II.

The restoration process

Criteria for Recognizing, Organizing, and Planning Ecological Restoration

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Andre Clewell, James Aronson, and James Blignaut

Introduction

In this chapter, we pose three questions. First, what criteria qualify a project as "ecological restoration" and distinguish it from other kinds of projects? Second, how can a project be organized, structured, and administered by its sponsoring institution or community in a manner that ensures that the distinguishing criteria for ecological restoration are satisfied? Third, what are the critical steps in planning a project so that it qualifies as ecological restoration and provides maximum value, including ecosystem services?

The concept of ecological restoration (sometimes called 'eco-restoration') has undergone substantial evolution during the past 30 years. It began as a simple proposition to put an impaired ecosystem back the way it was at a time when it was still whole, intact, and not degraded. At first glance, this seems reasonable enough, but it did not always work well, particularly at smaller spatial scales and at finer resolutions. The problem in "putting it back the way it was" assumed that nature was static and it could be repaired as if it were a work of art or architecture. Nature may appear static over the course of several years; however, natural ecosystems are dynamic, consisting of many living organisms belonging to a multitude of species that interact with each other, and respond to an ever-changing biophysical environment influenced by an ever-changing world and biosphere.

In addition, there was the problem of figuring out exactly what was meant by "the way it was" because historical records may be vague or absent. For example, the general trend of deforestation is obvious for a region like the Mediterranean Basin, but the historical ecological record is scant and generally inadequate for developing a model as the target of restoration at a specific site. To complicate this situation, people have been intimately involved for thousands of years in shaping our current ecosystems, to the point that several kinds of ecosystems can occupy one site, depending on past and present land usage (Blondel and Aronson 1999). This raises a problem because "the way it was" could be any of several different kinds of cultural ecosystems and some pre-cultural states. In addition, some landscapes have been modified by public works projects and other environmental alterations to the point that a former ecosystem could not possibly be put back "the way it was." Finally, even if it could be "put back," it may be liable to rapid modification from conflicting land use priorities among stakeholders.

When faced with these constraints, it is tempting to dismiss eco-restoration as quixotic and instead try to "put it back the way it formerly *functioned*". In other words, the species composition and community structure are less important than function. "Function" is shorthand for a suite of ecological functions, such as primary productivity, nutrient cycling, and food chain support. However, the principle meaning of "function" in this context, at least for most people, is the suite of ecological goods and services provided by intact, ecologically healthy ecosystems and that are of direct benefit for people. Examples of ecosystem goods are foods, timber, fiber, forage, thatch, fuelwood, and medicinals. Examples of ecosystem services are the provision of clean air and water; retention of flood waters; control of erosion; renewal of topsoil; enhancement of habitat for wildlife and rare species; sequestration of carbon, pollutants, and excess nutrients; pollination of crops; biological control of crop pests; and the fulfillment of human cultural needs of a spiritual, aesthetic, intellectual and recreation nature. People value ecosystems because they provide these goods and services.

The repair of ecosystem function is generally called *rehabilitation* rather than restoration. Rehabilitation poses its own, inherent disadvantages. One is that most rehabilitation programs are intended to resolve a particular problem, such as the recovery of grazing land or the provision of wildlife habitat. Site preparation and planting that are designed for one purpose generally provide only one appreciable service. In addition, ecosystems that are rehabilitated for a single purpose are readily susceptible to biological succession and may revert to their former conditions or change into states that were unanticipated and unintended.

The concept of ecological restoration has evolved considerably to the point that it fully embraces the restoration of function in the sense of rehabilitation, with the recognition that we can only restore to a *future* state. That future state may closely resemble the prior state, assuming that there have been no substantial changes in environmental conditions. However, global, regional, and local conditions are undergoing rapid change in climate and from sea level rise, as well as from multiple direct impacts of modern human activity. Consequently, the future state commonly develops under a new set of irreversible environmental conditions which temper the trajectory of an ecosystem to an altered state in terms of its species composition and community structure.

