# A NEW HABITAT CLASSIFICATION AND MANUAL FOR STANDARDIZED HABITAT MAPPING

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Abstract - Today the documentation of natural heritage with scientific methods but for conservation practice – like mapping of actual vegetation – becomes more and more important. For this purpose mapping guides containing only the names and descriptions of vegetation types are not sufficient. Instead, new, mapping-oriented vegetation classification systems and handbooks are needed.

There are different standardised systems fitted to the characteristics of a region already published and used successfully for surveying large territories. However, detailed documentation of the aims and steps of their elaboration is still missing.

Here we present a habitat-classification method developed specifically for mapping and the steps of its development. Habitat categories and descriptions reflect site conditions, physiognomy and species composition as well. However, for species composition much lower role was given deliberately than in the phytosociological systems. Recognition and mapping of vegetation types in the field is highly supported by a definition, list of subtypes and list of 'types not belonging to this habitat category'. Our system is two-dimensional: the first dimension is habitat type, the other is naturalness based habitat quality. The development of the system was conducted in two steps, over 200 mappers already tested it over 7000 field days in different projects.

Key words - habitat identification, landscape evaluation, large-scale mapping, naturalness-based habitat quality, nature conservation

## Introduction

Due to the intense technical development of the last centuries as well as due to the expansion of civilisation, the number and extent of natural and semi-natural areas decreased dramatically (MEA, 2005). In this situation, it is getting more and more obvious that the maintenance of habitats and communities in natural or close to natural state is a key factor for the balance of biosphere, thus for the maintenance of adequate quality of human life and, moreover, even for the subsistence of human being (MEA, 2005).

For the preservation of communities and habitats, the first step is the documentation of where and in what quality natural territories remained. This can be reached for example by regional scale surveys of actual vegetation. Although, the task is even bigger: a mere list of natural vegetation types is no longer enough, but the natural vegetation heritage must be surveyed with a complex - landscape ecological and conservational approach (Molnár *et al.*, 2007). Recently, in a project, Hungarian vegetation scientists conducted a multi-attributed vegetation survey of Hungary, nature-conservation and landscape-ecology based documentation of the present state of the vegetation of the country, called MÉTA (Bartha *et al.*, 2002; Molnár *et al.*, 2007). For the relatively quick, but detailed survey a new vegetation classification system had to be developed, which is suitable for the survey of actual vegetation (including degraded and secondary types as well) in a single field visit and, is accurate enough to ensure the standardisation of the recognition and the documentation as well.

In Europe, vegetation classification and description of the vegetation types was conducted purely for scientific purpose till the 1990-ies (see Braun-Blanquet, 1951; Borhidi *et al.*, 1999; Dierschke, 1994; Mucina *et al.*, 1993; Rodwell, 1991-2000; Soó, 1964-1980; Whittaker, 1980). Later monographs suitable also for conservation purposes appeared (Barr *et al.*, 1993; Pott, 1996; Borhidi & Sánta, 1999), and new vegetation classification systems especially for conservation purposes were developed (like Palearctic Habitat Classification, later EUNISHAB, recently Natura2000). Recently, several vegetation classifications and manuals/handbooks specifically for supporting inventories, surveys and mappings were published (Chytrỳ, 2001; Guth & Kučera, 2005; Fekete *et al.*, 1997; Fremstad, 1997; Kaligaric *et al.*, 2003; Rodwell *et al.*, 2002; Ruzickova *et al.*, 1996; Stanova & Valachovič, 2002). These new-line handbooks and manuals were compiled exactly for the survey of large territories or countries by a multitude of mappers. Compared to the previous vegetation syntheses, in these volumes higher emphasis was given for the recognition, survey and mapping of habitats in the field as well as for a complete coverage of habitats occurring in the landscape (urban, degraded and secondary parts as well).

Nevertheless, we think that publications dealing with the documentation of the aims of the projects and the manual and steps of the development of these new habitat lists are still missing, however, for the utilisation of the results of science in the conservation practise it is highly needed. Thus, in this paper we present the steps of development, the structure and contents of the Habitat Classification System and the Habitat Guide developed for the habitat mapping project of Hungary (MÉTA). Although it has been developed for the MÉTA project, this habitat classification system and manual is a highly suitable tool in any kind of mapping, survey, conservation evaluation of the Hungarian habitats.

## *What are the characteristics of a habitat classification suitable for mapping of large areas?*

In one hand, we are aware of the fact that the classification and the description of the variation of habitats realized in the nature can never be perfect (Whittaker 1980). On the other hand, we, as vegetation scientists, have to make efforts to do it so, even with many compromise. Characteristics of a habitat classification and a habitat guide suitable for an up-to date survey of actual vegetation are as follows:

- The categories have to cover all (semi-)natural vegetation types (without overlapping and gaps), thus the system has to be unambiguously interpretable for the whole territory;
- The system must be relatively simple, with not too many categories (80-120);
- The system should be suitable for several different purposes, so it should contain not only the phytosociological descriptions of the particular vegetation types but it should give information on several other attributes of vegetation (landscape-ecological, dynamical) and it should be conservation-minded;
- It should be built upon the previous knowledge of the mappers and classical vegetation classification systems, and, at the same time it should not require accurate knowledge of 'all' plant species (hence many people can use it with good reliability, not only experts in botany);
- It should be well-documented, the description of categories should be detailed and unambiguous;
- It should be an easy-to-teach, easy-to-learn system, since many mappers are expected to use it;
- The system should be tested thoroughly.

*WHAT KINDS OF SYSTEMS WERE AVAILABLE?*

Hungarian and Central-European vegetation and habitat classification – as a field of science – possess huge amount of knowledge and experience (Borhidi *et al.*, 1999; Fekete, 1980, Küchler & Zonneveld, 1988; Mucina *et al.*, 1993; Rodwell, 1991-2000; Soó, 1964-1980; Whittaker, 1980; Zólyomi, 1989). In the following paragraphs we present those works we built on during the development of the habitat classification system and the structure and contents of the habitat descriptions. None of the these systems were entirely suitable for the quick but detailed field-survey and documentation of actual vegetation data from a large area, although each of them contained approaches or parts which were built in the habitat classification system developed especially for the MÉTA project.

