A LOOK TO THE IMPLICATIONS OF THE GLOBAL CHANGE FOR THE HABITAT RESTORATION

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ABSTRACT

Warming climate and many human activities add together to exacerbate the drought effects on the ecosystems, but there are many ways to attempt to reduce or prevent these. Habitat restoration is a wide term that includes a range of activities. Although many techniques of the land rehabilitation are traditionally used since a long time, to adjust or to readdress these in order to solving or mitigating problems related to the global change seems necessary. Special attention has to be paid to consider as a target a future scenario different from those of the past. The main implications of the global change on the habitat restoration pertain to the planning and projecting phases, the choice of plants to be employed, the competition ability of the alien species, the difficulties in the conservation of river systems and wet zones, the wide spreading of parasites. The main guidelines for a habitat restoration with right attentions to the global change are explained and a case study of habitat restoration with mycorrhizal plants in Mediterranean burnt areas is showed to exemplify some consequences of the global change on the successful of the intervention.

KEYWORDS

Habitat restoration, global change

INTRODUCTION

Many environmental problems are linked with the climate change and desertification of arid, semi-arid and sub-humid regions is one of the most important. While global warming is added to many human activities (deforestation, expansion of cultivated or urbanized areas, new industrial, etc.) emphasizing the drought effects on the ecosystems, on the other hand there are many attempts to reduce or prevent such effects. Obviously the prevention includes reducing emission of pollutants (greenhouse gases in the first place) as the main action, but in the short to medium term it has to be juxtaposed by the land rehabilitation and the repair of natural processes.

Knowledge of botany and plant ecophysiology, as well as the techniques of environmental design are essential for the biodiversity conservation (Gitay *et al*, 2002). The actions for prevention and the strategy for combating desertification are based in large part on information obtained in research projects of the laboratories, experimental fields and botanical gardens. Not by chance one of the posters of the 2006 international year dedicated to the desert and desertification, highlighting the green of the plant world which contrasts with the typical colours of the desert.

HABITAT RESTORATION

Habitat restoration is a wide term that includes a range of activities: reclamation of abiotic site conditions, bioengineering, rehabilitation of natural values, restoration of functioning ecosystems, species reintroduction or repopulation, reforestation, etc. There are many language problems, because some words have several meanings and some have no real equivalent in different languages, so that we can create significant misunderstandings. For example, the term Land reclamation can be used to indicate reclamation of wetlands and aquatic areas or even for artificial nourishment of beaches (i.e. low sustainable environmental point of view) or to indicate the restoration of degraded habitats. Habitat restoration is often done using more or less innovative methods of the bioengineering. The recent success of the bioengineering has put into the background the fact that many of the techniques used for the fitting of the slopes, the consolidation of the dunes, the contrast to the shoreline erosion, etc have a strong tradition which is of cultural heritage especially of forest practitioners. In recent decades it has developed mainly the use of new materials for the most abiotic (polymeric three-dimensional geotextile mats, double twisted wire mesh with extra durability, new bentonite products, geomembranes, woven and non-woven fabrics, geogrids, biodegradable preseeded mats, etc) and new geometric design, but much remains to be done as regards the living material used in all interventions aimed at improving the natural and semi-natural environments.

GLOBAL CHANGE AND VEGETATION SCENARIOS

The effects of global change are not limited to the expansion of desert conditions in the most arid and ho zones, or to the reduction of the glaciers, but also occur in significant changes that affect, in temperate regions, the areas of all forest communities, the forest line, and the tree line.

For a better understanding of the processes affected by the global change, on tree line, are interesting, for example, the results of a genetic research conducted by Piotti e collaborators (Piotti, 2006; Piotti *et al*. 2005, 2007, 2009) on plants of Norway spruce that colonize abandoned pastures on the northern borders (up to 2200 m) of the Paneveggio Forest (Trentino, Italy). A large proportion of genes involved in the colonization comes from outside, most likely by members of the forest below. It has been suggested that the current conditions of temperature at tree line may be more favorable for genotypes from the band immediately below the uninterrupted forest edge. Even Pelham and Billington (1991) and Jump and Peñuelas (2005), argued that in general the gene flow from warmer areas could prove crucial for adaptation to new environmental conditions determined by the rise of average temperatures. The beech trees (*Fagus sylvatica*) in Montseny mountains(Catalonia, Spain) located within the lower limits show a growth much less than that detected at the higher altitudes (Jump *et al*.,2006, 2007). This phenomenon was started in 1975. Since 2003, growth was reduced by 49% compared to what happened before the decline. It is assumed that rainfall - not decreased - is not longer able to balance the loss by evapotranspiration, which is due to increased temperatures. The decline of beech can be observed along the southern edge of its range in different areas of the Mediterranean.

