REACTION
Restoration Actions to Combat Desertification in the Northern Mediterranean

METHODOLOGIES AND INDICATORS FOR THE EVALUATION OF RESTORATION PROJECTS

Proceedings of the first REACTION workshop
13 - 15 June 2003
Alicante, Spain

Deliverable D1

RESTORATION **ACTION**S TO COMBAT DESERTIFICATION IN THE NORTHERN MEDITERRANEAN (REACTION)

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Authors:	*R.V. Vallejo, S. Bautista, J.A. Alloza, J. Cortina, L. Rojo-Serrano, A. Vilagrosa, J. Aronson, D. Vallauri, C. Fontaine, D. Tongway, G. Enne, R. Scotti, A. Hatzistathis, P. Ganatsas, M. Madeira, A.Fabiao, D. Gabiña, J.C. Delgado, A. Aradottir, E. Rojas*

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Foreword

The REACTION workshop on "Methodologies and Indicators for the Evaluation of Restoration Projects" was held in Alicante (Spain) from 13th to 15th June 2003. The workshop was organised by CEAM Foundation and the University of Alicante (Spain). It was jointly organised with two other EC-project workshops, MEDRAP workshop on "Prevention and Mitigation to Combat Desertification in the Northern Mediterranean" and SCAPE workshop on "Challenges Facing Soil Conservation in Europe", in the framework of the Energy, Environment and Sustainable Development Programme of DG RTD.

Thirty-two people participated in the REACTION workshop, 21 experts and 11 stakeholders, from France, Greece, Italy, Portugal, Spain, Turkey, and Australia. The workshop was inaugurated by J. Gómez (General Director of Forest Resources. Conselleria de Medi Ambient. Regional Government), A. Marcilla (Research vice-chancellor of the University of Alicante), and M. Millán (Director of CEAM Foundation).

REACTION workshop included two main plenary sessions and a field trip to a restoration pilot area in Albatera (Alicante). The opening lecturer by David Tongway (Sustainable Ecosystems, CSIRO Canberra, Australia) gave an overview on the *Landscape Function Analysis Monitoring Procedure* and fostered the discussion on the nature and evaluation of degradation and restoration processes, and on the implementation of monitoring programs. Susana Bautista (University of Alicante) and José Antonio Alloza (CEAM Foundation) presented the key elements of the *REACTION questionnaire*, a tool for capturing and evaluating restoration projects. Myriam Martín (DGCN, Spain), Daniel Vallauri (WWF, France), Roberto Scotti (IATF, Italy) and Athanassios Hatzistathis (AUTH, Greece) presented advances in the search for suitable REACTION restoration projects in Spain, France, Italy and Greece, respectively.

The second session was devoted to the presentation and discussion of position papers on "Restoration measures to mitigate the consequences of desertification processes". Ramón Vallejo (CEAM Foundation, Spain) analysed ecosystem restoration strategies from the conceptual and technical perspectives. The position paper presented by James Aronson (CNRS, France) focused on evaluation criteria and methodology for the future use of foresters, park managers, and other users.

The round-table session entitled *Methodology for the Evaluation of Restoration Projects*, chaired by R. Vallejo, addressed key questions on objectives, indicators, methods, spatial and temporal scope, and target conditions for the evaluation of restoration projects. Following the workshop, major achievements and agreements on a common methodology for the evaluation of restoration projects were discussed, refined, and developed by REACTION National Working Groups and were incorporated to the final version of the REACTION Questionnaire (REACTION Deliverable D2).

The proceedings consist of five chapters and present the main conclusions resulting from REACTION workshop (Chapter 1), the opening lecturer by David Tongway (Chapter 2), REACTION position papers on restoration strategies, evaluation and monitoring (Chapters 3 and 4) and the restoration pilot area in Albatera (Chapter 5)

Ramón Vallejo, Susana Bautista, and Jordi Cortina

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Chapter 1

Conceptual framework, criteria and methodology for the evaluation of restoration projects: general conclusions

REACTION consortium
Rapporteurs: J. Cortina and S. Bautista
Dpt. of Ecology. University of Alicante, Spain

Introduction

The efficiency of restoration initiatives can be improved through the evaluation and transfer of technologies that are environmentally sound, economically viable, and socially acceptable. To approach the evaluation of restoration efforts in the northern Mediterranean from ecological, economic and socio-cultural perspectives, there is a need of incorporating recent advances on indicators and restoration methodologies, of defining the fundamental information needed and of harmonising evaluation protocols.

REACTION consortium aims at defining suitable analytical framework, criteria and methodology for the evaluation of restoration projects in the Northern Mediterranean, by reviewing and adapting recent advances on indicators and through the exchange of information between experts and stakeholders.

During the first REACTION workshop on Methodologies and Indicators, and the discussion period that followed the workshop, the key elements of the REACTION analytical framework for evaluation of restoration projects, and also the main structure and contents of the REACTION Questionnaire, were defined. The following sections report major agreement achieved.

Should the term restoration be precisely defined to avoid confusion?

There was a general agreement in keeping an open concept of restoration in REACTION, leaving room for a wide range of restoration approaches, from the promotion of autogenic restoration to a variety of reforestation actions, but avoiding extreme cases such as mining sites at this stage.

Current and original objectives of restoration projects

In the past, main objectives of reforestation were wood production, soil protection from erosion and water flow management. However, in the last decades the objectives have been moved to the achievement of socio-economic benefits, goods and services, such as soil protection, water quality, recreation, improvement of wildlife habitats, etc.

Both, original and current objectives should be taken into account, as the objectives defined when the project was conceived may not necessarily match current environmental perspectives and social demands.

On indicators and the REACTION questionnaire

Indicators of restoration success should include ecological, environmental, socio-economic and cultural attributes and must be simple, measurable, and sensitive to small changes in ecosystem trajectory, as expressed in structure and/or functioning.

The protocol for evaluation should include not only indicators conceived from the side of the observers but take the stakeholder's perspective, though both approaches may not coincide.

Indicators of regional land use such as population density, amount of forest and woodland surface area, etc., cultural indicators, precise socio-economic indicators, including ecosystem goods, etc. have been proposed (see Aronson et al, these proceedings). However, common concerns about the questionnaire focused on the excessive information and difficulties in dealing with socio-economic data, and therefore the protocol should find the suitable trade-off between information and simplicity.

Functional analysis is strongly recommended. The outputs of this type of analysis, such as Landscape Functional Analysis (D. Tongway, these proceedings), could be transferred to stakeholders through roundtable discussions and regulations.

There is a clear need of formulating clear unambiguous questions in the questionnaire.

On the criteria to judge the success of restoration

The criteria will include: (1) ecosystem quality attributes, based on recent advances on forest and land quality indicators, measuring actual quality of restored ecosystems, and (2) comparative functional approach, taking into account the original conditions of the restored sites.

Evaluation methodology should address environmental constraints and restoration technology applied. Stand, landscape, and holistic ecosystem perspectives are to be considered. Efforts should be made to integrate the results.

Overall environmental and technical description of the restored area will be useful for assessing the constraints and opportunities of restored sites, attending degree of degradation/conservation, and sensitivity to degradation impacts.

Should target conditions be defined?

J. Aronson suggested that if target conditions were to be defined for a given landscape during the evaluation process, they should be based on a set of parameters (as R.J. Hobbs has done in Australia). According to D. Tongway, this is true but difficult at this stage. He considered that target conditions could be an output of the project rather than a framework for evaluation.

On the application of the evaluation protocol

The evaluation system has to be simple and flexible, to cope with the different levels of data availability, and broadly generalisable to other systems and situations across a range of ecological, and socio-economic conditions.

After testing REACTION questionnaire, a suitable version may be prepared to be used for routine evaluation of restoration practices, and thus as a tool for adaptive management of Mediterranean woodlands.

Chapter 2
Landscape Function Analysis: a System for Monitoring Landscape Function

David Tongway

CSIRO Sustainable Ecosystems, PO Box 284, Canberra City, ACT 2601

Abstract

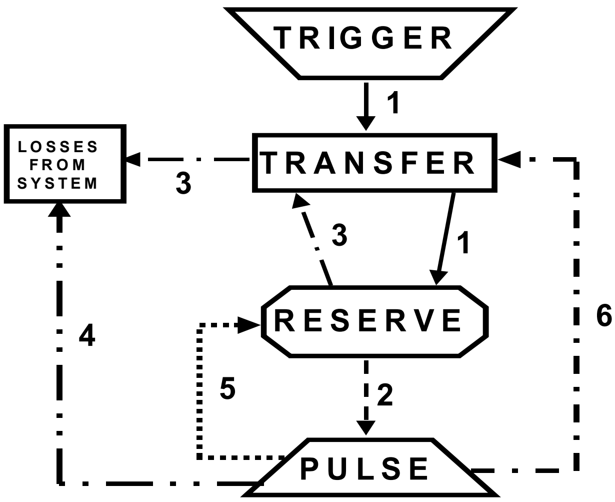
Landscape Function Analysis (LFA) is a monitoring system that uses quickly determined field indicators to assess the functional status of landscapes. As such, it complements existing procedures that assess species composition and /or abundance. It is comprised of three modules: a conceptual framework, a field methodology and an interpretational framework. It is intended to be used to generate chronosequences of data so the trends over time can be assessed. The conceptual framework is based on the “economy of vital resources” and focuses on the processes that regulate the spatial distribution and use of limiting resources. The field methodology uses indicators demonstrated to be well-related to a range of physical and biological processes and taking only a few seconds per indicator to assess in the field, with practice. Observations of system dynamics are made in two spatially nested scales (hillslope and patch). A software template generates a series of index values reflecting landscape function at both scales. The interpretational framework, based on an S-shaped response surface linking the least and most functional examples of a given landscape type. It facilitates the prediction of target values in rehabilitation and the proximity of monitored sites to a critical threshold that distinguishes “sustainable” from “unsustainable” management/climate combinations. The procedure enables critically vulnerable processes to be identified, so that rehabilitation procedures can be appropriately designed. LFA has been developed, tested and implemented in a range of climate types (200 to 4000 mm rainfall per year) and land-uses (pastoralism, mining, nature conservation, redesigning agriculture)