*The phytosociological approach*

In Hungary, as well as all over Central Europe, the phytosociological approach of the Zürich-Montpellier school has been the leading direction in vegetation science for a very long time (Dierschke, 1994; Schamineé *et al.*, 1995, 1996, 1998; Stortelder, 1999, Whittaker, 1980). One of the main concepts of the school is that in the vegetation it is possible to recognise assemblages of plant populations (*nodum*), which are repeated regularly in space and time (predictable mainly by site conditions and site history). In the identification and description of *noda*, the role of the floristic composition is primary (Braun-Blanquet, 1951). However, several kinds of problem occur when a phytosociological system is used for a complex survey of the natural vegetation (Bagi, 1997, 1998). In the following arguments we focus mainly on the situation in Hungary, since we had to develop our system for this region.

1. The phytosociological system does not describe the actual vegetation well, since:

- field sampling and partly the analysis are preferential, thus not complete;
- there are many vegetation types which can be only loosely characterised by merely the species composition (like considerably different dynamics or biomass with the same species composition, e.g. dry and wet *Puccinellia limosa* dominated alkali vegetation);
- in Hungary relatively few people developed the system and mainly by iterative complementation, in some cases with vegetation knowledge of only particular regions of the country, so it simply does not contain the vegetation of every region and landscape types;
- degraded sites are not covered by the Hungarian phytosociological systems or they are amalgamated to the natural units.

For all of these reasons it is even theoretically not possible to compile a system from phytosociological categories suitable for a vegetation survey at country scale.

2. It is hard to survey and map with the phytosociological categories, especially large, several 10 000 km2 wide territories, since:

- there are many problems with the documentation of vegetation transitions and non-typical coenostates (Bagi, 1997, 1998);
- sites with uncharacteristic vegetation are hard to document with phytosociological methods (e.g. stands characterised by a single species: *Alopecurus pratensis* dominated patches on alkali soils, on floodplains or even under drier site conditions);
- it is difficult to use this approach for mapping on a coarser scale than 1: 10 000, mainly because the categories are too fine.

3. Teaching the system is hard and slow, since besides the above mentioned points:

- there are too many categories, there are too many plant species that should be recognised in the field, and '*locus classicus*' sites are recommended to know a priori;
- there are no elaborated syntheses and guides especially for recognising the categories in the field;
- the number of well-skilled 'masters' in phytosociology is very low in Hungary.

Thus reaching the acceptable level of standardisation would have required so much time and experience which we simply did not have.

4. The world is changing and besides the floristic composition other aspects has become important, such as nature conservation value, dynamic status, land use characteristics and landscape ecological relations. The Zürich-Montpellier phytosociological school does not or only occasionally does take into account the direct and indirect human impacts, although the land use in the long run may result in characteristic vegetation patterns often considered as 'natural associations' (cf. Pott, 1981) by the school. This approach only superficially deals with the vegetation dynamics and succession, or the stages are dealt separately since phytosociology studies equilibrium states or states considered to be in equilibrium (Bartha, 2000). To sum it up, the dynamical and historical aspects or other ones related to these defining the development, appearance, and composition of present vegetation are nearly entirely out of the interest of the school (Mucina, 1997). The phytosociological classification is simply not developed for what we needed now. It is likely that only with a decade of deliberate improvement would it become suitable for our purposes. Nevertheless, it was feasible to adopt directly or indirectly many elements of the phytosociological system in our new system, especially in case of natural habitat types.

*European habitat classification systems: Paleartic Classification, CORINE Biotopes, EUNIS-Hab, Habitat Directive*

These systems are composed of phytocosiology-based habitat types. These habitat types are mostly distinguished by their floristical and geographical characteristics. The list of natural habitats is completed with many degraded and man-made habitat types, thus these systems can describe the actual landscape better than the phytosociological ones. These systems were supplemented step by step to the direction of Eastern Europe (due to the enlargement of EU), thus they contain many bias, which could not be solved even if there have been already several attempts for refinement. Several semi-natural habitat types which were planned to be documented by the MÉTA project are still missing from these systems (for example dry shrublands dominated by *Crataegus monogyna* and *Prunus spinosa*). In addition, the description of the habitat types is usually too short and heterogeneous to be used well in the MÉTA project. The systems are not tested, the categories are often ambiguous, thus the interpretation and teaching of these systems are difficult and we could not use them for our purposes as they were. Nevertheless, we draw several ideas from these systems (like semi-natural types among the natural ones in the list) and we aimed at reaching at least partial compatibility with the MÉTA system.

*Categories of topographical maps, CORINE Land Cover and physiognomy-based vegetation classifications*

With the categories of these systems it is possible to describe the whole present landscape, these are well-documented, simple, easy-to-teach systems, but for vegetation mapping their thematic resolution is too coarse. CORINE Land Cover maps (Anonymus, 1995) for example document the vegetation in patches of physiognomical units (closed forest, forest-grassland mosaic, open grassland, etc.) and they nearly totally ignore the floristic composition. With this approach it is possible to create habitat maps very quickly and cheap for large territories (countries, continents) with rather rough categories, but their suitability for the evaluation and documentation of the actual state of the vegetation is very limited (Büttner *et al.*, 1995, 2000, 2002). Since mapping with physiological categories has no traditions in Hungary (cf. Whittaker, 1980; Bagi, 1998) and the resolution of the categories of the land cover maps is much coarser than desired, for the MÉTA project we needed a more complex, more detailed vegetation classification. However, from the manual of the CORINE Land Cover project we adopted the idea of helping the correct identification of the types that are not belonging to a particular category, but are very similar to that.

*Forest site types*

In the forest site type approach in Hungary (Danszky & Rott, 1964; Majer, 1968) floristic composition plays an important role, as well as the composition of the canopy layer and the understorey layer by indicating the site conditions (water regime, pH and deepness of the soil). The definitions and descriptions of the forest habitat types in the MÉTA system were very much based on the Hungarian forest site types, as these are vegetation classifications, similarly to the MÉTA project, that take into account the needs of practice as well. Nevertheless we could not adopt them as they were since they do not describe the non-woody vegetation and they contain too many forest site types to be used feasibly for the survey of large areas. In addition, in the description of the forest site types more emphases is given to the floristic composition, and other aspects, such as physiognomy and vegetation dynamics are subordinated.

