Effect of microtopography on the early plant community dynamics following overseeding for the rehabilitation of a Mediterranean silvopastoral system

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Effect of microtopography on the early plant community dynamics following overseeding for the rehabilitation of a Mediterranean silvopastoral system

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Abstract. The sowing of selected seeds is often applied as post-fire rehabilitation practice in Mediterranean silvopastoral systems. Often, the topography of these silvopastoral systems is irregular, requiring low input and easy pasture rehabilitation practices, such as no tillage, low seed and fertilizer rates. In this paper, we studied the vegetation changes over four years, after a low-input overseeding (broadcasting) of non-native pasture species, within a post-fire rehabilitation program of a silvopastoral system in Sardinia (Italy). The main objective was to assess the relationship between topography, soil pH, and soil nitrogen content on the spatial and temporal dynamics of the grassland composition. The spatial patterns of the functional classes were only weakly influenced by nitrogen content, with a higher impact on introduced species in the first two years after overseeding, while the topographic variables had a desultory influence over the four years.

Keywords. Oversown grasslands – Silvopastoral systems rehabilitation – Topography – Vegetation dynamics – Wildfire.

Effet de la microtopographie sur la dynamique des communautés végétales, suivant le sur-semis pour la réhabilitation d'un système sylvo-pastoral méditerranéen

***Résumé**. Dans les systèmes sylvo-pastoraux méditerranéens le semis de semences sélectionnées est souvent appliqué comme une pratique de restauration post-incendie. Souvent, la topographie de ces systèmes sylvo-pastoraux est irrégulière, nécessitant de faibles intrants et des pratiques simples de réhabilitation des pâturages, comme le sur-semis direct et de faibles niveaux de semences et de fertilisation. Dans cet article, nous avons étudié pendant quatre ans la dynamique de la végétation, après un sur-semis manuel à faibles intrants avec des espèces fourragères non indigènes, dans un programme de réhabilitation après incendie dans un système sylvo-pastoral en Sardaigne (Italie). L'objectif principal était d'évaluer la relation entre la topographie, le pH du sol et la teneur en azote du sol, sur la dynamique spatiale et temporelle de la composition de la prairie. Les modèles spatiaux des classes fonctionnelles n'ont été que faiblement influencés par le contenu en azote, avec un impact plus important sur les espèces introduites, dans les deux premières années après le sur-semis, alors que les variables topographiques ont eu une influence irrégulière sur les quatre années.*

***Mots-clés.** Sur-semis de prairies – Réhabilitation de systèmes sylvo-pastoraux – Topographie – Dynamique de végétation – Incendie.*

I – Introduction

In silvopastoral systems, the rehabilitation through overseeding of pasture species is a suitable strategy for producing biomass palatable for grazers and for controlling invasive shrubs and spiny forbs (De Luis et al. 2003; Peppin *et al.* 2010). In the topographic irregularity of rangelands, microsite environmental variables play a key role in shaping the vegetation distribution patterns (Pueyo and Alados 2007; Gusmeroli *et al*. 2013). In this paper, we studied

the early vegetational changes after overseeding of a grassland degraded by a post-fire shrub encroachment in a Mediterranean silvopastoral system. We tested the hypotheses that micro-site environmental (microtopography, soil N content and pH) variations could influence the spatial plant community dynamics after overseeding.