The physiognomy and the flora of the beech forest are changing also. In Liguria (Italy), some data (Mariotti, s.d.; Vagge and Mariotti, 2009) are envisaging a reduction of more mesophilous forest communities related to eutrophic *Trochiscantho-Fagetum* (*Fagenion*) that would be partially replaced by communities of oligotrophic *Luzulo-Fagenion* or related to thermophilous *Cephalanthero-Fagion*. In Mediterranean area, beech and other deciduous oaks are in many cases replaced by more thermophilous species, such as holm oak, which is expanding towards higher altitudes than those achieved so far.

GLOBAL CHANGE AND HABITAT RESTORATION

With regard to the global climate changes it needs to adjust or to readdress the habitat restoration in order to solve or mitigate problems in the short- or medium time. The general guidelines of the ecological restoration have to re-orientated not only betting to rebuild the environment as it was before degradation or destruction, but looking to the surviving and establishing chances for pre-adapted planned neo-ecosystems.

The habitat restoration needs better:

- detail of the planning and projecting phases,
- choice of different species to be employed,

- selection and production of different plant ecotypes in the nurseries.

We must consider also other important implications:

- the competition ability of the alien species is often enhanced by the global change,
- the conservation of river systems and wet zones is more difficult than in the past,
- the widespread of parasites strongly reduces the fitness of plant, more than in the past.

MAIN GUIDELINES FOR A NEW ECOLOGICAL RESTORATION MODEL

The main guidelines for a habitat restoration with right attentions to the global change implications include:

(1) new address of the land and urban planning oriented to widen the green surfaces;

(2) use of plants (species and ecotypes) with selected ecological and biological characters:

a. lower water requirements,

b. higher drought resistance,

c. higher performance,

d. higher resilience to stress and fire;

(3) adoption of appropriate strategies for protecting transplants from environmental stress.

1 A new address of the land and urban planning

The dilemma may be choosing among the skyscraper more or less sustainable, but with a reduced consumption of surface (Gissen, 2003), the emergent model of the widespread city (*città diffusa* or *metapolis*) (Ascher, 1995; Indovina *et al*., 2002) that creates problems of transformation in urban and not urban areas (Detragiache, 2003), and the ideal garden-city (Howard, 1902). The future urban planning strategies should be aimed at greater conservation or increase of the green areas and at the naturalness restore.

Urbanization and the conversion of natural areas was constant almost anywhere. For example, the complete transformation of the coast from agricultural to urban has significantly affected the region Liguria in the last 150 years. By now only few sites show relicts of naturalness. The figures (Fig.1a, 1b and 1c) show the clear contrast between semi-natural aspects and those heavily modified by man even though very near each other.

The need for more green areas combined with a purely aesthetic led to the return of the plants in the city through the creation of special gardens. However, even if an advanced green technology is now available for the implementation of green building (green roofs, green walls, etc.), not all architects consider carefully the balance between the captured rainwater and the water requirements of the selected plants.

On the one hand there are correct solutions with reduced demand for water and from another side intensive green roofs that require continuous and abundant irrigation. It seems positive the spread of a new way of thinking the design of gardens and landscapes: the dry xeriscaping, or landscaping, namely the creation of xerophytic landscapes with low demand for water. Xeriscaping and xerigardening literally mean dry landscaping and dry gardening, but are generally used to refer to landscaping or gardening that maximize the efficient use of water in landscapes and gardens (Christopher, 1994; Chatto, 1996; Bennet, 1998; Rumary, 2001;Lockhart Ellefson and Winger, 2004).

Fig. 1 - Contrasts between the residues of naturalness that are found on the western side of Cape Mortola (a), the areas deeply transformed by long time terraced for agricultural purposes, but also with recent land modifications, as swimming pools, buildings and other artefacts of new construction, at Bordighera (b) and the almost continuous urbanization so much a part of the Ligurian coast and other parts of the Mediterranean (c).

2. Use of plants with selected ecological and biological characters

The use of species and ecotypes with a low water requirement, in gardening and environmental restoration interventions, is important. Native plants often require less water, but some species or ecotypes adapted to the conditions of arid and semi-arid regions are suitable for habitat restoration in temperate regions in prevision of the warming climate.

Equally important is the use of species and ecotypes with high drought resistance. This may be innate or induced by traditional methods of acclimation, or more advanced biotechnological processes.

There are few studies of the performance of species in restored vegetation communities. Efficiency might be increased by introducing only species with good performance, but this would lead to uniformity among restored habitats and would diminish the benefits of habitat restoration for national and regional biodiversity (Pywell *et al*., 2003; Hufford and Mazer, 2003). In general colonization ability and competitive ability increase performance, regeneration by vegetative growth or from the seed bank enhances performance, habitat generalists and species of fertile conditions perform well.