## Development of the categories and the manual

The solution tested and used by us was the expedient, consistent and new resynthesis of existing field experience of many vegetation scientists. For this we had suitable basis since there was an already developed habitat classification system in Hungary which we could use. This is the Á-NÉR1997 habitat classification system and manual ('Általános Nemzeti Élőhelyosztályozási Rendszer' – 'General National Habitat Classification System'), which is a practice oriented system developed in the framework of 'Hungarian National Biodiversity Monitoring Program' ('Magyar Nemzeti Biodiverzitás-Monitorozó Program', from 1997 onwards), especially for the survey and monitoring of habitats (Fekete *et al.*, 1997; Kun & Molnár, 1999).

This system and manual is still in use and already ca. 300 habitat maps have been created using it. This was the first book in Hungary aiming to develop a complete habitat list and detailed descriptions. The basis of this system are the units of the Hungarian phytosociological system (Borhidi *et al.*, 1999) and the '100 habitat list' of Németh and Seregélyes (1989), which was a first attempt to summarise the over 300 phytosociological categories into a shorter list of habitat types. Part of the categories (for example natural vegetation) were created by the amalgamation of some associations, since the developers used the classical phytosociological system as a reference since it was the only system tested and used at country scale. (Forest site type approach did not influence the development of the system that time.)

At the same time, the Á-NÉR system – since its aim was to categorise all of the habitat types throughout the country – brought several innovations. It introduced categories that describe semi-natural and man-made vegetation (mostly from the

CORINE Biotopes) which were only sporadically included formerly in the Hungarian vegetation and habitat classifications. Due to the aim of the development of the system – to be suitable for practice as well – historical aspects, dynamics, physiognomy and human influence were emphasised.

The categories of the Á-NÉR1997 system are called habitats, which reflect their essential role in the forming of the landscape and the human perception of landscape elements. The system was developed by a team of experts (ca. 20 persons), thus it reflects the views of an elite expert team. There are 1-2 page descriptions for each habitat category with the following chapters: code, definition, codes of the habitat type in other systems, site conditions, vegetation characteristics, sub-types, utilisation and conservation management, and related literature. The testing of the classification and habitat descriptions were left for the future.

In principle, the Á-NÉR1997 would have been suitable for the MÉTA project, but:

- during the field work with this system – several thousand days of survey and mapping – many problems, deficiencies, bias and misunderstandings were found (during mapping for the National Monitoring Program it was compulsory to present the problems occurring during the mapping in writing);
- the system was not standardised enough, since the easy-to-teach characteristics of vegetation (for example physiognomy and site conditions) were not prevailed;
- since it has been developed in the frames of an other project, it did not contain those conservational and landscape ecological aspects of vegetation that were aimed to be documented by the MÉTA project.

For all of these listed reasons we decided to revise this system. Our new, supplemented version is called Á-NÉR2003.

*The categories of Á-NÉR2003*

According to the aims and the preliminaries – integrating all knowledge and experience – a new, considerably re-shaped, reconsidered classification and manual had to be developed (Molnár, 2003; Bölöni *et al*., 2003). We could build upon huge amount of experience during the development of the Á-NÉR2003 system. Furthermore, this paper has been written after a next testing of more than 7000 days of fieldwork.

In the Á-NÉR2003 system the habitat is the basic unit as well. The system contains all the natural and semi-natural habitats of Hungary, we used general grouping categories for the highly degraded habitats (for the list of habitats see App. 1). Due to the smaller number of categories (86 compared to over 300 in the phytosociological system), the categories are wider and are more different from each other than in the classical phytosociological system. The classification has only one hierarchy level, and it is two-dimensional: the first dimension is the vegetation type and the other one is naturalness based habitat quality. There are descriptions for all naturalness categories in case of all vegetation types in the guide (see App. 2). The classification in the new system is not defined by syntaxonomical categories but by the combination of physiognomy, site conditions and floristic composition. Endeavouring to develop an easy-to-teach system and the smaller number of categories have led together to the weakening of the role of floristic composition, but the dominant and characteristic species still play an important role in the identification of the habitats. Since for the MÉTA project we did not need to classify all the secondary and agricultural vegetation types – the aim of this project was to survey the natural vegetation heritage of the country – we only included these lately, calling this updated version Á-NÉR2007.

Site history exceptionally can have primary role in the identification of the habitat (for example in the case of abandoned and still used wooded pastures). Plant associations were assigned to habitat categories *a posteriori*. Due to better standardisation, we limited phytogeography-based habitat classification. The main reason for this decision is that drawing the border between these habitat pairs on the field is rather ambiguous (e.g. between Pannonicum and Illyricum). In addition, there are two other projects running parallel with the MÉTA project, namely the floristic mapping of Hungary (Bartha *et al*., 2002) and the phytosociological database building (Lájer *et al*., 2007), both of which can serve better for drawing these orographical and regional border lines *a posteriori*, and thus the particular habitat can be subdivided easily to subtypes later.

In the Á-NÉR2003 system we included many secondary or semi-natural agricultural and forest habitats. We introduced categories which were not based on phytosociological logic, such as degraded non-woody and woody habitats (e.g. 'Uncharacteristic hardwood woodlands and plantations [RC]', 'Uncharacteristic meadows and tall herb communities [OB]'), stands affected by invasive alien species (e.g. 'Uncharacteristic woodlands and plantation mixed with non-native tree species [RD]'). In other cases unique landscape elements possess a separate category, like solitary trees ('Scattered native trees or narrow tree lines [RA]').

It can be stated that all of the aspects and elements which were used by us are present in one or more of the previously developed systems. For example there have been manuals published in which there are hints and advises especially to help mapping in the field (for example Ruzickova *et al*., 1996; Chytrý *et al*., 2001; Stanova & Valachovic, 2002), however we emphasise these more in the Hungarian system. Sub-types documenting the different states with different conservation values for all of the habitat types comprehensively were the first time included in a manual. Several other vegetation characteristics (for example regeneration potential) were documented and described in this new system for the first time.

