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REGENERATION POTENTIAL OF THE HUNGARIAN (SEMI-)NATURAL HABITATS I. CONCEPTS AND BASIC DATA OF THE MÉTA DATABASE

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Regeneration potential is regarded as a kind of functional indicator, which is applied for the assessment of the habitat quality and a kind of nature conservation value. In this context "quality" does not refer to the actual state but possibilities for the future. During the MÉTA project, regeneration potential have been recorded on the scale of the quadrates (35 km^2, 2,813 quadrates in Hungary), for each habitat of the quadrate (ignoring some featureless habitats). We have estimated three different kinds of regeneration potential: on spot, on the place of neighbours and on old-fields open water, bare rock. The categories used were: good regeneration ability, moderate, low, or there is no place for regeneration.

Values of regeneration potential on spot are usually rather high. Habitats with the highest regeneration potential are the aquatic ones, shrub vegetation, halophytic vegetation, marshes, grasslands with woodland origin, sand poplar-juniper woodlands, and the poorest is the regeneration potential of the forest steppe woodlands. Lower are the values of the regeneration potential of each vegetation type on the place of the neighbours. Relatively easily spread onto the neighbouring vegetation patches the halophytic habitats, poplar-juniper woodlands, the secondary shrub vegetation, some aquatic habitats, certain riverine vegetation types and marshes. Moderate or lower is this value of this regeneration potential category for the xeric highland woodlands, rocky habitats, xeric and mesic lowland woodlands, grasslands with woodland origin and some fen vegetation types. In spite of the rather low values calculated for the whole country, the following habitats regenerate relatively well on old-fields, open water or rock surfaces, or in abandoned vineyards: the dry secondary shrub vegetation, poplar-juniper woodlands, Scots pine woodlands, halophytic habitats, some aquatic habitats and marshes. Most habitats regenerate poorly, for example, the zonal woodlands. Never or barely regenerate on old-fields: some fen habitats, the steppe oak woodlands, mesic lowland woodlands, some rock habitats, acidophilous woodlands, the zonal woodlands, the rock and sand coniferous woodlands.

When comparing the values of regeneration potential on spot, on the place of the neighbours and on old-fields, most striking is the fact that the least habitats have moderate or high regeneration ability in case of the third kind of regeneration potential, and regeneration ability on adjacent vegetation patch represent a transitional state from this aspect. Some of the edaphic habitats are quite mobile (e.g. halophytic, marsh or certain fen habitats), while others migrate only rarely (rock or other fen vegetation types). Some habitats though regenerate admirably on spot, yet never invade new areas; for instance, rock vegetation, acidophilous woodlands, grasslands with woodland origin. Others has almost the same regeneration potential values on spot as on the place of the neighbours, e.g. some steppe woodlands and shrub habitats on their own clearings, or some habitats of secondary origin. Certain rock habitats, some fen and riverine vegetation types and some of the close woodlands regenerate well on spot, but almost never on old-fields. There are some habitats, which has high regeneration potential on the place of the neighbours, but has low values for the old-fields. Most of them are closed woodlands, shrub and certain fen habitats.

According to our expectations, the experience gained during the MÉTA mapping will give an impulse to the study on regeneration potential.

Key words: habitat evaluation for nature conservation, landscape ecology, vegetation dynamics

INTRODUCTION

Natural vegetation regularly suffers from disturbances even in its natural state, free from any human interference. Vegetation continuously degrades, the individuals grow old and they die as a result of diseases, parasites, additionally they have to cope with animal trampling, digging, natural fires, frost or drought. During the history of evolution the vegetation has adapted to natural disturbances, the results of which has been counteracted spontaneously (Pickett and White 1985); extinction occurs often locally, resulting in the loss of few individuals, so it cannot be observed with the naked eye. If disturbance affects wider area, a whole stand or a large vegetation patch (e.g. avalanche, forest fire or windfall), subsequent to disturbance the stand undergoes slow, gradual process of succession, however, it regenerates even in these cases. The processes of spontaneous regeneration, following natural disturbances have different pace in different vegetation types (Major 1974, Burrows 1990), and they may serve as references for prediction of vegetation dynamics in the mosaic landscape of today, influenced by the presence of the humankind.

