# Evaluation of Forest Restoration Projects

4

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## Introduction: The need

There is a consensus on the need for the evaluation of restoration and management actions (see for example, Clewell and Rieger 1997, Holl and Cairns 2002, Machmer and Steeger 2002, Thayer et al. 2003, SER 2004, Vallauri et al. 2005). The lack of evaluation and subsequent dissemination of the results of restoration actions limits the application of the best technologies and approaches available. Restoration treatments and techniques are often applied without questioning their efficacy. The cost-effectiveness of the restoration actions, particularly in relation to varying environmental and socio-economic conditions, remains poorly documented. The practice of restoration requires much better use of the existing restoration expertise and information, as well as improved understanding on the impacts of restoration strategies on the target socio-ecological systems.

Evaluation is the key element linking restoration practice and the advances in restoration science and technology (Fig. 1). The practice of restoration provides useful settings for tests of ecological and restoration theory (Bradshaw 1987, Jordan et al. 1987, Young et al. 2005). Similarly, the evaluation of the cost-effectiveness of new techniques across a number of real-world restoration projects provides the framework for technological advance. Moreover, monitoring and evaluation are critical components of an adaptive management approach to restoration (Murray and Marmorek 2003, Vallauri et al. 2005, Aronson and Vallejo 2006). For a given restoration action, evaluation provides feedback for the fine-tuning of the treatments and techniques applied, and thereby helps address the uncertainty inherent to ecosystem dynamics (see Chapter 5, this volume). For the general practice of restoration, evaluation helps managers learn from past restoration efforts and adapt restoration strategies and techniques in response to spatial and temporal variation in environmental and socio-economic conditions. Evaluation is needed to establish cost-effective thresholds for the various management alternatives, and to identify priority areas where actions could be most effective. Last but not the least is the two-way connection between restoration practice and society through evaluation, which provides both the

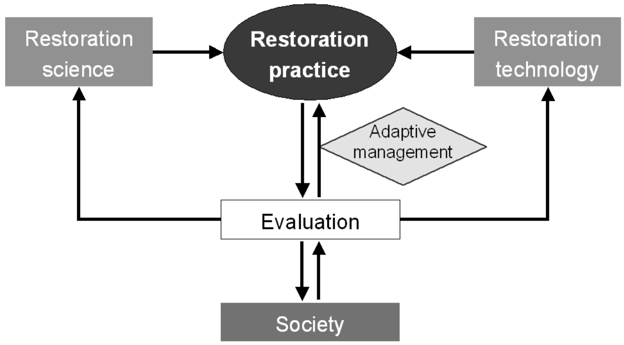


FIGURE 1. Schematic view of the linkages between restoration practice and restoration evaluation.

currency for disseminating the results and benefits of restoration and a way for incorporating social demands and perspectives into the restoration process.

Despite the unquestionable benefits associated with the evaluation of restoration actions, the actual number of restoration projects that are evaluated remains very low. Brooks and Lake (2007) examined records for 2,247 stream restoration projects in Australia and found that only 14% indicated that some form of monitoring was carried out. Berndhartd et al. (2005) reported than only 10% of >37,000 river restoration projects across the United States document any form of project monitoring, and little of this information is readily available for assessing the ecological effectiveness of restoration activities. Similarly, reforestation projects in the northern Mediterranean are rarely monitored and assessed (Bautista et al. 2010). As a result, restoration expertise remains under-utilised, hindering our capacity to incorporate what has been learned into future decision making. A number of recent review studies have addressed the need to evaluate the effectiveness of restoration actions (e.g., Maestre and Cortina 2004, Gómez-Aparicio et al. 2009, Rey Benayas et al. 2009, Bautista et al. 2010). These studies have provided useful information on the impacts of restoration on biodiversity and ecosystem functioning and have helped identify biotic and abiotic factors that determine the ecosystem response to restoration. However, as valuable as these independent studies can be, only regular feedback from the systematic evaluation of restoration projects provides the necessary inputs for adapting restoration strategies and techniques in response to environmental and socio-economic changes. Project evaluation should therefore be an integral component of any restoration action, and it should incorporate the active participation of managers and other restoration actors in the evaluation process.

Factors that impede incorporating evaluation into restoration efforts include the lack of long-term management programs for the restored areas and the all too common acritical assumption of theoretical paradigms (Cortina et al. 2006). Moreover, a more widespread and effective evaluation of restoration actions requires more work in developing, testing, and harmonizing evaluation tools and criteria (Aronson and Vallejo 2006). This chapter addresses this challenge by reviewing and discussing the state of the art on restoration evaluation, and presenting an integrated assessment protocol tailored to the long-term evaluation of forest restoration in the Mediterranean basin. Although most of the approaches discussed here are applicable to any type of restoration project, the chapter focuses on the evaluation of forest and dryland restoration to combat desertification.

## Evaluation approaches

The approaches for evaluating restoration actions are many, including, among others, comparisons between restored and non-restored areas or between restored and reference target areas (Brinson and Rheinhardt 1996, Gaboury and Wong 1999, Rey Benayas et al. 2009); comparisons with natural range of variability (Hobbs and Norton 1996, Parker and Pickett 1997, Allen et al. 2002); degree of achievement of restoration goals (Zedler 1995); degree of self-sustainability of the restored ecosystem (Lugo 1992, SER 2004); analysis of trajectories by establishing trends from periodic assessments of the restored area (Zedler and Callaway 1999); and comparative functional analysis of restored systems (Tongway and Hindley 1995, 2004). Most of these approaches can be grouped into one of the following main types: (1) measuring the achievement of specific goals and stages, (2) direct comparison with reference sites or between restoration alternatives, and (3) assessment of ecosystem quality. The three categories partially overlap, as both restoration goals and quality indicators are commonly defined in relation to some sort of reference. In practice, there are particular pros and cons associated with the implementation of each of these evaluation approaches (see below).

### *Achievement of restoration goals and evaluation*

Perhaps the most obvious evaluation approach is to measure the degree of achievement of the proposed objectives. Indeed, it is well-established in the literature that evaluation criteria need to relate back to specific restoration goals and explicit expectations (e.g., Aronson et al. 1993, Toth and Anderson 1998, Hobbs and Harris 2001). Ideally, based on the general goals of the restoration project and on the knowledge and understanding of the ecology of the system, explicit predictions are made of expected responses by biotic and abiotic ecosystem components that will then be monitored for evaluation (see Chapter 5, this volume); in turn, designing the appropriate monitoring and evaluation program helps refine and explicitly state the project specific objectives. In some cases, expectations could be written as statements of testable hypotheses, so that evaluation could simply be based on testing one or more null hypotheses (Thayer et al. 2003). However, less clearly defined objectives are more common for most restoration efforts.