1. Introduction

Landscape monitoring has typically been descriptive: restricted to evidence provided by a narrow range of biota or associated with theories of plant succession (Golley 1977, Brown et al 1998). In addition, these methods have not been designed to directly address how to rehabilitate landscapes needing action. Methods have also been largely tied to pastoralism as the only or main land-use. This situation is now changing, with a broader societal use of rangelands and a groundswell of public opinion demanding attention to degradation and biodiversity issues. Monitoring and comparing landscapes on an inter-regional and national basis in, for example, the Australian National Land and Water Audit, would be better facilitated if a single assessment procedure were widely applicable and the data directly comparable. Walker (1996) called for an understanding of how rangelands function by building conceptual models. Ludwig and Tongway (1997) presented a systems-based framework (trigger-transfer-reserve-pulse — TTRP, Figure 1) for the way in which rangelands function, based on how landscapes function to conserve and utilise scarce resources. This framework also facilitated the development of more detailed simulation models (Ludwig and Marsden 1995, Ludwig Tongway and Marsden 1999), enabling the role of these models to be seen in a wider, landscape context.

2. Method Development

The TTRP framework represents a sequence of landscape processes and feedback loops in an inclusive manner, enabling the structuring of environmental information. Methods to assess soil productive potential linked to plant performance had been developed to a certain stage (Tongway and Smith 1989, Ludwig and Tongway 1992), but needed the spatial and inter-regional context to become more useful to potential stakeholders. The "surface soil condition"(SSC) indicators were initially developed from geomorphic processes such as erosion, crust formation, litter decomposition and correlates observed in the field. The validity of these indicators was enhanced by laboratory experiments (Műcher et al. 1988, Greene et al. 1994) and field measurements (Tongway 1993, Greene 1992). These studies showed that the indicators had reliable relationships with measured variables such as infiltration rate, aggregate stability soil respiration and plant productivity. Spatial analysis of a number of landscape types (Ludwig and Tongway 1995) that identified patches where resources tend to accumulate and interpatches, where resources tend to be lost, suggested a landscape organisational context by which the soil indicators could be packaged for use at the hillslope scale for different landscape types.



Ref	Process
1	Run-off/Run-on processes within system, Storage/Capture, Infiltration, Deposition, Saltation capture
2	Plant germination, growth, Nutrient mineralisation, Uptake processes
3	Run-off into streams, Rill flow and erosion, Sheet erosion out of system, Wind erosion out of system
4	Consumptive processes: Herbivory, Fire, Harvesting, Deep drainage
5	Seed pool replenishment, Organic matter cycling/Decomposition processes, Harvest/Concentration by soil fauna
6	Physical obstruction/Absorption processes

Figure 1. The TTRP framework representing sequences of ecosystem processes and feedback loops. The table lists some of the processes operating at different locations in the framework.

In 1992-1995, National Soil Conservation Program funding brokered by Agriculture Western Australia facilitated the development of extensively applicable methods, integrating soil surface condition procedures with the emerging TTRP framework. This resulted in a nested hierarchical information organising system using rapidly acquired field assessment data The method was overtly linked to land system resource map bases and protocols (e.g. Mc Donald et al 1990, Mitchell et al. 1988; many others). We overtly recognised land units as sub-units within land systems, and the monitoring sites were located within explicitly defined land units.

3. The Method in Operation

"Landscape organisation" of the hillslope is the coarsest form of LFA data acquisition and is the first step in data collection. Data are collected on a line transect oriented in the direction of resource flow (usually down slope, but aeolian landscapes would use wind direction). Landscape features that tend to accumulate mobile resources are called "patches", and the intervening areas, where resources flow freely and/or are mobilised by overland flow are assessed. The rules for this step outlined in the technical methods manual (Tongway 1994, Tongway and Hindley 1995, 2004). Typically, the respective line intercept lengths of both patches and interpatches are measured, as well as the "obstruction width" of the patches (Figure 2). These data provide a "map" of the line transect in terms of resource regulation. Five indices of landscape function at the hillslope scale are derived:

(i) the number of patches per unit length of line transect,
(ii) the area of the patches (m2),
(iii) the patch area index (proportion of patches),
(iv) the mean interpatch length and
(v) the range in interpatch length

These data are used to monitor landscape function over time.

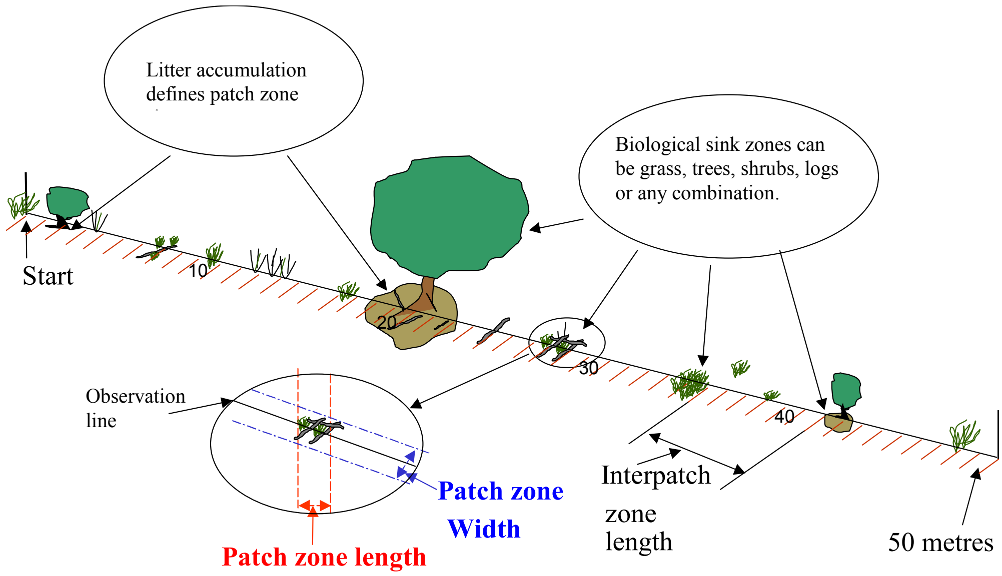


Figure 2. A diagram showing the types of resource obstruction that might be encountered on a landscape organization line transect.

In the second step, in each zone type, 11 soil surface indicators are assessed by observation on 1-m line transects located in five randomly selected areas on each patch and interpatch type, using rules for each indicator set out in the technical method manuals. These are called soil surface condition indicators (SSC). These indicators were developed to address all the processes identified in the TTRP conceptual framework. These observations are both simple and quick (typically 5-10 seconds each) after a little practice. Vegetation properties (such as density, species composition, size) are typically collected from the same transect as a separate data set using plotless, distance-measuring techniques (Bonham 1979) such as point-centred quarter and wandering quater, as well as indicators of habitat complexity for mammals and birds (Newsome and Catling 1979).

Turning Data into Information

An Excel template (Tongway and Hindley 2004, http//www.cse.csiro.au/research/program3/efa/) takes the raw field indicator data and produces tables of site functional properties. The SSC indicator data are used in three different combinations to reflect indices of soil productive potential: stability or resistance to erosion, infiltration/water holding capacity and nutrient cycling (Figure 3). The data are presented as percentage values. These data are expressed both at the individual patch scale as well as at the hillslope scale, by using the landscape organisation data to calculate the contribution of each patch/interpatch type.

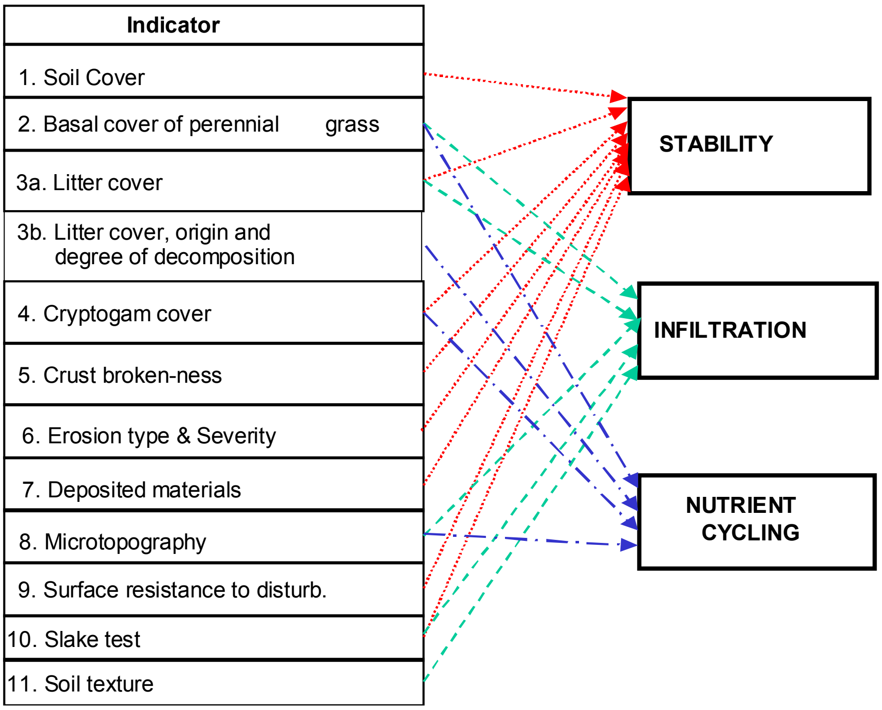


Figure 3. SSC indicators are merged in different combinations to produce emergent indices of soil productive potential.