Controlled experiments provide data on genetic resilience to stress and adaptability of individual plants to changing environments. The technology allows us to build genetic resilience to stress not only in crop plants.

There are several promising species for the restoration of extremely degraded lands with high resilience to fire (i.e.: *Brachypodium retusum*, *Ampelodesmos mauritanica*, etc.).

3 Adoption of appropriate strategies for protecting transplants

Cell shape, material and size of transplant container affect the growth and the development of the transplanted plants (Mc Creary and Lippit, 2000). Studies are necessary (i) to improve plant growth containers and methods for growing and transplanting, (ii) to promote the root growth and the maximized production of not damaged lateral root tips, (iii) to improve the protection of the bareroot seedlings, (iiii) to investigate advanced methods (biological or not) for protecting the transplanted plant against drought, parasites and for controlling the weeds.

Table 1 – Species used for the ecological restoration in the studied area. All mycorrhyzed plants come from nurseries Robin (France, Saint Laurent du Cros).

Species	Provenance	Quantity	Mycorrhizal	Not mycorrhizal
Quercus suber	Toscana (Italy)	3900	-	3900
Quercus suber	Valernes (France)	1500	1500	-
Quercus ilex	Valle Stura (Italy)	3500	-	3500
Quercus ilex	Valernes (France)	6000	4000	2000
Quercus pubescens	Valernes (France)	4000	2000	200
Fraxinus ornus	Toscana (Italy)	500	-	500
Ostrya carpinifolia	Toscana (Italy)	500	-	500
Total		19900	7500	12400

A STUDY CASE. RESTORATION IN A BURNT AREA

A study case of habitat restoration with mycorrhizal plants in mediterranean burnt areas is summarized to exemplify some consequences of the global change on the successful of the intervention. This was performed in Sestri Levante (east of Genoa) in an area burned repeatedly and heavily eroded, where, before the fires was a forest of maritime pine (*Pinus pinaster*), already severely damaged by insects scale (*Matsucoccus feytaudi*). The soil was almost entirely removed by erosive processes.

The reforestation was carried out with 1-2 years aged broadleaves seedlings, some of them mycorrhized by *Laccaria bicolor* (Maire) P.D. Orton and *Hebeloma crustuliniforme* (Bull.) Quél (Tab. 1). The goal of the investigation is to assess the effectiveness of the reforestation and the planted trees vitality (Zotti *et al*., 2007). The assessment was carried out five years after the plantation and focused on the plants of holm oak (*Quercus ilex* L.).

Many of the plants died or had reduced growth. The diagram of dispersion (Fig. 2) of data on growth of seedlings of holm oak shows, contrary to what might be expected (Nardini *et al*., 2000), a lower performance of the mycorrhized plants. Possible explanations for these failures are due to several factors, including: reduced presence of organic matter in the soil after the fires, low levels of nutrients, reduced microbial activity, no post-cultivation treatment, weather trend of the year 2003 with a very hot and dry summer, no use of local plant ecotypes and local mycelium, competition between the introduced mycelium and the local ones survived the fire, use of water and nutrient resources more by the fungal component that by the plant.