Poorly-defined objectives for evaluation may result from our limited understanding of the processes and factors, as well as the biotic interactions and assemblages that control ecosystem dynamics, which in turn limits the definition of the specific outcomes that could be expected from the restoration actions implemented. On the other hand, much of the recent scientific evidence suggests that ecosystems do not always undergo predictable and more or less gradual trajectories (Westoby et al. 1989, Zedler and Callaway 1999). Indeed, ecosystems can exhibit threshold dynamics, change between alternative metastable states, or suddenly develop in an entirely new direction (Hobbs and Norton 1996, Scheffer and Carpenter 2003, Rietkerk et al. 2004, Suding et al. 2004, Bestelmeyer 2006, Suding and Hobbs 2009). Restoration projects may therefore result in a wide range of potential outcomes, some of them being quite unpredictable. Several studies have suggested different approaches that take into account the uncertainty in space and time about restoration outcomes. These include establishing ranges of variability for target attributes, or a range of different potential targets that would be acceptable (e.g., White and Walker 1997, Allen et al. 2002, Palmer et al. 2006); setting goals that recognize multiple end points, considering new models of ecosystem dynamics (Suding and Hobbs 2009); and, in all cases, setting realistic expectations acknowledging the rather unpredictable nature of ecosystem dynamics and the possibility of multiple trajectories (Palmer et al. 2006, Choi 2004). The fact that restored ecosystems are not static also points to the need for establishing the suitable time frame in which to assess the achievement of the various stages envisioned. Depending on the specific type of project, defining several phases and associated goals may be appropriate (Aronson and Vallejo 2006).

Both the social context and the knowledge framework are dynamic, and each influences restoration decisions and objectives. Social values play an important role in defining restoration goals (Diamond 1987, Davis and Slobodkin 2004, SER 2004). Changing socio-economic conditions and new environmental problems can alter the social demands placed on wildlands and, accordingly, new restoration goals emerge. For example, since the 1990s, mitigating climate change has become a core objective of afforestation and reforestation programs worldwide. In the past, the main objectives of reforestation projects in the northern Mediterranean were wood production, soil protection from erosion, and flood control (Vallejo et al. 2006, Bautista et al. 2010); while in the last decades the objectives have shifted to other ecosystems goods and services of perceived socio-economic and ecological benefit, such as improvement of water quality, recreation, improvement of wildlife habitats, fire prevention, biodiversity conservation, etc. Many projects that could be considered as highly successful in meeting originally established objectives, would meet none or very few of the current social demands regarding biodiversity conservation and ecosystem services.

### *Reference systems for restoration evaluation*

Restoration ecologists usually advocate the use of target or model communities as reference systems to set restoration goals and evaluate restoration success (e.g., Aronson et al. 1993, Aronson and Le Floc'h 1996, Brinson and Rheinhardt 1996, White and Walker 1997, Ruiz-Jaen and Aide 2005). This idea, which is also stated by the SER Primer on Ecological Restoration (SER 2004), has been embraced by a number of restoration monitoring guidelines produced by environmental agencies (see, for example, Davis and Muhlberg 2002, Thayer et al. 2003). A reference system is any ecosystem or landscape showing the structure and function that is expected for an area to be deemed successfully restored. Given natural variability, some authors suggest the assumption of variation in the selected reference system, incorporating information from diverse sources extending across the ranges of ecological variation possible (e.g., White and Walker 1997, Allen et al. 2002).

Reference conditions are commonly defined in terms of compositional and structural elements. A restoration process aimed at reconstructing a prior ecosystem and re-establishing former communities is, however, a very difficult task, particularly at the landscape level (Henry and Amoros 1995, Hobbs and Norton 1996, Bradshaw 1997, van Diggelen et al. 2001). Several authors have called for an alterative approach based on evaluation criteria that focus on the functional aspects of the reference system, using specific services or certain functions as reference conditions (e.g., Brinson and Rheinhardt 1996, Choi 2004). Falk (2006) proposed to replace the more static concept of reference conditions by reference dynamics: a process-centered approach that places emphasis on ecological functions and ecosystem processes.

Historical data on pre-disturbed conditions or remnants of historic natural areas are common forms of target references (Holl and Cairns 2002, Hobbs and Harris 2001). However, candidates for natural reference areas in the Mediterranean basin, after centuries of land use and degradation, are very scarce (Vallauri et al. 2002, Aronson and Vallejo 2006). Moreover, several studies point to the usefulness of using historical data as reference information given the dynamic nature of communities in a changing environment and socio-economic context (Pickett and Parker 1994, Hobbs and Norton 1996, Choi 2004). Without denying that success stories exist, Hilderbrand et al. (2005) pointed out that much of the field evidence does not support that restored ecosystems will return to their pre-disturbed state, and warned against this assumption as it is used to justify exploitation of natural resources in undisturbed environments. Zedler and Callaway (1999) reported that few created or restored wetlands achieved structure or function equivalent to existing wetlands. Similarly, a recent meta-analysis review of 89 restoration assessments by Rey Benayas et al. (2009) reported that ecological restoration increased provision of biodiversity and ecosystem services by 44 and 25%, respectively. However, values of both remained lower in restored versus intact reference ecosystems, at least in decadal time scales.

Some studies suggest that rather than focus on restoring to some primeval state, a more profitable approach for restoration would be to focus on repairing damaged systems to the extent possible, considering both the ecological potential for restoration and societal desires (Higgs 1997, Hobbs and Harris 2001). In this approach, the pre-restored, degraded system can be considered as the reference with which to evaluate restoration. Defining the degree of improvement that could be considered a success is the particular challenge of this approach. Some degraded systems have shifted to a new state that is reinforced by internal feedbacks and cannot be restored to the previous state unless certain thresholds are passed (Whisenant 1999, Suding et al. 2004). Knowledge about these restoration thresholds is still very scarce (Maestre et al. 2006). Furthermore, due to the many interactions involved, a single predictive threshold value seems unlikely to emerge (Bestelmeyer 2006), which limits the definition of reference target values for evaluation.

Finally, evaluation can be centred on the comparison of restoration alternatives. This approach does not rule out including either intact reference systems or degraded pre-restored systems within the set of compared cases. Methods for generic functional analyses (e.g., Tongway and Hindley 2004, Herrick et al. 2005) and cost-benefit analyses (Macmillan et al. 1998, Kirk et al. 2004) are of particular interest for comparative restoration evaluation, as they provide indices that can be directly comparable across restoration sites differing in area or scale.

Whatever the references or restoration alternatives used for comparison, the selection of the variables to be assessed is key to the evaluation process. The structural and functional attributes of ecosystems do not always linearly covary, nor do the environmental and socio-economic impacts and constraints of restoration actions (Cortina et al. 2006, Rey Benayas et al. 2009). Therefore, when comparing between the restored area and the selected references and/or alternatives, results may vary greatly depending on the variables considered.

### *Evaluation as quality assessment*

This approach is related to existing tools and methods for ecosystem monitoring and assessment, which typically consider a wide set of attributes to evaluate ecosystem status and integrity. For example, WWF-World Wide Fund for Nature and IUCN-International Union for Conservation of Nature have developed an approach to landscape assessment of forest quality that can also be used to evaluate restored forests. This method is based on the following criteria: (1) Authenticity - including composition, pattern, functions, processes, and management practices; (2) Forest health - including health of trees and other forest flora and of fauna, and robustness to changing environmental conditions; (3) Environmental benefits - including biodiversity and genetic resource conservation, and soil and watershed protection; (4) Social and cultural values - including wood and non-timber products, employment and subsistence, recreation, and historical, cultural, aesthetic and educational values (Dudley et al. 2006).