4. Relationship of LFA Indices to Measued Variables

The three indices have been tested on a range of landscape types with rainfall varying from 200 to 4000 mm hr-1 and land uses that include extensive grazing, minesite rehabilitation, conservation of biodiversity and cropping practices, using existing published measurement types commonly used in soil science to measure soil properties and correlated the indices with the measured soil variables. When used across the full dynamic range of each indicator, we obtained good relationships across the range of landscape types and management regimes. The equations representing the correlations did not have the same coefficients across landscape types, but Fig. 4 indicates the quality of the "within landscape type" relationships.

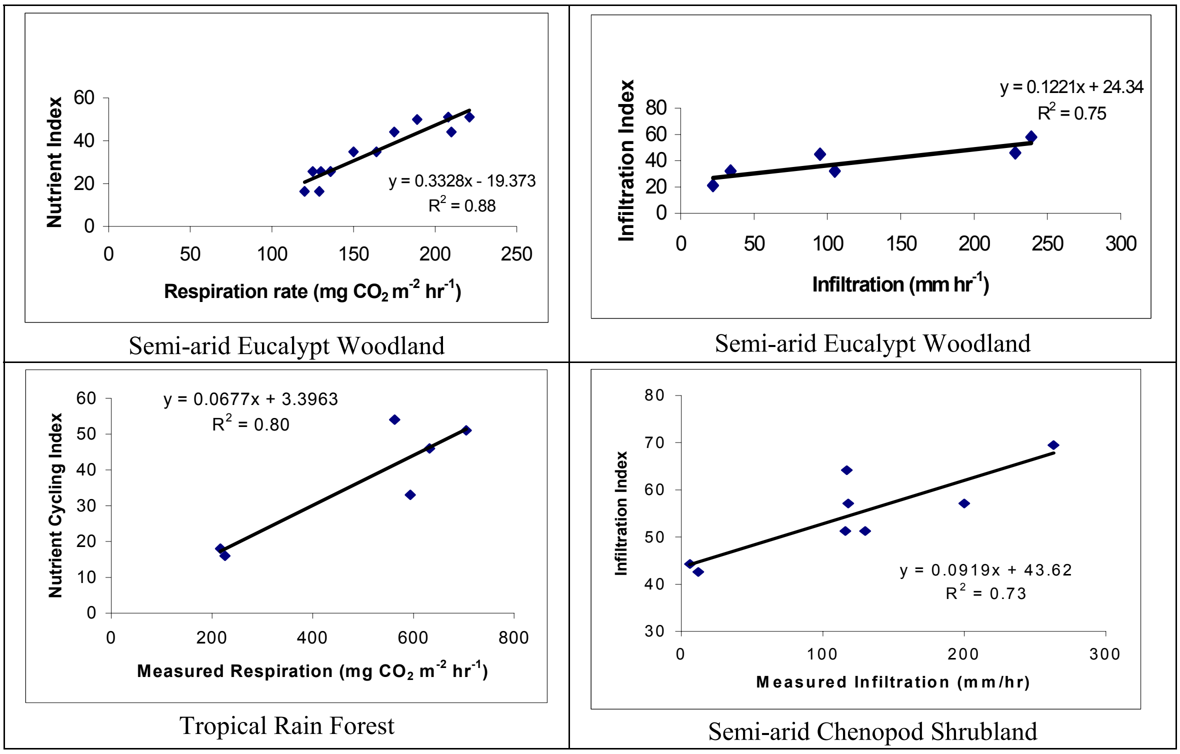


Figure 4. Relationships between LFA indices and measured soil variables in three contrasting landscape types.

5. Interpretational framework

These landscape indices need to be interpreted in the whole landscape context to make the most use of their information potential. With extensive experience, one might be able to place useful interpretations on each of the index numerical values, but this is a slow and haphazard process. The most recent development in LFA is the process whereby a response surface in the form of a sigmoidal curve is generated from field data (Tongway and Hindley 2000). The curve relates functional status with variation in stress and disturbance. To fit this curve, one needs data from both extremes of the available data space as well as intermediate values representing "typical" sites. The response surface (Figure 5, Tongway and Ludwig 2002) recognizes the upper asymptote as the "biogeochemical potential" of the site limited by climate and parent material and the lower asymptote as the lower limit of function under the existing land use stress. The slope of the line joining the asymptotes reflects the "robustness" or "fragility" of the system. The initial response of landscape function to stress and/or disturbance is markedly different. The fragile landscape deteriorates with low levels of applied stress and has a much lower base line, y0, then the more robust landscape. Four-parameter sigmoid curves of the form y = yo + a / 1 + e -(x-x□)/b provide four practical values reflecting the nature of the landscape. Critical thresholds (arrows) for each of the indices can be determined from field data.

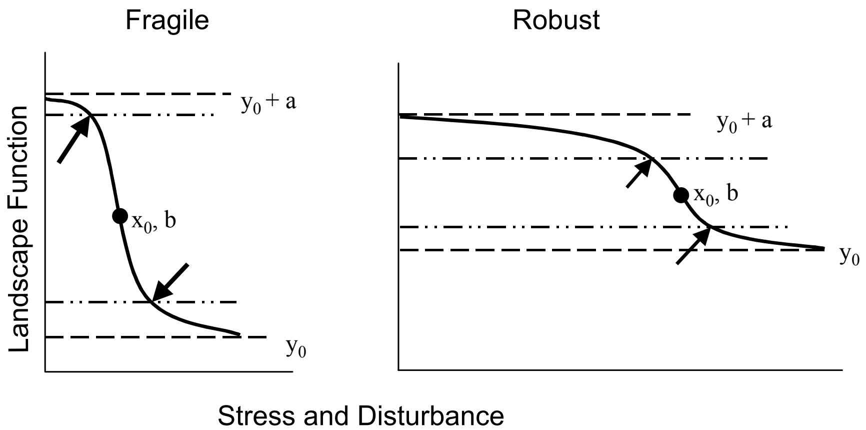


Figure 4. Examples of response curves for fragile and robust landscapes. The initial response of landscape function to applied stress/disturbance is markedly different. The fragile landscape deteriorates with low applied stress and has a much lower base vale (Y_0) than the robust landscape. Critical thresholds (arrows) for each LFA index can be determined by curve analysis.

6. Application of LFA data.

1. Rangelands. LFA can be used to examine rangeland functional state over time and against stochastic events like fire, flood or storm, to see whether a critical threshold has been approached or exceeded. The value of knowing the biogeochemical potential and the most disturbed site LFA index values enable a proper context for interpretation to be formed, particularly if a "fragile" site type is encountered. Such a site would require more careful or more frequent assessment than sites shown to be "robust" under its management regime. When plant cover is very low or absent, the amount of residual function can still be discerned.

2. Minesites. LFA has been useful in following the temporal development of rehabilitation on minesites (FigX). Here, the use of reference or analogue sites is very useful to obtain LFA values to act as ecological targets to reach to use for regulatory purposes. The temporal record also strengthens the ultimate case for bond return where satisfactory rehabilitation has been demonstrated by the development of the sigmoidal response curve.

3. Landscape design. LFA can identify critical missing processes in dysfunctional landscapes and thus enable appropriate rehabilitation procedures to be designed. This is not usually a feature of many other indicator systems that look only at identifying degradation. Most procedures concentrate on just assessing the degradation state alone without a causal link to biophysical restitution either implicit or explicit

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Chapter 3
The problem of evaluation and monitoring

James Aronson[1], Daniel Vallauri[2], and Christelle Fontaine[1]

[1]CEFE/CNRS
[2]WWF-France

1. Restoration - needs and challenges in the Mediterranean region

Reforestation and afforestation in degraded lands, including those of the Euro- and all other Mediterranean countries, are widely used as effective restoration actions to curtail or reverse land degradation, preserve biodiversity at landscape scales and, ultimately, to protect, enhance and stimulate rural economies. However, most of these efforts and experiences have been carried out on a local or national basis, with poor communication and exchange, let alone co-ordination, among the various countries.

Currently, the growing demand for degraded land restoration and rehabilitation in the northern Mediterranean is stimulating the rapid development of new technologies, especially in relation to civil engineering procedures to halt soil loss and erosion, to reduce the risk of wildfires, to revegetate degraded land with woody and herbaceous plants, to enrich depleted soils with beneficial micro-organisms (Rhizobacteria, mycorrhizal fungi, etc.), and more.

Investments in land restoration are also an increasingly large part of those funds devoted to wildlands and set-aside land management around the world, including southern Europe, and this trend appears certain to continue in the future. Indeed, many specialists assert that ecological restoration represents the best hope for nature conservation, as well as an essential element in sustainable development programmes, in rich and poor countries alike.

However, large gaps in our knowledge and know-how exist, in particular with regards the integration of site-specific or ecosystem-specific interventions at the landscape and regional levels, and the integration of ecological and socio-economic imperatives, constraints and other considerations.

Specifically, reliable indicators for diagnostic and monitoring systems and quality assessment and assurance mechanisms are scarce and largely untested. As elsewhere, the fast-growing but diffuse discipline of Mediterranean forest and woodland restoration requires much better co-ordination and exchange, as well as collaborative and interactive monitoring and evaluation procedures for on-going and projected research and development efforts. Ecological, cultural and socio-economic (livelihood) indicators must be developed, conjointly, and refined and tested in real-world situations of current interest.

Lack of available information on current restoration actions, and lack of a network for communication and co-operation, limits the dissemination of technology as well as diagnostic and integrative evaluation techniques among agencies, regional administrations and countries. Only by filling these gaps can we assure wider application of the best most successful planning, evaluation and implementation strategies and technologies available.

