Success: An Unclear, Subjective Descriptor of Restoration Outcomes

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ABSTRACT

The continuing development of the science of restoration is muddled by unclear and inconsistent use of the term "success." In recent issues of two journals, *Restoration Ecology* and *Ecological Engineering,* 116 papers employed the term to predict outcomes, judge outcomes, describe criteria for judging projects, or refer to an ecosystem attribute, all in the restoration context. Only ten papers used "failure." In this article I argue that ecologists can communicate with greater clarity and objectivity by omitting or clarifying the word success when publishing in the scientific literature. Many uses can easily be dropped (for example, compliance success can become compliance, and establishment success can be establishment). A common term, "restoration success" would be clearer if replaced with more specific terms (for example, project completion, achieving dense plant cover, supporting high species richness, or colonization by target species). At minimum, authors can define the term and use it consistently. When meant as a value judgment, it would help to say, "*In my opinion*, the project was a success" (or failure) and then specify on what basis the judgment was made. Thus, I recommend abstinence, substitution, and clarification of the term success to aid communication and help restoration ecology mature as a science.

Keywords: clarity, failure, objectivity, restoration science, scientific communication, success

The science of restoration ecology has matured substantially in recent decades, evidenced by new scientific books (e.g., Perrow and Davy 2002, Falk et al. 2006), treatment in ecology textbooks (e.g., Keddy 2000), participation by theoretical ecologists (Symposia at Ecological Society of America Conferences in 2002 and 2006), coursework at many universities (e.g., Gold et al. 2006), a Society for Ecological Restoration International (SERI, founded in 1987as SER), specialized journals (*Restoration Ecology, Ecological Engineering, Ecological Management & Restoration*), and articles in *Science* (e.g., Dobson et al. 1997, Bernhardt et al. 2005). In addition, many reports of restoration projects are increasingly thorough and data-rich (Ruiz-Jaen and Aide 2005).

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Despite these advances, the language of restoration ecology still needs clarification, particularly in the use of the term success. Confusion arising from the use of other terms has been reduced by redefinition. The term "diversity," for example, became clearer when separated into two components, richness and evenness (May 1975). "Importance" of species was ultimately quantified with an index (Curtis and McIntosh 1951). "Dominance" indicated strong influence, but became clearer using an objective index (Frieswyk 2005).

This paper is about the term success, which is widely used in restoration ecology, but is often undefined and unclear. Avian ecologists have already struggled with the term in clarifying the concept of "nesting success." Like "restoration success," nesting success is difficult to assess, because both the data collection and the object of the study change over time. That is, 1) an observer can locate different nests at each visit such that data are not necessarily comparable, and 2) nests can "fail" at any time from early nest construction to fledging of offspring. For avian ecologists, clarification involved subdividing nest success into "egg success," "hatching success," and "fledging success," with formulas for each (Mayfield 1975), an approach that has persisted (Germaine and Germaine 2002). The term nesting success now has consistently defined components and a relatively objective endpoint (the fledging of nestlings).

Restoration ecologists have yet to achieve clarity and objectivity in describing developing ecosystems. In an earlier critique, Zedler and Callaway (2000) pointed out that a yes/no term is inappropriate for characterizing a gradual and variable process, and in addition a single site will be assessed differently depending on time and criteria used in judging success (See Box 1 p. 165; also Jansson et al. 2005). In that paper we recommended replacing the term success with "progress" when describing stages of ecosystem development and "in compliance" to indicate when specific project objectives were met.

How Success Appears in the Restoration Ecology Literature

To analyze the use of success in the scientific ecological restoration literature, I reviewed two journals that focus on restoration science, *Restoration Ecology* and *Ecological Engineering: The Journal of Ecosystem Restoration* (previously subtitled *Journal of Ecotechnology*). Using examples of the use of success from these journals I address issues of clarity and objectivity and offer recommendations for improved scientific communication.

An electronic search of issues from January 2000 through July 2006 of the journal *Restoration Ecology* returned 80 articles with success in the title, abstract, or key words (excluding "nesting success" and "succession"). The same search of *Ecological Engineering* returned 36 articles. The resulting database of 116 papers shows that peer-reviewed articles in the restoration ecology field use the term success in many ways (Table 1). Within this database, two forum titles might have influenced authors' terminology: six of the *Ecological Engineering* articles appeared in the 2000 special issue, "Goal setting and success criteria for coastal habitat restoration" (Volume 15[3–4]), and a special section on "Resource heterogeneity and restoration success" in *Restoration Ecology* included one paper (Baer and Groninger 2004) with the word success in the abstract (and two that did not). Over the past six and a half years, I found no trend of increasing or decreasing use in the journals (Table 2).