The SER Primer (SER 2004) provides a list of nine ecosystem attributes as a guideline for measuring restoration success. The first attribute bases success on the similarity between the restored area and the reference sites, while the rest of the attributes can be considered as quality indicators (e.g., presence of indigenous species; presence of functional groups necessary for long-term stability; integration with the landscape; resilience to natural disturbances; self-sustainability) that focus on the actual condition of the restored area regardless comparisons with reference sites. Some of these attributes are perhaps too generic for being directly assessed and must be viewed as framework criteria for developing specific quantitative indicators.

In this approach, the restored area is assessed through a variety of quality indicators that reflect current social demands, yet they may not be the original target attributes considered by the restoration project. When no real, existing reference is available, or when there is no adequate information about pre-restored conditions, this approach can be the appropriate framework for evaluation.

### *Evaluation as information systems*

All the approaches above implicitly consider restoration evaluation as the evaluation of restoration success (Hobbs and Harris 2001). However, restoration success is a subjective and somehow unclear and elusive concept (Zedler 2007) that does not fully recognize and accommodate the many potential sources of variation and uncertainty concerning restoration outcomes, such as, for example, existing knowledge gaps on the ecological theory that supports the selected restoration strategies; the inherent uncertainty associated with both the on-the-ground implementation of restoration projects and the natural dynamism of the restored areas; the tradeoffs between ecosystem services; or the diverse, even contrasting perspectives among the various stakeholders. There are many contexts where measuring success is nevertheless feasible and appropriate. Thus, there are cases in which objectives or reference values for the attributes of interest, as well as their acceptable range of variability, are well defined and hence the meaning of *success* is clarified.

Rather than merely following a success *vs* failure approach, evaluation may be viewed as a process of creating information and knowledge on the restoration actions implemented, providing a more or less comprehensive and multifaceted description of the restoration outcomes. This approach considers evaluation as an information system that collects and provides useful data on ecosystem and landscape responses to restoration. It can therefore support any other approach to evaluation. According to this view, evaluation should rely on the widest range possible of attributes and perspectives, provided they are relevant (see the REACTION protocol below). The challenge for this approach is to organize and integrate the profuse information in a harmonized way, allowing conclusions to be drawn, avoiding redundant information, and keeping the number of attributes assessed manageable in practical terms.

## What to evaluate? Selection of attributes and indicators[1] for evaluation

A large number of qualitative and quantitative variables can be used to evaluate a restored ecosystem. Since the choices may affect the interpretation of restoration outcomes, the selection of variables for evaluation is often a thorny issue to address. Evaluation criteria have evolved parallel to changes in conceptual frameworks and perspectives for restoration, which have in turn been reflected in the type of attributes and indicators selected for monitoring and assessment. Thus, traditional evaluation approaches that commonly focused on technical aspects of compliance success (e.g., seedling survival rates in forest plantations; Alloza 2003),

1. Here the term indicator refers to any biophysical or socio-economic variable or statistic used to assess land condition.

have given way to approaches that also include structural and functional indicators of ecosystem health and integrity (Xu et al. 2001, Ruiz-Jaen and Aide 2005). Moreover, given the profound connections existing between the ecological and the socio-economic systems (Turner et al. 2003, Liu et al. 2007), it is increasingly recognised that the assessment of land condition must be based on both biophysical and socio-economic attributes (MEA 2005), which also applies to the evaluation of restoration actions (SER 2004, Zucca et al. 2009).

Irrespective of the biophysical or socio-economic attributes assessed, the selected indicators should be relevant, be sensitive to variations of environmental stress, respond to stress in a predictable and scientifically justifiable manner, but also be simple and measurable with a reasonable level of effort and cost (Dale and Beyeler 2001, Jorgersen et al. 2005). Because of the large spatial and temporal variability of ecosystems, particularly in drylands, recent studies suggest focusing ecosystem assessment on 'slow' variables (Carpenter and Turner 2000), both biophysical and socio-economic (e.g., soil fertility, market access), as high variability in 'fast' variables may mask fundamental trends and long-term changes (Reynolds et al. 2007). Similarly, the variables used should have low spatial variability – outside of recognised gradients.

In defining an evaluation approach and selecting the appropriate indicators, there are a number of key aspects to consider that concern the number of indicators, their spatial and temporal scope of application, and the scale, methods, and resolution of the measurements. Obviously, the options chosen largely depend on the objectives of the restoration project, but also on the conceptual framework that underlies the evaluation approach to be followed. Evaluation approaches based on few site-specific indicators would fit restoration projects with relatively straightforward, project-specific objectives or projects that are applied to a particular and relatively small piece of land over a limited period of time. For example, the local recovery of the population of certain species is often the primary goal of restoration, due either to ecological, economic or cultural reasons. The achievement of such a specific goal can be assessed through the monitoring of few indicators related to the dynamics and sustainability of the target population (Bash and Ryan 2002). Similarly, if the objective in a restoration project is to reduce the abundance of an invasive species and enhance the performance of a number of target native species, then evaluation should measure the abundance (e.g., cover, biomass) of the invasive species and the response (e.g., seedling survival, cover, growth, etc.) of the native species before and after treatment (Hartman and McCarthy 2004). However, the selection of appropriate indicators is not so straightforward for projects with more general goals, or for projects that apply to a relatively broad geographic area (i.e., to the landscape scale).

The ultimate goal of many ecological restoration projects is to recover ecosystem health and integrity, to return ecosystem structures, functions, and processes to reference conditions, and/or to enhance the provision of ecosystem goods and services (SER 2004, Blignaut and Aronson 2008). Which metrics should be used to evaluate projects with such general objectives? There is no universal prescription for what to measure in order to describe the ecosystem response to ecological restoration. In general, the spectrum of alternatives ranges from project-specific options to more broadly applicable selection of indicators, and from simple indicators of ecosystem integrity to indicator suites of a large variety of attributes (Fig. 2). In making these choices of evaluation approaches and indicators, there are several trade-offs to consider. On the one hand, the use of single indicators of ecosystem integrity can be a very cost-effective option that reduces monitoring effort, but it requires a profound knowledge of how well the indicator represents the structural and functional conditions expected for the restored system. Furthermore, the loss of information when many variables are integrated into a single index could mask real differences between management and restoration options. On the other hand, the more site- or project-specific the indicators, the more useful the resulting information for local managers to adjust restoration practice within an adaptive management framework. However, the evaluation results of such a tailored approach would apply only to the site and conditions under study, hindering the applicability to broad geographic areas and the comparison of restoration strategies across a variety of sites and regions.