*The manual*

As a manual of the habitat classification system we developed a survey-oriented, well-structured and detailed documentation (Bölöni *et al*., 2003). During the development of the system, we tried to synthetise the knowledge of many people: categories and descriptions were consulted by many experts in several rounds and many field botanists added their comments and critique to the system. The iterated supplementation, the several rounds of discussion not only served the standardisation but the collection and integration of local and personal vegetation knowledge. Thus finally the manual has more than 25 authors and more than 100 reviewers, which means that it comprises the 'knowledge' of several actual vegetation maps and unique vegetation types in unique situations. The resulting manual was again tested (in 34 landscape types by 160 persons) for two month right before we started the documentation of the vegetation heritage, the MÉTA project itself.

In the description of the habitat types we used these special rules:

A) In case of euhydrophyte habitats we took into consideration the water flow conditions;

B) In case of forest habitats we took into consideration the tree species composition, the stand structure, the composition of the understorey layer and the site conditions as primary factors;

C) In case of grassland habitats, the main characteristics and identification factors were the bedrock and the soil characteristics, presence and proportions of characteristic and dominant species.

In the detailed description of the habitats we listed the (a) definition, (b) site conditions, (c) physiognomy, (d) characteristic species, (e) vegetation and landscape context, (f) sub-types, (g) types not belonging to the type. These are supplemented - according to the aims of the MÉTA project – by the (h) naturalness categories and (i) regeneration potential for every habitat types (for an example habitat description see App. 3).

a) Definition is a few-sentence long description containing the main characteristics of the habitat and the minimum area above which the habitat patch should be documented in the MÉTA project. We note here that the definition is missing from every European habitat classification systems we are aware of; although, in our opinion it helps considerably the identification of the habitat types.

b) Site conditions describe the main abiotic factors (climate, bedrock, main soil characteristics, topography, elevation, main environmental processes) and range within Hungary.

c) Physiognomy tells the general appearance and the structure (including horizontal structure, height, cover) of the habitat type and their variation.

d) In the chapter 'characteristic species', the plant species important for the identification of the habitat type, dominants and characteristic subordinates or indicator species are listed.

e) In the chapter 'vegetation and landscape context' we list the habitat types or landscape elements that the habitat type usually is in close proximity to or forms a complex with.

f) In the chapter 'subtypes', the general aim was to name as many relevant vegetation types of Hungary as possible and to describe them shortly. We attempted to give a multi-aspect classification of these, especially for making identification of the habitat type easier and more accurate. In the description of subtypes, the consequent classification of the subtypes for all of the habitat types was not necessary and thus overlapping between the subtypes of different habitat types was permitted. In case of natural habitats, we always listed the phytosociological associations belonging to the particular habitat types, if it was possible. We could not do it for semi-natural habitats, since they were assigned to associations only occasionally. There are some cases when an association belongs to more than one habitat type (for example the closed *Aceri tatarici-Querce-*

*tum roboris* belongs to 'Closed and mixed steppe oak woodlands on foothills [L2x]', while the open stands of it belong to 'Open loess steppe oak woodlands with openings [M2]'). Thus, the boundary between the habitats is not necessarily the same as between the associations.The descriptions of subtypes are short if the vegetation type is well documented in the Hungarian literature. It is valid mainly for subtypes that considerably overlap with syntaxonomical categories (Borhidi & Sánta, 1999; Borhidi, 2003) and Á-NÉR1997 (Fekete *et al*., 1997). For subtypes different from these other systems, we attempted to give more detailed and expressive descriptions.

g) Among the 'types not belonging here' we listed the most frequent mismatches and gave the correct habitat type. This chapter gained higher importance because here the separation of the habitats can be specified by examples, which supplements the definitions well.

h) Naturalness, a habitat-specific attribute, was documented on the widely used, tested and well-accepted five grade scale (1-5, 5 means: the best possible state, 1 means: no (semi-)natural vegetation present) of Németh and Seregélyes (1989). For each habitat type we described shortly all naturalness categories, thus providing briefly the main characteristics of the structure, floristic composition, and site conditions of the habitat in the particular category. We used many examples, like if there is no water in a reed bed, it cannot reach higher naturalness category than 3; or a forest cannot be in the highest naturalness category if there are no old trees and high amount of deadwood; a stand severely affected by invasive alien species cannot reach higher naturalness category than 3. Although naturalness categories defined this way always comprise synthetic data which are loaded by high subjectivity, our list of examples is thorough, knowledge and experience of all mappers were collected and documented, and we paid much attention to bring the mappers to common ground. The question of naturalness is a typical situation of expert judgement, which occurs though much more often than expected even in tasks considered to be the most objective, for example when we choose the similarity index subjectively in a multivariate study. According to our experience so far, by this published list of examples the estimation of this vegetation characteristic became considerably more standardised.

i) We made an attempt to introduce a new concept to Hungarian vegetation science and landscape ecology, namely the regeneration potential of the habitats or rather the documentation and survey of this characteristic, as a habitat-specific attribute. The intention for doing this lied in our experience that by visiting several landscapes repeatedly it revealed that some vegetation types regenerate faster, others slower and there are ones that do not regenerate at all after a stronger disturbance (oversowing or ploughing). There are differences in the ways and speeds of regeneration among regions as well. If there are available propagule sources in the vicinity, often all species can re-colonise. The regeneration of habitats in a highly stressed environment or with low nutrient content, for instance, is more successful than in others, since there the establishment of invasive alien species is limited.

In the Á-NÉR2003 system we developed three kinds of regeneration potential: (1) at the same place in the same stand, (2) in the adjacent vegetation type (in case of a vegetation transformation), and (3) on the adjacent abandoned field (on disturbed, bare soil, or on bare rock). We compiled a list of examples for each habitat type, where we gave the supposed degree of regeneration (good, medium, bad) taking into consideration the species composition, the landscape context and the threatening factors.

## *Limitations of the Á-NÉR2003 System*

We succeeded to reach the main goals of the project: covering the whole country, not too many but not too broad categories, easy-to-teach system. Having tested the system in the MÉTA project, we realised however, that there are some problems with the habitat descriptions. These are of two main types: 1) in some cases, the authors of some habitat descriptions did not keep rules on the contents and structure, or simply there was not enough knowledge on the habitat type to create a good description; 2) the standardisation is still not perfect, the understanding and suitability of some descriptions are heterogeneous from region to region.

