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Ruderalization in the Man-Influenced Forests

Discussion paper [1]

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Abstract

An iterative algorithm (IDGAI) was used with the goal to indicate a measure of man influence on the herb layer change (i.e. ruderality) in set of forests in the Czech Republic. It is necessary to speak about two features of forest communities **1.** ruderalization (level of change in the plant species composition under man influence), **2.** potential ruderalization (measure of possibility the species composition to be changed under certain conditions).

Keywords

bioindication, herb layer, man-influence, ruderalization, species composition

The ruderalization of an ecosystem (a community) is a process of spreading (under the man impact) of some species to be not occurred originally in this ecosystem (community). The man impact may be both immediate (e.g. trampling, recreation) or mediated (e.g. air pollution). Origin of the new species may vary from the neophytes (*Impaties parviflora*) through the archeophytes (*Chenopodium album*, *Ballota nigra*) to the apophytes with primary distribution out of forests (*Agropyron repens*) or in other natural forests (*Urtica dioica*).

There are two terms commonly used by description of this change - ruderalization and synanthropization. Difference between use of both words is not clear. First, describe the process to become more ruderal during time. Second is used for process to become more synanthrop. It is obvious that synanthrop is more universal than ruderal but a border between they do not exist. The custom is probably to tell about ruderalization in forests.

The strength of human pressure on the ecosystem sufficient to attain the same level of ruderalization may be probably different by different forests. There is a continuum between natural and ruderal ecosystems (communities, stands). The plant species with optimum in a ruderal community is a ruderal species. The species with optimum in a natural community is a non-ruderal species.

For identification of the level of ruderalization (by index I_R) is possible to take further model known from the theory of community bioindication (Ellenberg et al.,

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[1] Nomenclature of the plant species follows Rothmaler (1982).

1991; Zólyomi et al., 1967; Landolt, 1977) in manner of use by Matějka (1993) (IDGAI [In-Direct Gradient Analysis with *a priori* Information] method):

$$I_R = \sum(e_i c_i / w_i) / \sum(c_i / w_i)$$

where c_i is cover of i-th species, w_i is weight coefficient of i-th species, e_i is measure of species ruderal property (species ruderality).

We are able to re-compute species ruderality indices (e_i) on the base of species distribution in set of communities with vary level of ruderalization (algorithm is the same as by bioindication; Matějka, 1993).

I carried out evaluation both level of community ruderalization and species ruderality in the set of man-influenced forest plant communities (plant coenological relevés) classified by Matějka (1995). The set consist of three subsets:

1. relevés from forests in the South Bohemia (see Matějka, 1994a) (63 relevés)
2. relevés published by Hadač and Sofron (1980) from Czech Republic (33 relevés)
3. relevés from plots of ICP-Forests monitoring (they were not published; for description of the programme see Matějka 1994b, 1995) (49 relevés)

Table 1. List of the ruderal species in the studied forests. These species were used on initializing of the procedure.

Aegopodium podagraria L.	*Galium aparine* L.
Aethusa cynapium L.	*Geranium robertianum* L.
Agropyron repens (L.) P.B.	*Geum urbanum* L.
Alliaria petiolata (M.BIEB.) CAVARA et GRANDE	*Glechoma hederacea* L.
Anthriscus sylvestris (L.) HOFFM.	*Impatiens parviflora* DC.
Arctium lappa L.	*Lactuca serriola* L.
Arctium tomentosum MILL.	*Lapsana communis* L.
Artemisia vulgaris L.	*Mentha* sp.div.
Bryonia dioica JACQ.	*Mycelis muralis* (L.) DUM.
Calamagrostis epigeios (L.) ROTH	*Polygonum hydropiper* L.
Carex hirta L.	*Rubus caesius* L.
Carex leporina L.	*Rubus hirtus* W. et K.
Chaerophyllum temulum L.	*Rumex obtusifolius* L.
Chamaerion angustifolium (L.) SCOP.	*Rumex acetosella* L.
Chelidonium majus L.	*Sambucus nigra* L.
Chenopodium hybridum L.	*Sambucus racemosa* L.
Epilobium adenocaulon HAUSSKN.	*Senecio viscosus* L.
Epilobium hirsutum L.	*Senecio vulgaris* L.
Equisetum arvense L.	*Stellaria media* (L.) VILL.
Fallopia convolvulus (L.) Á.LÖVE	*Tanacetum vulgare* L.
Fallopia dumetorum (L.) HOLUB	*Taraxacum officinale* agg.
Galeopsis bifida BOENN.	*Torilis japonica* (HOUTT.) DC.
Galeopsis pubescens BESSER	*Urtica dioica* L.
Galeopsis tetrahit L.	