Regeneration potential is applied during the MÉTA program for the characterisation of the future dynamics of the (more-or-less degraded) habitats that are under human impact. We estimated the time required for the spontaneous regeneration of the vegetation patches, and the degree of regeneration it can reach (Molnár *et al.* 2007). We regard regeneration potential as a kind of functional indicator, which is applied for the assessment of the habitat quality, a kind of nature conservation value. Here "quality" does not refer to an actual state, but the possibilities of the future. So studies on the regeneration potential basically aimed to predict the future changes of the actual landscape (see Riecken *et al.* 2006). Vulnerability of the vegetation type may also depend on its regeneration ability (see Riecken *et al.* 2006). According to Bastian (1996), the slower is the regeneration process of a patch/mosaic of habitat(s) following a potential degradation, the more valuable it is in the sense of nature conservation, and the more protection it needs. Regeneration subsequent to human disturbance was a general phenomenon even during the past millennia, e.g. this was proven to have happened several times in the case of riverine woodlands along the river Tisza (Magyari 2002). Zólyomi (1969) has also stressed that in some Hungarian landscapes all patches of certain habitat types (e.g. stands of species rich loess steppes) established as a result of secondary regeneration processes on previous earthworks, ridges or tumuli.

The main purpose of nature conservation is to protect the remnants of our natural vegetation in its functional state, and also to improve its functions. To reach this purpose it is not enough to compile mere lists of the occurrences of the remnant vegetation patches, we also have to know which patches of which landscapes have the possibility to survive for a longer period, to regenerate after degradation, and how the ecological functioning of a certain landscape can be improved (Bartha 2003). According to the experience gained so far, regeneration ability of the vegetation patches may depend on several different factors: vegetation type (e.g. woodland compared to marsh habitats), population dynamics of the composing species, e.g. dispersal ability (Peterken and Game 1984, Dzwonko and Loster 1992), secular vegetation dynamics of the vegetation type (Riecken *et al.* 2006), the extension of the patch, species richness, fine scale vegetation pattern (Virágh and Bartha 1996, Bartha 2007), land use (Poschlod and WallisDeVries 2002), site conditions (e.g. fen character, Seregélyes and S. Csomós (1990), halophytic character, Molnár and Borhidi (2003)), the conditions of the surrounding landscape, e.g. the amount and distance of propagule sources (Peterken and Game 1984, Dzwonko 1993), the abundance of invasive species (Rejmánek 1989, Botta-Dukát 2008). The rate and direction of regeneration dynamics may differ considerably in different landscapes, depending e.g. on the land use or the extension of the refugial patches (Bartha *et al.* 2006).

Measuring "dynamical goodness"

Research on vegetation dynamics is time-consuming, and requires rather complex methodology. In order to get data on the dynamics or the probable future changes of vast areas, we have to apply different approaches: (1) long-term, complex, experimental surveys on basic ecological problems in characteristic landscapes (Kovács-Láng *et al.* 2008); (2) less complex monitoring systems connected to these permanent, basic sites, e.g. permanent quadrates; (3) spatio-temporal substitution surveys; and finally (4) focused, and well-organized compilation and evaluation of the knowledge of botanists and nature conservationists (e.g. several-decade-long field experience on vegetation dynamics).

The majority of studies on succession measures the actual speed of succession (e.g. Prach *et al.* 1993, Myster and Pickett 1994), the state of regeneration is often not measured, because the processes are not compared to a real, idealised "natural" target state. If the aim of the study is the understanding of the regeneration of the old-fields, "wounds of the landscape", in addition to the speed of succession it is also important to document the direction of the succession and also the distance to a natural reference vegetation (Molnár and Botta-Dukát 1998, Ruprecht 2006, Otto *et al.* 2006). The initial species composition is also of basic importance: no matter how fast is the turnover of the species, if the whole process of succession starts with a series of weed communities. Regeneration intensity is determined by the speed of the invasion and the spread of the dominant and characteristic species of the natural habitats. The results show that old-fields regenerate slowly in some landscapes (e.g. Molnár and Botta-Dukát 1998), while this process is astonishingly rapid in other ones (e.g. Ruprecht 2006).

Conclusions may also be drawn on the assumed previous or the possible future dynamics on the grounds of the actually observable results of the previous processes or the state of the surrounding landscape. For woodlands, we are aware of methods that enables the estimation of certain dynamic traits (e.g. gap dynamics, changes in tree species composition) on the bases of structural data (e.g. the closure or species composition of the canopy layers, amount and quality of dead wood) – see for example Bartha *et al.* (2003) for Hungary, yet we are in great need of methodological development for grasslands and marshes (see Rabotnov 1985, Bartha 2007). During the mapping of Natura 2000 habitats in the Czech Republic, restoration ability of the mapped patches was evaluated. Among other traits (as whether there are any possibly applicable method or sufficient money for the restoration) regeneration ability was also appraised (Guth and Kučera 2005).

Attempts on the assessment of regeneration potential at the country scale

Due to the difficulties of the exact measurement of regeneration potential, the most effective way to fulfil the practical requirements of a country-wide assessment is the expert judgement of regeneration potential of the vegetation types. The regeneration ability of all the vegetation types in a country was only assessed so far in Germany (Blab *et al.* 1995, 2005, Riecken *et al.* 2006).

