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Abstract. The grasslands in the different Mediterranean zones around the world are an important component of the landscape. In the past, the central goal of managing these grasslands was to maximize the utilization of the forage resource for animal production. Nowadays the ecological point of view plays an important role as well. During the last several thousands of years the open lands around the Mediterranean Sea were often under heavy human utilization. Therefore these grasslands are mostly anthropogenic ecosystems maintained in dynamic equilibrium by cultivation, fire and intensive grazing. Consequently, a large part of these areas are considered degraded and their productivity is low. Human interventions are required in order to repair these degraded lands. Where degradation is very heavy and the land has no capacity to reach a high productive level, different interventions are essential. Rehabilitation or restoration of grasslands, which is the conversion of the degraded land into a functional ecosystem suitable for high forage production, is one of the options. This strategy can include a range of different eco-technological activities such as: controlled grazing, introducing annual and/or perennial legumes and grass species, controlled fire, input of exogenous nutrients (particularly phosphorus or nitrogen) and herbicide application. The goal of this paper is to present a short overview of rehabilitation measures that can be applied to increase forage production of degraded Meiterranean forage ecosystems.

Keywords. Degradation – Exogenous nutrients – Grazing – Restoration – Sown pasture.

Réhabilitation des pâturages méditerranéens.

Résumé. *Les pâturages dans les différentes zones méditerranéennes du monde sont une importante composante du paysage. Dans le passé, la finalité centrale de gestion de ces pâturages était de maximiser l'utilisation des ressources fourragères pour la production animale. De nos jours, le point de vue écologique joue aussi un rôle important. Pendant les derniers milliers d'années, les terres défrichées autour de la mer Méditerranée étaient souvent soumises à une lourde utilisation humaine. Toutefois ces pâturages sont principalement des écosystèmes anthropogéniques maintenus en équilibre dynamique par les cultures, le feu et le pâturage intensif. Par conséquent, une grande partie de ces zones sont considérées dégradées et leur productivité est faible. Les interventions humaines sont nécessaires afin d'améliorer ces terres dégradées. Là où la dégradation est très lourde et la terre n'a pas la capacité d'atteindre un niveau productif élevé, différentes interventions sont essentielles. La réhabilitation ou la restauration des pâturages, qui est la conversion des terres dégradées en un écosystème fonctionnel convenant à une forte production de fourrage, est une des options. Cette stratégie peut inclure une gamme de différentes activités éco-technologiques telles que: pâturage contrôlé, introduction d'espèces de légumineuses et de graminées annuelles et/ou vivaces, brûlage contrôlé, intrants de nutriments exogènes (en particulier phosphore ou azote) et application d'herbicides. Le propos de cet article est de présenter une courte révision des mesures de réhabilitation pouvant être appliquées pour augmenter la production de fourrage des écosystèmes fourragers méditerranéens dégradés.*

Mots-clés. *Dégradation – Nutriments exogènes – Pâturage – Restauration – Pâturage semé.*

I – Introduction

Grassland is defined as pastureland when referring to an imposed grazing-land ecosystem. The vegetation of grassland in this context includes grasses, legumes and other forbs, and at times woody species may be present (Allen *et al*., 2011). As for the Mediterranean grasslands, which are characterized by broadleaved, sclerophyllous, evergreen trees and shrubs (Raven, 1973), this definition can be expanded and also include these vegetation types. According to Le Houerou (1992), in the Mediterranean basin most native stands are depleted either by

woodcutting or by overgrazing or both, and many of them have been cleared for cereal cultivation with poor results in the long run. The annual Mediterranean grasslands are an important component of these areas mainly for animal production. In many cases they are considered to be in an extreme state of degradation or mostly an artifact maintained by cultivation, fire, and grazing against the continuing pressures of the invasion and regeneration of woody species (Seligman, 1996). In all cases, they are anthropogenic ecosystems (Tansley, 1935).

Generally, land use and with it the status and role of Mediterranean grasslands have undergone change during the last millennia (Nave and Dan, 1973). In countries around the Mediterranean basin, deep, fertile valley soils have been cultivated since the dawn of agriculture and have supported one of the more stable, sustainable systems of land use in the world (Seligman, 1996). In other Mediterranean zones in the new world agricultural land use is also intensive but its history is related to the relatively recent colonization of these countries. As fertile cultivated valley soils were finite, along the years people also cleared and cultivated shallower, rockier and more fragmented land areas (Nave and Dan, 1973). With time many of these marginal sites were abandoned and much of the land reverted to sclerophyllous woodland, dwarf shrub formations interspersed with grassland species such as annuals, but also hemicriptophytes (Nave and Dan, 1973; Noy-Meir and Seligman, 1979; Shmida, 1981).