Total number of species in the herb layer of all relevés was 325. I assessed a set of 47 species as ruderal (Table 1). Computation of indices was carried out by parameters:

Table 2. Results of computation of the species ruderality indices (e) and weight coefficient for species cover (w, in per-cent). The most important species according to the indication were selected (species with grades 1-3 and 7-9 of the 9-grade indication scale.

iteration:	1	2	3	1	2	3
	e	e	e	w	w	w
Galeopsis pubescens BESSER	3,58			4,9		
Dactylis polygama HORVATOVSZKY	2,64			2,3		
Moehringia trinervia (L.)CLAIRV.	2,02	1,82	1,62	2,2	0,6	0,8
Galium odoratum (L.)SCOP.	1,81			4,5		
Heracleum sphondylium L.	1,54			2,8		
Poa nemoralis L.	1,29			1,5		
Agrostis tenuis SIBTH.	1,08			3,3		
Hypericum perforatum L.		1,68			0,4	
Acer pseudoplatanus L. juv.	0,29	1,31	1,42	1,8	0,9	0,3
Viola riviniana RCHB.	0,60	1,09		1,5	0,5	
Rosa dumalis BECHST.		1,04	1,49		0,2	0,2
Dryopteris filix-mas (L.)SCHOTT		0,93	1,22		0,9	1,2
Athyrium filix-femina (L.)ROTH.	0,06	0,74	1,03	2,0	2,1	1,3
Vaccinium myrtillus L.	-1,04	-1,40	-1,31	9,0	12,0	15,9
Avenella flexuosa (L.)PARL.	-1,07	-1,49		17,4	28,7	
Holcus mollis L.	-1,13			2,0		
Arnica montana L.	-1,18	-1,26		1,2	1,6	
Calamagrostis villosa (CHAIX)J.F.GMELIN	-1,31			7,6		
Equisetum sylvaticum L.	-1,31			4,2		
Calluna vulgaris (L.)HULL	-1,35	-2,07	-2,01	0,9	1,8	2,3
Trientalis europaea L.	-1,36			0,4		
Dryopteris austriaca (JACQ.)WOYNAR		-1,46	-1,31		1,7	1,5
Luzula multiflora (RETZ.)LEJ.		-1,51			2,1	
Galium harcynicum WEIGEL		-1,97			19,5	
Vaccinium vitis-idaea L.		-2,01	-2,19		2,3	3,1

Table 3. Transformation of values of the 9-grade indication scale into the index e values.

value of the scale	1	2	3	4	5	6	7	8	9
e	-∞	-2,41	-1,00	-0,41	0,00	+0,41	+1,00	+2,41	+∞

- minimal considerable cover of a single species 0.1 %;
- maximal share of indifferent species in the relevé 60 %;
- minimal number of relevés for average computation 5.

Some results of three first iterations are in Table 2. It is possible to distinguish species along the scale not-ruderalized - ruderalized forest. The species with high ruderality indices are not ruderal species in generally. They are indicators of a potential high possibility of the community to become more ruderal under low anthropic pressure. The algorithm is not stabile for this indication but it converges to another feature of the ecosystem - probably to the nutrient supplementation. It is indicated by a correlation between potential ruderalization as indicated and nutrition status. Expected relationship potential ruderalization and light conditions in the stand was not observed.

Table 4. The TWINSPAN classification of the 146 relevés of forests in the Czech Republic. Each group is designated with a binary classification code. Number of relevés is given in the parenthesis. The group is described by plant indicators. Presented numbers are used for cut levels: 1 for cover more than 0.01 %, 2 for 6.25 % and 3 for 12.5 %. Average and maximal values of the indices I_R (level of ruderalization) are gathered in the lower part of the table for iteration 0 to 3.

