L'essentiel de l'information scientifique et médicale

www.jle.com

Le sommaire de ce numéro

http://www.john-libbey-eurotext.fr/fr/revues/agro_biotech/sec/sommaire.md?type=text.html

Montrouge, le 07/06/2011

Jordi Cortina

Vous trouverez ci-après le tiré à part de votre article au format électronique (pdf) :
On the restoration of degraded drylands

paru dans
Sécheresse, 2011, Volume 22, Numéro 2

John Libbey Eurotext

SECHERESSE

Research Article

Sécheresse 2011 ; 22 : 69–74

On the restoration of degraded drylands

Jordi Cortina[1]
Beatriz Amat[1]
Mchich Derak[2]
Maria Joao Ribeiro Da Silva[13]
Karen B. Disante[1]
David Fuentes[4]
Jaume Tormo[1]
Román Trubat[1]

[1] University of Alicante
Department of Ecology and IMEM
Ap. 99 03080
Alicante
Spain
<jordi@ua.es>
<beatriz.amat@ua.es>
<mariaribeirinho@gmail.com>
<kb.disante@ua.es>
<jautorbla@gmail.com>
<roman.trubat@ua.es>
[2] Direction régionale des Eaux et Forêts
et de la Lutte contre la Désertification du Rif
Avenue Mohamed 5
BP 722
93000 Tétouan
Morocco
<mchich78@hotmail.com>
[3] Coimbra University
Department of Life Sciences
Centre for Functional Ecology
3001 – 455 Coimbra
Portugal
[4] Fundación CEAM (Centro de Estudios
Ambientales del Mediterráneo)
Parque Tecnológico
c/Charles Darwin, 14
46980 Paterna
Valencia
Spain
<david.fuentes@ua.es>

Abstract

Drylands cover 41% of the earth's land surface and sustain 38% of the global population. The surface area of drylands affected by desertification is estimated at 10-20% of this land, making this one of the worst environmental problems worldwide. Measures to combat desertification include restoration actions. Recent advances in our understanding of dryland ecology have improved traditional restoration techniques and fostered the development of new eco-technology. However, the refinement of eco-technological tools and the success of experimental restoration projects have not been accompanied by parallel increases in the efficiency and reliability of management-scale restoration programs. In our experience, this is the result of uncertainties about the long-term effects of restoration actions, scarce knowledge on population and community dynamics, and cultural and socioeconomic constraints to the implementation of new techniques and the improvement of traditional ones. We suggest that i) adopting the ecosystem service approach to identify restoration targets and evaluate restoration actions, ii) integrating restoration actions into comprehensive development programs, and iii) creating networks of pilot and demonstration projects may foster participative, adaptive and integrative management plans, and contribute to livelihood quality in desertified areas.

Key words : arid zone, desertification, desertification control, planning, restoration.

Résumé

Sur la restauration des terres sèches dégradées

Les zones arides occupent 41 % de la surface terrestre et supportent 38 % de la population mondiale. Environ 10 à 20 % de la superficie des zones arides est touchée par la désertification, ce qui en fait un des pires problèmes environnementaux de la planète. L'implémentation de la restauration écologique est l'une des mesures de lutte contre la désertification. Les nouvelles avancées dans le domaine de l'écologie des zones arides ont contribué à l'amélioration des techniques traditionnelles de restauration et au développement de nouvelles écotechnologies. Cependant, le raffinement des outils écotechnologiques et le succès des projets expérimentaux de restauration n'ont pas été parallèlement accompagnés par une amélioration de l'efficience et de la fiabilité des programmes de gestion et de restauration. D'après notre expérience, cela est dû aux incertitudes sur les effets à long terme des actions de restauration, au manque de connaissance des dynamiques des populations et des communautés végétales et animales, et aux contraintes culturelles et socio-économiques qui rendent difficiles l'implantation des nouvelles techniques et l'amélioration des pratiques traditionnelles. Nous pensons que i) l'adoption de l'approche des services écosystémiques pour l'identification des objectifs de restauration et l'évaluation de ses actions, ii) l'incorporation des actions de

To cite this article: Cortina J, Amat B, Derak M, Joao Ribeiro Da Silva M, Disante KB, Fuentes D, Tormo J, Trubat R, 2011. On the restoration of degraded drylands. *Sécheresse* 22 : 69-74. doi : 10.1684/sec.2011.0301

doi: 10.1684/sec.2011.0301

Tirés à part : J. Cortina

restauration dans les programmes de développement intégré, et iii) la création de réseaux de projets pilotes et de démonstration, peuvent encourager les programmes de gestion participative, adaptative et intégrée et contribuer au bien-être humain dans les zones désertifiées.

