GOLF COURSE MANAGEMENT STRATEGIES FOR IMPROVING BIODIVERSITY IN NATURALIZED ROUGHS

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Introduction

Many golf courses are interested in reducing turfgrass mowed areas and replace them with low-maintenance habitats such as mulched beds, naturalized roughs, and wildflower banks in order to reduce inputs and increase biodiversity[1,2,3]. Golf courses are mainly characterized by plant communities with simplified botanical composition thus improving naturalized rough would help to enhance biodiversity as well as the aesthetic value of the site. Few studies investigated the importance of naturalized roughs in plant[4] and wildlife[5] biodiversity and especially their role in improving the complexity of golf course habitat and the surroundings.

Field surveys were performed in 2013 and 2014[4] to investigate vegetation structure and botanical composition of recently naturalized roughs in La Montecchia Golf Course, located in the Venetian Valley of northern Italy. In addition, a plot-trial was conducted for three years (2013-2015) in two selected areas of the naturalized roughs to evaluate the efficacy of different cultural practices in increasing plant population. The areas were characterized by reduced plant biodiversity due to excessive competitiveness of pre-existing or invasive species and residual soil fertility.

Methods

A field study was conducted at La Montecchia golf course in Selvazzano, north-eastern Italy (45°23'N, 11°45'E, and elevation 18 m) from April 2013 to May 2015 to determine number and abundance (%) of plant species of recently naturalized roughs.

Botanical surveys were performed with modified Braun-Blanquet method. Effective species numbers of order q=0 and q=1 were calculated for each homogeneous section of the naturalized roughs; effective number of order q=0 corresponds to species richness, while the order q=1 takes into account the influence of species rarity[6] down-weighing species with low abundance. Each section was classified on the base of its vegetation structure considering distribution in space of herbaceous, shrubby and woody layers: A) herbaceous layer without shrubs and trees; B) herbaceous layer and scattered trees; C) herbaceous and shrubby layers eventually with scattered trees; D) dominant woody layer (ground cover of 100%), referable to a forest structure; E) ditches and ponds. Matrix of species was subjected to hierarchical cluster analysis: the distance matrix was computed with the Euclidean method and average linkage method[7] was used to group data.

With the aim to rise plant biodiversity, a three-year study (2013-2015) was conducted in two selected areas of the naturalized sections dominated by *Agropyron repens* L. (Site 1) and *Festuca rubra* L. (Site 2). Three cultural practises were compared in a randomized complete block design with three replicates (plot size 12 m^2): *a*) mowed with biomass removal followed by verticutting; *b*) mowed with biomass removal followed by verticutting and supply of late-cut hay deriving from nearby permanent meadows, to provide seeds of local species; c) unmowed (control). For both sites cuts were made once in spring 2013, for treatment *b* the hay was distributed immediately after cut. The botanical surveys were performed in each spring season of 2013, 2014, and 2015.

The number of species and the percentage of dominant species were subjected to ANOVA performed separately for each site, and species matrices were used for principal component analysis (PCA). All statistical analysis was performed using R 3.1.3 (R Development Core Team) software.

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Results and discussion

The golf course surface is approximately 64 ha, of which 19% are naturalized roughs having a total of 131 species. Vegetation structure was mainly referable to type D including 40 homogeneous rough sections, while types A, B, C, and E counted respectively 16, 11, 22 and 8 sections. The cluster analysis returned 4 groups with group 1 clearly separated from the others and including sections referring to type D. The other groups were less clearly separated and included different vegetation types (data not shown). However, botanical composition of sections referring to group 2 was dominated by *A. repens* with a great abundance (30%) of *Cynodon dactylon* (L.) Pers., while group 3 included sections dominated by *C. dactylon*, *A. repens*, and *F. rubra*, and group 4 sections dominated by *F. rubra* with a percentage of *Festuca arundinacea* Schreber and *C. dactylon* ranging from 10 to 60. Studied sections differed for dimension and effective species number of both orders (q=0 and q=1). Number of species ranged from 5 to 43, with lower values in group 1. Since for the calculation of effective species number of order 1 the species with low abundance were sequentially down-weighted, the botanical composition resulted simplified in group 1 with few species having high percentage cover, and more complex in the other groups, although dominated by one or two species only.

Regarding plot trials, results of ANOVA for Site 1 revealed a significant effect of treatment and time on number of species, displaying higher values for treatments *a* than treatment b (9 vs 5) and highest values in the last year of investigation. The percentage of dominant species were affected only by time, revealing that treatments were not able to limit the dominance of *A. repens*. For Site 2, a significant interaction between treatment and time was found for species richness while, similarly to Site 1, the percentage of dominant species was affected only by time. Treatment *a* showed higher number of species in 2014 and 2015, demonstrating that the introduction of external seeds is able to improve biodiversity, but not to reduce the dominance of *F. rubra* (data not shown). The PCA showed that, in 2013, botanical composition was similar in all plots for both sites, while in 2014 a shift was observed in plots were treatments *a* and *b* were applied (Fig. 1). Marked changes were observed for treatment *a* of Site 2. In the last year of investigation (2015), the botanical composition returned to its original status.

According to other studies[8,9,10,11,12] our results suggest that cultural practices are necessary to increase the number of species and to promote the complexity of botanical composition. However, a single cut was not sufficient to reduce the abundance of dominant species (*A. repens* and *F. rubra*), even when local hay was added as external seed source.

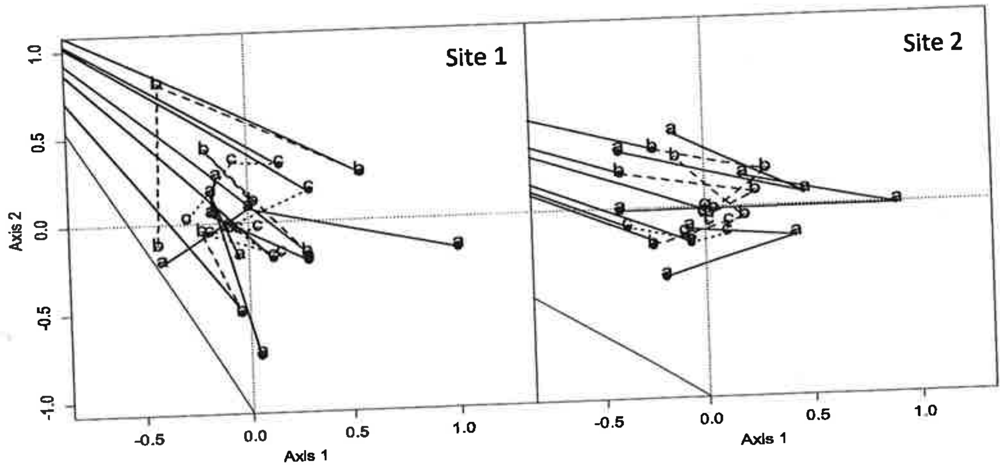

Figure 1. Principal component analysis (PCA) of Sites 1 (on the left) and Site 2 (on the right) along the first two axes. Full dots are plots surveyed in 2013; empty dots are plots surveyed in 2014 and 2015. Letters *a* (mowed and hey added, solid line), *b* (mowed, dashed line) and *c* (control, dotted line) indicate cultural practices. Dots of each block are joined with a line along time gradient.

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