Traditionally, the central goal of grassland management was maximizing the utilization of the forage resource for animal production. Forage utilization of the Mediterranean system depends on the type and seasonality of the vegetation, scale of enterprise, class of livestock, stocking rate, grazing management system, infrastructure, land tenure and socioeconomic context (Seligman, 1996). The annual cyclic change that is of greatest significance for animal production in Mediterranean pastoral systems is the cycle of forage availability and quality. The cool, wet Mediterranean winter and hot and dry summer impose strong seasonality that favors annual species and drought-resistant perennials (Seligman, 1996). It is therefore common to find in Mediterranean grasslands many species well adapted to long dry spells and grazing (Perevolotsky and Seligman, 1998). But as shown by Jackson (1985), where summer conditions are milder, perennial grasses and forbs are more prominent. The perennial grass species were found to be rare on productive soils of Californian rangeland (Wester**,** 1981), while more common on poorer sites with shallow soils, where competition with annuals is less severe (Edwards, 1992).

Systems with an herbaceous layer dominated by annuals were found to be more prone to ecosystem degradation under future global change regimes (Ruppert *et al*., 2015). Grasslands, like the *dehesa* of Spain, are found mostly on soils with fertility constraints that preclude the continuous cultivation practiced in the more fertile and usually deeper and heavier valley soils (Seligman, 1996). So, where traction (by animal or by machine) is feasible, grasslands have been maintained by periodic cultivation. In addition, it was shown (Ruppert *et al*., 2015) that increasing drought intensity reduced ecosystem resistance, and that annual systems were less resistant than perennial herbaceous systems. In contrast, annuals were found to recover faster after droughts than perennials (i.e., they are more resilient), especially under grazing. Coiffait-Gombault *et al*. (2012) showed low resilience of an old dry herbaceous Mediterranean ecosystem after human disturbance. Sternberg *et al*. (2015), on the other hand, showed high resistance of Mediterranean grassland in north-eastern Israel to grazing intensity and inter-annual fluctuations in climatic conditions.

In general, disturbance is an important factor in many ecosystems. Variations among disturbance regimes can affect ecosystem and community structure and their functioning (Hobbs and Huenneke, 1992). As mentioned, many of the open lands of the Mediterranean climate zone were under heavy human utilization during the last several thousands of years; this includes grazing at high stocking densities, which sometimes lead to degradation of the land. Grazing is the most degrading type of land use in the world (Papanastasis, 2009), particularly in arid and semiarid areas. According to Ghassali *et al*. (1999), the land degradation in north Syria

was caused by greatly increased populations of people and livestock which led to overgrazing, the uprooting of shrubs and trees for fuel and the encroachment of cultivation. As a result, the original perennial vegetation has been replaced by low densities of annuals and unpalatable spiny species. Also, in China it was shown that large parts of the rangelands have recently become degraded and desertification is a widespread problem, while the cause of degradation is over-grazing and over-cultivation (Han *et al*., 2008).

Human interventions are required in order to repair these degraded lands for increased forage production. In some cases, where degradation is light, the system is capable of returning to the lands' basic state, but in other cases, where degradation is severe there is no capacity of the land to reach a high productive level. According to Aronson *et al*. (1993a), rehabilitation of grasslands is the conversion of degraded land into a functional ecosystem suitable for forage production by a range of intervention strategies. Attempts to rehabilitate former ecosystem structure and functioning, both above- and below-ground, are the best ways to conserve biodiversity and ensure sustainable long-tern productivity in ecosystems subjected to continuous use by people in arid and semi-arid lands (Aronson *et al*., 1993b). However, in addition to the need for repairing the degraded landscapes, in many cases the basic production state of the natural grasslands in the Mediterranean zone is very low and a high cover of un-palatable shrubs is found. The improvement of these low productive areas can be facilitated by applying different interventions in order to increase significantly utilization and forage production of the land.

