How does surrounding vegetation influence succession in disturbed sites? Consequences for restoration

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Abstract:

Occurrence of desirable (target, including rare and endangered) and undesirable (usually ruderals, aliens, and strong competitors) in the surroundings of disturbed sites is expected to influence the course of succession as well as species composition of target stages. However, there are not many exact studies dealing with this matter. We present results of studies on the role of surrounding vegetation in the course of spontaneous succession in disused gravel-sand pits, various types of quarries, and soil heaps from coal mining. The following conclusions can be drawn: Nearly all (97.5%) species occurring in a disturbed site also occurred in its surroundings up to 100m from the site. Desirable and undesirable species did not principally differ in this matter. The closer are patches of (semi-)natural vegetation to a disturbed site, the higher probability is that target vegetation develops. It has the following practical consequences: It is highly reasonable to preserve at least some remnants of (semi-)natural vegetation during the mining or similar activities in the surroundings of a disturbed site. Eradication of undesirable species, especially invasive aliens, is recommended, if possible, at least up to the 100m distance. These principles should be implemented into mining plans and post-mining restoration programs.

Keywords: biodiversity policy, dry grasslands, extraction of soils and minerals, plants

Introduction

Occurrence of desirable (target, including rare and endangered) and undesirable (usually ruderals, aliens, and strong competitors) in the surroundings of disturbed sites is expected to influence the course of succession as well as species composition of target stages. However, there are not many exact studies dealing with this matter (Walker & del Moral 2003). We present results of studies on the role of surrounding vegetation in the course of spontaneous succession in (1) disused gravel-sand pits, (2) various types of quarries, and (3) spoil heaps from coal mining, comparing vegetation inside and outside the disturbed sites. Natural or semi-natural dry grasslands (steppes) and respective species were emphasized as valuable targets in the central European deciduous woodland zone. The following main questions were addressed: (i) Does the occurrence of different land cover categories in the surroundings influence the course of succession inside the disturbed sites? (ii) What is the similarity between species composition outside and inside the sites? (iii) Do different groups of species differ in this matter? (iv) What are implications for restoration practice?

Materials and methods

The following study sites, all in the Czech Republic, central Europe were included: 36 gravel-sand pits comprising 224 seral stages (each characterized by phytosociological relevé) aged 1 to 75 years, spread over the whole country (Study no. 1); 39 acid stone quarries comprising 135 seral stages aged from 1 to 92 years since abandonment (Study no. 2); 17 limestone quarries aged from 33 to 97 years (Study no. 3); 34 basalt quarries comprising 270 seral stages aged from 1 to 78 years (Study no. 4); 20 spoil heaps from coal mining comprising 89 seral stages aged from 10 to app. 100 years from dumping (Study no. 5). Except the gravel-sand pits, all the groups of disturbed sites were located in different parts of the country and each group spread over the area of several hundred km^2. Except Study no. 4, where different methodology was used, all species occurring up to 100m distance from each sampled site were noted and proportion of main land-cover categories was estimated. The latter was also determined in the 1km distance in Studies no. 1 and 2.

Species and vegetation data were mostly elaborated using multivariate statistics (ter Braak & Smilauer 2001).

Results and discussion

Gravel-sand pits *(Study no. 1)*

Proportion of arable land, wet grasslands, urban sites and woodland up to 1 km distance and occurrence of dry grasslands, wet grasslands and woods up to 100 m from sampling site significantly (CCA ordinations) influenced the course of succession. Among the habitats, only wetlands did not exhibited any significant influence on the course of succession (Rehounkova & Prach 2006). The landscape factors exhibited together even higher influence on the species composition of seral stages than local site factors which included, for example, pH and soil moisture.

98% of species occurring in the pits occurred also in the close vicinity up to 100m distance. On the contrary, 67% of all species occurring in the vicinity appeared also in the pits, among them 70% of grassland, 67% of woodland, 88% of wetland, 53% of ruderal and 70% of alien species. Only several wetland species which occurred in the pits did not occurred in their vicinity. Valuable dry wooded grasslands developed after app. 20 years of succession in pits in lowlands if their (semi-)natural remnants occurred in the close vicinity and the invasive alien *Robinia pseudacacia* did not. Fig. 1 illustrates the influence of the occurrence of the invasive alien tree *R. pseudacacia* up to 100m from a pit on the course of succession. If it occurred there, succession ran by a quite different way if it did not.