After checking the half of the filled in datasheets of the MÉTA project, some conclusion can be drawn on to what extent we succeeded to write habitat descriptions suitable for the purposes of the project:

1. There are habitat types that were easy to write a description for; these were identified well by the mappers, the habitat type is well standardised (e.g. '*Artemisia* salt steppes [F1a]', 'Beech woodlands [K5]').
2. There are some habitats hard to typify and identify, where the description helped the mappers in the fieldwork considerably, and thus the survey of the habitat is good or became much better than it was previously (e.g. 'Lowland oak-hornbeam woodlands [K1a]', 'Oak-hornbeam woodlands [K2]').
3. There are some habitats that were considered to be easy to recognise, although the survey gave heterogeneous results. So, it was revealed that the description and standardisation was not good enough (e.g. 'Riverine oak-elm-ash woodlands [J6]', 'Closed sand steppes [H5b]').
4. There were habitats hard to identify and the descriptions were probably not good enough as mappers understood the category heterogeneously (Mainly oak woodlands in the hilly regions, e.g. 'Turkey oak - sessile oak woodlands [L2a]').
5. We faced the problem that the same vegetation patch can be assigned to more than one habitat type (like a dried out, steppe-like *Molinia* meadow can belong to '*Molinia* meadows [D2]', 'Closed sand steppes [H5b]' and 'Mesotrophic meadows [D34]' at the same time; and none of these are incorrect).

Judgement of regeneration potential and naturalness is uneven as well. These synthetic vegetation characteristics should be more refined and standardised in the future as well. Differences appear partly due to the many different authors and partly due to the differences among regions. A small patch of forests of native tree species is rare in the inner part of the Great Hungarian Plain, and thus often higher naturalness is given to the stand compared to the same habitat type on the foothills. The regeneration potentials of these two stands can differ considerably as well. This should not necessarily be considered as a mistake, although, it is a fact and in the case of the analysis of the database and the refinement of the habitat descriptions one should be aware of this fact.

Our habitat classification system is not free from unevenness either. For example, some very similar vegetation types are listed in two different habitats (e.g. continental deciduous rock and steppe thickets are separated to two habitat types [M7 and M6]). In other cases, we united types which have considerable differences from some aspect (e.g. we amalgamated all of the closed, oak dominated forests of the Great Hungarian Plain without respect on the bedrock [L5]). There are two main reasons behind these inconsistencies: first is the general approach of vegetation scientists in Hungary; many colleagues were averted from some of the desired changes, while the second is the gaps in our knowledge on the vegetation types.

Handling of vegetation mosaics is not uniform either. There are habitats which usually do not occur alone, but they form a mosaic pattern or adjacent with others (e.g. 'Thermophilous woodland fringes [M8]).

Nonetheless, we have a unique opportunity that we have a system tested by 200 mappers at the same time in the field in all regions (!) of the country. The widening expert knowledge coming from this process is invaluable for the further development and refining of the system; the final version of which we will publish as a book.

## Conclusions

After 10 years of working on the development and the testing of the system, we think that the development of a good habitat classification system is an iterative process lasting for decades (similar to the already developed phytosociological systems). The new system should be tested by many mappers in many regions.

Observing all these, we conclude that a completely standardised habitat classification is only an idealistic aim which can never be reached. Mere publication of the manual is not enough; experiential learning of the participants together in the field is needed for effective standardisation. Mere habitat description is not enough either; a manual helping explicitly the identification process in the field is needed. It is worth defining the characteristics of the habitat types and the boundaries between them together with definitions and lists of examples.

Because of the heterogeneity of the different regions, a system suitable for all regions can be developed only by knowing all regions, which means that the contribution of many authors and many reviewers are needed.

As a consequence of the diversity of European landscapes, a well-standardised and easy-to-teach habitat classification for whole Europe is a goal to be reached only in several decades. Moreover, it is not possible to develop a good system if the area where the system should be applied is expanding always (e.g. gradual enlargement of the European Union).

In case of large vegetation databases, the collected data will be heterogeneous (Cherill & McClean, 1995, 1999; Smart et al., 2003) even if the manual was specified and standardised, and thus the quality control of the data and the handling of bias and heterogeneity must be an important part of work prior to any analysis.

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## Appendix 1. Habitat categories of the Á-NÉR2007 system

Euhydrophyte habitats: A1 - Standing water communities with *Trapa*, *Lemna*, *Salvinia* and *Ceratophyllum*, A23 - Euhydrophyte communities with *Nymphaea*, *Nuphar*, *Utricularia* and *Stratiotes*, A3a - Slowly running water communities with *Potamogeton* and *Nymphoides*, A4 - Euhydrophyte communities of fens, A5 - Athalassal saline euhydrophyte communities

Marshes: B1a - Eu- and mesotrophic reed and *Typha* beds, B1b - Oligotrophic reed and *Typha* beds of fens, floating fens, B2 - *Glyceria*, *Sparganium* and *Schoenoplectus* beds, B3 - Water-fringing helophyte beds with *Butomus*, *Eleocharis* and *Alisma*, B4 - Tussock sedge communities, B5 - Non-tussock beds of large sedges, B6 - Salt marshes, BA - Mosaic/Zonation of marsh communities of channels, ditches and artificial lakes

Flushes, transition mires and raised bogs: C1 - Soft and hard water flushes, C23 - Transition mires and raised bogs

Rich fens, eu- and mesotrophic meadows and tall herb communities: D1 - Rich fens, D2 - *Molinia* meadows, D34 - Mesotrophic meadows, D5 - Water-fringing and fen tall herb communities, D6 - Tall herb communities of floodplans and marshes

Colline and montane hay meadows, acid grasslands and heaths: E1 - *Arrhenatherum* hay meadows, E2 - *Festuca rubra* hay meadows and related communities, E34 - *Cynosurion* grasslands and *Nardus* swards, E5 - *Calluna* heaths,

Halophytic habitats: F1a - *Artemisia* salt steppes, F1b - *Achillea* salt steppes on meadow solonetz, F2 - Salt meadows, F3 - Tall herb salt meadows and salt meadow steppes, F4 - Dense and tall *Puccinellia* swards, F5 - Annual salt pioneer swards of steppes and lakes

Dry open grasslands: G1 - Open sand steppes, G2 - Calcareous open rock grasslands, G3 - Acid open rock grasslands