Mots clés : désertification, lutte contre la désertification, plannification, restauration, zone aride.

Ecological restoration to combat desertification

Drylands cover more than 40% of the land, sustain more than 1/3 of the global population and host a significant number of hot-spots of biological diversity. Drylands worldwide are however currently threatened by desertification (Reynolds *et al.*, 2007) Over the last decades, international organizations launched ambitious initiatives to evaluate the extent of desertification, understand its causes and, ultimately, combat dryland degradation. The attention of restoration ecologists concerning actions to combat desertification has been comparatively limited. For example, the number of restoration projects from arid, semiarid and Mediterranean areas included in the Society for Ecological Restoration International (SERI) Global Restoration Database[1] is relatively low (22 of a total of 226 projects). Similarly, the number of scientific papers on dryland restoration appearing in international environmental journals, including *Restoration Ecology*, the official journal of the Society for Ecological Restoration International, is also low (8 of a total of 183 articles; [Aronson *et al.*, 2010]). Of these papers, very few deal with passive restoration (the release of the stress factor; [Aronson *et al.*, 2010], whereas this is one of the most commonly employed management options to revert dryland degradation (Requier-Desjardins *et al.*, 2009).

The ''desertification'' research community seems to be aware of the principles of ecological restoration. United Nations Convention to Combat Desertification (UNCCD[2]) Article 2.2 explicitly mentions as one of its objectives ''*. . .the rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions, in particular at the community level*'', which is largely in agreement with the aims of ecological restoration[3]. Indeed, National Action Plans (NAP) within UNCCD go a step further by explicitly mentioning ecological restoration as one of their objectives and lines of action (e.g., the Spanish NAP[4]). But to what extent have the aims of ecological restoration been adopted by projects to combat desertification?

There is no simple answer to this question. First, projects have multiple objectives, including unwritten ones that can be critical. For example, the official aims of the Spanish National Reforestation Program, a vast endeavor launched in 1939, were biophysical (wood production, hydrological control and soil protection), whereas the creation of employment was probably the main (implicit) priority in a ruined post-war country (Pemán *et al.*, 2009). An evaluation of these actions that does not take into account their socioeconomic impact, is biased and of little use. Second, societal aims and aspirations change across generations and across regions. The success of a particular action cannot be measured in the same way in areas where consumption of local natural resources is high as in areas where natural resources are imported. Similarly, priorities may change in the time lapse between project inception and process evaluation. This is particularly important in drylands, where climate and societies currently change at a faster rate than do ecosystems. Third, our understanding of community dynamics, ecosystem processes and the benefits provided by restored ecosystems is often too poor to accurately predict the outcomes of management practices. Because of this uncertainty, evaluating the distance between restored and reference ecosystems and the rate at which the former approaches the latter becomes a challenging task. Fourth, reference ecosystems may no longer exist, or may not be particularly functional or diverse, and thus not necessarily desirable (Cortina *et al.*, 2006). Last but not least, most projects to combat desertification have hardly been evaluated and monitored. The strong emphasis on the control of technical aspects of project implementation contrasts with an almost total absence of integrated *a posteriori* evaluation. With no proper evaluation, there is no way to verify if the outcomes of a project to combat desertification qualify as ecological restoration or not.