The goal of this paper is to give a short overview into the rehabilitation of degraded/low productive Mediterranean grasslands and the strategies that can be used in order to achieve this aim. Aronson *et al*. (1993a) have argued that for ecosystems subjected to long periods of human disturbance, three alternatives to continued degradation can be defined: restoration, rehabilitation and reallocation. Reallocation, which is assigning a new use to the landscape that does not necessarily bear an intrinsic relationship with the pre-disturbance ecosystem's structure or functioning (Aronson *et al*., 1993a)**,** will not be discussed in this paper.

II – Sown pastures for grassland rehabilitation

In order to achieve significant improvement in forage production in degraded and/or poor natural grasslands, the question to be decided on, in order to enhance this goal, is which activities should be included in the rehabilitation process. Accordingly, it will be possible to apply different intervention actions, while first of all focusing mainly on the functioning of the land and repairing it by recovering its compatibility for grazing. For this purpose lengthening the green season and improving the quality of dry-season pasture has been an ongoing research objective, while examining the possibility of introducing annual legumes (Ewing 1999), annual grass species and perennial grasses (Menke, 1988).

As soil degradation limits the potential of the re-establishment of native plants, biological nitrogen fixation can play an important role in land remediation (Perez-Fernandes *et al*., 2004). Sown pastures that are relatively recent newcomers to the agricultural scene, particularly in the Mediterranean region (Davis, 1952), can serve as one of the more effective strategies for improvement of the landscape for forage. In Australia, the introduction of sown annual pasture legumes and also annual grass in rotation with wheat were already common during the 1930s on drier and more basic soils (Seligman, 1996). By 1970 much of the wheat-sheep belt in Australia was under sown self-seeding legumes and mixed annual species pasture. This strategy of sowing pastures for rehabilitation of grasslands has become more common during the last few decades and is applied in many grazed landscapes of the different Mediterranean zones.

1. Introducing annual and perennial legumes and grasses

Productivity can be enhanced by a range of interventions that favor annual forage legumes, as they are essential components of the Mediterranean grazing resources for ensuring balanced feeds to ruminants (Papanastasis and Papachristou, 2000). Accordingly, the efforts to introduce annual pasture legumes in the different Mediterranean regions of the world are continuing (van Heerden and Tainton, 1987; Ovalle *et al*., 1993). It is important to establish the annual legumes' ability to grow widely, while being a productive element of systems nitrogen fixation, and to be part of the anticipated land-use system (Ewing, 1999). As such, these species have the attributes required to be useful in practical programs to rehabilitate degraded ecosystems (Ewing, 1999). The main mechanisms of germination control in the reproductive regeneration of annual legumes are seed bank dynamics, hard seededness and its breakdown pattern (Sulas *et al*., 1999; 2000).

The possibility of improving pastures in marginal lands by sowing wild Lucerne (*Medicago sativa* L.) and annual medics (*M. polymorpha* L., *M. truncatula* Gaerten and *M. rigidula* All.) was studied on uncultivated land at Ballobar, Spain (Delgado *et al*., 2000). In the "Espinal" – Mediterranean agroforestry system of dryland in Chile, experiment results confirm that legumes adapted to dryland conditions for ecological and economic rehabilitation showed rapid beneficial effects on productivity, soil, biodiversity and total value (Ovalle *et al*., 2008).

The southern Australian Mediterranean agriculture system depends heavily on annual pasture legumes grown in rotation with cereals and subterranean clover, and annual medics as the dominant species (Loi *et al*., 2000). In the more humid regions of South Australia, the perennial Mediterranean grass, *Phalaris maritima*, generally with *Trifolium sub-terranean* is the basis of intensive pasture. Annual legume pastures such as those of the dryland farming system of southern Australia have shown the potential to increase productivity in most of the Mediterranean-type environments (Puckridge and French, 1983). The value of legumes as nutritious food and forage crops and for soil rehabilitation has been recognized for thousands of years, but the use of self-regenerating annual species of *Trifolium* and *Medicago* in rotations with cereal crops is a southern Australian development (Puckridge and French, 1983). Therefore, a broad range of annual pasture legume species have been evaluated in Australia, with a particular focus on the needs of emerging farming systems. The development of new pasture legumes should consider traits that confer ease of domestication, as well as those of high productivity and persistence (Loi *et al*., 2008). Historically, *Trifolium* and *Medicago* have been the dominant genera, but in addition, many other species were tested. One of the additional options is the agronomic adaptation of *biserrula*, whose ease of seed harvesting and processing were compared with those of current pasture species with highly desirable attributes (Carr *et al*., 1999).