For example, irrigation may lower the water table over a broad region and cause irreversible changes in a natural ecosystem that has not otherwise suffered any abnormal stress or damage. If that same ecosystem were degraded, damaged, or destroyed from another impact such as overcast surface mining, and eco-restoration were performed for its recovery, then the target of restoration would be the expected future state with a lowered water table and not a former state that emulated the nostalgic past. In addition, restoration efforts would attempt to facilitate all ecosystem services of value to stakeholders and the restoration target could undergo further adjustment to accommodate the fulfillment of those values. Cultural modification of ecosystems for such purposes is not new and has been practiced globally for many millennia. In this new conception, 'restoration' becomes a powerful metaphor rather than an attainable reality, because only the future can be 'restored.'

We call this approach that addresses ecosystem states, ecological functions and service, and the satisfaction of human values "holistic ecological restoration" (Clewell and Aronson 2007). We recommend that all holistic restoration projects be conceived to help satisfy three "Rio Conventions" pertaining to the amelioration of climate change, reversal of desertification, and protection of biodiversity, which were adopted by the United Nations Conference on Environment and Development at the 1992 Río Summit (Blignaut et al. 2008). Eco-restoration contributes to climate amelioration by increasing carbon sequestration and providing vegetative cover that reduces the dissipation of solar radiation into the atmosphere as heat (Clewell and Aronson 2006). It also contributes to the reversal of desertification by recovering biotic community structure, and it returns biodiversity that had been lost. Eco-restoration simultaneously and synergistically addresses all three accords in some degree, depending on the availability of local institutions with appropriate environmental policies in place, sufficient scientific knowledge of the ecosystems being restored, and the local capacity to implement strategies and techniques for effective restoration. The degree to which a restoration project can address these Río Summit Conventions depends on local socio-economic, political, scientific, and technological conditions. Nonetheless, restoration should be conceived with all three in mind. It should also be clear that in our rapidly changing world, on-going maintenance or management will be required, in most or all cases, following completion or closure of a restoration site or project. In the next section we will explore these ideas in more detail, and in the context of specific projects.

Project Criteria

The question arises: What are the criteria that distinguish ecological restoration from another kind of project, for example, from afforestation? Actually, afforestation can serve as an important component in a restoration project, but not necessarily from the perspective of silviculture that is conducted exclusively for the production of wood products. In silviculture, competing native grasses and shrubs are commonly removed mechanically or treated with herbicide to reduce competition that could retard planted tree establishment. Only good quality nursery stock is planted to optimize favorable wood development. Measures are taken to protect the project site from potentially damaging fires. In a restoration project, native grasses and shrubs are protected, and more species may be introduced, even at the risk of reducing tree establishment and growth. A certain percentage of silviculturally inferior trees are acceptable, and indeed even desirable, for planting, because these may become ill-formed and provide denning cavities for animals. Fires, other than lethal crown fires, may be encouraged or even ignited to mimic historical conditions or to create spatial heterogeneity within the project site. In short, restoration projects may borrow heavily from other fields such as silviculture in terms of their methods; however, the intent of restoration has substantially greater amplitude than other kinds of projects. This example on afforestation serves to emphasize the importance of being clear on exactly what we mean by ecological restoration.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2002). Ecosystems that have undergone such impairment have likely suffered from the ecological simplification of their community structure, or characteristic species were lost and replaced by more weedy, generalist species or by invasive non-native species. The impaired ecosystem may have lost some of its beneficial soil properties and the ability to recycle mineral nutrients efficiently, or the capacity to maintain and regulate a favorable moisture regime or microclimate. Restoration is the process of returning an ecosystem to wholeness in these respects and to a state of ecosystem health, much as a physician would heal a patient.

Once restored, the formerly impaired ecosystem should display these ecological attributes:

- appropriate species composition that is sufficient to allow development of normal community structure;
- absence of invasive, nonnative species, to the degree considered necessary to protect the health and integrity of the system;
- presence of all functional species groups or their likely spontaneous appearance later as the restored ecosystem matures;
- suitability of the physical environment to support the biota;
- normal ecosystem function or at least the absence of signs of dysfunction;
- integration with the surrounding landscape in terms of normal flows and exchanges of organisms, materials, and sources of energy;
- absence of external threats from the immediate landscape to the integrity and health of the restored ecosystem to the greatest practicable extent.