The previous considerations may help to harmonize opposing views on the objectives of ecological restoration in drylands. For example, the spread of alien species constitutes a major environmental concern in the drylands of California, the Northern Mediterranean, South Africa and Australia, where control of aliens such as *Acacia saligna*, *Opuntia* sp. and Eucalyptus sp. is a major management priority (Van Wilgen *et al.*, 2001). Conversely, species that are removed from these areas are currently being planted in drylands of Africa and Asia (*figure 1*). In some cases, the use of alien species may be justified for the production of goods such as forage and fuelwood, and the provision of ecosystem services such as carbon sequestration and soil protection because they facilitate the establishment of native species or because alien planting is one of the various actions included in a larger management plan. Similarly, agreement is lacking on the impact of shrub encroachment (the increase in density, biomass and cover of native shrubs in former grasslands) in studies from different dryland areas (Schlesinger *et al.*, 1990; Valone *et al.*, 2002; Maestre *et al.*, 2009). Disagreement may reflect the complexity of this process (Huxman *et al.*, 2005), but also cultural bias against/in favour of grasslands and shrublands. As a result, depending on the context, both the removal and planting of woody species become major priorities of ecological

[1] Society for Ecological Restoration International (SERI). Global Restoration Network Database. www.globalrestorationnetwork.org/ [Oct. 10th 2010].

[2] United Nations Convention to Combat Desertification, UNCCD (www.unccd.int/).

[3] Society for Ecological Restoration International Science & Policy Working Group. *The SER International Primer on Ecological Restoration*. www.ser.org & Tucson: Society for Ecological Restoration International, 2004.

[4] Programa de Acción Nacional contra la Desertificación. 2008. www.mma.es/portal/secciones/biodiversidad/desertificacion/programa_desertificacion/pdf/PAND_agosto_2008.pdf.

Figure 1. An example of opposing views on environmental problems and restoration targets from the western Mediterranean.

A) *Opuntia ficus-indica* f. *inermis Weber* plantation in South Tunisia; B) invasive *Opuntia ficus-indica* L. Mill in Sierra Filabres (Almería, Spain.
Contrasting management techniques are used to expand or eradicate this species on both shores of the Mediterranean.

restoration in different drylands (Brudvig and Asbjornsen, 2009; Cortina *et al.*, 2011). How can we reconcile such contrasting views? Do they all qualify as ecological restoration? We suggest that the definition of restoration targets in terms of community composition, ecosystem functioning and the provision of goods and services represents a suitable way to integrate such disparate management practices into a general framework of dryland restoration.

A new framework for dryland restoration

As mentioned above, integrated evaluation and monitoring were not considered fundamental parts of management programs to combat desertification, and this failure was partly responsible for unwanted outcomes of these actions. Their targets were usually defined on the basis of one or only a few objectives (the establishment of tree cover, the increase in biodiversity, the introduction of a particular species), disregarding their impacts on the provision of other goods and services. For example, information on the effects of conifer plantations on biodiversity, water and carbon balance or aesthetics is often scarce, despite the significance of these plantations in drylands worldwide ([Maestre and Cortina, 2004; Pausas *et al.*, 2004, [*figure 2*]. Over the last decades, this lack of information has fuelled bitter discussions on the benefits of these plantations that are frequently based on partial views and subjective perceptions.

By the end of the 20th century, a new paradigm based on the incorporation of an integrated ecosystem approach into actions to combat desertification emerged in response to programs that were excessively focused on single or a few services (Le Houérou, 2000). This new paradigm was based on the use of native species, low impact techniques aimed at keeping what was left of the original community composition and ecosystem functioning, and the development of new ecological knowledge. This trend was promoted by innovative technological tools, which were often based on traditional practices. These include expertise on a wide array of species, innovations in the production of quality seedlings, the use of amendments to improve soil fertility, the design of low-impact and efficient techniques for soil preparation (*figure 3*), runoff capture and water harvesting, the assemblage of protocols to control unwanted species, and the use of mutualistic and facilitative interactions (Sheppard *et al.*, 2006; Bainbridge, 2007; Cortina et al., 2011). Still, despite these advances, the success of restoration actions is not guaranteed.

Ecological uncertainties

Re-establishing functional and self-sustaining landscapes under semiarid conditions is particularly challenging. The combination of harsh climatic conditions, degraded soils and impoverished communities increases the probability of failed successional trajectories leading to undesired communities, further degradation and wasted efforts. We suggest that failures are frequently related to poor understanding of species ecology and community dynamics, along with inability to integrate climatic variability.