Dry and semi-dry closed grasslands: H1 - Closed rock grasslands, species rich *Bromus pannonicus* grasslands, H2 - Calcareous rock steppes, H3a - Slope steppes on stony ground, H4 - *Bromus erectus*-*Brachypodium pinnatum* xero-mesophilous grasslands, dry tall herb communities and forest steppe meadows, H5a - Closed steppes on loess, clay, tuff, H5b - Closed sand steppes

Non-ruderal pioneer habitats: I1 - Amphibious communities on river gravel and sand banks, I2 - Semi-desert vegetation on loess cliffs, I3 – Pioneer grasslands on rocks and walls, I4 - Open vegetation of shadowed rocks

Other non-woody habitats: OA - Uncharacterisic wetlands, OB - Uncharacteristic meadows and tall herb communities, OC - Uncharacteristic dry/semi-dry grasslands and tall herb communities, OG – Trapled and ruderal vegetation on gravel, OD – Stands of invasive forbs, OF – Tall-growing ruderal vegetation

Bush vegetation and woodland margins: J1a - *Salix cinerea* mires, J3 - Riverine willow shrub vegetation P2a - Mesic shrub vegetation, P2b - Dry shrub vegetation with *Crataegus*, *Prunus spinosa* and *Juniperus*, M6 - Continental deciduous steppe thickets, M7 - Continental deciduous rock thickets, M8 - Thermophilous woodland fringes, P2c – Non-native bush vegetation or *Reynoutria* stands

Riverine and swamp woodlands: J1b - Birch mire woodlands, J2 - Alder and ash swamp woodlands, J4 - Riverine willow-poplar woodlands, J5 - Riverine ash-alder woodlands, J6 - Riverine oak-elm-ash woodlands

Mesic deciduous woodlands: K1a - Lowland oak-hornbeam woodlands, K2 - Oak-hornbeam woodlands, K5 - Beech woodlands, K7a - Acid beech woodlands, K7b - Acid oak-hornbeam woodlands

Dry deciduous woodlands: L1 - Closed termophilous oak woodlands, M1 - White oak scrub woodlands, L2a - Turkey oak - sessile oak woodlands, L2b - Turkey oak - pedunculate oak woodlands, L2x - Closed and mixed steppe oak woodlands on foothills, L4a - Closed acid oak woodlands, L4b - Open acid oak woodlands, L5 - Closed lowland steppe oak woodlands, M2 - Open loess steppe oak woodlands with openings, M3 - Open salt steppe oak woodlands with openings, M4 - Open sand steppe oak woodlands with openings, M5 - Poplar-juniper steppe woodlands

Rock woodlands: LY1 - Ravine woodlands (mesic rock woodlands rich in *Acer pseudoplatanus*), LY2 - Mixed forests of scree, rocky slopes, rich in *Tilia* spp., LY3 - Limestone beech woodlands, LY4 - Mixed relic oak woodlands on rocks

Mixed coniferous woodlands: N13 - Acid coniferous woodlands, N2 - Calcareous Scots pine woodlands

Other woody habitats: RA - Scattered native trees or narrow tree lines, RB - Uncharacteristic (often pioneer) softwood woodlands and plantation, RC - Uncharacteristic hardwood woodlands and plantation, RD - Uncharacteristic woodlands and plantation mixed with non-native tree species, P45 - Wooded pastures and sweet chestnut woodlands, P7 - Extensive orchards with ancient cultivars (often invaded by shrubs and trees), P1 – Young stands of native trees, P3 – New afforestation, P6 – Parks, botanical gardens, P8 – Clear cuts,

Woodland plantations: S1 – *Robinia pseudoacacia* plantations, S2 – American poplar plantations, S3 – Other non-native deciduous plantations, S4 – Black and Scots pine plantations, S5 – Other coniferous plantations, S6 – Spontaneous stands of non-native tree species, S7 – Tree lines mostly with non-native species

Agricultural habitats: T1 – Annual intensive arable fields, T2 – Perennial intensive arable fields, T3 – Vegetable and flower plantations, greenhouses, T4 – Rice fields, T5 – Sowed or fertilised grasslands, sports-grounds, T6 – Mosaic of small agricultural parcels, T7 – Intensive vineyards and orchards, T8 – Traditional vineyards and orchards, T9 – Gardens, T10 – New abandonments on arable lands, vineyards and orchards, T11 – Nursery gardens, *Salix viminalis* plantations, T12 - Plantations of energy plants

Other habitats: U1 – Cities and areas with blocks of flats, U2 – Garden suburbs and recreation areas, U3 – Villages, U4 – Yards, premises, wreckage, dumping grounds, U5 – Mine dumps, dumping grounds covered by ground, U6 – Open mines, U7 – Sand, clave, gravel and pit mines, loess walls, U8 - Rivers and streams, U9 – Lakes and ponds, U10 – Farms, U11 – Roads and railroads

## Appendix 2. The categories of naturalness (modified after Németh & Seregélyes, 1989)

5: Rich in species that are specialists, typical natural species of the habitat; stands with good structure, and of substantial ecological value; one of the best 10-50-100 stands in the country; with no or low cover of weeds and invasive species; site conditions of natural state.

4: A state designated as "good", "close to natural", "well recovered"; structure of vegetation of good quality; dominated by natural species, rich in characteristic species, but with few disturbance tolerant ones; often combines the features of the vegetations from categories 3 and 5 (this is the broadest category of naturalness): 1. patches with low number of species, perhaps with several weeds, but with admirable structure, 2. patches quite rich in species, but without a good structure, 3. ageing forest stands, but missing certain species or with poor structure, 4. one of the vegetation layers is of considerably higher quality, than the other one.

3: Moderately degraded / in a mean regeneration state; dominated by natural species, but with few characteristic ones; in other cases with several characteristic species but with numerous disturbance tolerant ones, possibly even with weeds, as well, site conditions often moderately degraded, poor vegetation structure (homogeneous, with stands of equal age or with unnatural patchiness of vegetation) / in other cases with better structure but with uncharacteristic species composition.

2: Considerably degraded / scarcely regenerated state, with uncharacteristic species composition, dominated by disturbance tolerant, weedy and invasive species, vegetation structure collapsed or undeveloped (monodominant, patches of equal age, few species co-existing), vegetation often fragmented, site conditions often poor, usually no natural vegetation type can be appointed. Could the original type be recognized, its state is "quite poor", often because of the high cover of invasive species.