In these studies each vegetation type was assigned to one category of regeneration ability – treated as an indicator: (1) regeneration impossible (virgin forests, relicts); (2) low possibility of regeneration (more than 150 years are required, but even after that time, only low would be the level of regeneration due to the isolation of the stands); (3) hard to regenerate (15–150 years are required, yet some of the species need more time); (4) regeneration is possible (15 years are enough, yet some of the species need more time); (5) it has no sense to estimate regeneration ability (woodlands of invasive species, plough lands as the state of destination). Two different kinds of regeneration were distinguished: regeneration after the cessation of disturbance ("regeneration through succession") and regeneration on newly established sites (old-fields) ("Neuentwicklung durch gestaltendes Eingriffen des Menschen"). Only a single value is assigned to each vegetation type, but they also mentioned that high differences might be observed between regions. (Indeed, experience show that the same habitat type can have dissimilar regeneration ability in different landscapes, and also the values of the different habitats may also be differing within a certain landscape.) Riecken *et al.* (2006) also stressed that often the landscape itself, which surrounds the habitats of high regeneration potential, enables only partial regeneration (as a result of fragmentation and insufficient species richness of the propagule sources). Regeneration potential is regarded as a useful support for defining the priorities of nature conservation – e.g. in decisions on compensation (or whether a lost habitat could even be compensated for?).

In Hungary, surveys on regeneration only started in the past few years, however, high amount of naturalists' experience was gained chiefly from nature conservation management and from landscape history. Thus, during the MÉTA program first we characterised the regeneration ability of the habitats in different situations, under different landscape conditions based on expert knowledge (Habitat guide, Bölöni *et al.* 2003, 2007, an example is given in the Appendix), then during mapping the local possibility of regeneration was estimated for each habitat type in each MÉTA quadrate. In the present article, at first we describe the methodology of data acquisition, then we summarise the preliminary conclusions of the data obtained from the whole country.

METHODS

Data types in the MÉTA database

Regeneration potential was documented on the spatial scale of the MÉTA quadrates (35 km^2, the total number of the quadrates was 2,813 in Hungary, Horváth *et al*. 2008), for each detected habitat type of the quadrate. (Regeneration potential was not documented for those habitats, where this value has no biological sense. These were the degraded, featureless vegetation types: OA, OB, OC, RA, RB, RC, RD; wooded pastures, extensively managed orchards: P45, P7, because we are not interested in the regeneration processes leading to these vegetation types, but regeneration to (semi-)natural habitats.) The abbreviations of the habitat types are resolved in Appendix of the volume.

We have evaluated three different kinds of regeneration potential:

– (1) potential for regeneration in an existing stand in case of a potential mean degradation (that does not affect the whole stand), i.e. the capability of a certain habitat to reach its best (most natural) state in its actual landscape environment following degradation (this value was assessed on the bases of species richness, patch size, vegetation pattern, land use, neighbourhood in the landscape, abundance of invasive weeds, etc.);
– (2) potential for regeneration in the place of a neighbouring habitat type, i.e. the ability of a certain habitat to restore itself on the place of an adjacent vegetation by replacing it (without any human inference) (e.g. a dried out meadow is invaded by the species of a neighbouring steppe; a clearing is invaded by the adjacent forest); the facilities of the local stands (whether the species pool or the size of the original vegetation patches are sufficient for the colonisation) and the state of the local landscape (barriers hindering the spread, the disturbance level of the landscape, the site conditions of the vegetation patches) should be taken into consideration during the assessment;
– (3) potential for regeneration on "vegetationless" areas, i.e. the ability of a habitat type to colonise the abandoned old-fields (or the open water surfaces in case of aquatic communities, the open rock surfaces in case of rocky vegetation); when estimating this potential, we have to examine whether the habitat type has the ability to (re-)colonise the area, or whether there are any old-field (open water or rock surface) of suitable site conditions in the landscape (for instance, a dried out meadow can only regenerate into a dry grassland after tillage).