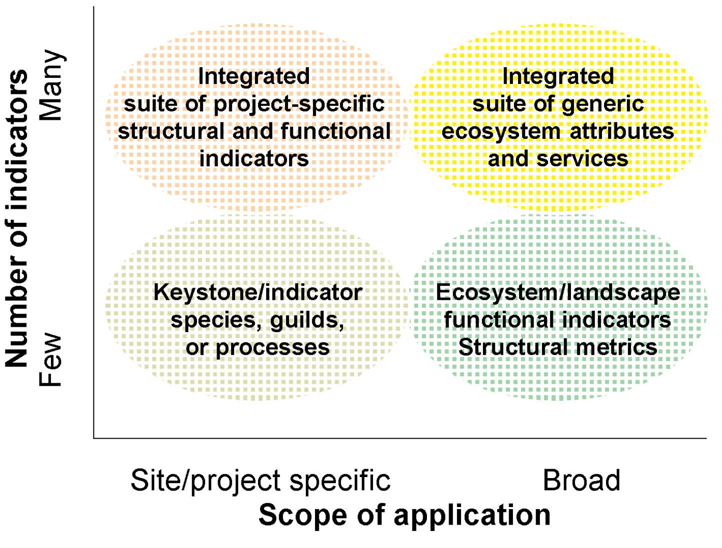


FIGURE 2. General range of alternatives for ecological evaluation of restoration projects as defined by the number of indicators and their scope of application.

## *Evaluation approaches based on few holistic indicators*

Simplification towards essential indicators that could characterise ecosystem recovery adequately is obviously a cost-effective approach to evaluation. For example, measures concerning indicator species, umbrella species, guilds, or assemblages of indicator species are often used as surrogates of ecosystem function and integrity (e.g., Williams 1993, Patten 1997). The structural and functional requirements of indicator species should reflect the conditions expected in the restored ecological system. This approach requires the development of a conceptual model that outlines the structure of the community, including interrelations among ecosystem components (Block et al. 2001). Therefore, the accurate use of these indicators depends on a high level of knowledge of the target system. Although evaluation protocols based on indicator species are relatively site-specific, when based on general taxa or guilds (e.g., bird populations, biological crusts) they could be applied to a broad range of sites and project types (Neckles et al. 2002, Bowker et al. 2006).

General indicators of community structure, such as species richness, diversity, and evenness, can also be used for evaluating general ecosystem response to restoration (e.g., Reay and Norton 1999, Passell 2000, Gómez-Aparicio et al. 2009). These structural indicators may or may not accurately reflect the recovery of ecosystem function (Ryder and Miller 2005), and, of course, do not take into account species identities and their potential role as keystone species, noxious weeds, or any other particular role played by single species or functional groups. However, recent results indicate that biodiversity is positively related to the ecological functions that support the provision of ecosystem services in restored areas (Rey Benayas et al. 2009). Biodiversity assessments typically focus on particular biota, ranging from general groups (e.g., plants, vertebrates, herbaceous species) to specific taxa or guilds (e.g., butterflies, resprouting shrubs), often resulting in a combined approach based on biodiversity and indicator taxa (Kerr et al. 2000).

Vegetation cover and composition are the most common metrics used for evaluating restoration projects, as it is often assumed that the recovery of fauna and ecological processes will follow the establishment of vegetation (Ruiz-Jaen and Aide 2005). Since vegetation cover is relatively easy to assess, it is commonly used as a surrogate of ecosystem functions and habitat quality (Reay and Norton 1999, Robichaud et al. 2000, Wilkins et al. 2003, Wildham et al. 2004). However, vegetation cover alone cannot always reflect how well an ecosystem is functioning. For example, a number of studies in semiarid areas have shown that shape, spatial orientation and arrangement of plant patches within a landscape greatly influence hydrological functioning (e.g., Ludwig et al. 1999, Puigdefábregas 2005, Bautista et al. 2007).

During the last decade, a variety of functional assessment approaches that assume a tied relationship between semiarid ecosystem functioning and the spatial pattern of vegetation have been proposed. The theoretical framework for these approaches considers that landscapes occur along a continuum of functionality from highly patchy systems that conserve all resources to those that have no patches and leak all resources (Ludwig and Tongway 2000). Some of the functional assessment methods are based exclusively on single vegetation/soil pattern attributes (Bastin et al., 2002; Ludwig et al., 2007; Kéfi et al. 2007, Mayor et al. 2008), while others also incorporate properties relative to the soil surface condition (Tongway and Hindley, 2004; Herrick et al., 2005). For example, the “Landscape Functional Analysis” (LFA) methodology (Tongway and Hindley, 1995, 2004) assesses ecosystem functional status through a set of easily recognizable soil and landscape features, from which indices of infiltration, stability and nutrient cycling are derived. These indices are expected to reflect the status of water conservation, soil conservation, and nutrient cycling processes in the target ecosystems.

## *Evaluation approaches based on large suites of indicators*

On the other end of the spectrum of options (Fig. 2) is evaluation based on a relatively large suite of indicators aimed to present a more comprehensive diagnosis of the restoration effects. An integrated suite of indicators may be specific for certain sites, problems or project types (Keddy and Drummond 1996, Davis and Muhlberg 2002, Palmer et al. 2005) or may mostly rely on general metrics that can be used for assessing a wide range of cases. Several authors have promoted approaches that combine both general and case-specific indicators (e.g., Neckles et al. 2002, Jorgersen et al. 2005). The use of multiple indicators maximizes the amount and variety of information provided on the restored area and is the best approach possible when there is not sufficient scientific knowledge to support the use of single holistic indicators as proxies for the function and integrity of the target ecosystem.

Numerous authors have proposed lists of attributes that can be used as conceptual frameworks for designing ecological restoration projects and evaluating restoration success (e.g., (Ewel 1987, Aronson and Le Floc'h 1996, Hobbs and Norton 1996, SER 2004, Palmer et al. 2005). The SER Primer (SER 2004) proposed a list of nine attributes that includes diversity and other structural properties (such as presence of indigenous species and presence of functional groups necessary for long-term stability), and general ecosystem functions (such as resilience to natural disturbances and self-sustainability). Ruiz-Jaen and Aide (2005) supported the use of the SER attributes, but promoted a simplified framework that considers three main categories: diversity, vegetation structure, and ecological processes. Although these attributes and categories provide a useful basis for guiding the selection of indicators for evaluation, they need further specification to be readily assessed through site-specific criteria (Choi 2004). There has been a greater emphasis on biophysical criteria for evaluating the outcomes of restoration efforts, while socio-economic indicators are less addressed. Because of its focus on provision of services is directly linked to human well-being, the conceptual development by the Millennium Ecosystem Assessment (MEA 2005) has provided a robust integrated framework for evaluation. Nevertheless, there still is a great need for practicable methodologies that integrate biophysical, socio-economic, and cultural indicators (See REACTION approach below).