In addition, the introduction of annual and perennial legumes and grasses for sown pastures was tested in different countries around the Mediterranean basin. A series of experiments on communally-owned grasslands in the barley-livestock zone of north Syria were conducted to test the hypothesis that introduction of Mediterranean annual legumes will increase productivity. In those studies a response in biomass was shown to be limited to the seeding of the legume component, although total biomass increased (Ghassali *et al*., 1999). In Algeria**,** Sulla *(Hedysarum coronarium)*, a perennial legume, was examined. The results showed that this species should be developed, particularly in isolated and disadvantaged areas to which it could be adapted (Issolah and Yahiaoui, 2008). In addition, Chebouti and Abdelguerfi (1999) evaluated 48 populations of *Medicago orbicularis* (L.) Bart, for flowering time and for winter and spring growth. In Tunisia, Lucern (alfalfa) is known to be the most important sown perennial fodder as well (Loumerem *et al*., 2008).

In Chile, South America, Del Pozo and Aronson (2000) presented examples of inter-and intra-specific differences that can be useful when introducing or disseminating annual legumes for pasture improvement, rehabilitation, erosion control and/or long term soil restoration programs.

They showed range managers that the development of appropriate mixtures of species and accessions for combined use is a promising strategy.

In addition, annual and perennial grass species were tested for rehabilitation of the land in different Mediterranean zones around the world. This included *Dactylis glomerata*, followed by *Lolium perene* and *Phalaris aquatica*, which were introduced in the *Montado* areas of Portugal and showed high persistence (Carneiro *et al*., 2008). Some spontaneous populations of tall fescue originating from five different countries were also studied in Algeria (Mohguen and Abdelguerfi, 1999). In addition, variability and productivity of 13 autochthonous populations of *Lolium rigidum* from Aragon, Spain, were also studied in order to use this species as a self-reseeding annual grass (Delgado and Andres, 1999).

2. Introducing perennial nutritious shrubs and trees

Using forage shrubs to improve the quality of dry-season pasture has been an ongoing research objective for some time (Le Houerou, 1980). *Atriplex* spp. were tested (Le Houerou, 1992) in addition to different herbaceous legume and grass species in the Mediterranean basin as a means of arid land rehabilitation, since huge areas in the region had undergone processes of severe degradation or had been subjected to desertification, particularly over the past four decades. Planting *Atriplex* spp. was found to be one of the most efficient ways to reclaim these lands, as its planting can achieve spectacular results in two to three years, with higher productivity than the range under pristine conditions (Le Houerou, 1992).

Using leguminous shrubs could improve pastoral value. Introduction of inoculated shrubby legumes as a pioneer species is important and was found to ameliorate the characteristics of the soil (Perez-Fernandes *et al*., 2004). Some native legumes typical of semi-arid Mediterranean areas, such as *Coronilla minima* ssp., *Lotoides* (Kock) Nyman and *Anthyllis cytisoides* L. or *A. terniflora* (Lag.) Pau, are abundant at intermediate stages of succession and were shown to have potential as fodder shrubs (Ibanez and Passera, 1997; Robles *et al*., 2002). Some of the legume shrubs provide highly palatable forage and the protein content of their foliage is often regarded as an important nutritional supplement for the low quality dry summer pastures. Outstanding species among these are the trees medick (*Medicado arborea*) and tagasaste (*Chamaecytisus palmensis*) (Seligman 1996). Introducing *Bituminaria bituminosa*, which is a widespread Mediterranean perennial leguminous bush species, may potentially serve as a fodder crop in Mediterranean grasslands (Sternberg *et al*., 2006) as well. In this case, preliminary results indicate that there is enough variability in *Bituminaria bituminosa* to select lines with high rates of seed production, retention and germination (Correal *et al*., 2008). Growing this plant in dense stands in rotational paddocks may provide alternative sources for natural fodder protein and for reducing the potential costs of artificial feed supplements (Sternberg *et al*., 2006). Nevertheless, the lack of proved benefits for livestock production from forage shrubs has restricted the large scale development of these plantation projects (Seligman, 1996).