The following categories were applied for the evaluation of regeneration potential:

– (a) good regeneration ability – The original or the actually potential vegetation or a vegetation type favourable from the nature protection's point of view (compared to itself) has high potential for regeneration (there is available source of species and physical place for regeneration). The result of regeneration process is natural or semi-natural vegetation. (We used "compared to itself" because the time scale of regeneration in a *Festucetum vaginatae* stand is not more than 10–20 years under favourable conditions, while the regeneration of an old-growth beech forest certainly takes much longer time);
– (b) moderate potential for regeneration – The habitat has limited ability of regeneration; it has the possibility for the process in the landscape, but the original habitat re-establishes slowly (much more slowly than in the previous case) or incompletely (succession ceases), and the vegetation is dominated by weeds and indifferent species;
– (c) low potential for regeneration – A certain habitat cannot regenerate in the landscape either because of the insufficient source stands or due to the hindering effect of the rapid spread of invasive species. Even if the process of regeneration begins, it does not result in the original habitat type; though the dominant species of the community may be present, they do not constitute a matrix, and even after a longer period, only a vegetation far from the natural state can be found on the area (endless stand of weeds, vegetation of weedy bushes, etc.);
– (d) there is no place to regenerate – There are no patches in the landscape that could be colonised by the species of the vegetation type; e.g. there are no site of marsh, fen, halophytic or rock character for the colonisation.

Standardisation

Evaluating regeneration potential is considerably subjective (basically due to our lack of knowledge, our differing attitude and level of knowledge), so we developed the following standardisation to make the assessment as impartial as possible. Based on our previous experience (Molnár *et al.* 2001), instead of elaborating more detailed definitions and more accurate criteria, in the Habitat guide we (1) specified the factors that determine the regeneration potential of a certain habitat type, and (2) for each vegetation type we gave a detailed list of examples for each categories of the regeneration potential (we elaborated about 720 examples of regeneration potential altogether, Bölöni *et al.* 2003, 2007, Molnár *et al.* 2007, an example is given in the Appendix).

When preparing the examples we have taken the following aspects into consideration: the actual state of the stand (e.g. species richness, the re-colonisation ability of the species, the competition potential of the disturbance tolerant species), site conditions (e.g. available water and nutrient content of the soil), the status of the landscape (amount of propagule sources, mobility of the species in comparison with the distance of the propagule sources), land use (e.g. forest management, grazing). The examples were elaborated by one or few experienced botanists with wide knowledge of a certain landscape, based on their field experience. The examples were subsequently lectured by other botanists. The aim of the list of examples was to make the mappers to compare the actually mapped vegetation patch to particular examples rather than to theoretical criteria. We would like to stress that not the real regeneration potential was necessarily estimated, since we do not have sufficient knowledge to do this, however, we standardised the process of assessment. The application of merely three categories means robusticity, that partially compensates our insufficient knowledge. In the field trainings we found that standardisation was basically effective, yet considerable heterogeneity remained in the database (see Molnár *et al.* 2007).

RESULTS

The regeneration potentials of the vegetation types calculated for the whole country are summarised in Table 1 and shown in Figure 1.

Regeneration potential on spot

Usually these are rather high values (the majority of habitats has moderate or better regeneration potential in more than 75% of the quadrates). Good is the regeneration ability of aquatic habitats (A1, A23, A3a, A5), shrub vegetation (P2a, P2b), halophytic habitats (F1a, F1b, F2, F4, F5), marshes (B1a, B2, B3, B6), hay meadows (E1, E2), sand poplar-juniper woodlands (M5), etc. Forest steppe woodlands (M4, L5, M3, M2, L2x) has the lowest potential of regeneration on spot.

Regeneration potential on the place of the neighbours

Values characterising the regeneration ability on the place of an adjacent vegetation patch are lower than ones of the previous category were, in case of all the habitat types; two-thirds of the habitats has good or moderate regeneration potential in merely less than 50% of the quadrates.

Relatively good regeneration ability was documented on the place of the neighbours in case of halophytic habitats (F1a, F1b, F2, F4), poplar-juniper

Table 1

Values of regeneration potential of the vegetation types, calculated for the whole country (the assessment of 207 mappers in 2,813 quadrates). Values are given as the percentage proportion of moderately and well-regenerated occurrences (quadrates) to the total number of occurrences (i.e. each habitat types were compared to itself). Habitat types were ranked according to the mean value of the three different aspects. Since assessment process of the regeneration potential is not absolutely standardised and objective, values of the table are regarded as rough approximations, they should not be applied for fine comparisons