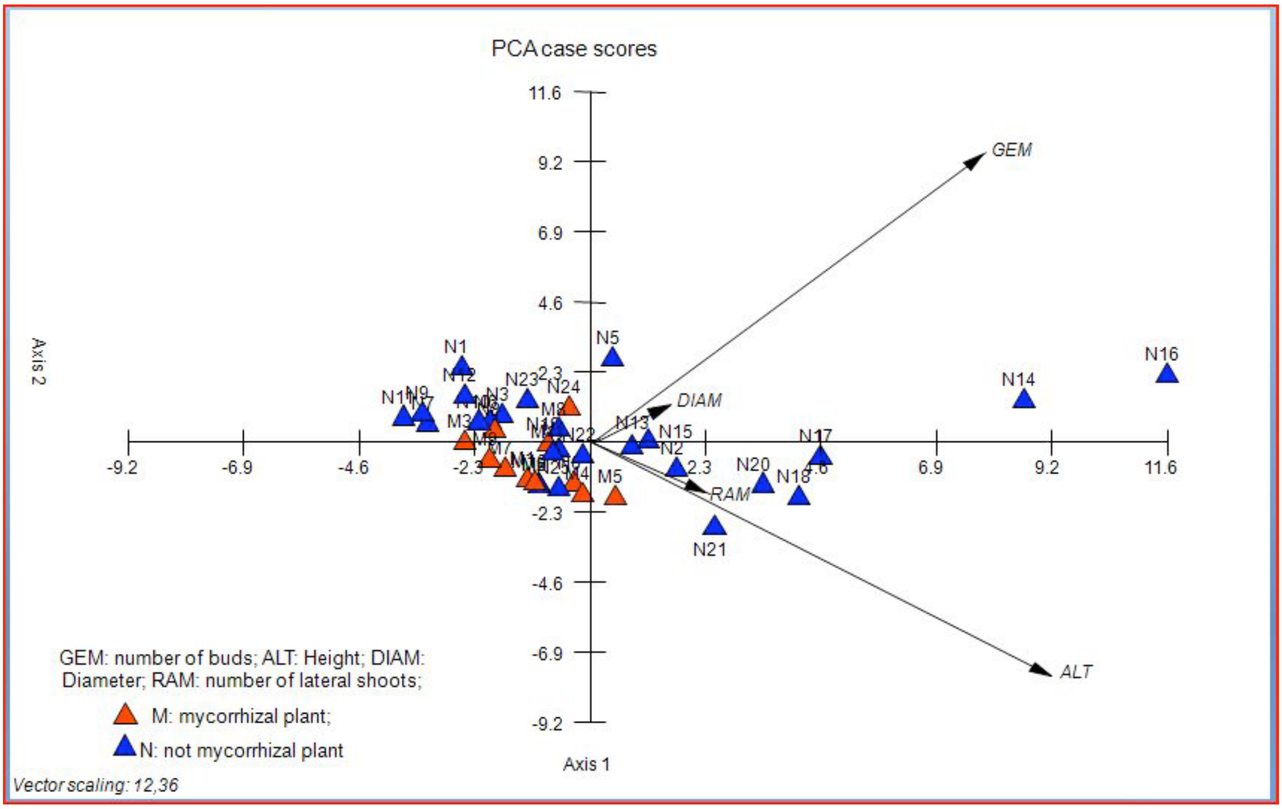

Fig. 2 - Diagram of dispersion obtained by principal component analysis (PCA). Data from each plant were recorded on a 4-dimensional space represented by the trunk diameter, height above the ground, the number of buds and number of lateral branches. The mycorrhized plants are showed in red with letter M, while not mycorrhized plants are in blue, with the letter N. The origin of the axes is located in the center of gravity of the points-plants system.

Innovative technologies, such as use of bags from organic fabric, filled with amended substrate and biota (Kohler *et al*., 2006) or other techniques (Bowker, 2007), such instead to the traditional planting pit technologies could perhaps have better success. Furthermore locally collected field inocula appear to be more effective than commercial inocula for establishing late-successional plant species (Rowe *et al*., 2007).

Conclusions

The solution for restoring ecosystems will not come from regression analyses or replicated studies, but the deep, searching, intelligent, humble inquiries into the human past and prospect, to the varieties of human experience, value and creativity, and of course to the many ways we have both loved and despoiled nature (Higgs, 2005). What kind of habitat or ecosystem of reference should we aim at restoring? This is the most important question to which we must respond every time we act on areas that show serious environmental problems. Restoration actions are often very expensive and not very fruitful. Interspecific relationships (predation, competition, hybridization) seem to have a significant impact on results and can sometimes completely destroy the efforts. Global change can have a significant effect on these results. It is therefore necessary to combine the experience of good governance of the territory with that of the most scientific experiments. We must carefully define the goal of the actions rather than revive the past in the name of pure search of the wilderness and prefer to support the natural processes that in the medium and long term include the ongoing adaptation to climate change. The ultimate goal of restoration is to create a self-supporting ecosystem that is resilient to perturbation without further assistance (Urbanska *et al*., 1997). Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER, 2004). Recently, the Society of Ecological Restoration International (SER, 2004) has produced a Primer that includes ecosystem attributes that should be considered when evaluating restoration success. They suggested that a restored ecosystem should have the following attributes: (1) similar diversity and community structure in comparison with reference sites; (2) presence of indigenous species; (3) presence of functional groups necessary for long-term stability; (4) capacity of the physical environment to sustain reproducing populations; (5) normal functioning; (6) integration with the landscape; (7) elimination of potential threats. Ruiz-Jean and Aide (2007) suggest to assess measures that can be categorized into three major ecosystem attributes: (1) diversity; (2) vegetation structure; and (3) ecological processes. Ecological restoration is an intentional activity that initiates or accelerates an ecological pathway—or trajectory through time—towards a reference state (SER/IUCN, 2004). The reference state is therefore the point of arrival, to achieve what is necessary to calibrate the techniques and materials used, but not necessarily the reference state is the same as in the past in the site of intervention. Most of the above principles should be respected for a successful restoration respectful to the biodiversity. But, after the evaluation of the possibility of a spontaneous restoration, we must examine more precisely for each habitat the chance to self-maintain in long term and for this also the global change effects.

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