## *Scale and resolution for indicator assessment*

To address the widest scope of restoration effects on ecosystems, landscapes, and society, as well as their cross-scale interactions, a multiscale approach to evaluation is always advisable. For example, regarding forest restoration projects, a stand- or site-scale assessment may focus on technical aspects, structural and functional ecosystem attributes, and on a market-based economic valuation perspective (prized goods and services), while landscape- and regional-level indicators would describe general impacts on the environment and public/social welfare (Fig. 3). Similarly, short-term evaluation may rely on technical and ecological indicators that communicate implementation and compliance success, allow for predicting the likelihood that a function is occurring, help identify problems, and guide

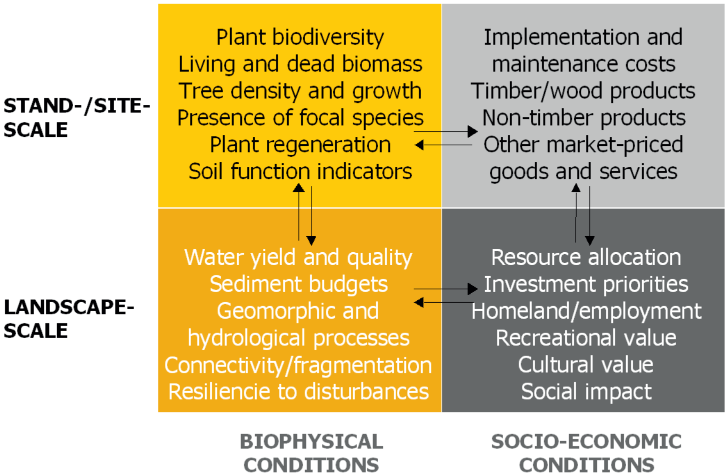


FIGURE 3. Example of a multi-scale integrated framework and indicators for evaluating forest restoration projects.

adaptive management. For example, early assessment of seedling survival and growth in reforestation projects can help predict the likelihood that the desired forest structure is eventually achieved, and allow for corrective actions if needed (see Chapter 5). However, most restoration projects require a number of years for some expected processes and dynamics to take place and, therefore, goal achievement and general structural and functional quality of the restored areas should be evaluated using long-term assessment data.

As with any ecological study, the choice of spatial and temporal resolution for the monitoring and evaluation depends on the variables and questions being addressed (White and Walker 1997, Block et al. 2001), but also on the decisions made by the practitioners regarding the trade-off between the effort needed and the information provided. Assessment methods range from simple, qualitative assessments based on field observations (e.g., a high-medium-low ranking system, photo-points, visual estimates) to relatively complex protocols based on quantitative measurements of critical ecosystem attributes (Machmer and Steeger 2002). Regarding the time frame for monitoring, assessment methods range from single-time assessment to continued observations designed to assess trajectories and account for the interannual variability of ecosystem functions.

The relatively recent extraordinary development and accessibility of products from global and regional scale remote-sensing (RS) systems have led some international bodies to recommend the integrated use of RS-based geospatial information with ground-based observations to assess vegetation and soil condition (MEA 2005, ICCD/COP8/CST 2007). Indeed, there is an increasing use of RS technology to trace land condition at the landscape scale (Díaz-Delgado et al. 2002, Roder et al. 2008, van Leeuwen et al. 2010), though its utility for assessing the efficiency of restoration actions remains limited (van Leeuwen 2008).

## An integrated protocol for the evaluation of forest restoration in the northern Mediterranean: The REACTION approach

Since the late-19th century, and particularly during the first half of the 20th century, significant national-scale attempts to restore degraded drylands were implemented in the northern Mediterranean countries. These efforts were mostly based on large afforestation and reforestation programs (see Chapter 1). In many cases, the restoration strategy relied on the introduction of fast-growing pioneer species, with the assumption that these species would then facilitate the introduction of late-successional hardwoods (Pausas et al. 2004). The main species planted were native pines, such as *Pinus brutia*, *P. halepensis*, *P. nigra*, etc., though exotic species also were planted. As a whole, these large-scale reforestation programs constitute an impressive testing ground for assessing restoration strategies and techniques. However, most reforestation actions were not followed up with subsequent monitoring and the results obtained have rarely been assessed (Gómez-Aparicio et al. 2009). Since the real outcome of a reforestation project can only be evaluated comprehensively in the long term, i.e., after several decades, the projects implemented during the 19th and 20th centuries offer a unique opportunity to assess the potential of reforestations as tools for restoring Mediterranean forests. Acknowledging this opportunity, the REACTION project (Restoration Actions to Combat Desertification in the Northern Mediterranean)[2], has recently developed an integrated approach to evaluate forest and woodland restoration actions in the northern Mediterranean. The REACTION evaluation protocol (http://www.gva.es/ceam/reaction) was not only conceived as an evaluation methodology but also as an information system designed to compile and disseminate the information derived from the restoration projects evaluated.

The evaluation of old reforestation projects entails major difficulties such as the lack of monitoring data, the lack of reference sites, and the highly heterogeneous, and often very scarce, information available about project goals and implementation. In addition, the originally established goals commonly meet none or few of the current social demands regarding ecosystem services. To address these challenges, the REACTION approach combines three main evaluation criteria: (1) degree of achievement of specific initial project objectives, (2) comparative analysis between pre-restoration degraded conditions and current conditions, and (3) analysis of current quality of the restored system irrespective of initial project goals. Furthermore, the REACTION protocol has been designed as a broad framework that uses a wide variety of indicators, optimising the use of existing available information and requiring minimum field assessment. The selected indicators relate to ecosystem integrity and services, and to socio-economic and cultural attributes that are relevant for Mediterranean conditions.

The REACTION protocol includes eight sections (Table 1). Sections I to IV provide context information on the site and the restoration project, while sections V to VII address the

2. REACTION was funded by the European Commission under the Fifth Research, Technology, and Development Framework Programme, and involved research groups and forest managers from Freece, Italy, France, Portugal, and Spain.

evaluation of the restored area. Most of protocol considers a landscape perspective for evaluation, as many of the expected biophysical and socio-economic impacts of forest restoration projects appear at the landscape scale. However, sections IV and V compile context and evaluation data for any single restoration unit[3] or stand included within the project, and are meant to be replicated as many times as the number of restoration units in the project.