Code	Short name	On spot	Neighbours	Old-fields, etc.
F1b	*Achillea* steppe	100	93	78
M5	Poplar-juniper steppe woodland	96	90	65
P2b	Dry shrubland	99	88	65
F1a	*Artemisia* steppes	99	78	64
F2	Salt meadow	99	78	62
N13	Calcifuge pine woodland	71	53	56
B1a	*Phragmites*, etc. in marsh	95	69	44
B6	Salt marsh	96	70	44
F3	Alkali meadow steppe	76	59	44
A3a	*Potamogeton*, *Nymphoides*	99	76	36
A5	Saline euhydrophyte	100	66	36
I1	Amphibious communities	93	18	35
D6	Tall herb (floodplain)	87	65	34
G1	Open sand steppes	76	45	34
P2a	Wet shrubland	98	80	34
F4	*Puccinellia*	100	75	32
J4	Riverine willow-poplar woodland	93	66	31
E1	*Arrhenatherum* meadow	94	47	30
A1	*Lemna*, *Salvinia*, *Trapa*	99	67	29
A23	*Nymphaea*, *Stratiotes*	96	65	29
B2	*Glyceria*, *Sparganium*	96	70	29
H4	*Brachypodium* grassland	84	47	28
H5a	Loess steppe	67	37	27
B3	*Butomus*, *Eleocharis*	97	63	25
D34	Marsh meadows	89	58	25
E2	*Festuca rubra* meadow	96	39	25
H5b	Sand steppe	84	30	20
J3	Riverine willow scrub	94	64	19
I2	Loess cliff	63	19	18
B5	Non-tussock sedge	89	49	17
M8	Thermophilous fringe	94	63	17
G2	Calcareous rock grassland	84	50	15
H3a	Slope steppes	92	23	14
D2	*Molinia* meadows	76	39	12
F5	Annual salt pioneer	95	58	12
B1b	*Phragmites*, etc. in fens	72	32	10
E5	*Calluna* heath	90	15	10
G3	Acid rock grassland	93	36	9

Table 1 (continued)

Code	Short name	On spot	Neighbours	Old-fields, etc.
I4	Rock cliff	95	29	9
E34	Mountain meadow	92	15	8
J1a	Willow mire woodland	85	58	8
M6	Steppe thicket	69	59	7
L2x	Closed, mixed steppe woodland	54	25	6
D5	Fen tall herb, *Petasites*	88	33	5
H2	Rock steppes	89	19	5
K1a	Lowland oak-hornbeam woodland	86	14	5
K2	Oak-hornbeam woodland	89	26	5
K7b	Calcifuge oak-hornbeam woodland	88	51	5
A4	Euhydrophyte in fens	92	29	4
J2	Alder swamp woodland	89	44	4
L2a	*Quercus cerris-petraea* woodland	84	23	4
L2b	*Quercus cerris-robur* woodland	72	12	4
J6	Riverine oak-ash-elm woodland	73	27	3
K5	Beech woodland	93	19	3
L5	Closed lowland oak woodland	35	11	3
B4	Tussock sedge	77	20	2
J5	Riverine ash-alder woodland	91	44	2
M2	Loess steppe woodland	53	30	2
L1	Closed termophilous oak woodland	85	11	1
LY2	Slope woodland	91	3	1
M1	*Quercus pubescens* woodland	92	51	1
C1	Water flush	88	35	0
C23	Transition mire	85	31	0
D1	Rich fen	82	14	0
H1	Closed rock grassland	94	3	0
J1b	Birch mire woodland	82	27	0
K7a	Calcifuge beech woodland	91	13	0
L4a	Open calcifuge oak woodland	92	10	0
L4b	Closed calcifuge oak woodland	77	10	0
LY1	Ravine woodland	91	1	0
LY3	Beech rock woodland	71	5	0
LY4	Oak rock woodland	92	13	0
M3	Alkali steppe woodland	46	44	0
M4	Sand steppe woodland	23	13	0
M7	Rock thicket	89	13	0
N2	Calcareous pine woodland	80	17	0

woodlands (M5), secondary shrub vegetation (P2a, P2b), aquatic habitats (A1, A23, A3a, A5), some riverine habitats (J3, J4, D6) and marshes (B1a, B2, B3, B6). Moderate or worse is the regeneration potential of the dry woodlands of the hills and the mountains (L1, L2a, L2b, L4a, L4b, K1a, K5, K7a), rock habitats (H1, H2, M7, LY1, LY2, LY3, LY4), dry and mesic lowland woodlands (L5, M4), grasslands with woodland origin (E34, E5) and the rich fens and tussock sedge beds (D1, B4).

Regeneration potential on abandoned old-fields (or open water or rock surfaces)

We got the lowest ability of regeneration in this very case. Though having rather low values on the country scale, relatively high was the regeneration potential on abandoned old-fields, vineyards, open water or rock surfaces in case of the following habitat types: dry shrub vegetation (P2b), sand poplar-juniper woodlands (M5), acidophilous coniferous woodlands (N13), halophytic habitats (F1a, F1b, F2, F3), some aquatic habitats (A3a, A5) and marshes (B1a, B6). The majority of habitats regenerates rather poorly. Never or scarcely regenerate: some fen, sedge or bog vegetation types (D1, C23, J1b, C1, B4, J2), steppe oak woodlands (M2, M3, M4), mesic lowland woodlands (J6, L5), some rock habitats (H1, M1, M7, LY1, LY2, LY3, LY4), acidophilous woodlands (K7a, K7b, L4a, L4b), zonal woodlands (L2a, L2b, L1, K5) and calcareous Scots pine woodlands (N2).