2. Restoration goals

In line with the most recent definition of ecological restoration (SER International 2002), the basic objectives of restoration actions in the Mediterranean basin are:

First, to stop degradation, especially desertification processes affecting the most sensitive Mediterranean ecosystems. Then, to promote improved ecosystem and landscape function and structure, taking into consideration that both groups of attributes do not relate in simple nor unique ways and should be undertaken with a long term vision

To assist secondary succession through stimulating natural regeneration, by (i) making use of recognised succession trajectories (Fig. 2), that offer a referential multi-attribute system of potential restoration trajectories in terms of improving structure and function; (ii) using known reference systems, such as known or attributed original vegetation and semi-natural, humanised landscapes; and (iii) fully exploiting the potential of native species, ecotypes and provenances.

To increase ecosystem resilience, especially in relation to the most threatening disturbances, i.e. wildfires, extreme drought events, and gradual drift to hotter and drier climates.

To promote self-regenerating systems that will be as independent as possible from further human control and subsidies (economic long term viability).

To ensure ecosystem sustainability and health of the ecosystem. Semi-natural systems enabling the development of biodiversity and certain natural (such as dehesas, and montados) could be an efficient mid-term or full answer to restoration in a given cultural landscape..

3. Goal of the program REACTION

The specific goal of REACTION is to create a co-operative and multidisciplinary programme on woodland and forest Restoration in the Northern Mediterranean region, involving researchers, foresters, land owners, NGOs and others. This Accompanying Measure should help optimise the many dispersed knowledge on activities that are underway at the present time, but uniformly characterized by low levels of interaction and synergy, apart from publications in scientific periodicals. In this way, REACTION should aid new research and development programmes arising in the future, not only in the area of restoration and reforestation, but also in the related fields of desertification and sustainability science.

An additional goal is to disseminate the methods and results of successful and sustainable restoration projects in desertification-threatened lands, trying to match efficiency, acceptable cost and adaptability to local conditions, in social, ecological and technical engineering terms. Sustainability will reside not only in the positive environment impact of interventions, but also in the positive interactions between environmental and socio-economic factors. These findings will provide tools for the effective implementation of National Actions Plans (NAPs) and for the design of co-ordinated restoration actions in the framework of the Regional Action Programme (RAP).

It is the intention of the Consortium that the current initiative in countries of the northern shores of the Mediterranean could and should also be pertinent and useful in the southern and eastern countries of the Basin, where ecosystem degradation is much more widespread and increasing in scale. Mediterranean forest and landscape restoration, as defined here, is certainly a relevant response throughout the region, from ecological, social and economic points of view.

The specific measurable objectives of REACTION are:

To review and exploit existing experience in land restoration and recent advances on indicators and methodologies to evaluate the results of forest and woodland restoration projects, from combined ecological, economic and socio-cultural perspectives. This objective will include the exploitation of results on desertification monitoring indicators arising from recent EC R&D projects. It will also consider indicators being used for the evaluation of sustainable development throughout the circum-Mediterranean region.

* To facilitate exchanges among scientists from the various participating institutions.

* To build up a database of relevant information and experiences on restoration of degraded land throughout the Annex IV countries (and in some isoclimatic regions elsewhere).

* To facilitate access to high quality information for forest, woodland and park managers, scientists and policy-makers, providing tools for the promotion of techniques and initiatives for sustainable mediation and afforestation actions.

* To disseminate successful initiatives, effective practices, and guidance on land and ecosystem restoration for stakeholders and the general public.

* A detailed set of indicators for monitoring restoration success with indication of priorities and methodology to be used.

4. Monitoring and evaluation

4.1. SMART indicators

To be effective, single indicator should be SM(a)RRT. That is:

Simple. Examples: vegetation cover (%), N° of perennials and of annual plant species present;

Measurable, Examples: % of 'badlands'in a given landscape or watershed;

Adapted to the context, which is of course in constant flux (evolution), ecologically, socially, and economically. Exs. Biodiversity indices, and indices of productivity - timber and non-timber products-, and money flow for restoration and monitoring;

Reliable, ex. ecological function really demonstrated – not an easy task: indicators of structure & composition however are easier. Exs, life form spectrum, number of strata in the vegetation, …;

Relevant, - should be linked, if possible, to critical stage(s) of ecosystem change in response to restoration or other management (cf. the notion of ecological thresholds – a key theme for research development in restoration ecology. In this context, it may be useful to distinguish between 'generic', or broad criteria, expressing or reflecting biodiversity, flows and functions, structure and contingency, as opposed to 'specific' indicators that may change somewhat over time. Long term, identify 'generic' criteria but use specific indicators at each stage.

Ex. Generic Criteria for "Soil functioning/restoration after erosion". In the Saignon case, at Year + 10 following planting, i.e. 1890s, the only relevant, specific indicator could have been "% of the soil surface stabilized ; At Year + 50, soil depth (on marls only) could have been monitored; at Year 120, initial colonisation by earthworms, and at Year 50 or Y 200, using earthworm would be useless and a loss of money…see SAIGNON case study).

And, completing our SMARRT acronym,

Timely. Indicators should be chosen to take into account the contingency factors imposed by past uses and degradation. The framework for monitoring ideally should be developed from the beginning of the restoration programme but reappraised regularly. Ex. in the Saignon case study – sanitary conditions of the forest, with specific reference to parasites, such as mistletoe (Viscum album L.), should have been monitored over the last 120 years, but were only a matter of concern and monitoring in the past 10 years. An error not to be repeated!

Indicators should also be sensitive to small changes in a system's trajectory, as expressed in structure, composition and/or functioning, and broadly generalizable to other systems and situations across a range of ecological, and socio-economic conditions (Aronson et al. 1993a,b; Aronson & Le Floc'h 1996).

A large number of descriptors and indicators are possible, and many have been described in various technical literatures. How to choose among them? In line with the above-mentioned criteria, and in light of the specific objectives and budgetary constraints of REACTION, it should be possible to collectively set priorities. For vegetation components of a site or project, it is clear that a number of inter-related indicators will be needed (see below), since no single parameter can be sufficient. Furthermore, most of the relevant traits are relatively easy and low-cost to collect. In regards soils, however, the reverse is true. Data collecting is slow and costly. Therefore, integrative variables must be sought.

For example, when dealing with ecosystem responses, Cation Exchange Capacity is relatively easy to measure and highly pertinent to all other soil parameters. By contrast, potential infectivity by rhizobia and/or mycorhizae are extremely valuable traits to monitor, but exceedingly difficult for all but specialists to study and monitor.

Obviously, we will not be working with many of these indicators in REACTION, but we offer these examples for purposes of clarity.

Furthermore, the relevance, sensativity and reliability of many indicators vary greatly across time scales. Thus, CEC is not very sensitive over a short time period, whereas Leaf Area Index might be.

Finally, following Kelly & Harwell (1990) , complementary sets of indicators should help indicate one or more of the following subjects :

- Intrinsic importance (endangered and/or otherwise threatened species, communities, …);
- Early warnings of impending problems, e.g., infestations by processionary worms (Matsucoccus spp.) or Mistletoe (Viscum album);
- Sensitivity & reliability in prediction (stress specificity, signal-to-noise ratio high, Minimize false positives)

Which indicators help provide quick and strong evidence of Sustainability, or the absence thereof ?

4.2. A framework for monitoring

In general, ecological terms, at least four different levels of hierarchical organisation should be considered, as portrayed in Table 1. This list of attributes, which could be analysed to evaluate the restoration success, must be complemented by socio-economic attributes indicating the socio-economic success of the restoration programs.

It should be noted that in attempting to the diagnosis, evaluation and monitoring of something so complex as an ecosystem, landscape or – to use a newly emerging term – socio-ecosystem, a degree of subjectivitycan never be excluded. To increase objectivity, and fairness, two strategies pertain.

A) A complementary panaché of several to many attributes should be selected, covering at least two different hierarchical levels.

B) Furthermore it can be recalled that all such evaluations should ideally be considered as relative. Thus, the exercise can benefit greatly if comparisons are carried out between comparable sites within a landscape, or else among landscapes.

The level of landscape is both the most critical and the most difficult of the four included in Table 1.

4.3. Some principles to help set up monitoring

The framework for monitoring restoration success is based on basic principles (from WWF/IUCN, 2003 modified):

Naturalness/ecological integrity of forests should increase at a landscape scale. Under forest landscape restoration, some sites may – if appropriate and in a first stage - be dedicated to highly unnatural tree cover if these fulfil legitimate social and economic needs. However, restoration should have a net increase in naturalness and integrity (biodiversity and ecosytem functionning) within the landscape.

Environmental benefits should at least remain stable at a site scale and should increase at a landscape scale. Forest management that results environmental damage – such as soil erosion, fertiliser run-off, pesticide spray drift or downstream hydrological effects – is incompatible with the wider aims of forest landscape restoration.

Livelihoods secured at a landscape scale. Forest landscape restoration may not improve social well-being at every site, but should improve it on a landscape scale. The involvement of key stakeholders in decision-making processes should help to ensure that issues relating to human well-being are fully addressed. Cultural aspects should be addressed to strengthen initial restoration efforts.

Further, in Aronson & Le Floc'h (1996), additional considerations and options for landscape level indicators are discussed. In our opinion, however, strictly economic considerations should receive a higher level of attention than they have in that earlier paper. Both ecological, economic and socio-economic indicators should be agreed upon and tested. These should be SMaRRT for the purposes of diagnosis (including evaluation and monitoring) and comparison. They should reveal current conditions, and reflect on what has been done in the past by foresters, and other forest managers. They should reflect on ecosystem 'health' (i.e., relative absence of disease or pests of epidemic proportions) as well as diversity and productivity at plot and landscape scales. They should also reveal to what extent the afforestation, reforestation or explicitly restoration-oriented project has, or should improve the delivery of ecosystem services, including soil retention and watershed protection, as well as leisure activities and the protection of biodiversity; especially through the prevention of catastrophic wildfires (Vallejo, 1996; Vallejo et al., 1998, 1999, 2003). Sustainable delivery of ecosystem goods or products should also be evaluated, in the case of private lands, or public lands not set-aside as nature reserves. These goods can include edible mushrooms and wild fruit, game animals for hunters (rabbits, wild boar, some birds), and various wood products.