1: Totally degraded / state that just begins to regenerate, solely with weeds and uncharacteristic, indifferent species.

## Appendix 3. Example Habitat description from the Habitat Guide

### F1a - *Artemisia* salt steppes

***Definition:*** *Festuca pseudovina* and generally *Artemisia santonicum* dominated, short-grass, dry (occasionally wet) steppes rich in salt-tolerant species. Meadow and meadow steppe species are rare. The stands are usually extended. Minimal stand size to document in the MÉTA project: few square metres

***Site conditions:*** These steppes are representatives of the Central Asian alkali steppes in the Carpathian Basin, the most widespread and characteristic alkali steppe type in the Great Hungarian Plain. The *Artemisia* salt steppe (*Artemisio santonici-Festucetum pseudovinae*) is not a zonal climax vegetation type, but an edaphic stabilised successional stage. In the forest steppe zone of the Carpathian Basin, the alkali steppes communities of the southern regions – such like the *Artemisia* steppes – are more widespread than in the northern forest steppe belt of Russia, however only extrazonaly and edaphically. Alkali steppes can develop in such areas, where the water and the leaking of precipitation into the soil reaches each other, and thus the salt from the deeper layers of the soil moves close to the surface. For the starting of this process three factors, (1) the closeness of water table level to the soil surface, (2) high amount of salt in subsoil water and (3) continental climate are needed. Water supply of *Artemisia* steppes is extremely fluctuating, similarly to other alkali vegetation types. In the spring they are partly covered with water, while in the summer they dry out totally, and the soil cracks deeply. The soil type of the *Artemisia* steppes in the Danube–Tisza Interfluve is solontsak-solonetz, in the Tisza Valley it is solonetz. The upper 10 cm of the soil (sometimes only the upper 1-2 cm) is leached, and thus slightly acidic. Nevertheless, the B layer is always alkali and has characteristic pillared structure. Surface water erosion creates the characteristic microtopography of alkali steppes, especially on solonetz soils.

*Artemisia* salt steppes are widespread in the former ancient floodplains of large rivers and in the basins of loamy-sandy low ridges. Part of these steppes is ancient (continuous steppe from the Pleistocene), the other part developed secondarily due to the water regulations. Majority of the extended stands in the Danube–Tisza Interfluve (e.g. Apajpuszta) has been developed from *Puccinellia* alkali mud vegetation by drying out. The soil profile of these stands shows secondary steppe character and layers developed after the drying out. This phenomenon was observed in the Hortobágy region as well. Secondary stands along the Tisza river has developed mainly from stands with meadow soils.

Drainage of alkali steppes did not influence much the water supply of the upper layers, however, by shrink of the water table level, the possibility for leaching is higher, and it is already observable in some regions (e.g. Hevesi-puszták, Bihari-sík, Ágota-puszta).

***Stand structure:*** Grazed stands are low. In the non-grazed ones *Artemisia* grows high and becomes dominant. There are no trees or shrubs. Tall grass species (*Alopecurus pratensis* and *Elymus repens*) are rare, they are penetrating from the adjacent meadows.

***Characteristic species:*** Continental, Pontic and Ponto-Mediterranean floristic elements are the characteristic ones. *Artemisia* steppes are not very species rich, however, their flora and fauna is special and even sub-endemisms occur in them (*Plantago schwarzenbergiana*, *Trifolium angulatum*). Due to the severe abiotic (lack of water) and biotic (grazing) stress, the disturbant-tolerant and annual species are common. Part of these is not stenohalophiton (real alkali species), but pseudohalophiton (salt tolerant species). Characteristic species are: *Artemisia santonicum* subsp. *monogyna* és subsp. *patens*, *Festuca pseudovina*, *Limonium gmelini*, *Podospermum canum*, *Trifolium retusum*, *Trifolium angulatum, T. parviflorum*, *Ranunculus pedatus*, *Bupleurum tenuissimum*, *Gypsophila muralis*, *Lotus tenuis* (*L. glaber*), *Cerastium dubium*, less frequently: *Plantago schwarzenbergiana*, *Kochia* (*Bassia*) *prostrata*, *Plantago maritima*, *Aster tripolium* subsp. *pannonicus, Prospero paretheticum*. Species of loess steppes (e.g. *Dianthus pontederae, Salvia nemorosa*, *Verbascum phoeniceum*), tall-growing forbs (e.g. *Aster punctatus*, *Artemisia pontica*) and meadow species (e.g. *Centaurea pannonica*, *Cichorium intybus*) are rare or totally absent. Degradation is mainly caused by severe overgrazing. In this case *Bromus mollis* (*B. hordeaceus*), *Hordeum hystrix*, *Poa bulbosa*, *Erophila verna*, and different lichens and mosses (*Cladonia magyarica* és *Cl. convoluta*, *Cl.furcata*, *Ceratodon purpureus*) proliferate. In the best, only slightly grazed stands occur these mosses: *Entosthodon hungaricus*, *Phascum floerkeanum*, *Tortula ruralis*, *Phascum cuspidatum*, *Polytrichum piliferum*, *Brachythecium albicans*, *Bryum tricolor*, *Barbula unguiculata*, *Bryum alpinum* és a *Pleurochaete squarrosa*.

***Vegetation and landscape context:*** Mostly alkali steppe landscape mosaicing with low loess ridges and meadows, however in some cases it forms homogenous stands of thousand hectares. In the zonation below the *Artemisia* steppe there are *Pucinellia* alkali mud vegetation, and annual salt pioneer swards and alkali meadows, above it there are *Achillea* salt steppes, loess steppe patches and ploughlands.

***Subtypes, sub-units, types belonging here:***

1. The typical *Artemisia* steppe: *Artemisio-Festucetum pseudovinae*.
2. *Limonio-Artemisietum* stands with low cover of *Festuca* – if species of *Puccinellia* swards and pioneer halophytes are lacking, and the cover of the perennial species reaches 50%.
3. *Gypsophilo-Festucetum* stands (with mosses and high cover of *Gypsophila*)
4. Patches that are secondary as the *Achillea* pastures, but resembling more the *Artemisia* salt steppes (*Achilleo-Festucetum artemisietosum*).