<table>
<tr><td colspan="5">0 (81)</td><td colspan="4">1 (65)</td></tr>
<tr><td colspan="5">Vaccinium myrtillus 1
Betula pendula 1
Avenella flexuosa 1</td><td colspan="4">Poa nemoralis 1
Fragaria sp. 1
Urtica dioica 1</td></tr>
<tr><td colspan="2">00 (48)</td><td colspan="3">01 (33)</td><td colspan="3">10 (60)</td><td>11 (5)</td></tr>
<tr><td colspan="2">Avenella flexuosa 3</td><td colspan="3">Senecio fuchsii 1
Mycelis muralis 1
Rubus idaeus 1</td><td colspan="3">---</td><td>Caltha palustris 1
Filipendula ulmaria 1
Juncus effusus 1</td></tr>
<tr><td>000 (4)</td><td>001 (44)</td><td>010 (3)</td><td colspan="2">011 (30)</td><td colspan="2">100 (56)</td><td>101 (4)</td><td></td></tr>
<tr><td>Calamagrostis villosa 3</td><td>---</td><td>Calamagrostis arundinacea 2
Fagus sylvatica 1</td><td colspan="2">---</td><td colspan="2">Poa nemoralis 1
Luzula albida 1
Fragaria sp. 1</td><td>Geum urbanum 1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>0110 (21)</td><td>0111 (9)</td><td>1000 (9)</td><td>1001 (47)</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Oxalis acetosella 2
Senecio fuchsii 1
Avenella flexuosa 2
Viola reichenbachiana 1</td><td>Quercus petraea 1
Pinus sylvestris 1
Impatiens parviflora 1</td><td>Oxalis acetosella 1
Acer pseudoplatanus 1</td><td>Fragaria sp. 1
Quercus robur 1</td><td></td><td></td></tr>
</table>

I_R - Average

0	-2.38	-2.34	-2.40	-1.60	-0.67	-2.01	-1.66	0.01	-2.16
1	-2.83	-2.48	-2.11	-1.45	-1.05	-0.62	-1.3		
2	-2.71	-2.54	-1.79	-1.29	-1.34	-0.68	-1.04		
3	-2.08	-2.28	-1.09	-1.28	-0.88	-0.36	-0.45		

I_R - Maximum

0	-2.31	-1.45	-2.39	0.12	0.55	-1.18	0.26	0.58	-1.91
1	-2.65	-1.07	-2.05	0.15	-0.66	0.93	0.99		
2	-2.55	-1.32	-1.58	-0.12	-0.84	-0.68	-0.04		
3	-1.58	-0.85	-1.09	-0.46	-0.48	-0.36	-0.05		

Together 146 relevés were classify into 9 groups using the TWINSPAN procedure (Table 4). There are some differences between grades of ruderalization of the forests classified in different groups. The highest potential ruderalization occurs in some relative nutrient rich forests of the oak altitudinal belts (TWINSPAN classification group 100). Acidophile mountain spruce forests and some nutrient-pure forests of the beech altitudinal belts are more resistant to change under anthropogene pressure.

Potential ruderalization is a feasibility of change. We need a solution of the following questions (compare Lepš, Osbornová, Rejmánek, 1982):

1. Is there a relation between potential ruderalization and stability of the community?
2. Are some plant species indicators of the community stability / instability?

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Ruderalizace v kulturních lesních ekosystémech

S cílem stanovení míry ruderality jednotlivých druhů bylinného patra v člověkem ovlivněných lesích na území České republiky byl použit iterativní algoritmus dříve navržený pro bioindikaci ve fytocenózách za použití ekoindexů (IDGAI). Zjistilo se, že s ohledem na procesy ruderalizace je nutno rozlišovat dva termíny: Vlastní ruderalizace je skutečným momentálním stavem fytocenózy. Potenciální ruderalizace je „vnímavostí“ společenstva vzhledem k vnějším tlakům, je mírou úměrnou pravděpodobnosti, že za určitého tlaku dojde k ruderalizaci, tedy ke změně druhové struktury společenstva. Zde je jasně vidět návaznost na problematiku stability společenstev.