SHORT-TERM EFFECTS OF HERBICIDE TREATMENT ON THE VEGETATION OF SEMIARID SANDY OLDFIELDS INVADED BY ASCLEPIAS SYRIACA L.

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Abstract: In Hungary, large abandoned agricultural areas have been invaded by the non-indigenous common milkweed (*Asclepias syriaca* L.). This species hinders the regeneration of sandy oldfields to open sand grassland (Pannonic sand steppes - Annex I 6260 habitat type). Glyphosate application is a cost-effective control method that helps avoid soil surface disturbance and subsequent germination of milkweed seeds in the soil. However, it affects non-target plant species negatively, as well. In our study we explored the effects of the treatment on the non-target vegetation. Glyphosate spraying was applied to three oldfields in the Kiskunság National Park to control vigorous stands of A. syriaca in July 2006. Shoot number of A. syriaca and percentage cover of plant species were estimated in $1m^2$ permanent plots before and after treatment (June 2006 and June 2007). Elimination of common milkweed was successful in the short term. Multivariate analysis showed a general shift of species composition following herbicide spraying. The share of summer annual herbs and grasses increased significantly, while perennial grasses and herbs decreased in cover. A significant decrease in the average cover of sand grassland specialist species were detected, while weedy species increased in their abundance. The revealed changes showed that it is an effective way to control common milkweed in the short term. However, it disturbs the underlying vegetation so that it relapses succession back to an earlier stage, rich in annual species in the case of the open patch types, while helps to proceed succession when the vegetation has been closed by clonal grasses.

Keywords: 6260 * Pannonic sand steppes, invasive species, landuse change, population control, reclamation of former agricultural land

Introduction

In Hungary, the majority of open sand grassland habitats (Pannonic sand steppes - Annex I 6260 habitat type) were cultivated and abandoned during the 20th century. Common milkweed (*Asclepias syriaca* L.) is a non-indigenous invasive plant species that has been invading large areas of sandy ex-arable lands. This species hinders regeneration of sandy oldfields by inhibiting colonization and resource aquisition of natural species due to shading effects, high competitive capacity and allelopathic compounds (Kazinczy et al. 2004).

Glyphosate application may be a cost-effective way to control dense stands of common milkweed (Bagi 1999). It helps avoid soil surface disturbance and subsequent germination of milkweed seeds. However, as a non-selective herbicide, glyphosate affects both target and non-target species in the plant community (Mason and French 2007). Herbicide applications usually mean catastrophic disturbance events to the non-target vegetation. However, some dominant clonal species of the initial vegetation may have blocking effects on secondary succession similar to that of common milkweed. Suppressing these species simultaneously may facilitate regeneration processes.

The aim of the study was to explore

i, the effectiveness of the treatment in controlling common milkweed in the short term,

ii, the effects of the treatment on the non-target vegetation with different dominant plant species.

Materials and methods

The study sites are situated near the strictly protected Fülöpháza Sand Dunes in the Kiskunság National Park, Hungary. The climate is continental with a strong semiarid character, particularly in the summer months. Mean annual temperature is 10.5 ^{o}C and mean annual precipitation is 550-600 mm. The soil of the site is coarse textured sand soil with high calcium-carbonate, low organic matter content and extreme soil moisture regime (Várallyay 2006). The three study sites have been abandoned for approximately 20 years. They are similar according to abiotic characteristics and their distance from natural vegetation. The potential vegetation is considered to be open sand grassland (*Festucetum vaginatae*, a subtype of 6260 habitat). Altogether three patch types were distinguished on the basis of dominant grass species at the three sites. *Poa* type is characterized by the clonal *Poa angustifolia* that has a phalanx growth form and builds monodominant stands by creating thick litter layer (Oborny and Cain 1997). *Cynodon* type is dominated by the grass *Cynodon dactylon* with guerilla growth strategy. Moss type can be described by a high moss *(Tortula ruralis)* percentage cover and the absence of perennial grasses. *Cynodon* and Moss types form open patches with more species than *Poa* type.

In June 2006 glyphosate (Medallon, 2 l ha^{-1}) was applied by machine broadcast to the study sites. Since the common milkweed was not controlled properly at the used dosage, two weeks later the treatment was repeated with 7 l ha^{-1} Medallon solution.

Altogether 48 randomly selected 1 m^2 plots were designated for monitoring in the three study sites. Because of differences in within site heterogeneity of the vegetation, the following number of plots were sampled at the sites: 10, 8, 30. Percentage cover of each vascular plant species was estimated in June 2006 and June 2007.