Additionally, Indicators could be developed which serve to evaluate forest management practices prior, during and following restoration efforts. An acronym to define good forest management practices is ACCORD: Action-oriented, Consistent, Cooperative, Open, Regional, and Decentralized.

Table 1. Partial list of vital attributes, classified by hierarchical organisation level and according to relation to the diversity, flows and functioning, structure and contingencies of the ecological system. For further discussion see Aronson et al. (1993a), Aronson & Le Floc'h (1996).

Hierarchical level	System components			
	Diversity	FLOWS AND FUNCTIONS	STRUCTURAL FACTORS	CONTINGENCY FACTORS
Population	Genotypic and phenotypic diversity	GENE FLOW : pollination, seed production MATTER AND ENERGY : food and energy available FUNCTIONS : intraspecific interaction	**Age structure, sexual ratio** Height, productivity	HUMAN IMPACT : present and past uses ENVIRONMENT: chorology, autecology, distance to seed sources
Community	**Diversity of species and functional groups among plants, animals & microorganisms** Keystone species	GENE FLOW : hybridation MATTER AND ENERGY : water efficiency, cations exchange capacity, cycling indices FUNCTIONS : productivity, interactions among populations	Tree species richness, life form spectrum Total vegetation cover, vertical heterogeneity Age, aboveground and below biomass, productivity	HUMAN IMPACT : present and past uses ENVIRONMENT: 'ecological niche'
Ecosystem	**Diversity of species, habitat and functional groups** KEYSTONE COMMUNITIES	GENE FLOW : vector of seed dissemination and pollination, seed stocking, predation MATTER AND ENERGY : soil cycles indices FUNCTIONS : regeneration, productivity, soil biological activity, seed distribution, host population control	***otal land cover, soil surface conditions*** Microbial biomass Number of dead trees	HUMAN IMPACT : present and past uses ENVIRONMENT : type of sites
Landscape	**Ecodiversity, diversity of functional groups** Keystone ecosystems	GENE FLOW : patterns of dissemination MATTER AND ENERGY : cycling indices, fluxes among ecosystems FUNCTIONS : disturbance regime, connectivity	Land forms and units, ecotones, corridors Organisms regularly crossing ecotones	HUMAN IMPACT : present and past land-use ***VVIRONMENT: ecosystem zonation***

[1] Note that whilst carbon sequestration might seem to be an ideal indicator, any use of this would require careful handling to ensure that WWF's position on the Kyoto Protocol of the Framework Convention on Climate Change is not undermined.

Table 2. An example of set of criteria and indicators for monitoring forest restoration (from WWF/IUCN, 2003, modified)

Criteria	**Examples of specific indicators**
Indicators relating to biodiversity and naturalness	
Forest composition and pattern	• Amount/proportion of natural forest (i.e., forest made up of natural species and allowed to develop natural characteristics) • Proportion of forest containing several different successional stages
Forest ecosystem function and process	• Distribution of rare or threatened forest-dependent species • specific indicator of natural forest processes – e.g. over-mature trees, amount of dead wood, cavity trees
Forest fragmentation and extent	• Area of forest in the landscape compared with original forest extent • Median size of forest stands
Indicators relating to environmental services	
Environmental services	• Water quality and quantity • Changes in stream sediment load
Environmental resilience and resistance	
Indicators relating to socio-economy	
Increased livelihood opportunities	• Indicators of forest economy and uses (production, green tourism…) • Number of jobs supported by forests in the landscape • Numbers of key NTFPs available on a sustainable basis
Reduced human vulnerability	Need indicators relating to specific "pressure points" within a landscape
Increased equity	Specific indicators will be needed relating to targets in a landscape, e.g.: • Number of traditional livelihoods supported • Opportunities for participation in management decisions
Enabling political and institutional environment	• Enabling legislation • Funding • Positive government incentives
Indicators relating to cultural aspects	
Maintenance of cultural values	Specific indicators will be needed relating to targets in a landscape, e.g.: • Protection/restoration for sacred sites in forests • Number of recreational visits to forests and woodland • Forest/Restoration actions as part of the local culture • Sensitivity to forest protection and restoration

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APPENDIX. Forest Restoration: A 120-Year-Old Program in France

We focus on one of the oldest national afforestation programs ever undertaken for erosion control in Europe, implemented in France on approximately 60,000 hectares of mountain 'badlands' between 1860 and 1914 (see Vallauri et al. 2002).

Among other case-studies carried out, we present here the results from the Saignon experimental watershed in Haute Provence (southwestern Alps, France), where restoration begun in 1876. No particular preference was given to native species in the selection of species since, at that time, the French Forest Service was planting Austrian black pine (Pinus nigra Arn. subsp. nigra Host.), together with black locust (Robinia pseudo-acacia L.), and seeding native shrubs (e.g., Ononis fruticosa L., Hippophae rhamnoides L.) and native grasses (especially Achnatherum calamagrostis (L.) P. Beauv.).

These efforts have proved effective at stopping the average 0.7 mm/year erosion rate of marly 'badlands'. However, although rehabilitated in the sense that erosion has been halted and the badlands re-forested, these ecosystems are currently facing two important ecological problems - lack of spontaneous tree regeneration, and the growing number of severely pest-damaged black pines, which are attacked by the mistletoe Viscum album L. On-going management confront the fact that currently the 120-year old forest stands are:
* Dominated by an exotic pine species sensitive to pest damage, especially mistletoe.
* Nearly monocultural and even-aged in the top canopy.
* Becoming senescent.
* Overly dense (up to 5000 trees per hectare, where no thinning at all has been done).

One problem is finding a native forest area to serve as « reference » ecosystem when evaluating restored sites to determine the success of restoration efforts. After centuries of degradation, such an historical reference site no longer exists anywhere in the Haute Provence region on the sensitive black marls between 600 and 1200 metres above sea level.

Furthermore, full soil restoration after erosion, starting from raw marls, is expected to take at least a few more centuries, which makes the choice of a reference forest ecosystem somewhat moot, except in broad terms of desired ecosystem trajectories. However, a wider regional ecological survey (including paleoecological and historical data), clearly indicates that the pre-degradation forests were characterized by downy oak (Quercus humilis Miller) as the dominant tree species, together with other broad-leaved trees and a small percentage of native pines (Pinus sylvestris L). This is sufficient to orient restoration efforts at the present time.

Going native

Our research focuses on the ways and means to restore this native forest and, on a long term basis, establish viable forest ecosystems in the study area. Within a dynamic conceptual framework for achieving true restoration, various functional indicators and restoration success criteria have been used to assess the ecosystems afforested in the Saignon experimental watershed, including soil fertility, soil biological activity
(earthworms), plant diversity, forest stand growth, pest dynamics, native tree seed dissemination, and tree seedling establishment.

One hundred and twenty years after the first tree plantings, the plant communities are still early seral assemblages for the most part, with Austrian black pine occurring alone in the canopy. In contrast, most of the marly soils have physically recovered part of their total depth, with layers of fragmented and altered material equal to 50 cm, but their structure and chemical fertility is still poor. Autogenic soil restoration is proceeding however, largely engineered by earthworms (up to 49 individuals and 27 grams/m2). Two dominant earthworm species are presumed keystone: Lumbricus terrestris and Octolasion cyaneum. Clearly, the re-establishment of indigenous tree species is apparently not inhibited by site fertility, nor by lack of nearby seed pools. However, we hypothesize that excessive stand density is responsible for poor regeneration of native plants because of the lack of direct light for germination and early development, and since it discourages the birds and rodents controlling seed dissemination. Mortality of pines due to infestation by mistletoe, Viscum album ssp. austriacum, is now creating large openings and this should be specially managed.

Specific management rules are being reviewed and revised by the French Forest Service, including the Saignon forest, but are complex to implement because of pest dynamics and of forest stand age. The main goal assigned to the forest remains erosion control, but the new strategy should rely on natural processes (soil and water processes, wind and bird dissemination of propagules), to ensure the reintroduction of native biota. To speed it up, however, careful thinning of the existing pine stands must be undertaken as soon as possible so as to provide more open patches suitable for native tree seed dissemination, germination and growth.

Forest restoration is a long term responsibility and an ecologically based process. The strategy to establish a pioneer stage of the ecosystem (nurse species, shrubs, etc.) to boost the natural resilience of the degraded ecosystem is appropriate and desirable. In contrast, the tactics commonly adopted in forestry today are often short-sighted, seeking to establish tree monoculture of an adapted tree species, including exotics, but under-estimating long-term goals and ecological necessities. Restoration forestry should better integrate, and in any case, should regularly assess the intrinsic long term viability of the forest ecosystem under manipulation. This can be done using a wide range of success criteria and ecosystem attributes adapted to the current successional stage. This implies, among other things, to actively, and as early as possible, monitor the reintroduction of native organisms diversity and the re-establishment of the various ecological forest functions and services provided by healthy forest ecosystems: clean water, erosion and watershed control, recreation and conservation of indigenous biodiversity.