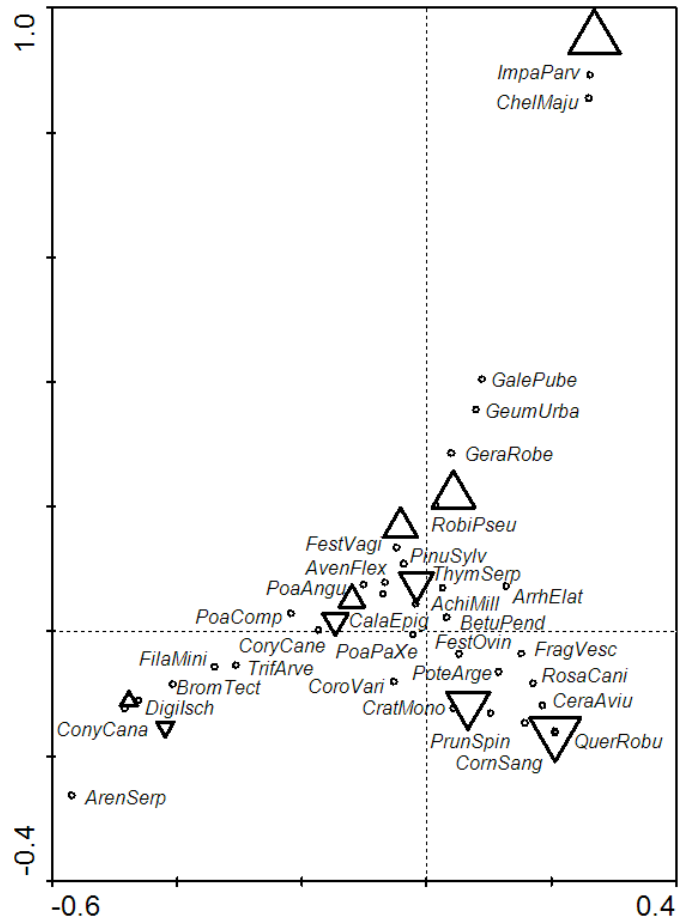

Fig. 1 – CCA ordination of samples from differently aged seral stages (centroids, increasing size of the symbols indicates increasing age) sorted according to the presence (▲) and absence (▼) of fertile *Robinia pseudacacia* in the vicinity (from Rehounkova & Prach 2008, Study no. 1).

Quarries *(Studies no. 2,3,4)*

Proportion of urban sites, grassland, and woodland (either up to 1km or 100m distance) and arable land (only up 100 m distance) in the surroundings, significantly (CCA ordination) influenced the course of succession, while wetlands (both up to 1km and 100m distance) and arable land (only up to 1km distance)did not. Altogether 98% of species occurring in the quarries (Study no. 2) occurred also in their close vicinity, again except some wetland species and two ruderals. 76% of species occurring in the vicinity occurred also in the quarries, among them 87% of grassland, 74% of woodland, 89% of wetland, 73% of ruderal, and 81% of alien species. Because of the comparably wet and cold region where the study was conducted, species typical for dry grasslands were not present, while those typical for mesic and wet grasslands were, however forming only small patches inside woodlands. Similarity between species lists inside and outside the quarries increased during succession reaching nearly total similarity in the oldest stages (Fig. 2).

In the case of limestone quarries (Study no. 3) we compared species lists in each quarry and its surroundings using unconstrained ordination (DCA) – Fig. 3. Quarries formed with their surroundings distinct

pairs in the ordination diagram indicating again a close influence of the surrounding vegetation on the course of succession in the disturbed site. If woodland prevailed around a quarry it developed also inside the quarry. In those quarries not surrounded by woodland, dry grasslands prevailed.