I repeated the search using the term "failure," to see how its use contrasted with the more positive term success. The search resulted in only ten papers. Several of these, including my own (Zedler and Callaway 2000), use the term failure as a contrast with success.

Table 1. Examples of how "success" appears in recent restoration ecology papers. About half of the abstracts and titles (42 %) used success generally (for example, restoration success) and about half (43 %) used the term with a more specific qualifier (for example, establishment success). The term "success criteria" appeared in 8 %. The most common uses are listed; others are variations that are not listed (to conserve space). The lists favor newer papers.

Predicting outcomes
places where "restoration has a high likelihood of success and will be sustainable over the long term" (White and Fennessy 2005)
modeling helps "to evaluate the overall success of the restoration scheme" (Bockelmann et al. 2004).
"high degree of uncertainty about the potential success of any restoration effort" (Thom 2000)
"long-term success . . . remains to be determined" (Moyes et al. 2005)
Judging outcomes
Absolute (yes/no)
"restoration success" (Ruiz-Jaen and Aide 2005)
"restoration or creation success" (Havens 2004)
"success of the Delaware Bay wetland restorations" (Teal and Weishar 2005)
"the two restoration projects have been successful" (Forup and Memmott 2005)
Conditional
"limited success" in controlling sediment (Larson et al. 2001)
"varying success" of attempts to raise soil pH (Dorland et al. 2004)
"success of created wetlands relative to natural wetlands" (Cole and Brooks 2000)
"increasing success" (Sweeney et al. 2002); "increase its success" (Henry et al. 2002)
"success may be improved" (Diaz et al. 2006)
"mixed reforestation success" (Kruse and Groninger 2003)
Criteria for judging projects
"success criteria" (Ehrenfeld 2000); "criteria for success" (Stanturf et al. 2001)
"success standards" should include arthropods (Longcore 2003)
"indicators of success or sustainability" (Parrotta and Knowles 2001)
"mitigation success" (Lewis 2000)
"an objective basis for judging project success" (Neckles et al. 2002)
Referring to an attribute of an ecosystem or project
"compliance success," "functional success," "landscape success" (Kentula 2000)
"seeding success" (Isselin-Nondedeu et al. 2006)
"colonization success" or variations (Tormo et al. 2006, Hardej and Ozimek 2002)
"establishment success" (Tinsley et al. 2006)
"successful seed production" (Mulligan and Kirkman 2002)
"regeneration success" (Dulohery et al. 2000)
"reclamation success" (Cano et al. 2002)
"revegetation success" (Tormo et al. 2006)
"success of transplants" (Page and Bork 2005)
"success of reforestation" (Jiménez et al. 2005)
"success of the corridor in providing habitat" (Jansen 2005)
"basins of various widths were equally successful" (Campeau et al. 2004)
"amendment success" (Reid and Naeth 2005)
"successful rehabilitation practices" (Aerts et al. 2004)
a species "success" (Baer and Groninger 2004)

Table 2. Use of the terms "success" (92%) and "failure" (8%) in two journals from 2000 to 2006. EE = *Ecological Engineering;* RE = *Restoration Ecology.*

	Success		Failure	
Year	*EE*	*RE*	*EE*	*RE*
2006	4	7	1	0
2005	4	15	0	0
2004	4	13	0	1
2003	0	15	0	1
2002	13		1	2
2001	5	10	0	0
2000	15	7	3	1
Sums	36	80	5	5
Totals	**116**		**10**	

Few authors judged entire projects or programs as failures. One exception, Stanturf et al. (2001), described Mississippi's 1992 Wetlands Reserve Program as "failed on 90% of the area" (p. 189) based on afforested land that achieved "at least 247 stems per ha of acceptable species (mostly native, dominant canopy species) after 3 years" (p. 192). A second exception, Wilkins et al. (2003), judged eucalyptus woodland restorations as failures on the basis of low similarity in composition and community structure (height, cover) to reference sites and high similarity with pastures. In both these cases authors clarified what expectations were not met. A few other authors reported "partial success" and "limited success," indicating that a yes or no evaluation was not adequate to describe ecosystem development (Table 1).