Chapter 4
Strategies for Land Restoration

Ramon Vallejo[1], Susana Bautista[2], Juan Carlos Delgado[2], Asa Aradottir[4] and Eduardo Rojas[5]

[1]CEAM Foundation, Paterna, Spain
[2]University of Alicante, Spain
[3]TRAGSATEC, Madrid, Spain
[4]Icelandic Soil Conservation Service, Islandia
[5]UPV, Valencia, Spain

BACKGROUND

For more than one hundred years land restoration has been conducted in many areas of the world, and especially in Europe, to combat land degradation. In the early initiatives, reforestation aimed to preserve watersheds, reduce flash flood occurrence, fix sand dunes, and provide labour as well as timber and other forest products in marginal areas. Millions of hectares were reforested for these purposes in Europe from the late XIX century. Therefore, reforestation was a common practice to rehabilitate degraded lands under dry conditions well before the general acceptance of the term 'desertification' (in the 1970s). In recent times, the objectives for reforestation programmes have been enlarged to address other global threats and goals, such as combating desertification and climate change, and improving biodiversity.

Since the early restoration works, many elements affecting restoration approaches have deeply changed. First of all, the objectives. The conception of restoration, namely reforestation, had a twofold main objective, e.g. preserving soil and water resources and enhancing forest cover. For these objectives, restoration was conducting through monospecific plantations, using in general pines (or other conifers) due to their frugality, fast land cover and easy management, as well as the perspective of some revenue for local population (acceptance). Exotics were sometimes used, less in the Mediterranean area than in the Atlantic rim. From approximately the 1970s, socioeconomic changes in the Southern European countries dramatically changed the social demands from forests and wildlands in general. Whereas productivity was still important in the best lands other objectives were emerging, such as: 1) combating desertification, that embodies previous actions for watershed protection for example although acquired a wider scope at the ecosystem and landscape levels; fire prevention and post-fire restoration has appeared as a major issue from the last quarter of the XXth century; 2) recreational and cultural use of wildlands has taken over productive use in many areas from the 1960s; 3) improving biodiversity introduce a new framework for restoration projects as species diversification become a critical issue since the 1980s; 4) mitigating climate change is becoming an important objective since the 1990s, that can be addressed though increasing forests surfaces to fix carbon. Finally, the shift in the weight of direct productivity objectives to other objectives providing goods and services with no market value so far (externalities) introduce a new economic framework of reference. It seems clear that restoration strategies and techniques must be adapted to the new social framework.

Recent scientific and technical advances in Ecology, Plant Biology, Soil Science, Geomatics and others, provide new perspectives for innovating the technology for land restoration. In the last two decades, restoration ecology as been emerging as a discipline, with scientific and technical journals (e.g. Restoration Ecology and Ecological Restoration), books (e.g. Jordan et al. 1987, Whisenant 1999; Perrow and Davy 2002 a,b), professional societies and meetings. Thus there are significant advances and possibilities in this field, which should benefit restoration practices everywhere.

As an example of evolving approaches, the traditional reforestation based in planting one single tree species, within a reduced set of species, has to evolve to plurispecific restoration based on a wide set of species choices to match the potential diversity of habitats, degradation stages, and management objectives occurring. Native species offer a high potential for contributing to restore degraded ecosystems. Native herbaceous, shrubs and tree species might be used depending on the specific degradation stage of the ecosystem and the managerial objectives addressed.

As a consequence of the changing situation, during the last years restoration projects respond in their conception to very diverse range of objectives, both new and old ones, and their technical set up can be very diverse as well, sometimes even contradictory from one country/region to another. It seems clear that the efficiency of restoration initiatives can be improved through the evaluation and wide dissemination of technologies to fight desertification that are environmentally sound, economically viable, and socially acceptable. This approach can be actively promoted in the framework of an exchange of experiences and data between experts and stakeholders from the various affected countries. In addition, traditional knowledge and know-how need to be conserved and used jointly with the new techniques. This will require a close collaboration between planners, managers, ecologists, and other specialists at the local, national and regional levels.

RESTORATION OBJECTIVES TO MATCH PRIORITIES IDENTIFIED IN THE TERMS OF REFERENCE TO PREPARE THE REGIONAL ACTION PLAN TO COMBAT DESERTIFICATION.

1 The most sensitive areas in term of desertification hazard. Once sensitive areas are identified, the next step would be to define threshold conditions of degradation that allow successful restoration, both in social, economical and technical terms. It is wasteful to conduct costly and extensive reforestation programmes in extremely degraded lands without a consistent prevision of the chances of success. A third step would be to specifically design mitigation/restoration techniques for these extremely sensitive areas, including both active and passive measures, related to the driving degradation forces (active desertification) or to past disturbances that are still promoting desertification. The baseline for these activities should be a thorough analysis of past reforestation actions conducted in the most sensitive and degraded areas. In the same way, monitoring and data base elaboration should be intrinsic components of all restoration projects.

2. The common regional benchmark and indicators for processes and mitigation. 3. The collection and analysis of technical and scientific data.

The huge amount of mitigation experiences all over the Mediterranean countries and elsewhere should be compiled, elaborated, evaluated, and made available to the various stakeholders at the various management levels. Most of this useful information is in “grey literature”, that is technical, often local reports, national publications, that are of difficult access. It requires the collaboration of stakeholders at the various management levels to make that information available. The establishment of a network of pilot projects would be a powerful tool to facilitate the dissemination of the best available technologies (this point is specifically dealt in theme II.2).

4. The exchange of data and information. In relation to the previous point, poor communication is probably the critical shortcoming that limits a widespread use of the best available technology. The target should be improving communication especially at the practitionist level, but exchanges at the scientific and top management level are more efficient. These exchanges should channelled through

the national structures within the respective National Action Plans to Combat Desertification, in the national languages.

5. The involvement of civil society within the RAP processes. In many European countries, restoration projects were traditionally conducted by public bodies in public forest lands. Recently, public subsidies aim at stimulating private owners to be engaged in land conservation and restoration. In addition, conservationist NGOs as well as other trusts increasingly promote land restoration using public and private funds. The challenge is to integrate the large potential, both economical and technical, of public administrations with the initiatives of the civil society, often limited in both funding and technical skills.

6. The traditional knowledge and practices safeguarding the quality of Mediterranean landscape. In the area of land restoration, traditional practices are not always a guarantee of efficiency and adaptation to the goals of combating desertification. As far as the relations between man and nature are being modified, old practices could not be either applicable now or appropriate. By the contrary, there are traditional practices that might be used nowadays and, perhaps, reshaped on the light of the recent scientific and technical advances. One example of that could be the use of water harvesting techniques for soil preparation in reforestation. This is a more than 2000 years-old technique from the Middle East used for irrigating foot-slopes in semi-arid and arid regions. Now, the technique is successfully applied using backhoe tractors, minimising ecological and visual impact of soil preparation in reforesting semiarid degraded lands.

THE CASE OF SEMI-ARID LANDS DESERTIFIED THROUGH LONG-TERM OVER-EXPLOITATION IN THE PAST

Land abandonment in semi-arid climate usually causes further land degradation. In the Mediterranean, the drier the climate, the slower the ecosystem regeneration capacity after disturbance, and this especially apply for soil aggradation. In the case of semi-arid lands, abandonment is usually followed by further degradation, with the destruction of soil conservation structures (like terraces).

Degradation factors are often relict (Puigdefábregas & Mendizabal, 1998) in N Mediterranean, and this a very important fact to take into consideration. The drier the climate, and/or the more degraded the land, the more spatially heterogeneous the ecosystem, with patchy vegetation and resources (“fertility islands”) distribution. Therefore, spatial variability has a prominent role in dry land and degraded ecosystem processes. The question for these cases where vegetation is interspersed by bare soil patches (often with the top soil crusted and compacted), is to what extent this heterogeneity is fully functional, and bare soil is necessary for the survival of vegetation patches, being the whole the maximum potential in equilibrium with the environment, or, by the contrary, degraded patches are producing losses of resources (especially related to extreme events) that might be repaired by improving soil surface properties and introducing woody, deep rooting species.

General Strategy: as disturbed ecosystems are characterised by net resource losses (water, soil, and nutrients), restoration is conceived to increase resources capture and conservation onsite (regulation, cycling and ecosystem utilisation) (Ludwig & Tongway, 1995). However, contradictory goals could be found in densely inhabited areas. For example, in a more global context, at the landscape scale and in managed lands, resources redistribution in space could be desirable for human societies, e.g. reducing water interception/infiltration/capture in catchments for maximising runoff and water accumulation in reservoir for human consumption (Van Wesemael et al. 1998).

2. semi-arid lands, with scarce and patchy resources distribution, mostly water, where direct rainfall inputs in shallow soils, often having low infiltration capacity, do not allow either natural or artificial plant colonisation of bare soil. Improving soil water infiltration, water holding capacity, and runoff

harvesting are the main strategies to restore these semi-arid degraded lands, the most threatened by desertification. Terraced old fields usually concentrate the deeper soils in the hill-slopes, therefore they constitute preferential spots for land restoration. In addition, these terraces are suffering a slow structure degradation process following abandonment that should be prioritised in restoration plans to avoid rill erosion development.

3. Spatial components of restoration (especially critical in patchy semi-arid). The restoration of semi-arid degraded lands should be based on the introduction of vegetation according to natural vegetation patterns, with the aim of recover previous landscape processes. Such restoration efforts can be improved by incorporating knowledge on the spatial heterogeneity of soil resources and vegetation. When plant cover is very low, i.e. below 30%, the spatial patterns of surface soil properties like compaction, physical crusts and rock fragments are critical for seedling establishment due to their prevailing role in water redistribution on the soil surface and infiltration dynamics (Maestre et al. 2003). When vegetation is not so degraded, the “resource islands” typically formed under the vegetated patches can be used to foster restoration success. These fertile patches are points of high biological activity where facilitation often dominates over competitive interactions between plant species, and, as recent studies shown (Maestre et al. 2001), can improve the establishment of woody seedlings in semi-arid environments, like in other degraded areas with wetter and/or colder climates.