The restored ecosystem is resistant or resilient to frequent or common stresses and disturbances. Examples are winter freezes, summer droughts, periodic grass fires, and in coastal regions, exposure to saline aerosols. In addition, the restored ecosystem is self-organizing and therefore self-sustainable without evidence of arrested development. However, extreme events may disrupt even the most carefully conceived and executed project. In the coming century, this may be increasingly likely in the Mediterranean region, and elsewhere, as a result of anthropogenic climate changes (IPCC 2006).

The ecosystem should be restored with a target or model in mind, which is called a *reference ecosystem, reference model,* or *reference*. The reference reflects the desired state that the restored ecosystem is expected to approximate after it has attained ecological maturity. The reference can be one or more actual ecosystems, or it can be a representation of them, such as a published ecological description. It can be the historic ecosystem as recorded in photographs or museum specimens. It can be a remnant of the historic ecosystem that still persists on the project site or on a similar site nearby. It can be synthesized from a number of sources which collectively portray a reasonable approximation of historic conditions (Egan and Howell 2001). The reference model should accommodate recent environmental changes on site or in the vicinity that will influence future ecosystem states and the overall trajectory of ecosystem development in the spirit of holistic restoration and “restoring to the future”.

Selection of the reference is critically important to restoration. Without a reference, the project lacks a valid starting point that reflects local environmental conditions and biota. A trajectory is equivalent to the wake of a boat which reveals where you have been and the direction you are headed. Likewise, the trajectory reveals where the ecosystem has been in the recent past in terms of its composition and structure. It also tells you the direction it is going, relative to its probable future state, from clues in the biota and in the current environment. In other words, it is the basis for the prediction of future conditions and thus the development of a realistic reference model for restoration. Without a reference, the predictive element in restoration is lacking, and it would be more accurate to call the project re-vegetation or ecological engineering rather than restoration.

Most terrestrial ecosystems are culturally modified or crafted in some degree. This is not surprising, because we humans comprise a dominant biological species, and we evolved in concert with the rest of nature. Cultural ecosystems, which include nearly all ecosystems that occur in the Mediterranean region, were ‘sculpted’ and redesigned by people, and most are still managed by them. Humans have domesticated or “gardenified” these ecosystems in the course of their transformation and the practical, intentional management of them, and of the larger landscapes in which they occur.

Of course, not all traditional management of ecosystems was sustainable in the past, and many of them caused land degradation. For example, humans who lived in small villages throughout the Alps modified the composition and structure of their forests as they harvested wood products and wild foodstuffs and introduced livestock and forage species. Such activities transformed alpine forests into cultural ecosystems that basically retained their productivity and forested aspect. However, land use intensified to the point that these forests were degraded or entirely destroyed, leaving bare and severely eroded slopes (Hall 2005). The selection of a reference for restoring an intact cultural ecosystem assumes that traditional cultural activities and land usage will be practiced, or that appropriate ecosystem management will be substituted for traditional practices, after restoration activities have been completed. Otherwise, the restored system may transform into another, less desirable state. It is critical to apply landscape perspective, as that is the scale at which most people perceive and communicate when it comes to issues of general, social interest. Sometimes, of course, the operative scale of an individual property – a farm or domaine – can be appropriate as well.

Organizational Criteria

Ecological restoration differs from civil engineering, architecture, landscape design, gardening, agronomy, silviculture, and related disciplines, on account of its being dynamic, open-ended, and lacking a static end-product. In these other disciplines, the product is carefully molded to specifications that are clearly prescribed in plans and drawings, whether it is a bridge or building, grain field or row-planted forest, etc. The product of ecological restoration is nature. Nature by definition is distinct from human artifice and cannot be authentic if it is molded to fit a preconceived notion. The process of ecological restoration merely initiates or accelerates natural processes in a manner that allows nature to recover and to heal itself.