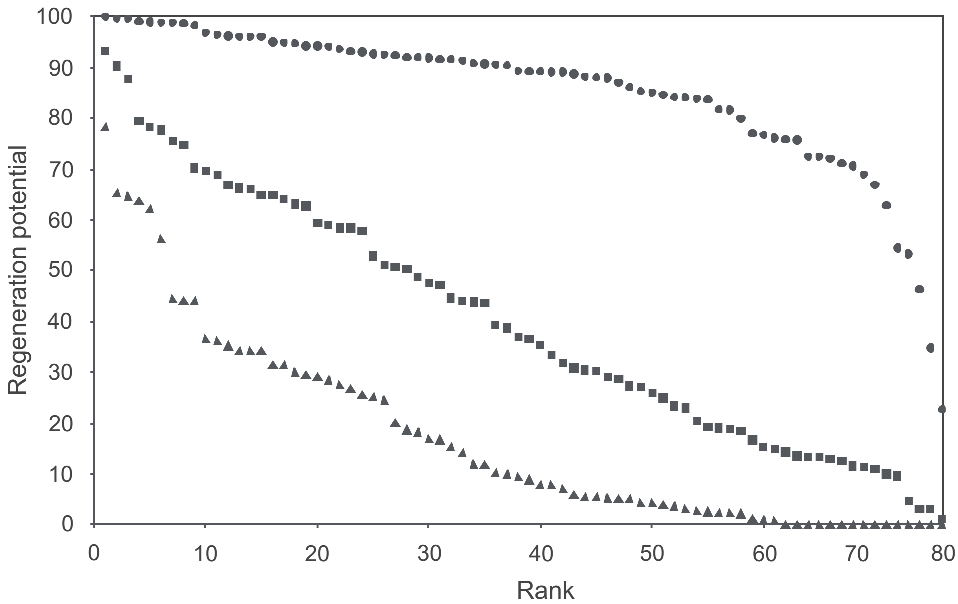

Fig. 1. National averages of the regeneration potential values of habitat types, sorted in a descending order (rank-regeneration potential curves). Top: regeneration on spot, middle: regeneration on the place of neighbours, bottom: regeneration on old-field, open water, bare rocks

Comparing the different kinds of regeneration potential

If we compare the regeneration potentials on spot, on the place of the neighbours and on old-fields, a remarkable tendency is that the number of habitat types with low regeneration potential increases from the first towards the third kind of regeneration value. Some edaphic vegetation types spread easily (e.g. halophytic habitats, marshes, some fens and sedges), others only to a restricted extent (rock habitats, the other part of the fen vegetation). Some habitats have good regeneration ability on spot, but never spread onto other areas; these are, e.g. the rock habitats (LY1, LY2, LY3, LY4, H1, M7), acidophilous woodlands (L4a, L4b, L7a, L7b), grasslands with woodland origin (E34, E5). Other habitat types regenerate as easily on spot as on the place of the neighbours, for instance, some forest steppe woodlands, the shrub vegetation on their own clearings (M3, M5, M6), and some habitats of secondary origin (F1b, P2a, P2b). Some of the rock habitats (e.g. LY2, M1, H2), some fen, swamp (B4, J2, A4) and riverine habitats (J5, J6) and closed woodlands (L1, K2, K5, L2a, L2b, K1a) regenerate well on spot, but almost never on old-fields. There are certain habitats that regenerate well on the place of the adjacent vegetation patch, but poorly on old-fields: some woodland types (M1, M2, J2, J5, J6, L1, K5, K7b), shrub vegetation (M6, J1a) and some fens and sedges (B4, A4, D5).

DISCUSSION

The results show that almost each habitat type has high potential for the regeneration on spot. This can be explained by the fact that human land use of the past thousands of years lead to the disappearance of those habitats (or varieties of them) that could not regenerate themselves (e.g., surely some kind of forest steppe woodlands on loess and halophytic sites, the vast steppe shrub vegetation or some types of fens). Only those habitats survived by today, that has at least moderate potential for regeneration, at least on a medium time scale (scale of centuries) (see Sümegi *et al.* 1998, Molnár 2007).