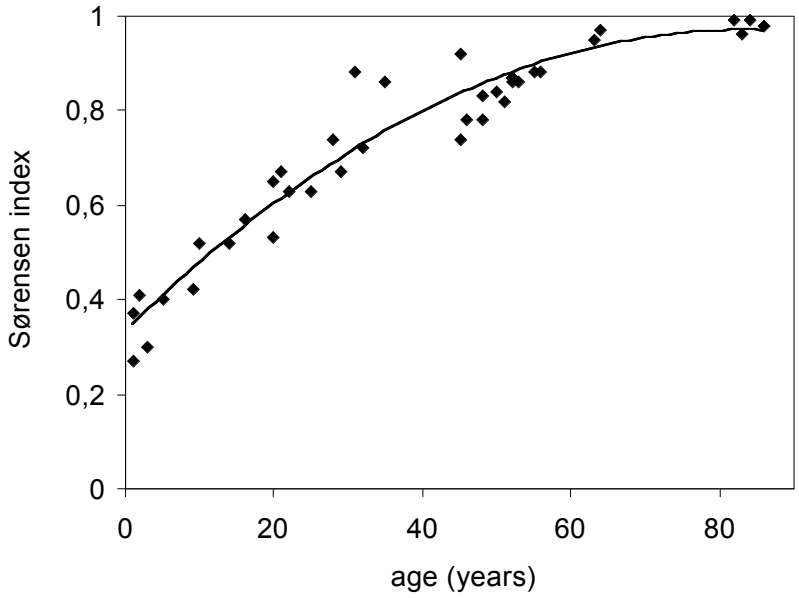

Fig. 2 – Increasing similarity between species lists inside and outside quarries (Study no. 2) during succession.

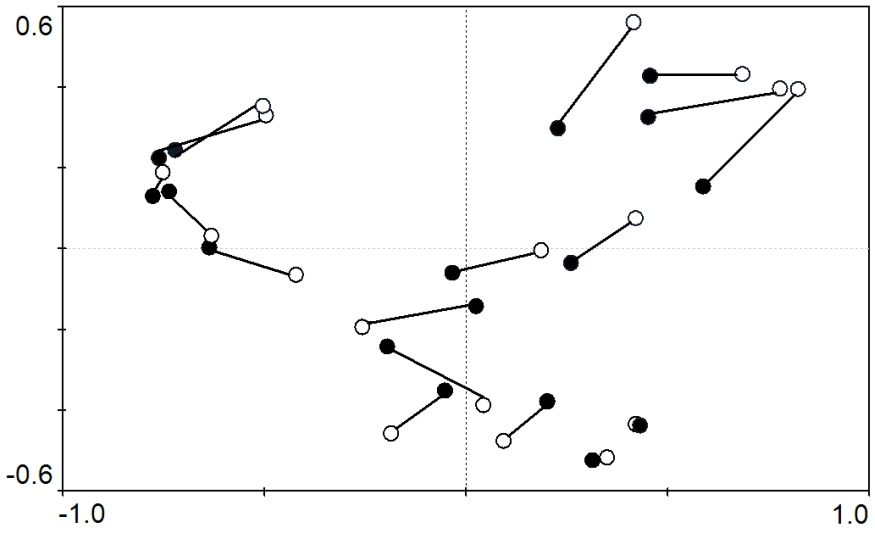

Fig. 3 – DCA ordination based on the abundance (1-5 scale) of species inside (white) and outside (black) the quarries. Close positions of samples indicates close similarity between the species composition inside and outside a quarry (Study no. 3).

In Study no. 4 it appeared decisive the occurrence of fragments of natural vegetation in the close vicinity of a basalt quarry. If natural or semi-natural grassland (steppe) fragments occurred up to 30m from the margin of a quarry that was a high probability that similar target stage develops in the quarry after some 25 years (Novak & Prach 2003, Novak & Konvicka 2006).

Spoil heaps from coal mining *(Study no. 5)*

Occurrence of arable land, ruderal sites, grassland and woodland in the surroundings appeared to have significant (CCA ordination) influence on the course of succession, while occurrence of urban sites, scrubs and wetlands did not.

Conclusions

The following conclusions can be drawn: Occurrence of most land-cover categories in the surroundings of a disturbed site significantly influenced the course of succession. The only exception was mostly represented by wetlands of which many species can be dispersed to a long distance especially by water fowls. In average, nearly all (97.5%) species occurring in a disturbed site also occurred in its surroundings up to 100m from the site and similarity in species composition inside and outside the disturbed sites increased in time. Desirable and undesirable species did not principally differ in this matter. The closer were patches of (semi-)natural vegetation to a disturbed site, the higher probability was that target vegetation developed. It has the following practical consequences: It is highly reasonable to preserve at least some remnants of (semi-)natural vegetation during the mining or similar activities in the surroundings of a disturbed site. Eradication of undesirable species, especially invasive aliens, is recommended, if possible, at least up to the 100m distance. These principles should be implemented into mining plans and post-mining restoration programs.

Acknowledgements

The study was supported by the following grants: GAAVCR IAA600050702, MSM 6007665801 and AVOZ 60050516.

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