3. Mixed species grassland for pasture

At the landscape level, legumes can be combined with other herbaceous or woody species as part of the agro-pastoral or silvo-pastoral systems (Papanastasis and Papachristou, 2000). As so, the best model to optimize both livestock nutrition and environmental impacts was shown to be the perennial grass-legume mixture (Lelievre *et al*., 2008). In an experiment conducted in Sardinia, Italy it was suggested that mixtures are important for pasture improvement. It was found that sowing a simple mixture of 4 or 5 species is probably the most cost-effective way for farmers to improve or establish a balanced mixed pasture (Franca *et al*., 2008). In another case, a 4-species mixture of grass/legume and fast/slow establishing species (*Lolium rigidum, Dactylis glomerata, Medicago polymorpha and Medicago sativa*) were examined. The results suggest that the use of mixtures of different functional types may increase productivity and its

seasonal distribution and decrease the growth of unsown species (Porqueddu *et al*., 2008). However, to date only few adapted perennial cultivars have been registered and only seeds from French and Australian cultivars are available. As a result, there is insufficient use of these grasses (Lelievre *et al*., 2008).

III – Ecotechnologies for improving forage production

Rehabilitation of the land is required in degraded Mediterranean grasslands after long periods of continuous disturbances, including heavy grazing, as well as other human activities. Many of these Mediterranean lands are usually characterized by soils that are deficient in one or more plant nutrients (Seligman, 1996) and the productivity of the herbaceous vegetation is very low. Therefore, without any additional treatment to the land, a high cover of the unpalatable shrubby component is a common phenomenon. In order for the competition of herbaceous vegetation to be effective against shrub encroachment, soil fertility should be high enough to allow vigorous seasonal growth of the herb species (Zohary, 1973). In such a shrubby vegetation state, with no additional treatments, the natural succession process will not lead towards the recovery of the vegetation to a highly productive state of forage for grazing. A large part of these lands are characterized by a dense cover of unpalatable plants, mostly shrubs with low value for animal grazing. Therefore, in order to achieve significant improvement it is necessary to apply different artificial interventions.

Effective rehabilitation requires technologically appropriate inputs for the prevailing socioeconomic circumstances (Ewing, 1999). As shown by Sternberg *et al*. (2015), grazing pressure influences the species composition of the grasslands. Accordingly, modifying grazing management on degraded grazing land can very well contribute to its recovery process. But this can be achieved where only the grassland's biotic functions have been damaged. In this case, an appropriate grazing management regime should include a stocking rate adjusted to the grazing capacity of the restored land, the right kind of animal species, and an appropriate grazing system (Papanastasis, 2009). In other cases, where the physical environment has been damaged too, an appropriate grazing management by itself is not enough in order to restore the degraded grazing lands (Papanastasis, 2009). Accordingly, effective strategies are required for the rehabilitation of the grassland and for the improvement and establishment of the forage. These strategies should include combined treatments in addition to control of grazing (intensity and timing), such as fire, input of exogenous nutrients (particularly phosphorus), herbicide application (Henkin *et al*., 1996,1998), and the addition of legume seeds (Ewing, 1999).

In the Aegean island of Lesvos, Greece most of the grazed areas were invaded by the dwarf shrub *Sarcopoterium spinosum*; a rehabilitation trail was designed therefor increasing forage production. The strategy included removal of plant cover by mechanical means, fertilization, reseeding with a mixture of *Dactylis Glomerata*, *Medicago sativa* and *Trifolium subterraneum* and protection from grazing. In that study it was shown that rangeland rehabilitation in semi-arid islands, including removal of undesirable plants, is feasible through a combination of mechanical treatment, reseeding and animal grazing (Hadjigeorgiou *et al*., 2008). In another study conducted in the Western Galilee, Israel, on lands that were dominated by the dwarf shrub *Sarcopoterium spinosum*, it was shown that under an appropriate management system including: grazing, periodic control of the shrub component, and occasional soil nutrient amelioration can lead to the development of attractive open woodland with a productive herbaceous understory (Henkin, 2013).