THE CASE OF BURNED LANDS

Wildfires are a major disturbance in Annex IV countries that may deserve restoration actions for burned lands. The first question to address is in which conditions post-fire restoration is needed. A second issue would be to set priorities for restoration. A third question would be how restoring burned lands. The general restoration objectives in the framework of the UNCCD are the preservation of soil, water and biotic resources.

Establishing priorities in post-fire restoration

Extensive areas of wildland in the Mediterranean Basin have suffered major transformations in their land use and fire regime throughout the second half of the XXth century. The restoration strategy needs to promote plant communities adapted to the present and future regime of disturbances so as to ensure the sustainability of the restored lands.

The sequence 'summer fire → heavy autumn rains' is frequent in Mediterranean climates. Therefore, in the more fragile soils where plant regeneration rates are slow, the risk of soil erosion is extreme on steep slopes. It is assumed that soil erosion is the most serious ecological impact of fire because its low reversibility. Therefore, the main priority in reducing the ecological impact of fire is assumed to be soil conservation.

Shrublands dominated by obligate seeders are fire prone and show low resilience after fire. The introduction of sprouter shrubs and trees would reduce fire hazard and improve the resilience, diversity and structure of these formations. Many sprouter shrubs and tress are late successional and show low ability to naturally colonize degraded lands. Therefore, artificial introduction is often required.

A third aim of land restoration regions is to increase formations approaching the maximum biological potential. The prevailing fire regime in some ‘hot’ areas of the Region does not allow the persistence of pine forests. For that areas, the plantation (and/or seeding) of shrub and tree resprouters is proposed in fire-prone shrublands to improve the resilience and maturity of these ecosystems. Evergreen broad-leaved trees, with tap roots, are highly resilient to many types of disturbance.

Therefore, post-fire restoration strategy face three main environmental issues, following the priorities established according to the ecosystem degradation risk:

i) Soil protection and water conservation. Soil is a non renewable primary resource which may be exposed to the risk of degradation and erosion after fire. Water is a critical resource limiting ecosystem productivity in drylands, and burned lands are exposed to dramatic increase in runoff producing offsite degradation: floodings and siltation in lower lands.

ii) Promotion of fire resilient plant communities. Assuming that fire risk is inherent to Mediterranean ecosystems, a second priority is to improve ecosystem resistance and resilience in relation to fire.

iii) Forest cover restoration. As Mediterranean landscapes are mostly dominated by early successional (fire prone) ecosystems, a third general objective is to promote mature formations, both forests and shrublands, depending on the bioclimatic conditions.

Approach

The first step in case of wildfire is to estimate the degradation risk of the affected lands and its spontaneous recovery capacity. From existing cartography and/or field expert judgements, the managers in collaboration with local scientists should determine what areas might be subjected to high erosion risk in the short-term, that is low plant recovery capacity, steep slopes and erodible soils. These areas fall in the objective i), and typically concern soils developed over marls and other soft substrates, sandstones, gypsum, with poor vegetation cover dominated by obligate seeders. In the very short-term, a first decision to take is about the management of dead wood. In these sensitive areas, post-fire logging very often results in severe rill erosion processes and further site degradation (Mayor et al., 2002). However, any limitation to exploit charred wood should take into account the economic consequences for the owner that have to be compensated. Those areas having abundance of species bearing resprouting capacity usually guarantee high recovery capacity, quite independent of postfire weather conditions. In those cases, only long-term measures are needed.

i) Soil protection and water protection: This scenario corresponds to highly degraded vegetation, on steep slopes, and eroded soils. These situations are characterised by low plant cover the year following the fire, which is insufficient to protect the soil against erosion. In the most typical situations, wildfires occur in summer, and in autumn there is a high risk of heavy rains in the Mediterranean Basin. The slope protection to reduce soil erosion and runoff requires the development of effective measures in the very short-term. Mulching and seeding immediately after fire is an effective measure for soil protection and for stimulation of the first phases of plant regeneration in degraded plant formations. Soil erosion losses decreased after the addition of mulch (with and without seeding) in dry and semiarid climate and could be an effective treatment for the restoration of burned areas with high erosion risk. Seeding effectiveness is more impredictible as it largely depends on the rainfall conditions during the first months after the application. Seeding techniques are inexpensive and applicable to wide areas with no environmental impact.

ii) Promotion of fire resilient plant communities. Planting of resprouting shrubs and trees is proposed to improve the restoration of burned and degraded areas. The assumption is that introduction of sprouting trees and shrubs will enhance the ecosystems resilience after wildfires. Controlling (e.g. clearing) fire-prone shrublands with very high fuel accumulation combined with woody resprouter introduction could be a measure to break fire cycles. Thinning of dense young pine stands is also required in order to allow their evolution to mature mixed forests, with resprouter shrubs understore.

iii) Forest cover restoration: For sustainable reforestation actions in fire-prone Mediterranean landscapes, the simultaneous or sequential introduction of conifers (mostly pines) and hardwoods (mostly oaks but also other diversifying species like Fraxinus, Acer, Sorbus, etc.) will take advantage of the complementary features of both species groups, e.g. water stress resistance and fast growth of pines and high fire resilience (efficient resprouting capacity) of Mediterranean hardwoods. The final aim is to increase the likelihood of plantation success and to reach to mature potential forest as soon as possible. This will also provide higher diversity and landscape heterogeneity. However, in dry Mediterranean conditions, plantations of broad-leaved resprouting species usually face very high seedling mortality. The use of specific techniques to improve water-use efficiency significantly increased survival and growth of these sensitive species. Specifically, in our study area we found that, under the current economic and technical framework of extensive land restoration projects, seedling survival and growth can be increased by the use of water harvesting, tree-shelters, nurse plants and organic amendments.

For close coppices, selective thinning enhances tree structure and reduces fuel accumulation. In those open woodlands, inoculation with truffle (Tuber melanosporum) will add an important economic value when soil (on limestones) and climate conditions (summer rain) are appropriate.

ECONOMIC CONSTRAINTS AND OPPORTUNITIES IN PRIVATE AND PUBLIC FOREST LANDS

Land suitable for forest restoration in Mediterranean countries is owned by families, communes and the State. In the northwestern countries (P, E, F, I) the prevailing ownership is private, especially if the previous use has been marginal agriculture, whereas communal if the areas had been used for extensive grazing. In the Eastern Mediterranean countries and the southern rim, state ownership is prevailing despite important user rights for local population sometimes conflicting with restoration objectives.

In the past, public investment have been the absolutely prevailing instrument in forest restoration around the Mediterranean, even in the northwestern countries. This provoked frequent conflicts with local population, uniformity and size problems as well as social integration of the new created forests. This favored important fires. In the past 20 years, due to the reforms in the CAP, subsidies for afforestation in the EU countries – recently also in accession countries - have developed to the most relevant financial instrument, whereas public investment have dropped in relation to the past.

Constraints

The financial dependence from the CAP prioritises afforestation linked to set aside of agricultural land, giving incoherence to the objective of land restoration under Mediterranean conditions, especially in mountainous areas. In the Mediterranean EU countries, set aside started long ago and the agricultural area is rather low in the mountains whereas the restoration priorities are located in badlands and burned areas, generally classified as other forest lands.

New social demands, practical and scientific knowledge and scarcity of labor provoke important increment in the cost of restoration and limit the spatial effect of the financial means invested.

Despite in the past years the size of the burned areas has reduced significantly in those countries due to better means and coordination, an important part of the budget of the forest services is devoted to direct fire prevention and extinction, draining resources that could be allocated to restoration projects. Specialists though signalize the extinction paradigm and the latent risk of catastrophic fires in the future in case of simultaneous fires and/or extreme climatic conditions (Castellnou, 1999).

Fragmentation of private land on former marginal agricultural land brings a difficulty for restoration processes. Infrastructures and residential and industrial settlements are enlarging, mainly on agricultural land in costal areas, but also on forest lands around the Mediterranean.

Opportunities

Forest area is increasing in all Mediterranean EU countries despite the important fires of the past decades and the low investment level in restoration. The main explanation is the natural expansion of forests in the mountain areas due to rural decline and high efficient pioneer species (Pinus halepensis). In Spain forests have grown from 12 to 15 million ha between 1970 and 2000 and the growing stock 60% in the same period (MMA, 2003). It should also not be forgotten that the Natura 2000 network asks to maintain certain secondary shrubs formations. So, the area to be restored has significantly been reduced.

New tertiary uses, as residence, rural tourism, etc. are changing significantly the values, in part captured by specific services or products, but also in the development of the estate values (Merlo & Rojas, 2000). Nature trusts are developing fast as new investment form, mainly related to nature preservation but also restoration projects. Finally, earmarked environmental taxes may be used in the future for restoration projects (Segura, 2003).

Suggestions

Several conclusions may be obtained for future restoration policies:

It is important to overcome cliché views concerning Mediterranean forest fires. A strong insurance approach as in agricultural policies has been avoided by strengthening the causal perspective in this relevant issue. As well, EU funding has not been allocated for restoring burned areas in order to avoid perverse effects. Forest insurance implementation would assure restoration in the most frequent present forest degradation process, would equilibrate the public expenditure in restoration and gain an important alliance in improving the overall performance.

A more equal balance of the public means invested between fire extinction and forest land restoration and sustainable management is desirable.

Conduction of spontaneous restoration processes gains importance requiring new technical skills scientifically reviewed.

Passed successful restoration should be steward in order to facilitate their full natural and social integration.

Protection strategies shall integrate active measures like restoration (see the case of the Microreserves in Valencia Region, Laguna, 1999).