Sponsors of ecological restoration projects are commonly governments or transnational agencies like the European Union, World Bank, or United Nations. Some projects are sponsored by non-government organizations (NGOs) such as the World Wildlife Fund or Conservation International. In some parts of the world, restoration is sponsored by local community-based organizations (CBOs) with local government, business, or philanthropic support. Yet others are sponsored by tribal communities on commonly held lands in remote rural regions with the assistance of agency personnel or other experts. A few projects are conducted by individual land owners and managers on their own initiatives.

Governments, transnational institutions, and larger NGOs commonly sponsor a variety of kinds of activities, probably all of them (except for restoration) with a clearly described end-product. The production of that end-product is ensured if the project sponsor generates carefully conceived plans and maintains careful quality control throughout the life of the project. Activities are conducted by technicians who must adhere closely to design criteria, contract specifications, and sometimes regulatory standards. The final product can be weighed, tested, or subjected to other empirical measures and evaluated according to criteria specified in project plans.

This approach is inappropriate for ecological restoration projects, where the end-product consists of a dynamic ecosystem consisting of living, interacting organisms and cannot be predicted with precision, at least at smaller spatial scales. The rationale for restoration is not to produce a single – or very few – services or products, such as a specific crop. Instead, ecosystems are restored to fulfill a wide array of tangible and intangible products and services. Nonetheless, larger institutions are managed in accordance with their internal protocols by professionals who may have never visited a restoration project site. Consequently, restoration is commonly treated as if it were an engineering function using steel, concrete, and other inert materials.

The product of restoration –an intact functional ecosystem– is a long-term investment of land and effort that must fulfill the values of those who stand to benefit from it. These values are personal and cultural, objective and subjective. They include ecological services of economic consequence, and they satisfy cultural needs such as serving as outdoor venues where ecological literacy of school children can be elevated. They are reservoirs of biodiversity. They allow restoration practitioners to find satisfaction in repairing what a previous generation had destroyed. The fulfillment of these and other values may be as important as the restored ecosystem itself, and some values could continue to provide fulfillment indefinitely for generations. Many values are not amenable to empirical measurement, and others can only be estimated indirectly. Therefore, the importance of all restoration projects that are conducted according to an engineering paradigm is necessarily underappreciated.

Obviously, sponsoring organizations must apply very different approaches towards conducting restoration and appreciating its results. One way would be to determine to what degree each of the seven bulleted items listed earlier in this section have been attained. Another would be to compare a completed restoration site with its pre-project condition or, alternatively, to its reference model, making allowances for differences in ecological age between them. A third approach is to develop short-term objectives which, if reached, would signal early development that should eventually lead to the achievement of project goals as indicated by the reference model. Another approach is to apply sociological criteria to evaluate the attainment of values. The approach to evaluation of a restoration project must be nuanced and requires sophistication that reflects project objectives and goals. If, for example, restoration was conducted to compensate for specified environmental harm, then the approach to evaluation should be to demonstrate compliance with relevant norms. If the rationale for restoration was to satisfy more broadly conceived cultural values, then the criteria should measure progress towards longer-term goals (Zedler 2007). An exercise of evaluation for forest restoration projects is developed in Chapter 4.

The conduct of the project also requires a different approach. Preconceived design criteria may prove to be ineffective, and mid-course corrections may be needed. Project goals may not be served by a strict technological approach. Instead, the restoration practitioner needs to have leeway for what Aldo Leopold (1949) called "intelligent tinkering". Ecosystems are quite complex, and they develop sequentially in a milieu of variable environmental conditions. A perceptive practitioner can "read" the landscape and administer corrections for problems that could not have been anticipated in the project planning stage. For this reason, project management requires flexibility, and project budgets should include funds for contingencies that can be made available quickly.