5. Dried *Puccinellietum* stands, if they are already co-dominated by *Festuca* and *Artemisia* (e.g. close to Apaj) (*Artemisio-Festucetum puccinellietosum*).

6. Pioneer vegetation of the open leached alkali soil surface, with the dominance of *Artemisia* (soil surface already leached, but the deeper layers still saline, species characteristic of the pioneer alkali soils are replaced by those of the Artemisia steppe).

***Types not belonging here (typical mistakes)***

1. Patches of *Achillea* salt steppes lacking stenohalophytes. [F1b]

2. Non-halophytic *Festuca pseudovina* stands formed on abandoned arable lands on loess embedded in vast halophytic steppes, quite poor in species [OC]. In addition to the characteristic elevating relief they can be recognized based on the characteristic species, which are not those of the halophytic habitats, but the ones of the steppe-like arid grasslands (mainly *Festuco-Brometea*). If species of the loess grasslands can be found on the habitat, it should be classified as [H5a]. Caution: typical *Artemisia* salt steppes of certain landscapes may contain species of the loess steppes (but in this case together with several halophytes).

3. Stands in a transitional state towards the vegetation of the annual salt pioneer swards, *Puccinellia* swards and salt meadows, with more species characteristic of the latter ones. [F2, F4, F5].

Note: categories F1a and F1b often cannot be distinguished unambigously. In such cases: F1a – if the habitat has more halophytes, F1b – if it has more species characteristic of steppe or flood-plain meadows.

***Naturalness:*** Species richness, number and dominance of halophytes are important features when evaluating the naturalness of *Artemisia* salt steppes. In stands closer to the natural state more steno- and astenohalophytic species occur. One reason for the degradation is leaching caused by draining of the habitat, which decreases the values of extreme environmental factors and thus enables glycophytes to colonise the area. For weeds this vegetation is hard to colonise, it easily regenerates and it has its own weedy species. According to our experiences, around the stands closer to the natural state the vegetation mosaic of the salt steppes on the landscape level is also more natural and more diverse. Permanent over-pasturing provokes species-loss and makes the habitat more weedy, but only around the folds and the wells has it serious effects. Existence of weeds is hard to recognise in spring, they are more visible from June.

Dominant species are resistant to degradation. The habitat is not threatened by invasive species or the invasion of shrubs. The number of annual halophytes depends not on the naturalness of the site but on the spring inland waters and the amount of litter from the previous year. Leaching is the only process that may cause the alteration of this vegetation type into an other one. Patchiness and physiognomy seems to be of minor importance when evaluating naturalness. Landscape context has insignificant effect on the naturalness of the stands. Burning does not ruin it considerably, mechanical damage causes only temporary weed-colonization.

5: rich in halophytes, often diverse micro-topography; without species of the loess steppe, tall herb salt meadows or mesotrophic meadows; being as vast as possible (covering at least a hectare-wide area), and be a part of a complex zonal system or mosaic of vegetation (be loess steppes at higher and salt pioneer swards and salt meadows at lower regions), there is no sign of draining and leaching (e.g. only few glycophytes on the Artemisia steppes or no Artemisia on the pioneer salt habitat)

4: stands with patches of weeds (e.g. Bromus mollis), but rather with mean species richness, dominated by halophytes; over-pastured stands, that are a part of a less complex zonal system or mosaic of vegetation

4: stands on leaching soil, but still rich in halophytes also belong to this category

4: those secondary patches also belong here that have properly regenerated species composition and dominance structure, relatively rich in species, not homogenous, not weedy (diverse micro-topography regenerates much more slowly)

3: stands with low number of species, *Artemisia* or *Festuca pseudovina* are sometimes completely missing

3: stands with low number of species, *Artemisia* or *Festuca pseudovina* are sometimes completely missing, and *Bromus mollis*, *Hordeum hystrix*, *Poa bulbosa* has high abundance (should both *Artemisia* and *Festuca pseudovina* – and even other halophytes – be missing, the habitat is rather [OC])

3: those patches are also classified here, that are secondary (stripes of plough-in, signs of a former fish pond or a rice-field are visible, the surface is suspiciously flat), but regenerated poorly, has low number of species, are quite homogenous, sometimes weedy (simple micro-topography, occasionally with patches of open alkali soil surface; overlaps of *Artemisia* steppes and pioneer salt swards are characteristic, since they do not separate well)

2: this kind of stand is very rare, since it cannot be invaded by weeds to such extent or become so uncharacteristic (only if it is leached as well, but then it is not a salt grassland, but [OC])

2: stands exposed to serious mechanical damage – and thus collapsed, weedy, sparse and has few species – temporarily and very locally can reach this state of degradation

***Regeneration potential:*** 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 especially degraded habitats (along roads, ditches). The potential of rare species for regeneration is unknown, but rather higher than low. In habitats with non-leached soil, the competitive ability of non-halophytes, invasive species and shrubs is very 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 that the vegetation pattern or physiognomy plays in regeneration. The regeneration of the *Artemisia* salt steppe is principally limited by the improper extent of salinization in the soil. In case of low salt-concentration, loess-steppe-like dry grassland (usually *Achillea* salt steppe) regenerates. The significance of landscape context lies merely in that it determines the propagule-resources. 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 pasture on regeneration. Burning does not destroy the habitat considerably. Following disking, ploughing, abandonment of a rice-field, mechanical damage of the soil this vegetation type regenerates relatively well.

***Regeneration potential (dynamic naturalness) on spot***

Good: All stands of naturalness category at least "4". 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 over-pasture.

Mean: Degraded (mainly from naturalness category "3") and smaller (only few ha) stands.

Poor: There is no such *Artemisia* stand but for the ones un-salinized due to leaching (since they do not regenerate as *Artemisia* but "degrades" 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, 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 water) is restricted.

Poor: In case of natural salinity and water-content of the soil this vegetation type cannot "move" in the landscape.

***Regeneration potential (dynamic naturalness) on neighbouring arable field***

Good: If the soil of the arable field is properly salinized (often only the edge regions of the fields are of this kind, because on the middle, higher parts chernozem soil is already formed)

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

Poor: There is no such situation.

[Hungarian version is written by Molnár Zs., Bagi I. and Tímár G.]