Changes in common milkweed percentage cover and shoot numbers were used to estimate common milkweed control efficiency. Average species richness total percentage cover were calculated per plot and compared between the two sampling periods using paired t-test. Vegetation changes were interpreted with changes in life form strategies of Raunkiaer (1934). The statistical significance of the response of each category to glyphosate application was tested by the use of paired t-test. Percentage values were arcsin transformed to conform the normality assumptions of the test. Principal Coordinate Analysis of relative abundance data of the underlying vegetation was used to test alterations in the composition of vegetation patch types following glyphosate application.

Results and discussion

Control of common milkweed was successful in the short term. Average percentage cover and shoot number decreased significantly from 28.8 to 0.5 (t_{47} = 11.25, $p < 0.001$), and average shoot number from 17.3 m^{-1} to 1.8 m^{-1} (t_{47} = 10.47, $p < 0.001$). Petrov and Marrs (2000) studied the recovery of bracken (*Pteridium aquilinum*) after

glyphosate treatment and found that there was a rapid bracken recovery within 5 years where there were no follow-up treatments.
In the longer term we expect a similar recovery of *A. syriaca* where no further treatments will be applied because there is a strong propagule pressure due to the surviving individuals and large infestations around the study sites.
Our results showed that the vegetation under milkweed was highly impacted by the glyphosate treatment in spite of the initially dense invasive stands that usually act as an umbrella and protect the underlying vegetation from the full effect of chemicals (Måren et al. 2008). Average total cover decreased dramatically from 67.4 to 32.6 (t_{47} = 12.2, p < 0.001). In general, the share of summer annual herbs and grasses increased significantly, while perennial grasses and herbs decreased in cover (Fig. 1). This shift can be evaluated as a degradation since the reference community is dominated by perennial grasses and herb species.

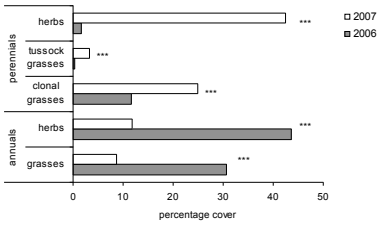

Figure 1. Changes in the life form strategies based on cover abundance of aboveground vegetation data before and after glyphosate application, for the total sample. Significance level is indicated by *** (p<0.001).

Multivariate analysis showed that glyphosate application greatly homogenized the initially heterogeneous vegetation patch types (Fig. 2).

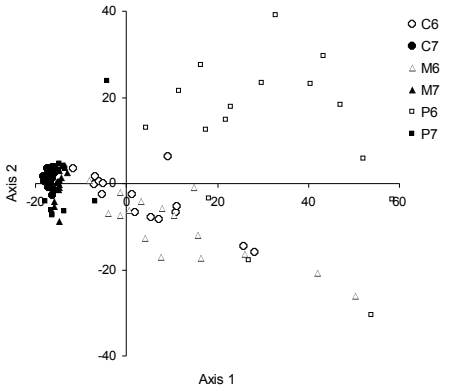

Figure 2. Ordination diagram of the Principal Coordinate Analysis based on cover abundance data of the aboveground vegetation. The eigenvalues for the two axes are 54.0 and 16.1, respectively. Abbreviations: P – *Poa* type, M – Moss type, C – *Cynodon* type; 6 – June 2006, 7 – June 2007.

Moss and *Cynodon* types changed in a similar way due to their similar species composition and open structure. The largest changes were detected in *Poa* type, which changed differently compared to the other types. Herbicide application opened up the initial dense *Poa* clones that had previously prevented the development of a diverse vegetation. This explains the highly significant changes in the average species number: an increase in *Poa* type (from 10.5 to 13.8, $t_{15} = -3.21$, $p = 0.006$) and a decrease in Moss type (from 12.1 to 9.1, $t_{15} = 5.06$, $p < 0.001$) and *Cynodon* patches (from 12.5 to 9.6, $t_{15} = 3.64$, $p = 0.002$). Glyphosate application set the associated vegetation back into an earlier successional stage rich in annual species. This can be evaluated as a catastrophic event in case of the open Moss and *Cynodon* patch types. However, glyphosate opened up monodominant *Poa* patches and thus helped to proceed vegetation development into open sand grassland.

Conclusions

Herbicide application proved to be an effective way to control common milkweed in the short term. However, in the longer term a recovery of *A. syriaca* is expected if no further treatments will be applied. Non-target vegetation was heavily affected by herbicide control. Glyphosate relapsed the vegetation back into an earlier stage of succession in case of open patch types, while helped to proceed succession where the vegetation development was hindered by clonal grass species of phalanx growing strategy.

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