In different studies it was shown that productivity of herbaceous vegetation on P deficient soils is very low and consequently vegetation highly responds to P enrichment of the soil. It was shown that phosphorus fertilizer alone increased herbage growth, while inducing dominance of annual legumes (Rossiter, 1966; Ofer and Seligman, 1969; Osman *et al*., 1991; Osman and Cocks, 1993; Henkin *et al*., 1996, 1998, 2000, 2010). The above-ground biomass of herbaceous sward patches increased not only as a consequence of nutrient amelioration, but also because

of reduced competition with the lower shrub cover following fire and/or herbicide application (Henkin *et al*., 1998). On the other hand, it was shown that shrub recovery, which was dependent on its residual cover in the first year following fire and/or herbicide treatment, was further retarded by competition with the vigorous herbaceous vegetation that benefited from nutrient amelioration (Henkin *et al*., 1998). Moreover, a long-term shift in productivity of the herbaceous component of the grazed ecosystem was found to be triggered by a P nutritional pulse that induced a feedback loop based on changes in the botanical composition of the herbaceous vegetation, the animal- vegetation interaction, grazing and supplementary feeding regimen of the cattle (Henkin *et al*., 2010). But although legumes dominated the botanical composition of the sward for more than ten years as a response to a single P application (Henkin and Seligman, 2000), in order to maintain the dominance of the herbaceous vegetation in the long-term, it may be necessary to repeat the treatments after 10 years (Henkin, 2013). Application of N fertilizer is also important for rehabilitation as it can stimulate early growth and shorten the period of early-season pasture scarcity even in the semiarid margins of the Mediterranean zone (van Keulen and Seligman, 1992).

The Australian agro-ecological context is also characterized by severe phosphorus deficiency in many of the soils. Vegetative growth, especially of annual N-fixing leguminous species, is found to be very responsive to the application of phosphorus fertilizer and provides high-quality forage and a modest but significant and cheap source of N (Cock, 1980). In addition, the legumes were found to boost the yield of wheat in the rotation and the growth of other nitrophilous annuals. Thus, the use of subterranean clover *(Trifolium subterraneum* L.) and various *Medicago* species, together with applications of superphosphate is common in Australia in order to improve soil fertility and increase cereal yields, and consequently with the result of greater sheep and cattle production (Puckridge and French, 1983). In Australia, because of the severe phosphorus deficiency in many soils, fertilizers have been applied for a long period to annual Mediterranean-type pasture as a routine practice (Wild, 1958).

Papanastasis and Papachristou (2000), in Greece, also showed that the presence of forage legumes can be enhanced by appropriate management including proper grazing combined with balanced fertilization, seeding, planting and prescribed burning. In Lebanon, Osman *et al*. (1999) showed that significant improvement of pasture productivity was found in degraded Mediterranean pasture after sowing with native legumes, fertilization and exclusion of grazing during April-May. This raise was followed by an additional increase in economic benefits for the users.

The methods of improving the pastures in the Exdtremadura "dehesa" in Spain are based also on a combined treatment strategy including: sowing of legumes, phosphorus application and grazing (Viguera *et al*., 2000). The improvement and exploitation of the "dehesa" agro-silvopastoral systems in Spain must be founded on the principles of preservation of the environment and the idea of creating systems that can be maintained by correct usage of natural resources. Fertilization of the natural pastures, the introduction of new pasture species and varieties, the favoring of the bush species that are of high forage value and the preservation of the arboreous stratum are methods which allow to preserve that ecosystem (Olea and Viguera, 1999). But, one obvious interpretation is that plantations carried out on harsh sites would require higher technological inputs and investments to achieve a given target than those on less harsh sites (Vallejo *et al*., 2012).

IV – Restoration and conservation for biodiversity and amenity

In general, rehabilitation will not lead to a change in land functioning but to a different and improved vegetation composition and land structure. Restoration is the conversion of degraded ecosystems to the pre-disturbance status of the land, which means recovery of what was lost, while the main target is not improvement of production. According to Aronson *et al*. (1993a), ecological restoration is a complete or near-complete return of a site to its pre-existing state and

it takes in account structure, functioning and composition of vegetation. Resilience, which is the ability of the ecosystem to recover after a disturbance, and stability, which is largely determined by the dominant herbaceous life history, plays an important role in this process. Where the return to pre-disturbance status is possible, restoration of the land is a feasible aim; if conversion to a pre-disturbance/pre-degraded status is no longer possible and the target is increasing productivity, rehabilitation must be achieved.