The literature shows many examples where management techniques were

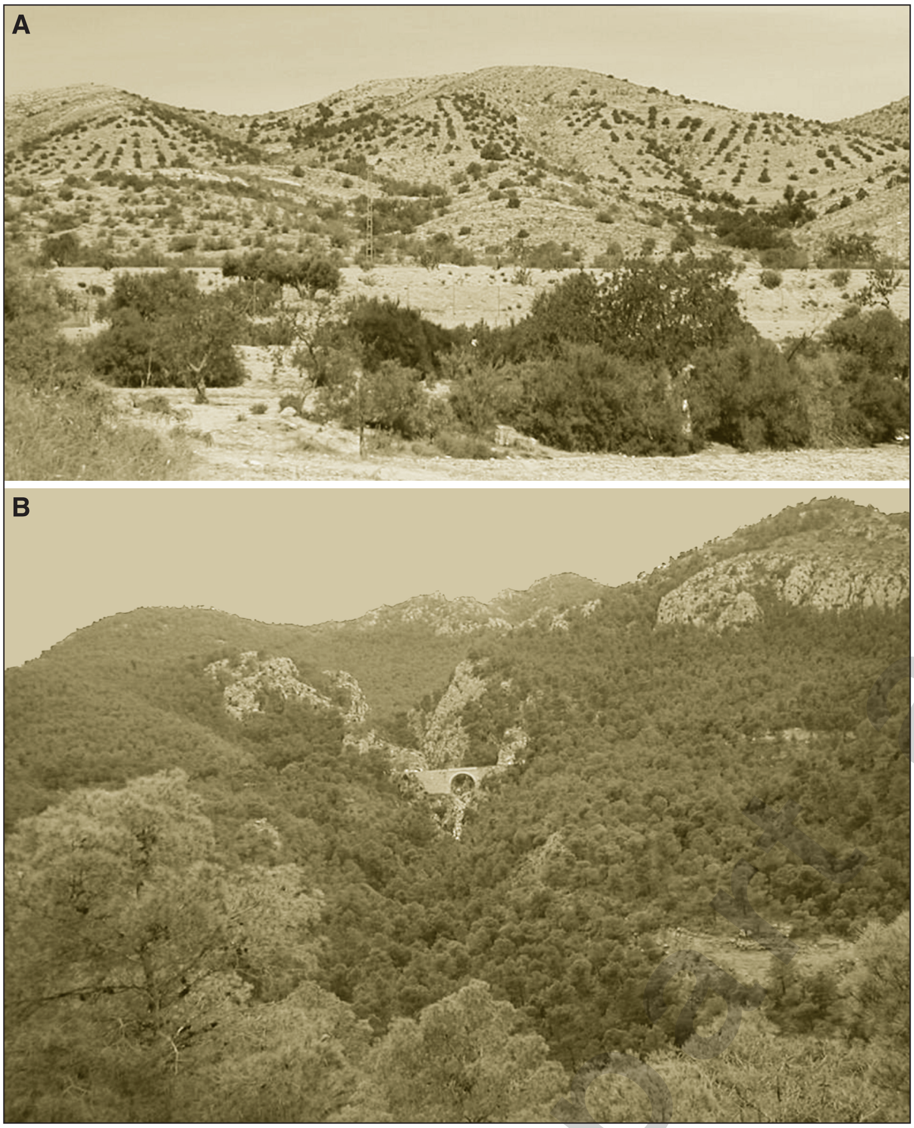

Figure 2. Examples of *Pinus halepensis* plantations used to restore plant cover in South East Spain.

A) *Pinus halepensis* Mill. plantations in Elx ; B) *Pinus halepensis* Mill. plantations in Ricote valley (South East Spain).
This species has been widely used to restore plant cover in semiarid Mediterranean areas with contrasted success. Knowledge on the ecological impact of these plantations however remains limited.

applied before enough information on their consequences was available. These include the use of alien herbaceous species in burnt areas of the American West (Robichaud *et al.*, 2000) and the establishment of *Lupinus nootkatensis* in eroded slopes on Iceland (Magnússon, 1997). For example, woody species such as *Quercus coccifera*, *Pistacia lentiscus* and *Rhamnus lycioides* have been extensively used for the restoration of *Stipa tenacissima* steppes in South East Spain (Cortina *et al.*, 2011), where they are considered keystone species. However, our knowledge on the natural dynamics of these species, on their long-term recruitment rate, longevity, sensitivity to soil properties and ability to face long intense drought is scarce.