II – Materials and methods

The study was conducted over four years (1997–2001) at the Campu Massidda public forest located in Usellus, Western Sardinia, Italy (latitude 39°50′N, longitude 8°49′E). The topography of the study area is hilly and the dominant vegetation is characterised by both the association of holm oaks (Quercus ilex) with several Mediterranean shrubs and cork oak (Q. suber). The soil is clay-sandy sub-acid (pH = 6.1), with 1 g N kg−1 dry soil (Kjeldahl) and 0.05 g P2O5 kg−1 dry soil (Bray and Kuntz). The climate of the area is Mediterranean semi-arid with an average annual rainfall of 610 mm. In 1992, the forest was destroyed by a wild-fire. In the following years, shrub encroachment of Cistus spp. occurred. Thus, with the aim of establishing an improved pasture, an area of 4.8 ha was cleared and manually oversown in October 1997, using an annual grass/legume mixture composed of two commercial varieties Trifolium yanninicum var. 'Trikkala' and T. brachycalycinum var. 'Clare', and local cultivars of Medicago polymorpha var. 'Anglona' and Lolium rigidum var. 'Nurra'. The seed mixture was composed of 9 kg ha–1 of 'Anglona', 10 kg ha–1 of 'Trikkala', 5 kg ha–1 of 'Clare' and 1.5 kg ha–1 of 'Nurra'. At the seeding, 80 kg ha–1 of P2O5 and 20 kg ha–1 of N were applied as diammonium phosphate (18% N, 46% P2O5, 0% K2O). During the 4 years of the study, the area was lightly grazed by a flock of 120 Sarda bred dairy sheep, for 2 weeks in winter and 2 weeks in spring. In the first year, winter grazing was avoided in order to facilitate the initial establishment of the oversown species. The oversown area of 4.8 ha was divided into 192 units of 20 × 12.5 m (Fig. 1).

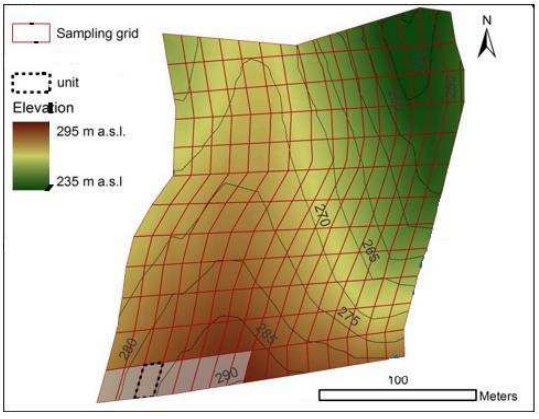

Fig. 1. Study area and sampling design representation.

The floristic composition of the vegetation in spring over 4 years was estimated by recording contacts with a sward stick (Barthram 1986) at the four vertices of a 30x30 cm quadrat placed 6 times randomly within each of the 192 units. Nine "functional classes" (FCs) were identified: subclovers (T), burr medic (T), annual ryegrass (L), grasses (G), autochthonous legumes (AL), Cistus spp. (CI), spiny Carduaceae (CA), spiny Rubus spp (Ro) and other species (A). The following topographic variables were considered: aspect, slope, Topographic Position Index (TPI), Topographic Weatness Index (TWI) and Heat Index (HI). TPI classifies the soil

morphology: positive TPI values indicate hummocks, negative TPI values indicate depressions. TWI describes the tendency of the soil to accumulate sediment: the greater degree of accumulation is assigned to the areas with greater concavity and lesser slope. HI is used as a proxy for heat load. At the center of each sampling unit, soil samples were collected and the total N content (Kjeldahl method) and pH (H2O) were determined. The effect of topographic and soil variables on the spatial variability of FC's was studied performing a Redundancy Analysis (RDA) with the package Canoco ver. 4.5 (ter Braak, 1995).

III – Results and discussion

The environmental variables explained the 5.0%, 7.9%, 4.6% and 5.5% of the total variance, respectively from the first to the fourth year of the study. The effect of total N and, at a lesser extent, TWI, pH and slope, was significant on spatial variability of pasture composition. In the sowing year, a significant impact of soil N content on the spatial pattern of FCs was observed (P-value ≤ 0.004), with a slight effect on the distribution of oversown species (Fig. 2A).