Planning Criteria

Restoration projects may seem simple enough, but they can be disarmingly complex. Scheduling, for example, requires knowing when weather and other conditions are favorable for each step in site preparation, when seeds can be gathered, and how long it will take for nursery stock to reach its prime for out-planting, as well as the usual complications to secure equipment when it is needed and to muster labor. The planning process includes an inventory of the project site prior to restoration in order to document its condition, determine appropriate strategies and methods of restoration, and later to assess the efficacy of restoration. Stakeholders should be notified and engaged in the project to the greatest possible extent. Otherwise, the value of the project may not be appreciated by local citizens, and it will garner disrespect instead of protection and stewardship. Pre-project monitoring of hydrological or other environmental conditions may be necessary in order to establish a baseline for project planning and evaluation. Selection of the reference model is another task that must be completed before project goals can be finalized and planning begun. In short, there are many steps to a restoration project. Ignoring any of them can be costly both in terms of time to completion and funding.

Recordkeeping is of considerable concern. A thorough photographic record is essential, including many photos of the project site prior to the implementation of project activities. Otherwise, the achievement and significance of restoration may be lost to all but a few practitioners. Other recordkeeping is helpful for orienting new personnel who are engaged midway through a project that could take a decade or more to complete.

Government agencies, transnational institutions, and larger NGOs commonly engage project planners who are not necessarily restorationists and who may never have the opportunity to work at the project site. Instead, they develop layers of GIS maps and use standard landscape designs and software to prepare as-built images. If a design group is engaged, they should work closely with the restoration practitioners who will be engaged to fulfill project plans. This is not always done, and the practitioners may not even be hired until the plans are complete. Practitioners can anticipate problems and conditions that may be invisible to professional planners. Their collaboration can prevent costly problems that could arise during project implementation.

The Society for Ecological Restoration International (SER) has developed a checklist and summarized scheme of the steps for any ecological restoration project (Clewell et al. 2005). This document is available on the SER website (www.ser.org), and was printed verbatim as an appendix by Clewell and Aronson (2007). We recommend that this checklist be employed in any ecological restoration project to ensure that all steps are undertaken and that none are missed. The document is designed for use by personnel at every level, from directors within the sponsoring organization to project managers and restoration practitioners in the field. Specific restoration techniques that are applicable in the Mediterranean region are described by Whisenant (1999) and Bainbridge (2007) (see also Chapter 8, this volume).

Some projects are local initiatives by CBOs, tribal councils, or individual property owners or managers. Such projects have the advantage that restoration practitioners have responsibility, authority, and control over all aspects of a project, and they are not beholden to an administrative hierarchy that can hinder project implementation if unanticipated events or misunderstandings occur. Furthermore, practitioners can work collegially to develop contingency plans or conduct “intelligent tinkering”. In addition, community based projects are particularly amenable to stakeholder participation and the development of stewardship organizations that will provide the completed project with protection, local management, local use and appreciation, and local political support. However, locally sponsored projects are commonly under-funded and hindered by inaccessibility to equipment and expertise and are necessarily small-scale and not particularly complex.

A better model, which already has some precedence and is worthy of serious consideration, is what we call the “inside-out” approach. Instead of a technocratic “top-down” approach whereby governments and other large institutions impose a bureaucracy that reduces the role of the practitioner to that of a field technician, or a “bottom-up” approach whereby CBOs are strapped by insufficient funds, expertise, and equipment, the “inside-out” approach combines the benefits both without retaining their drawbacks. The "inside-out" approach is so-designated because local people are working from within their own ecosystems to restore them (Waltner-Toews et al. 2003). Projects are established locally by CBOs as local initiatives and conducted primarily by local restoration practitioners. Large institutions (government agencies, transnationals, larger NGOs) enter into partnership with the CBOs to lend financial support, expertise, and specialized equipment, and also to provide a regional perspective to which the local project contributes. In this manner, these larger organizations or institutions operate in more of a collegial manner. The CBO is allowed some leeway to make its own mistakes and take corrective measures. The larger entities in the partnership can step in and rescue a project, at least temporarily, if the CBO or its restoration team falters or collapses for any reason. Stakeholder interest and engagement is optimal under this arrangement, and the values generated by a restoration project are maximized.

Acknowledgements

We thank Susana Bautista and Ramón Vallejo for many helpful comments on the manuscript.

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