The success of restoration actions also depends on climatic variability. Years with less moisture than average take a toll on forest plantations. Two alternative management options may be taken: assume that sporadic recruitment is an intrinsic trait of these species and plan interventions on time scales that match natural processes (*i.e.*, the traditional approach), or compensate harsh environmental conditions with increasing technological inputs (including watering, mulching, runoff harvesting, etc.) at a higher economic cost. In both cases, it would be good to improve our ability to forecast climatic conditions, a goal that looks closer now than some decades ago (Holmgren and Scheffer, 2001; Mariotti *et al.*, 2002). This topic is particularly relevant, as climatic conditions in drylands worldwide may become even harsher in the near future (Giorgi and Lionello, 2008). As dryland restoration is planned on a time scale of decades, further knowledge on species ability to cope with new climatic conditions is urgently needed.

Finally, identifying the underlying causes of failures in restoration actions demands the design and implementation of comprehensive evaluation and monitoring programs (Bautista and Alloza, 2009). They should be based on suitable indicators that can be applied by practitioners and designed to feed back on management. It is worth noting that a proper evaluation of restoration actions should include indicators of stakeholder perceptions. To achieve this and other goals discussed below, social participation is a must.

Beyond ecology

Ecological restoration represents a unique way of improving the provision of goods and services while enhancing livelihoods in degraded drylands. However, restoration actions are too often carried out by the Forest Administration or particular groups of interest with no further social involvement. This is not only a source of conflict, but a missed opportunity to develop adaptive management, promote people involvement and motivation and to improve restoration success.

Various tools may contribute to these goals:

1. People may not be sensitive to specific aspects of community composition and ecosystem functioning, but they may better understand changes in ecosystem services such as water and fuelwood production and soil protection, services that affect their day-to-day life (Safriel and Adeel, 2005). Ecosystem services provide a common language to negotiate and reach consensus;
2. Restoration should not be implemented in isolated actions but integrated into comprehensive development programs. There are many examples of this approach in developing countries that

Figure 3. Technological tools and deeper knowledge of biotic and abiotic interactions are partly responsible for recent improvements in restoration practices.

A) The spider back-hoe facilitates the establishment of target key species, avoiding deleterious effects of large slope modifications; B) *Stipa tenacissima* L. shadow benefits seedlings of woody species such as *Pinus halepensis* (Gasque and García-Fayos, 2004).

developed countries should adopt to improve the efficiency of these interventions (Dongier *et al.*, 2003; Raddaoui, 2009). This point is particularly challenging, as it demands collaboration between different government Departments and effective participative management. Furthermore, integrated projects provide the opportunity to adjust the duration of the actions to ecologically and socially meaningful time scales;

3. A network of pilot and demonstration projects needs to be established to test new techniques at a management scale, provide evidence of good management practices and contribute to knowledge exchange [Li *et al.*, 2007; Vilagrosa *et al.*, 2008], *figure 4*).

Ecological restoration is expensive. For example, the cost of a 3-hectare plantation in SE Spain is similar to the total cost of a graduate student (ca. 7,000 euros per year[5]. Thus, we must be very careful before advocating public expenditure in restoration actions. Some alternatives to fund restoration programs aimed at combating desertification may be forwarded. First, the economic benefits derived from restoration programs may pay for the costs. For example, in Morocco the costs of desertification may be 5 times the costs of restoration (4.6% *versus* 0.8% of the Gross Domestic Product, respectively [Requier-Desjardins *et al.*, 2009]. Second, the involvement of non-governmental organizations (NGOs), communities and most directly affected stakeholders may reduce the costs of restoration actions. Finally, integrating restoration actions into development programs may provide access to other sources of funding. As an example, European programs such as the Agricultural Fund for Rural Development (EAFRD), the Regional Development Fund (ERDF), the Cohesion Fund and the LIFE-Environment and LIFE-Nature include measures related to ecological restoration.

