Landscape context determining spontaneous restoration of post-mining sites

Karel Prach a coll.

Restoration Working Group, Faculty of Ceske Budejovice, and Institute of Botany CAS, Trebon, Czech Republic

www.restoration-ecology.eu
Importance of the landscape context at

- **local** (surrounding vegetation or land cover)
- **regional/country** (climate, landscape structure)
- **global** (type of biomes, latitude)

**scales**

*Only spontaneous succession (= passive or spontaneous restoration) considered*

(In CZ 98% of sites disturbed by mining have potential to restore spontaneously)
Spoil heaps from coal mining
Stone quarries
Extracted peatlands
Fig. 2 – Increasing similarity between species lists inside and outside (up to 100m) quarries during succession.

Trnková et al. 2010
Figure 2. Correspondence ordination analysis. Envelopes delimit positions of sample plots inside (dashed line) and outside (full line) the post-mining area.

Kabrna et al. 2013

Spoil heap from coal mining
Role of an invasive species (*Robinia pseudacacdia*)

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.

Řehounková, Prach (2008)
Sand pits
Regional scale

Fig. 3a. DCA ordination of vegetation samples represented by centroides. Climatic regions: region 1 - empty symbol, region 2 - gray symbol, region 3 - black symbol; habitats: ▲ - flat bottoms, ● - dumps, ■ - debris on the foot of walls, ◆ - walls. Size of symbols corresponds to succession age.

Novák, Prach (2003)
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.

*Prach et al. (2015), data P. Karešová*
Summarizing table on the influence of the surrounding land cover on the course of succession:

- X significant influence at least in one scale (100m or 1km)
- 0 nonsignificant influence
- - not analyzed

<table>
<thead>
<tr>
<th></th>
<th>Urban &amp; ruderal</th>
<th>Arable</th>
<th>Grassland</th>
<th>Woodland</th>
<th>Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel-sand pits</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Quarries I.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Quarries II.</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Spoil heaps</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Extracted peatlands</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
DAtabase of Successional Series (DASS):

21 types of series (40 particular)
3,700 vegetation records, age 1 - >150 years
1013 species (about 1/3 of the Czech flora)
    591 target species
    277 Red-List species
    152 alien species
    54 invasive aliens
EDaSS

prach@prf.jcu.cz
Country scale sand pits, peatlands

<table>
<thead>
<tr>
<th>Partial CCA (significant variables)</th>
<th>Explained variability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peatland</td>
</tr>
<tr>
<td>Age</td>
<td>2.2</td>
</tr>
<tr>
<td>All abiotic sites factors</td>
<td>16.8</td>
</tr>
<tr>
<td>All landscape factors (Land cover up to 1000m; Land cover up to 100m; Altitude; Temperature; Precipitation)</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Řehounková, Prach (2006); Konvalinková, Prach (2014)
Table 1 Results from CCA and forward selection analysis, successional age was used as a covariate.

<table>
<thead>
<tr>
<th>Mean series</th>
<th>Explains %</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic/Acidic</td>
<td>1.06</td>
<td>***</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.90</td>
<td>***</td>
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<tr>
<td>Humid areas</td>
<td>0.47</td>
<td>***</td>
</tr>
<tr>
<td>Precipitation</td>
<td>0.43</td>
<td>***</td>
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<tr>
<td>Urban areas</td>
<td>0.32</td>
<td>***</td>
</tr>
<tr>
<td>Traffic</td>
<td>0.30</td>
<td>***</td>
</tr>
<tr>
<td>Agriculture areas</td>
<td>0.24</td>
<td>***</td>
</tr>
<tr>
<td>Water bodies</td>
<td>0.24</td>
<td>***</td>
</tr>
<tr>
<td>Forests and seminatural areas</td>
<td>0.19</td>
<td>***</td>
</tr>
<tr>
<td>Village Yes/No</td>
<td>0.17</td>
<td>***</td>
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<tr>
<td>Streams</td>
<td>0.11</td>
<td>***</td>
</tr>
</tbody>
</table>

Vítovcová et al., in prep.
Global scale

(a) Abandoned fields

(b) Mining sites

Success of succession (percentage of studies)

Latitude

0°–20°  20°–40°  40°–(>60°)

successful  partly successful  unsuccessful

Prach et al., submitted
Recommendations

(concern not only spontaneous restoration)

(i) Provide inventory of species of the surrounding habitats at least up to 100 m from a disturbed site prior to design a restoration project and consider land cover in the broader landscape.

(ii) Prescribe if possible preservation of semi-natural habitats in the close vicinity to a disturbed site even before mining activities begin and during them.

(iii) Control invasive aliens or other undesirable species not only in the disturbed site, but also in its surroundings, at least up to 100 m distance.

(iv) Provide restoration measures also of the surrounding areas if ownership and legislation allow this.
Restorationists should carefully consider the landscape context of disturbed sites more than until now because of its profound impact on restoration processes, and thus success of restoration projects.
Near-natural restoration vs. technical reclamation of mining sites in the Czech Republic

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Thanks for your attention

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