Regeneration potential on old-fields turned out to be surprisingly low. According to the results, considerable future regeneration can only be expected in landscape of high species richness (e.g. mountains, some lowland fen regions), edaphic areas (old-fields with high level of inland water, saline areas, sand dunes) and some grazed or mown habitats (e.g. fens, floodplains). Values decreasing sharply with the habitat types indicate that the regeneration ability on old-fields is determined by few factors. Surveys, conducted hitherto, seem to support this idea. The increase of the distance causes a serious decrease in the number of colonising species (Peterken and Game 1984, Dzwonko 1993). Distance, as an implicit factor, explains those cases, when there is no suitable site for the species to colonise the old-fields (in case of rock or fen habitats). We have to notice that old-fields are not only the possible areas of natural regeneration processes, but they can also turn into serious accumulation and propagation sites of invasive species. Thus, detailed surveys on the vegetation dynamics of the old-fields are of considerable importance.

Regeneration on the place of the neighbours is probably determined by several different factors. It may depend on the inner stability of the habitat, the abundance of invasive species, the mobility of the species, the fine scale structure and the environmental conditions (pollution, land use) of the landscape, the grazing animals (paths of their movement, the frequency of grazing); so the processes are too complex to interpret. The actual low mobility of the species warns us that local degradation and climatic change would generally result in species loss and homogenisation of the vegetation. These processes may be restrained if climatic change affects more "healthy" stands that has higher potential for regeneration, or if we can support the mobility of the species, e.g. by the development of ecological networks, or extensive grazing on wider areas (Poschlod and WallisDeVries 2002).

It is a general conclusion that all habitat regenerates more easily on the place of the neighbour than on old-fields. We have found two exceptions. One of them is the acidophilous mixed coniferous woodlands that need acid soils, that was previously provided by local, special, traditional rotation of tillage, grazing and forest (Tímár 2002). The other exception is the Nanocyperion vegetation, because its species are of low competitive ability.

In Germany, regeneration of 54% of plant communities is difficult or impossible and only 21% of them has higher regeneration potential (the process of regeneration cannot be interpreted in case of 25% of them) (Riecken *et al.* 2006). The situation is slightly better in Hungary: *ca* 40% of the (semi-)natural habitats can partially regenerate, and about 60% of them cannot regenerate or only to a limited extent. In Germany the highest is the regeneration potential of the edaphic, extensively used landscapes (Alps and the seashore). Similarly, the highest is the regeneration potential of the halophytic, aquatic and rock habitats in our country. Riecken turns the attention to the fact, that the habitats being actually in the state of regeneration, i.e. the extension of which is increasing (*ca* 9% of the German communities), are either non-valuable (e.g. secondary shrub) vegetation, or a transitional state established as a result of the degradation of valuable plant communities (e.g. a fen degraded to a mesotrophic meadow) or species poor grasslands regenerating on old-fields. Consequently, simultaneously with regeneration the landscape itself becomes homogenised. The same tendency can be observed in Hungary too: regenerating habitats with the largest extension are secondary species poor shrub habitats, having established on abandoned pastures and hay fields (P2a, P2b), mesotrophic meadows (D34) with continuously decreasing groundwater level and low species number (having formed on the place of dried out aquatic habitats) or *Achillea* short grass secondary steppes (F1b) established on the place of leached halophytic habitats.

When evaluating the results, we have to bear the general features and the spatial heterogeneity of the data quality in mind. According to our experience, in case of some habitats considerable deviation is caused by (1) the low number of occurrences (A4, J1b), (2) the dominance of a single or a few mappers in the assessment of the vegetation type (N13), (3) problems with the assessment (e.g. woodlands), and sometimes (4) wrong data. The quality assurance of the MÉTA program proved that the quality of the data is appropriate for evaluations on the country scale even in the present state of the database. However, analyses at a finer spatial scale require further methodological developments and more field work based case studies.

FUTURE PROSPECTS

Assessment of regeneration potential means a similar problem of today as the static "goodness" of nature conservational value was at the beginning of the 1980s. The categories of naturalness-based habitat quality was prepared then by Németh and Seregélyes (1989), and it was tested in the following two decades in many landscapes. Subsequently it was corrected, elaborated in details, and today it is regarded as an established standard (Bölöni *et al.* 2003, 2007), though its categories and the algorithm of the classification have never been tested in quantitative surveys. The classification system of dynamical naturalness (i.e. regeneration potential) was developed in the past few years during the MÉTA program, based on Tibor Seregélyes' idea.

