of projects in the GRN.
  - Most projects used a reference ecosystem as a target but also included goals for ecosystem functions or biotic–abiotic interactions. More developed guidelines for achieving desired functions in addition to historical species assemblages could help practitioners achieve multiple goals.
  - Attributes related to ecosystem stability (elimination of threats, resilience, and self-sustainability) were described in the SER Primer but were rarely included as goals in GRN projects. Greater specification of how to achieve these goals might increase their use in practice.
  - Social goals were common to restoration projects but not discussed by the SER-defined attributes. Explicit social guidelines in the SER Primer might help practitioners achieve these goals without sacrificing traditional restoration.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Projects cataloged in the Global Restoration Network, the biome they occurred in, whether they were an experiment and whether their goals were reflected in the Society for Ecological Restoration Primer attributes of a restored system (Table 1) and other social attributes (Table 2). "Yes" indicates the project had a goal related to the attribute that was measured, "no" indicates that the project had a goal related to the attribute but that it was not measured, blank cells indicate the attribute was not reflected in the project's goals.