To allow for analysis of the conditions and technical approaches that influence restoration outcomes, data on the environmental and socio-economic context and on the

TABLE 1. General structure of the REACTION evaluation protocol.

| | |
|---|---|
| I. GENERAL INFORMATION | 1. GENERAL DESCRIPTION<br>2. DATA SOURCES |
| II. SITE DESCRIPTION | 1. CLIMATE<br>2. TOPOGRAPHY<br>3. GEOLOGY<br>4. SOILS<br>5. ECOLOGY<br>6. DEGRADATION IMPACTS AND DRIVERS |
| III. RESTORATION PROCESS | 1. GOALS<br>2. PLANNING<br>3. COST AND FINANCING<br>4. GENERAL TECHNICAL DESCRIPTION<br>5. MONITORING AND ASSESSMENT<br>6. ENVIRONMENTAL OR TECHNICAL UNITS |
| IV. TECHNICAL DESCRIPTION BY RESTORATION UNITS | 1. UNIT DESCRIPTION<br>2. SPECIFIC ENVIRONMENTAL CHARACTERISTICS<br>3. PROMOTION OF AUTOGENIC RESTORATION<br>4. PRIOR ACTION ON BRUSH VEGETATION<br>5. SITE PREPARATION<br>6. PLANTING AND SEEDING<br>7. FIELD TREATMENTS/MAINTENANCE WORKS/ MANAGEMENT |
| V. ASSESSMENT BY RESTORATION UNITS | 1. PLANTATION/SEEDING RESULTS<br>2. STRUCTURE AND BIODIVERSITY<br>3. FUNCTIONS AND PROCESSES<br>4. STAND/UNIT HEALTH |
| VI. PROJECT ASSESSMENT | 1.LANDSCAPE AND ENVIRONMENTAL ASSESSMENT<br>2.SOCIO-ECONOMIC ASSESSMENT |
| VII. EVALUATION SUMMARY | |
| VIII. EXPERT JUDGEMENT | |

3. Restoration unit refers to any area or stand within the restoration project area that present particular enviromental (e. g., microclimate, geology, soil type) or technical (e. g., treatment applied, implementation date) characteristics.

technical characteristics of the restoration project are core to the evaluation protocol. Thus, section II of the evaluation protocol describes the climate, topography, geology, soils, and ecosystems, as well as the main degradation impacts and drivers in the target restoration area. Section III organizes the available information on project design and implementation through a set of questions about goals, planning, financing, and other technical details (Table 2). Finally, section IV describes specific environmental characteristics and technical details of the restoration action for each stand or landscape unit within the restoration project.

The assessment of the restoration units and/or forest stands within the restored area provides information on plantation/seeding results, ecosystem structure and diversity, ecosystem functions and processes, and stand health (Table 3). This biophysical evaluation focuses on the current quality of the restored ecosystems, taking into account recent advances in indicators for land quality assessment (see, for example, WWF 2002). The structural quality of the restored area is measured through a number of biodiversity, key species and spatial pattern indicators. The functional evaluation relies on indicators that reflect hydrological and nutrient cycling processes, as they are particularly relevant for the conservation of limiting resources in Mediterranean degraded and desertification-prone lands.

Project evaluation at the landscape level encompasses both biophysical and socio-economic assessment (Table 1). Landscape and environmental assessment provides information on the distribution of ecosystem types in the area; the presence and types of protected areas; landscape pattern (habitat connectivity/fragmentation); visual impacts; and flooding and erosion assessment at the catchment/landscape scale as compared with pre-restoration conditions. The socio-economic assessment focuses on information about land use, ecosystem goods and services, employment, and the recreational, educational, and cultural values of the restored land (Table 4).

Finally, section VII summarizes the project evaluation by grouping the information provided by the large variety of indicators considered in the previous sections into a small suite of categories that represent ecosystem structure and services (Table 5). This final summary contributes to the standardization of project evaluation, facilitating comparisons among projects and context conditions.

In addition to assessing the restoration projects through the various sections and indicators described above, the REACTION protocol includes a process where expert overall judgments of both natural resource managers and researchers involved in the evaluation of the restoration project are obtained. This provides insights not readily available in the assessment of the data and facilitates the engagement between researchers and managers.

Major innovations of the REACTION protocol are the large amount of detailed information compiled on well-documented restoration projects; the integrated approach to evaluation, and the regional (Mediterranean) scope. The REACTION evaluation methodology has been applied to 40 forest restoration projects implemented in Greece, Italy, France, Spain, and Portugal, ranging in size from ~100 to 3,500 ha. The projects aimed mostly to restore pine forests and mixed pine-oak forests and are representative examples of the varied approaches to forest restoration in the northern Mediterranean. A key outcome of the REACTION project was the Database for Mediterranean Restoration Projects (http://www.ceam.es/reaction), an open-access database that includes the projects compiled and evaluated.

TABLE 2. Questionnaire for the description of the design and implementation characteristics of a restoration project (section III in the REACTION evaluation protocol).

| III. RESTORATION PROCESS (DESIGN AND IMPLEMENTATION) |
|---|
| III.1. RESTORATION GOALS |
| **1. What were the general project's defined objectives?** |
| **2. Project scope:** ☐ Restoration programme ☐ Pilot project ☐ Research ☐ Educational ☐ Other |
| **3. Structure goals:** a) Target biological communities/ecosystems to be restored:<br>b) Does this project target the protection or conservation of specific species? *Species*:<br>c) Does this project try to introduce a species as part of restoration or conservation efforts?. List species:<br>d) Does this project try to eradicate a species as part of restoration or conservation efforts?. List species:<br>e) Other structural goals (e.g., promote understorey cover, increase growth, establish forest mosaic, etc): |
| **4. Functional goals and expected ecosystem services:**<br>☐ Agriculture production ☐ Biodiversity conservation ☐ Fire control ☐ Air quality<br>☐ Forestry production ☐ Wildlife habitat ☐ Weed control ☐ $CO_2$ sink<br>☐ Grazing/pasture lands ☐ Flood control ☐ Seed source ☐ Other:<br>☐ Hunting ☐ Erosion control ☐ Water quality |
| **5. Goals at landscape level:**<br>☐ Increase connectivity ☐ Increase landscape diversity ☐ Increase forest surface ☐ Rural planning ☐ Other: |
| **6. Which ecosystem goods were expected to be obtained/increased?**<br>☐ Wood products: ☐ Animal products:<br>☐ Non-timber forest products (e.g., edible mushrooms, aromatic plants, etc.): ☐ Others: |
| **7. Was the enhancement of the recreational/tourist/cultural value of the area a specific goal?** If yes, provide details: |
| **8. Was the creation of jobs a specific goal?** If yes, specify number and type (permanent/seasonal): |
| III.2. PLANNING |
| **1. Main stages provided for the control/reduction of degradation causes (passive restoration)?**<br>When and for how long were these stages to be carried out? |
| **2. Main stages provided for the field work (active restoration)?**<br>When and for how long were these stages to be carried out? |
| **3. Does the forest have a management plan?** If yes, what is the legal/policy framework? |
| III.3. COST, FINANCING, AND PARTICIPANTS |
| **1. Project cost and financing**<br>a) Total cost of implementation (Euros): Ref. Date: c) Sources of financing:<br>b) Average annual cost for maintenance (Euros): Ref. Date: d) Other relevant information: |
| **2. International, national or regional programmes and/or plans related to the project:** |
| **3. Agencies/groups involved in the project**: |
| III.4. GENERAL TECHNICAL DESCRIPTION |
| **1. Structures and facilities developed (if any) within the project**. Describe: |
| **2. Has any traditional technology been applied?** Describe: |
| **3. Has any innovative technology been applied?** Describe: |
| **4. Are there any quality standards for the seedlings?** Describe: |
| **5. Are there quality standards for the work?** Describe: |
| **6. Are there defined success criteria for the project?** Describe: |
| III.5. MONITORING AND ASSESSMENT |
| **1. Was there any monitoring/assessment carried out?** If yes,<br>a) Which elements were taken into account?: ☐ Technical ☐ Ecological ☐ Socio-economic<br>b) At what intervals/period was the monitoring carried out? c) Describe briefly the monitoring methodology: |

TABLE 3. Questionnaire for the technical and ecological assessment of restoration projects by means of the REACTION protocol.