Implementation

A specific Northern-Mediterranean perspective is clearly needed to take into account the peculiarities in landscape structure, ecological conditions, land use history and socio-economic conditions, and thus meet the particular conditions of the northern Mediterranean region established in the UNCCD Annex IV. In recent decades, Mediterranean countries have made a serious effort to combat desertification through a wide array of technical approaches. However, most of these experiences have been developed on a national, and even local, basis, with poor communication and very limited co-ordination among the various countries. Detailed databases on reforestation and afforestation are lacking, and co-ordination between actions has been very limited.

There is an unprecedented accumulation of technological capability in the field of restoration in the world today, much of which remains largely unrecognised, under-utilised and inadequately shared. Therefore, existent information is difficult to utilise due to poor and restricted dissemination, and to the lack of translation into information that can be directly used by decision-makers, at both the national and international levels. It seems clear that the efficiency of restoration initiatives can be improved through the harmonisation and transfer of technologies to fight desertification which are environmentally sound, economically viable, and socially acceptable. This approach can be actively promoted in the framework of an exchange of experiences and data between experts and stakeholders from the various affected countries.

Specific recommendations

1. A permanent body, including the various NAPs committees (scientist and high level managers) could establish, centralise, maintain and update land restoration databases, including the network of pilot projects, taking care of disseminating the information in the appropriate format for the various stakeholders.

2. Restoration projects should include evaluation and monitoring schemes, both incorporated in the project budget. That information should feed restoration databases through standard forms.

3. Forest insurance implementation would assure restoration in the most frequent present forest degradation process

4. Past successful restoration projects should be steward in order to facilitate their full natural and social integration.

5. Restoration activities could be in the form of conducting natural, spontaneous regeneration after disturbances. Research efforts should concentrate in this area.

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Chapter 5
Restoration Pilot Area: Albatera (Alicante, Spain)

S. Bautista, A. Vilagrosa, J.A. Alloza, and R. Vallejo.

CEAM Foundation, Spain

The Albatera pilot area is a 25 ha catchment located in Alicante province, in Southeast Spain, one of the most desertification affected areas in Europe. Land degradation has been driven by the synergetic effect of past exploitation and management –grazing, marginal agriculture, wood gathering– and harsh environmental conditions such as scarce and highly variable rainfall and soils prone to erosion. Further anthropogenic disturbances, such as terracing, roads, water channelling for irrigation, etc., have deeply altered soil surface and landscape.

According to off-site damage occurrence, indicators of land degradation, and the expertise of local stakeholders and managers, spontaneous reversion of degradation processes can not be expected at management time scale –e.g. one to three generations, even if most of the desertification driving forces have ceased. In these conditions, ecosystem functioning need to be repaired by restoration actions.

The demonstration project in Albatera is an example of collaboration and technology transfer between the scientific community and stakeholders. It was launched by the General Directorate for Nature Conservation (Ministry of Environment, Spain), with the collaboration of the Department of Environment of the Valencia Region. Project management was carried out by the Forest Service of Alicante and the scientific advice was carried out by CEAM Foundation, University of Alicante, and CIDE.

Past reforestation programmes in the area were conducted through monospecific pine plantations, commonly carried out affecting natural vegetation and involving intense site preparation and heavy machinery. These actions, mainly aimed at controlling erosion and floods, have yielded poor results and in some cases promoted ecological and management problems.

The restoration programme implemented in the Albatera pilot area has been designed as a set of ecologically sound, multi-purpose measures, adapted to the complex problem addressed.

Target problems:

Loss of ecosystem functions: water infiltration and nutrient cycling are not fully functional in the degraded area; productivity is therefore greatly reduced. The system is producing net losses of resources.

Deeply altered landscape patterns due to past and current land uses: terracing, irrigation works and channelling, and derived gullies and rills.

Off-site damage due to flooding. According to the Land Action Plan to Prevent Flooding in the Valencia Region (PATRICOVA, Regional Government), the Albatera-Crevillente range, which includes the pilot area, is one of the hot spots of flooding risk in the province of Alicante.

Restoration approach and objectives

Ecological restoration in desertification-prone areas is conceived to increase the capture and conservation of resources in order to prevent exceeding some resource depletion thresholds. The main objectives of the restoration programme in Albatera pilot area were:

√ To repair ecosystem functioning by creating fully functional vegetation patches that contribute to a process of re-allocation of water, materials and nutrients and to the general productivity of the territory.

√ To increase ecosystem diversity, stability, and resiliencie.

√ To prevent further surface and landscape degradation, soil erosion, and off-site damage.

The designed site-specific restoration strategy to achieve these goals includes:

- To address within-site heterogeneity by identifying landscape functional units and designing specific actions for every units.
- The introduction of vegetation according to small-scale heterogeneity and natural spatial patterns.
- To avoid clearance of existing vegetation; to foster spontaneous plant growth by applying organic amendments
- According to the potential vegetation in the area, to introduce evergreen trees and shrubs with high potential cover, high capacity to develop a dense canopy and accumulate litter, and fast recovery from disturbance so to confer increased resilience to the whole ecosystem.
- A wide set of species choices to match the potential diversity of habitats, degradation stages, and management objectives.
- To improve seedling quality.
- Improvement of plantation success by exploiting recent research results and applying the best technology available. Specifically, under the current economic and technical framework, seedling survival and growth can be increased by the use of water harvesting treatments, tree-shelters, nurse plants and organic amendments.
- Site preparation aimed at maximising water harvesting but minimising impact on soil surface.
- To prevent damages due to terrace collapse by creating soil-retaining vegetation barriers of deep-rooting and high cover shrubs and trees.
- To establish a monitoring programme

Lessons learned

Though the pilot project of Albatera is just at the implementation stage, some lessons can be drawn from the design stage and from some preliminary experimental results:

Collaboration at local (site) level among scientists and stakeholders, and society involvement are key milestones towards successful application of restoration programmes, and therefore should be always fostered.

Restoring degraded/desertified lands is a complex task that faces a complex process. The introduction of desirable species or the increase in plant cover are surrogates of the main goal: restoring ecosystem functioning, allowing self-sustainable system organisation.

Limiting conditions prevailing in very degraded land increase the cost of restoration actions, which apply the best technology to cope with the scarcity of resources and the stressing environment. Low-cost land restoration techniques often fail in so hard conditions. Therefore the cost-benefit analysis for best-technology actions is expected to yield a very positive balance.

Monitoring and data base elaboration should be intrinsic components of all restoration projects. Furthermore, establishing a monitoring system has a positive feedback effect on the quality of the restoration project design.

Annex 1. Participants in first REACTION workshop

Participants in REACTION workshop. Alicante 13-16 June 2003			
First	**Last name**	**Affiliation**	**E-MAIL ADDRESS**
Maite	Aguinaco	IAMZ-CIHEAM, Zaragoza, ES	aguinaco@iamz.ciheam.org
J. Antonio	Alloza	CEAM, ES	Jantonio@ceam.es
Pietro	Antinori	Agronomist, FIDAF Consultant. IT	p.antinori@mclink.it
James	Aronson	CEFE-CNRS, Montpellier, FR	aronson@cefe.cnrs-mop.fr
Susana	Bautista	University of Alicante, ES	s.bautista@ua.es
Beatriz	Bueno	Tech. Office NAP-Combat Desertification, ES	desertificacion@mma.es
Antoine	Cornet	IRD, FR. Focal Point representative (FR)	Antoine.Cornet@mpl.ird.fr
Jordi	Cortina	University of Alicante, ES	Jordi@ua.es
J. Carlos	Delgado	TRAGSATEC, ES	jcds@tragsatec.es
Elvira	Díaz	IRNAS, CSIC, Sevilla, ES	elvirad@irnase.csic.es
Giuseppe	Enne	NRD, Sardinia, IT	nrd@uniss.it
Christelle	Fontaine	CEFE-CNRS, Montpellier, FR	ch_fontaine@yahoo.fr
Dunixi	Gabina	IAMZ-CIHEAM, Zaragoza, ES	gabina@iamz.ciheam.org
Miguel	G. Bartual	Regional Forest Administration, Alicante, SP	miquel.garcia@cma.m400.gva.es
Athanasios	Hatzistathis	AUTh, Thessaloniki, GR	thanos@for.auth.gr
Victor	Louro	DGF- Ministry of Agriculture, PT	victor.louro@dgf.min-agricultura.pt
Manuel	Madeira	ISA, PT	aa15309@isa.utl.pt
Myriam	Martín	Tech. Office NAP Combat Desertification, ES	desertificacion@mma.es
Araceli	Martínez	Tech. Office NAP Combat Desertification, ES	desertificacion@mma.es
J. Antonio	M. Artero	DGCN, Ministry of Environment, Murcia, ES	jamartinez@dgcn.mma.es
Millán	Millán	CEAM, ES	Pilarz@ceam.es
Giovanni	Monaci	CFVA-RAS, Sardinia, IT	giomonaci@tiscali.it
Eduardo	Rojas	UPV, Valencia, ES	erojas@forestal.net
Leopoldo	Rojo	DGCN, Ministry of Environment, ES	leopoldo.rojo@dgcn.mma.es
María	Sanz	CEAM, ES	mariasanz2@yahoo.es
Roberto	Scotti	IATF-Uni.Fi, IT	roberto.scotti@unifi.it
Maurizio	Sciortino	ENEA, IT.Focal Point representative	sciortino@casaccia.enea.it
David	Tongway	CSIRO, AU	David.Tongway@csiro.au
Chr.	Tourlakidis	Dir. Reforestation Service, Thessaloniki, GR	thanos@for.auth.gr
Daniel	Vallauri	WWF-France, Marseille, FR	dvallauri@wwf.fr
Ramón	Vallejo	CEAM, ES	vvallejo@ub.edu
Alberto	Vilagrosa	CEAM, ES	a.vilagrosa@ua.es
Gerhard	Zabel	Training C. Rural Development, Algarve, PT	qdf@qdf.pt
Claudio	Zucca	NRD, Sardinia, IT	nrd@uniss.it