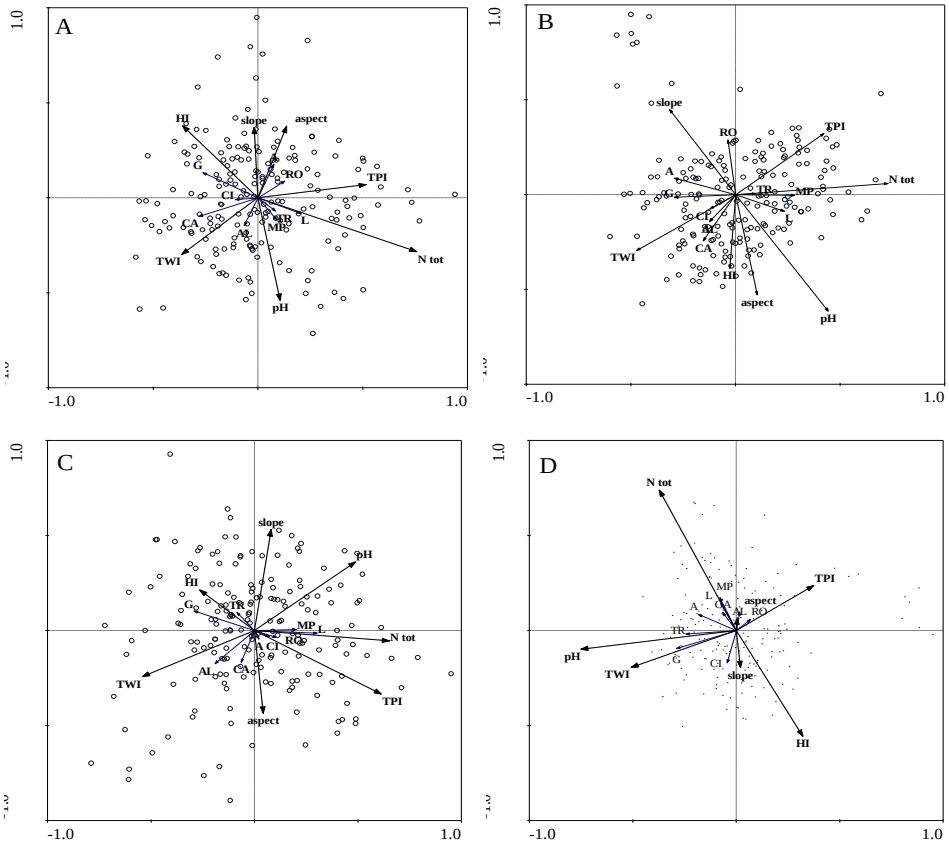

Fig. 2. Biplot between the functional classes and the environmental variables from Redundancy Analysis (RDA) for the first (A), second (B), third (C) and fourth (D) year of the trial.

In the second year (Figure 2B), the results showed a significant effect of soil N content, TWI and slope (respectively with P-values of 0.0002, 0.006 and 0.048).

M, G and T were positively correlated with soil N content; all native FCs, except Ro, resulted positively correlated with TWI. In the third year (Figure 2C), soil N and TPI significantly influenced the presence of M, G, RO and CI (P-value = 0.016 and 0.014, respectively). In the fourth year (Figure 2D), spatial distributions of G, A and T were positively correlated with pH (P-value = 0.0040) and TWI (P-value = 0.045). In our study, sown burr medic and annual ryegrass were facilitated in locations rich in total nitrogen and, to a lesser extent, in potentially drier and sunny convexities. Native grasses and, at least in the second year, other native FCs as CA and AL, tended to be more abundant in concavities where sediments and water flows more likely accumulated. Sown subclovers, in contrast with the other two oversown mixture components, initially did not show any response to topography, but at the end of the study occupied the same concavities of native grasses, in potentially less dry and deep soil conditions.

IV – Conclusions

Soil N and some topographic variables seemed to slightly influence the grassland composition patterns, with oversown species mainly concentrated in the nitrogen-rich convexities of the hillslope, while native grasses in concavities, where sediments and soil moisture were likely higher. At the small scale and relatively low variation of environmental variables of our study, topography is not an essential factor to be taken into account for the design and implementation of rehabilitation programs for improving pastures.

Acknowledgments

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