## V. ASSESSMENT BY RESTORATION UNITS*

| **1. Project acronym/code** (see I.11b): | **2. Unit number/code** (see IV.1.2): | **3. Reference (assessment) date:** |
|---|---|---|

### V.1. PLANTATION/SEEDING RESULTS

*Indicate the average or the most representative data for each variable (when applicable) and species.*

**1. Have the performance standards for the seeds/seedlings been attained?** *(Only if there were quality standards)*
☐ Yes ☐ No ☐ Partly ☐ Unknown

**2. Have the performance standards been attained for the work (site preparation, plantation,...)?**
☐ Yes ☐ No ☐ Partly ☐ Unknown

| | | | | |
|---|---|---|---|---|
| **3. Plant cover (%)** | Total: | Tree species: | Shrub species: | Herbaceous species: |
| **4. Above-ground biomass (kg/ha)** | Total: | Tree species: | Shrub species: | Herbaceous species: |

| **5. Species used** For each species used, indicate: | by planting | by seeding | a. Survival (%) | b. Density (individuals/ha) | c. Cover (%) | d. Height (m) | e. Diameter at breast height (cm) | f. Basal diameter (cm) *(only for young plants)* | g. Wood volume (m3/ha) | h. Natural regeneration? (yes/no) | i. Average age (years) | j. Age distribution: Mixed – young | j. Age distribution: Mixed – old | j. Age distribution: Mono |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ☐ | ☐ | | | | | | | | | | ☐ | ☐ | ☐ |

### V.2. STRUCTURE & BIODIVERSITY

**1. Stand/unit age:** ☐ Old ☐ Mature ☐ Young

**2. Tree canopy structure:** ☐ Multi-layered ☐ Mono-layered ☐ Absence of tree layer

**3. Understorey:** ☐ Varied and multi-layered ☐ Herbaceous layer and scatter woody plants ☐ Absent ☐ Other
Describe:

**4. Spatial distribution of trees:** ☐ Regular ☐ Slightly clumped ☐ Patches and gaps

**5. How natural is the composition of tree species?** ☐ Fully ☐ Partly ☐ Exotic

**6. How natural is the composition of other species?** ☐ Fully ☐ Partly ☐ Exotic

**7. List the alien species present, if any:**

**8. Cover of resprouter species:** Total: Tree species: Shrub species:

**9. Biological inventories:** *Please list species inventoried and indicate number of species by taxa*, if available

| **Taxa** *For each taxa, indicate:* | **a) Before the project. Reference date:** | **b) After the project. Reference date:** |
|---|---|---|
| | Inventory: | Inventory: |
| | Dominant species: | Dominant species: |
| | Rare / Endangered / Threatened / Protected: | Rare / Endangered / Threatened / Protected: |
| | Total number of species inventoried: | Total number of species inventoried: |

**10. Absence of keystone or dominant species that would be expected**: ☐ Yes ☐ No ☐ Unknown
If yes, please list:

**11. Are any functional groups (shrub layer, annual legumes, perennial grasses, etc.) missing or endangered?**
☐ Yes ☐ No ☐ Unknown. If yes, please list:

**12. Presence of key species indicative of ecosystems at particular succesional stage**: ☐ Yes ☐ No ☐ Unknown
If yes, please list:

**13. Presence of key species indicative of integrity of food webs:** ☐ Yes ☐ No ☐ Unknown
If yes, please list:

**14. Are there any genetic data available**: ☐ Yes ☐ No ☐ Unknown
If yes, please list:

* This section is meant to be applied to each restoration unit in the restored area.

TABLE 3 (cont.). Questionnaire for the technical and ecological assessment of restoration projects by means of the REACTION protocol.

| V. ASSESSMENT BY RESTORATION UNITS | | | | | |
|---|---|---|---|---|---|
| **1. Project acronym/code** (see I.11b): | | **2. Unit number/code** (see IV.1.2): | | **3. Reference (assessment) date:** | |
| V.3. FUNCTIONS & PROCESSES | | | | | |
| **1. Are there significant amounts of dead wood present in varying stages of decomposition?**<br>☐ Snags ☐ Down logs ☐ Not significant | | | | | |
| **2. Average organic horizon thickness (cm):** | | | | | |
| **3. Soil surface conditions:**<br>Bare soil (%):<br>Degree of soil sealing/crusting: ☐ None ☐ Slight ☐ Moderate ☐ Severe<br>Presence of significant patchy or continuous biological crust? ☐ Yes ☐ No | | | | | |
| **4. Erosion/accumulation type**<br>☐ None<br>☐ Sheet erosion<br>☐ Rill erosion<br>☐ Gully erosion<br>☐ Badlands<br>☐ Accumulation<br>☐ Wind erosion/deposition<br>☐ Others (describe): | | | **5. Erosion/accumulation intensity**<br>☐ Nil<br>☐ Slight<br>☐ Medium<br>☐ Moderate<br>☐ Severe<br>☐ Extreme | | |
| **6. Stand dynamics**<br>Succesional dynamics measured or observed (e.g., abandoned crop→gorse shrubland→pine forest→mixed forest):<br>a) Since the project implementation: → → → →<br>b) Of non-restored reference area nearby during the same period: → → → → | | | | | |
| **7. Did any relevant disturbance, such as fire, severe drought/frost, floods, pollution event, etc., affect the restored unit since project implementation?** ☐ Yes ☐ No ☐ Partly | | | | | |
| **8. Disturbance regime and Regeneration pattern** (for each major disturbance recorded in the area, indicate)**:**<br>Disturbance type:<br>Date/s (year/s):<br>Autosuccesion (yes/no): | | | Relevant composition change (yes/no):<br>Relevant land degradation (yes/no):<br>Describe regeneration pattern: | | |
| **9. Any available data on stand productivity/carbon sequestration?** Describe: | | | | | |
| V.4. STAND/UNIT HEALTH | | | | | |
| **1. Are there significant pests, diseases or invasive species?** ☐ Yes ☐ No | | | | | |
| **2. Are there significant damages caused by abiotic factors?** ☐ Yes ☐ No | | | | | |
| **3. Species affected** | **4. Dead trees/shrubs** (None, Some, Many) | **5. Degree of defoliation** (None, Slight, Moderate, Severe) | **6. Degree of discoloration** (None, Slight, Moderate, Severe) | **7. Main abiotic factor causing the damages** | **8. Main biotic factor causing the damages** |

* This section is meant to be applied to each restoration unit in the restored area.