Challenges in Evaluating Restoration

Restoration projects rarely include clear, commonly agreed on endpoints or have simple formulas for judging outcomes. An ecosystem restoration project might be judged successful by whether or not it can sustain itself without maintenance. It is virtually impossible to measure self-sustainability of an ecosystem in the short term, however, and very difficult to predict future possibilities for sustainability given the complexities of ecosystems and the many uncertainties surrounding stressors at multiple spatial scales (local land care, watershed development, the potential for catastrophic events, and climate change).

Although restoration ecology is an applied and interdisciplinary science that overlaps with social needs, and although we often need to consider how many groups will judge outcomes, our goal as scientists is to be objective in communicating with one another. As scientists, we do not actually measure success; we measure conditions, structure, processes, ecosystem development, similarity to reference sites, and potential for self-sustainability (by various metrics or indicators). Longcore (2003), for example, argues for using arthropods to assess success, Shuwen and colleagues (2001) use birds, Paller and colleagues (2000) use fish assemblages, Coen and Luckenbach (2000) use shellfish, and Bell (2001) uses ecosystem functions. I endorse including estimates of species diversity, key population abundances, and functioning of critical components of ecosystems to assess restoration *progress* (a graded evaluation). It is important to note, however, that none of these assessments offer the certainty of an all-or-nothing judgment of success or failure. In addition, even if the goal is specified in detail, for example, to establish arthropods equivalent in abundance and composition to those of reference data, the judgment of success or failure would still be subjective. For example, if 50 percent of the criteria were met (or any proportion other than 0 or 100 percent), either success or failure could be argued based on personal feelings, prejudices, or interpretations.

Subjectivity creeps into the restoration literature perhaps because stakeholders benefit from a positive judgment. Restoration is a competitive practice with high stakes and sometimes legal implications. Practitioners and their clients are judged by funding organizations, regulators, and the public. The practitioner wants to show that work was effective; the client wants to show that the investment was worthwhile; regulators want to close the books in order to address new projects. Pressure is strong to describe ecosystem development and projects as "successful" in promotional contexts. Scientists need to aim for objectivity and clarity when evaluating outcomes.

Writing with Clarity and Objectivity

If scientific restoration writing were objective, the literature would report both failures and successes (assuming an unbiased peer review process). Instead, only 10 of 126 abstracts in this survey used "failure" (Table 3). Since the first use of success in *Restoration Ecology* abstracts (March 1993, Volume 1, Issue 1), authors have more clearly identified restoration targets, evaluating multiple ecosystem attributes, and using modern statistics to compare data (Ruiz-Jaen and Aide 2005). Nevertheless, river restoration reports rarely include any assessment or monitoring (Bernhardt et al. 2005). This led Palmer et al. (2005) to specify five criteria for "successful projects," including "improve the river" and "do no harm." These two terms are unlikely to provide objective measurements, unless scientists agree on what constitutes improvement and lack of harm.

Given the open-ended process of ecosystem development, we need to be consistent in the timing and use of evaluation (e.g., Neckles et al. 2002). In the mitigation arena, projects are often judged after 5 years, based on whether or not they comply with mandated conditions. In either case, success is an unnecessary term; "compliant" is sufficient. As Quammen (1986) pointed out 20 years ago, projects are in compliance when a specific list of targets has been met, while ecological assessments involve additional measures and understanding of why targets are hit or missed. Today, we look for attributes shared by a well-defined reference domain (Ehrenfeld 2000) or a match with some other "guiding image" (*sensu* Palmer et al. 2005). A project that is in compliance with specific objectives might have serious shortcomings by ecological criteria.

Recent literature includes many examples of increasing specificity and clarity in measures of ecosystem performance. For example, Tullos et al. (2006) evaluate the "success of restoration activities in re-establishing benthic habitats" as "the difference in the presence of indicator genera between pairs of upstream-restored reaches" (p. 228). Kiehl and Wagner (2006) judge hay transfer as a "successful method to establish species-rich grasslands with a high proportion of target species" (p. 157). "Performance criteria" can substitute for "success criteria," and the hay transfer method can be described simply as having established target species.

Restoration ecology will mature as a science when our work is clearly communicated. I have three recommendations in this regard:

1) **Abstinence**. Success is often unnecessarily joined with existing ecological terms, for example, restoration success, compliance success, establishment success, colonization success, regeneration success, and revegetation success. If there is confusion about the basic terms, they need to be defined. Establishment, for example, can be defined as growth to reproductive age. The term "restoration success," I argue, conveys no more *scientific* information than does "restoration." The term "restored" can mean either that some actions were taken or that the targets were met. Referring to restoration

Table 3. Examples of how "failure" appears in the restoration ecology abstracts.