As defined, restoration of ecological communities is important to counteract the global losses in biodiversity (Bullock *et al*., 2001) and in species-richness (Pywell and Putwain, 1996; Young, 2000). An increase in richness could be a restoration management target in degraded ecosystems (Bonet, 2004); in some cases it suggests maximizing high quality herbage production in re-sown grasslands by maximizing biodiversity (Bullock *et al*., 2001). In a study conducted by Bullock *et al*. (2001), they restored biodiversity, not only achieving a higher species number in a species-rich treatment, but also establishing plant communities which resemble their semi-natural target communities. In any case, it is the fragmentation and degradation of the landscape that both restorers and rehabilitators must combat with. Restoring a degraded landscape can be achieved by different interventions. It was shown that endozoochory, cattle dung application, also has a potential to be a highly effective mechanism for the dispersal of viable seeds in Mediterranean grasslands, but this is important particularly for restoration of species-richness in abandoned pastures (Traba *et al*., 2003).

In terms of conservation, there are two processes that have dominated the Mediterranean ecological scene for a long period of time. One is the successional process that in many cases ends with the dominance of woody vegetation and the strong continuous involvement of humans in affecting the local landscape and ecosystem. Conservation, which is defined as the preservation of an existing ecosystem, as restoration does not aim to improve the production system, and can include few external interventions. Consequently, the problem is that nature conservation practices within such a context should start with a decision concerning what the natural state to be preserved is (Perevolotsky, 2004). If the Mediterranean annual grassland is the pioneer stage after a short or long-term disturbance, the question will be, to what stage of plant formation along the successional trend, the conservationists are aiming.

One of the options for conservation is complete abandonment of the land. It was shown that areas at different abandonment stages and under different moderate grazing regimes will contribute to higher diversity (Bonet *et al.,* 2001). However, intensification or abandonment of grazing could both lead to land degradation (Bonet, 2004). Land use previous to abandonment effects vegetation patterns, and recognition of these patterns could be an essential tool for the prediction of changes in Mediterranean landscapes (Pausas, 1999). Bonet (2004) attempted to describe and analyze patterns in vegetation dynamics during the land abandonment process in a Mediterranean semi-arid area, emphasizing the effect of land use history. He showed that species richness on loam soils quickly increased during the first decade of abandonment and decreased later during the rest of the recorded periods, allowing maximum species richness to develop during a relatively early stage of the succession process. As mentioned by Bonet (2004), protocols for conservation and restoration could consider the following aspects:

(i) Introduction of ‘‘late successional shrubs’’ in early stages of the succession.

(ii) Restoring old fields by using natural succession if a seed bank or adjacent seed source is present in remnant patches of natural vegetation.

(iii) Maintaining moderate grazing levels during the grassland stage.

In addition to biodiversity aspects, the aim of restoration or conservation of Mediterranean grasslands could also rise from an aesthetic point of view. Recreation activities that include hiking, picnicking, and enjoyment of the scenery require the access provided by open woodlands. Accordingly, it was shown that the most preferred landscape for all uses was found to be an open woodland formation with productive herbaceous patches (Henkin 2011).

Considerable conservation efforts have been invested in attempting to protect the dense shrub forest (maquis), since this vegetation formation is important as the habitat of specific flora and fauna. Therefore the main conclusion is that open landscapes, as shaped by the grazing of goats or cattle, presented greater structural diversity and were preferred over other open or very dense landscapes (Henkin *et al.,* 2007). From that aspect, restoration and conservation of these land types are highly valuable.

V – Conclusions

As many of the grasslands in the Mediterranean zones were under heavy human utilization, including intensive grazing, a large part of them have been degraded. Some of these lands can be rehabilitated in order to improve utilization of the forage resource for animal production. The rehabilitation strategy includes a range of different agro-technological activities such as control of grazing, introducing annual and/or perennial legume and grass species, introducing forage bushes and trees, fire, inputs of phosphorus and nitrogen and herbicide application. This paper presents some insight into these rehabilitation activities as a means of increasing forage production in degraded and low productive Mediterranean grasslands. These activities were examined during the last few decades in all Mediterranean zones around the world. In many of the studies the results show a significant improvement of the ecosystem in terms of forage production, but in many cases the improvement in animal production is too low to justify the cost of rehabilitation.

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