Conclusions

Actions to combat desertification should adopt the principles of ecological restoration to meet the challenges posed by this worldwide environmental problem. At the same time, restoration ecologists should devote further attention to degraded drylands in accordance with the magnitude of this problem. Technological tools and strategies to combat desertification have significantly improved over the last decades, but uncertainties about the outcomes of restoration actions, particularly in response to climate change, are still substantial. Our understanding of the ecology of key species should be increased to improve our ability to prescribe efficient restoration actions. But ecological and technological improvements will have a modest impact on dryland capacity to provide ecosystem services and contribute to human welfare unless participative, adaptive and integrated management strategies are implemented.

[5] CRUE. *La Universidad española en cifras.* Conferencia de Rectores de las Universidades Españolas (CRUE). 2010. Available at www.crue.org.

Figure 4. Demonstration site in Albatera (South East Spain) where new protocols and techniques to restore degraded semiarid lands have been implemented.

Acknowledgements

This text was written thanks to the funding received from project RECUVES (Spanish Ministry of the Environment, Rural and Marine Areas; 077/RN08/04.1), project GRACCIE (Spanish Ministry of Science and Innovation, Consolider-Ingenio 2010 Program; CSD2007-00067) and Generalitat Valenciana (Programa G. Forteza; FPA/2009/029). We thank Marjolein Visser for her kind invitation and Ramon Vallejo for his common sense, effort and inspiration. CEAM Foundation is partly funded by Generalitat Valenciana and Fundación Bancaja.

References

Aronson J, Blignaut JN, Milton SJ, Le Maitre D, Esler K, Limouzin A, *et al,* 2010. Are socio-economic benefits of restoration adequately quantified? A meta analysis of recent papers (2000-2008) in Restoration Ecology and 12 other scientific journals. *Rest Ecol* 18: 143-54.

Bainbridge DA, 2007. *A Guide for Desert and Dryland Restoration: New Hope for Arid Lands.* Washington (DC): Island Press.

Bautista S, Alloza JA, 2009. Evaluation of forest restoration. In: Bautista S, Aronson J, Vallejo VR, eds. *Land Restoration to Combat Desertification. Innovative Approaches, Quality Control and Project Evaluation.* Valencia: Fundación CEAM.

Brudvig LA, Asbjornsen H, 2009. The removal of woody encroachment restores biophysical gradients in Midwestern oak savannas. *J Appl Ecol* 46: 231-40.

Cortina J, Maestre FT, Vallejo R, Baeza MJ, Valdecantos A, Pérez-Devesa M, 2006. Ecosystem composition, function and restoration success: are they related? *J Nature Cons* 14: 152-60.

Cortina J, Amat B, Castillo V, Fuentes D, Maestre FT, Padilla FM, *(submitted).* The restoration of vegetation cover in the semi-arid Iberian southeast *J Arid Environ.*

Dongier P, Van Domelen J, Ostrom E, Ryan A, Wakeman W, Bebbington A, 2003. Community-Driven Development. In: The World Bank, ed. *PRSP Sourcebook.* Volume 1. Washington (DC) : World Bank.

Gasque M, GarcÕa-Fayos P, 2004. Interactions between *Stipa tenacissima* and *Pinus halepensis*: consequences for reforestation and the dynamics of grass steppes in semi-arid Mediterranean areas. *For Ecol Manage* 189: 251-61.

Giorgi F, Lionello P, 2008. Climate change projections for the Mediterranean region. *Global Planetary Change* 63: 90-104.

Holmgren M, Scheffer M, 2001. El Niño as a window of opportunity for the restoration of degraded arid ecosystems. *Ecosystems* 4: 151-9.

Huxman TE, Wilcox BP, Breshears DD, Scott RL, Snyder Ka, Small EE, *et al,* 2005. Ecohydrological implications of woody plant encroachment. *Ecology* 86: 308-19.''http://dx.doi.org/10.1890/03-0583''dx.doi.org/10.1890/03-0583.

Le Houérou HN, 2000. Restoration and rehabilitation of arid and semiarid Mediterranean ecosystems in North Africa and West Asia: A review. *Arid Soil Research and Rehabilitation* 14: 3-14.