TABLE 4. Questionnaire for the socio-economic assessment of restoration projects by means of the REACTION protocol.

| VI.2. SOCIO-ECONOMIC ASSESSMENT |
|---|
| **1. What types of exploitation were and are most common in the area?** For each type, provide:<br>1- % of project area before* the project (*Indicate the reference date):<br>2- % of project area at present:<br>3- Date of abandonment (if applicable): |
| **2. Does significant grazing take place in the project area?**<br>Indicate species and livestock population (data on past, present and projections for future, if available) |
| **3. Are timber and other wood products exploited?:**<br>a) Type of timber and other wood products (species): b) Volume produced/year:<br>c) Is timber and other wood products felled for use by local people?. If yes, describe: |
| **4. Are non-timber forest products gathered?**<br>a) Products gathered:<br>b) What is their economic importance? (high/medium/low):<br>c) Does hunting take place? |
| **5. Employment**<br>a) Did project implementation works generate jobs for the local population?<br>b) Does the restored area provide jobs at present? ☐ Yes ☐ No ☐ Occasional ☐ Permanent. Describe:<br>c) Number (approximate) of people employed in the restored area? Occasional/year:_____ Permanent:_____ |
| **6. Homeland**<br>a) Are people living in the restored area? Indicate type of lifestyle: ☐ Indigenous ☐ Settled ☐ Part-time/Second home<br>b) Human population dynamics in the project area in the last 20 years:<br>Type (increase/decrease): ____ Rate of change (low/medium/high): ____ |
| **7. Recreational and educational value**<br>a) Uniqueness of particular sites within the restored area? If yes, describe:<br>b) Do people use the restored area for recreation?<br>c) Average number of visitors/year (*approximate value*):<br>d) Presence of tourist or educational facilities (*visitor centre, guide trails,...*): If yes, list number and types:<br>e) Types of activity (walking, hunting,...)<br>f) Is the area used for scientific work? If yes, describe: |
| **8. Cultural value**<br>a) Does the project area have particular significance to local inhabitants?<br>b) Are there important cultural or religious sites present in the project area?: (*World Heritage sites, sacred groves, trees, burial sites, buildings,...*). List sites, types, designations and indicate if they have official protection:<br>c) Presence of culturally important landscapes: *(land management, grazing system,...)*. Describe:<br>d) Are there references in folklore, literature, etc. to the project area?<br>e) After the project implementation, were there any negative impacts to cultural sites/landscapes? Explain briefly:<br>f) Have the cultural sites/landscapes been protected in the framework of the project? |
| **9. Local participation**<br>a) In relation to the project, the local population has a position of?<br>☐ Participation ☐ Indifference ☐ Opposition ☐ Boycott<br>b) Are local people involved in decisions about the project area?<br>c) What is the nature of participation?<br>d) Has a participatory approach been implemented concerning local people's perception of the project?<br>Was it intended to make the population:<br>- more sensitive to risks (wildfires, floods, erosion, etc.)? ☐ Yes ☐ No ☐ Unknown<br>- more aware of the advantages of ecological restoration? ☐ Yes ☐ No ☐ Unknown<br>- other? (Please specify) |

TABLE 5. Summary table for the evaluation of restoration projects by means of the REACTION protocol.

| VII. SUMMARY* | |
|---|---|
| **VII.1. ACHIEVEMENT OF PROJECT GOALS** | |
| **1. Have the defined success criteria been attained?** (Yes/No/There were not defined success criteria)<br>-Only for some restored units and/or criteria. Describe: | |
| **2. Have the structural goal(s) been attained?** (Yes/No/ Partly/Only for some units). Describe: | |
| **3. Have the functional goal(s) been attained?** (Yes/No/Partly). Describe: | |
| **4. Have the landscape goal(s) been attained?** (Yes/No/Partly). Describe: | |
| **5. Have socio-economic goals been attained?** (Yes/No/Partly). Describe: | |
| **6. According to survival and growth of planted/seeded species, the plantation/seeding success was:**<br>(Very high / High / Medium / Low /Very low) | |
| **VII.2. STRUCTURAL QUALITY** | |
| **1. How natural is the composition of the restored ecosystem(s)?** (Fully/Partly). Explain: | |
| **2. How natural/mature is the structure and pattern of the restored ecosystem(s)?** (Fully/Partly). Explain: | |
| **3. Presence of important biodiversity** (Yes/Medium/No): | |
| **4. In the restored area, the project has:** (increased / decreased / conserved biodiversity) | |
| **VII.3. FUNCTIONAL QUALITY** | |
| **1. Ecosystem dynamics:** | Does the restored ecosystem regenerate naturally? (Yes / Not fully). Explain:<br>Do natural successional dynamics occur? (Yes / No /Partly). Explain: |
| **2. Overall functioning**: | How are the soil characteristics? (Stable / Slightly degraded / Seriously degraded)<br>How is the potential for nutrient cycling? (High / Medium / Low)<br>How is the ecosystem productivity? (High / Medium / Low) |
| **3. How is the overall ecosystem health?**<br>☐ Good *(No relevant pests, diseases, invasive species, or dead/damaged plants by abiotic factors)*<br>☐ Medium *(Some individuals affected; low severity level)*<br>☐ Poor *(Relevant pests, diseases, invasive species, or dead/damaged plants by abiotic factors)* | |
| **4. The project significantly increases:** | Resistance (e.g., to grazing, pests, fire, drought): ☐ Yes ☐ No ☐ Partly<br>Resilience (e.g., to fire, pests, drought, etc.): ☐ Yes ☐ No ☐ Partly<br>Erosion control: ☐ Yes ☐ No ☐ Partly<br>Flood control: ☐ Yes ☐ No ☐ Partly |
| **VII.4. LANDSCAPE QUALITY** | |
| **1. The project significantly increases:** | Forest surface: ☐ Yes ☐ No ☐ Slightly<br>Connectivity of formerly isolated populations: ☐ Yes ☐ No ☐ Slightly<br>Integration among forests and other habitats: ☐ Yes ☐ No ☐ Slightly<br>Habitat diversity: ☐ Yes ☐ No ☐ Slightly<br>The protected surface: ☐ Yes ☐ No ☐ Slightly |
| **2. Aesthetic value:** | ☐ Very high ☐ High ☐ Medium ☐ Low |
| **VII.5. SOCIO-ECONOMIC BENEFITS** | |
| **1. Cultural value:** | Does the project area have particular cultural significance to local inhabitants? ☐ Yes ☐ No<br>The project has ☐ increased ☐ decreased ☐ preserved ☐ created ☐ damaged the cultural value of the site<br>Degree of local participation: ☐ High ☐ Medium ☐ Low |
| **2. Has the project generated ecosystem goods for the local population?** ☐ Yes ☐ No<br>Amount of timber and non-timber goods provided: ☐ Very high ☐ High ☐ Medium ☐ Low | |
| **3. Has the project enhanced ecosystem services?** ☐ Yes ☐ No Describe: | |
| **4. Does the project contribute to fix/support/increase rural population by increasing tourist and recreational value, by direct employment, or by providing homeland?** ☐ Yes ☐ No ☐ Slightly | |

* The answer of each question is meant to be derived from the information compiled in the respective previous sections and items.

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