"success or failure" (Short et al. 2000, Hackney 2000, Parkyn et al. 2003)
"failure of restoration treatments" (Wilkins et al. 2003)
attempts . . . are "doomed to failure" (Crisman et al. 2005)
"causes for the failure of restoration projects" (Feunteun 2002, Ewing 2002)
"causes for recovery failure are discussed" (Imbert et al. 2000)
"explanation for the failure of many . . .species to colonize" (Kleijn 2003)
"despite past failures to establish . . ." (Williams et al. 2002)

Box 1. Assessments of Success and Failure Reflect Beholders' Views.

The pathway of restoration is often slow and not necessarily smooth. In addition, people involved will evaluate a project as a success or failure depending on their interests as well as specific measurements used to evaluate. For example, the 8-ha Friendship Marsh restoration project at Tijuana Estuary was completed in 2000, after sediment had been excavated and tidal water returned to the former salt marsh. Proponents of the project immediately celebrated its "success" because the excavation was complete (pers. obs. at the opening ceremony). Other events were evaluated as failures however: (1) the reintroduction of seawater was delayed while anthropological concerns were addressed (pot shards were uncovered and the project was halted while consultants excavated 100 plots in search of evidence of a significant Native American archeological site; finding none, the project proceeded). Because of this delay, tidal flushing was restored too late to capture seeds of native plants, so few plants recruited (Morzaria-Luna and Zedler 2007). (2) Tidal amplitudes and rainfall were then minimal, so the marsh plain became a salt flat, and thousands of plantings died (Zedler et al. 2003); (3) the creek networks nearly filled with sediment (Wallace et al. 2005). (4) The berm designed to keep out sediments breached in 2004 and inflowing sediments elevated the marsh plain (Wallace et al. 2005), smothering plants and benthic invertebrates.

On the other hand, shorebirds visited the bare, unvegetated flats and fed on the abundant invertebrates (P. Roulliard, pers. comm.). Intertidal flats are rare in southern California, so the "failed marsh" was a "successful shorebird feeding habitat." Or was it? After five years, vegetation began colonizing the bare, salt-crusted marsh plain (Wallace et al. 2005), and at six years, it had 21 percent cover. Shorebird visitation decreased. In addition, the channel-edge mudflat, which was designed for shorebirds, accreted enough sediment to support 52 percent plant cover in year six. One species, pickleweed (*Salicornia virginica*), colonized and became dominant. This could be judged as a success of one species, or a failure to develop community diversity. Meanwhile, the endangered light-footed clapper rail (*Rallus longirostris levipes*) was sighted several times in the dense cordgrass—indicating successful achievement of Wildlife Refuge goals.

Assessments of success depend on perspective, goals, and time. From a scientific perspective, this site was a planned experiment (with and without tidal creek networks) that in many ways tested specific methods of restoring Californian salt marshes. While the site succeeded in advancing science (through many publications), many of our experiments could have been judged failures, as described above. This story emphasizes the importance of clarifying evaluation criteria and avoiding success or failure as descriptors.

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"status," however, is a more accurate alternative (as in Aerts et al. 2004).

2) **Substitution.** Success can often be substituted by a more precise term. "Compliance criteria" can be easily substituted for "success criteria" (for example, specific metrics of plant growth in seagrass mitigation; Short et al. 2000). "Ecological assessment" would serve when authors determine if a project has met specified ecological standards (Stanturf et al. 2001). "Project criteria" works where project goals involve more than ecological criteria (for example, cost, public education, aesthetic appreciation). Pre-existing alternatives include transplant survival instead of "success of transplants." A term like "increased success" could be avoided by substituting "progress toward the target." The term success needs to be defined in every situation, but substitution with a precise term would avoid later confusion resulting from success being quoted out of context.

3) **Clarification.** Authors who choose to use the term success in scientific communications can be clear by signaling when they are making a value judgment (for example, *in my opinion it was a success*) and stating the basis of that judgment (that is, which objectives were achieved) along with the time of the evaluation (for example, at five years). Saying "in my opinion" is particularly important when referring to the long-term target of sustainability when only short-term data are available (e.g., Parrotta and Knowles 2001, White and Fennessy 2005, Toy and Chuse 2005).

In summary, I suggest abstinence where the term success can easily be dropped and substitution where more specific metrics provide clarity. If authors insist in using success in the scientific literature, they can still clarify when an opinion is being given. Increased clarity and objectivity will help the science of restoration ecology mature.

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