Li G, Jiang G, Li Y, Liu M, Peng Y, Li L, Han X, 2007. A new approach to the fight against desertification in Inner Mongolia. *Environ Cons* 34: 95-7.

Maestre FT, Bowker MA, Puche MD, Belén Hinojosa M, MartÕnez I, GarcÕa-Palacios Pn, *et al.*, 2009. Shrub encroachment can reverse desertification in Mediterranean semiarid grasslands. *Ecol Letters* 12: 930-41.

Maestre FT, Cortina J, 2004. Are *Pinus halepensis* plantations useful as a restoration tool in degraded semiarid Mediterranean areas? *For Ecol Manage* 198: 303-17.

Magnússon SH, 1997. Restoration of eroded areas in Iceland. In: Urbanska KM, Webb NR, Edwards PJ, eds. *Restoration Ecology and Sustainable Development.* Cambridge: Cambridge University Press.

Mariotti A, Zeng N, Lau KM, 2002. Euro-Mediterranean rainfall and ENSO - a seasonally varying relationship. *Geophys Res Letters* 29. doi: 10.1029/2001GL014248.

Pausas JG, Bladé C, Valdecantos A, Seva J, Fuentes D, Alloza J , *et al.*, 2004. Pines and oaks in the restoration of Mediterranean landscapes of Spain: New perspectives for an old practice ö a review. *Plant Ecol* 171: 209-20.

Pemán J, Blanco R, Ruvireta J, 2009. Análisis del impacto de la actividad repobladora en la estadÕstica del desempleo, durante el perÕodo de tiempo entre 1946-1961, en varias provincias españolas. *Cuadernos de la SECF* 30: 319-24.

Raddaoui B, 2009. Participatory monitoring and evaluation of a project to combat desertification in drylands (case study in Centre Western Tunisia). In: Marini A, Talbi M, eds. *Desertification and risk analysis using high and medium resolution satellite data.* The NATO Science for Peace and Security Programme. Dordrecht: Springer Science and Business Media B+V.

Requier-Desjardins M, Jauffret S, Ben Khatra N, 2009. La lucha contra la desertificación. In: *Terramed. Nuevas Perspectivas para el Desarrollo Rural en el Mediterráneo.* Madrid: Ciheam; Ministerio de Medio Ambiente y Medio Rural y Marino.

Reynolds JF, Stafford-Smith DM, Lambin EF, *et al*, 2007. Global desertification: building a science for dryland development. *Science* 316: 847-51.

Robichaud PR, Beyers JL, Neary DG, 2000. *Evaluating the Effectiveness Of Postfire Rehabilitation Treatments.* USDA General Technical Report RMRS-GTR-63.

Safriel U, Adeel Z, 2005. Dryland Systems. In: Hassan R, Scholes R, Ash N, eds. *Ecosystems and human well-being, current state and trends.* Vol 1. Washington: Island Press.

Schlesinger WH, Reynolds JF, Cunningham GL, Huenneke LF, Jarrell WM, Virginia RA, *et al.*, 1990. Biological feedbacks in global desertification. *Science* 247: 1043-8.

Sheppard AW, Shaw RH, Sforza R, 2006. Top 20 environmental weeds for classical biological control in Europe: a review of opportunities, regulations and other barriers to adoption. *Weed Res* 46: 93-117.

Valone T, Meyer M, Brown J, Chew R, 2002. Timescale of perennial grass recovery in desertified arid grasslands following livestock removal. *Conservation Biology* 16: 995-1002.

Van Wilgen BW, Richardson DM, Le Maitre DC, Marais C, Magadlela D, 2001. The economic consequences of alien plant invasions: Examples of impacts and approaches to sustainable management in South Africa. *Environment, Development and Sustainability* 3:145-68.

Vilagrosa A, Chirino E, Bautista S, Urgeghe A, Alloza JA, Vallejo VR, 2008. Proyecto de lucha contra la desertificación: regeneración y plan de manejo de zonas semiáridas degradadas, en el T.M. de Albatera (Alicante). *Cuadernos de la SECF* 28: 317-22.