Experience gained during the MÉTA mapping – as we hope – may give an impulse to future studies on the regeneration potential. For some vegetation types it is important to examine the time required for the moderate and total regeneration in different landscapes, and how the state of the stand itself and the condition of the neighbouring landscape affect the regeneration process. Surveys on the succession of old-fields were already conducted (and are being conducted actually) in Hungary, with the direct or indirect purpose of the study of regeneration ability (e.g. Bartha *et al.* 1991, Hochstrasser 1995, Molnár and Botta-Dukát 1998, Margóczi 1998, Házi 1998, Csecserits and Rédei 2001, Matus *et al.* 2003, Ruprecht 2006, Margóczi *et al.* 2007, Ónodi *et al.* 2008, Bartha *et al.* 2008, Hudák unpubl., Purger unpubl.). Moreover, monitoring, that has become a regular task by now, and the long-term ecological surveys may open new perspectives, too. Nevertheless, getting reliable results will be impeded in the future by the fact, that the predictions of vegetation dynamics will be hindered by the actual and presumably accelerating climatic changes and the alterations of the land use.

However, on the grounds of the MÉTA database, it is worth to analyse the differing regeneration ability of the major landscapes of Hungary, and the dependence of regeneration potential upon, e.g. the naturalness of the landscape, the soil quality of the plough lands (in the sense of agriculture), the elevation above sea level and the development state of the settlements. The results would provide useful conceptual information for both the national and regional strategies of nature conservation and rural development.

If we look for the vegetation types with the highest vegetation-based natural capital value (total extension in the country multiplied by the mean naturalness) (Czúcz *et al.* 2008), we find that the highest values belong to the beech, oak-hornbeam and Turkey oak woodlands, mesotrophic meadows, reed beds and halophytic meadows. This means that the future of the Hungarian landscape (e.g. ecosystem services) depends on these particular vegetation types. Among these habitats, woodlands does not regenerate on new areas, but they regenerate well on spot, the others have high potential for regeneration both on spot and on new areas. This means that we have the possibility to do much for the future of our landscapes (i.e. we have to protect our woodlands in their actual area; in case of the other vegetation types the actual area should be protected on one hand, and their potentially new habitats should also be protected, on the other).

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APPENDIX
Regeneration potential of the *Artemisia* salt steppes (code: F1a) (Example from the Habitat guide, Bölöni *et al.* 2003, this section was written by Zs. Molnár)

This type of habitat usually regenerates easily. Basically, regeneration depends on the existence of the dominant and characteristic halophytic species in the neighbouring area rather than directly on the species richness. Most character species may survive even in degraded stands. The potential of rare species to regenerate or colonise is unknown, but rather higher than low. In habitats with non-leached soil, the competitive ability of non-halophytes, invasive species and shrubs is poor. The halophytic disturbance tolerant species are suppressed by the dominant species. We have no information on the inherent dynamics of the stands, and on the role vegetation pattern or physiognomy plays in regeneration. The regeneration of the *Artemisia* salt steppe is principally limited by low salt concentration. In this case, loess-steppe-like dry grasslands (usually *Achillea* salt steppe) regenerates. The significance of landscape context lies merely in that it determines the propagule sources. Though, we have no data on the seed bank of the soil, it may have importance in the re-colonisation of certain species (annual *Trifolium* spp.). We do not know the effects of grazing on regeneration. Burning does not destroy the habitat considerably. Following disking, ploughing, abandonment from rice-cultivation, mechanical damage of the soil (e.g. trampling) this vegetation type regenerates relatively well.

Regeneration potential (dynamic naturalness) on spot

Good: All (semi-)natural (non-degraded) stands. Sometimes even the more degraded ones, if they are more expanded (min. 10 ha) and the landscape is natural i.e. it is a mosaic of different vegetation types; properly regenerate even after overgrazing.

Mean: Degraded and smaller (only few ha) stands.

Poor: There is no such *Artemisia* stand but for the ones desalinised due to leaching (since they do not regenerate as *Artemisia* but "degrade" into *Achillea* steppes).

Regeneration potential (dynamic naturalness) on neighbouring vegetation patches

Good: In case of leaching it invades the pioneer vegetation of the open alkali soil surface (*Camphorosmetum*), sometimes even the *Puccinellia* swards, in case of desiccation in some years it may invade even the neighbouring salt meadows.

Mean: If the extent of leaching and drying is lower: its invasion into the pioneer salt vegetation (because of the salt concentration) and into the salt meadows (because of the spring inland waters) is restricted.

Poor: In case of natural salinity and water-content of the soil this vegetation type cannot "move" in the landscape, because vegetation mosaic is very stable.

Regeneration potential (dynamic naturalness) on neighbouring arable field

Good: If the soil of the arable fields is properly salinised (often only the edges of the fields are of this kind, because in the middle, higher parts chernozem soil is typical).

Mean: If the soil of the arable field is poorly salinised, since a non-halophytic dry grassland has the possibility to develop there.

Poor: There is no such situation.