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THE FUTURE ECOLOGICAL VALUE OF THE HUNGARIAN LANDSCAPE

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Introduction

From an economic aspect, landscapes have different, direct and indirect values, or according to Naveh (1984), hard and soft values. Most of the hard values can be measured well, e.g. the values of the direct economic benefit, such as the NPP or the ecological value used in landscape ecology (Marks et al. 1989). From economic considerations, some authors rank the use value of landscapes into this category, though it cannot be measured directly. However, there are certain real, measurable data to rely on (Rodge 1990). For instance, people spend a considerable sums to visit national parks; or the value quitness can be expressed when the prices of two flats of otherwise similar quality are compared, with one of them situated in a noisy street and the other in a quiet one. The indirect values of landscapes, such as recreational value, nature conservation value and aesthetic value, are usually poorly defined: they contain many subjective elements, which are difficult to measure. This limitation must be considered in the planning and managing of landscapes.

In this study, currently available information is used to analyse the probable changes in ecological value of one of the most characteristic landscapes in the Carpathian Basin, the Danube - Tisza Interfluve, in the next 50 years. A dark future is often predicted for the Danube - Tisza landscape, due to direct and indirect human effects, the growing aridity, the falling groundwater level and the impoverization of the local population.

The Danube - Tisza Interfluve is a plain interspersed with numerous orchards and vineyards, covered with blown sand. Its central part, accounting about 60%, has semi-cohesive and cohesive blown sand and anchored dunes, embracing flat interdune basins with a high groundwater table. It is covered by a patchwork of sandy pusta or acacia - poplar vegetation. Its NE and SW parts are loessy plains covered by chernozem soil with a deep-lying groundwater level. It is a cultivated steppe. The W. part is an elevated flood plain with meadow soil.

Method

The analysis involves an assessment of the changing value of the future landscape through modification of the ecological value. The ecological value is a category used in geography; it is not strictly defined, and thus it can be approached in various ways. It can mean the condition of the ecotopes, the productivity of the landscape or the utility factor of the landscape. In the course of the analysis, an attempt was made to calculate the change in the ecological value from all three aspects, which therefore fulfilled a controlling role for one another.

The essence of the applied method is the estimation of the consequences due to the ecological values of the 20 and 50 - year climatic and water turnover data sequences in the Carpathian Basin and the Danube - Tisza Interfluve as the test area. This approach, however, has number of weak points. The exactness and errors of a long-range ecological prognosis are difficult to assess. The dynamics of the changes predicted in the landscape building factors may differ greatly and the changes can occur in different directions or at different levels (e.g. the transformation of a forest association may take 80 to 100 years, while that of a grassland takes some 10 years).

The condition of the ecotopes was defined in accordance with a German proposal (by Marks et al. 1989) on the basis of the maturity, naturality and diversity of the vegetation. The scores for each of the factors were added and averaged for large areal units of the landscape. The investigation of different ecological demands (T - temperature, W - water supply, R - soil reaction) of the vegetation has had considerable traditions in Hungary since the mid 1960s (Soó 1964). Long-term data are available on the pusta vegetation in this form. This structure is mostly harmonized with the above mentioned, quantified German system.

In the second approach an effort was made to calculate the regional differences in the NPP value by using the Thortwhaite Model (in Leith 1974).

The ecological value shift was finally supplemented by an analysis of the land use albedo system in order to detect the positive or negative direction of the landscape utility caused by the forced changes in land use.

Initial data

The climatic changes induced by thehuman impact in the past 100 years are explained by experts in different ways (some have even expressed doubt that there has beeen such a change), but most of them agree that measurable changes have taken place in an accepted trend. They also concede that the global changes can be modified to various degrees at the local level. Later, therefore, we consider only the climatic data sequences in the Carpathian Basin. There are several groups of sequences (as in Mika 1993, Szász 1993 and Varga-Haszonits 1993). The predicted changes are similar as regards the two most important elements: temperature and humidity.

The estimates by the above experts include a 1 mm annual precipitation loss for the forthcoming 100-120 years and this trend is considered to be probable for the next few decades. The predicted rise in temperature, induced largely by artificial effects, is about 0.1-0.2 °C per decade (see Table 1), with a slight acceleration in its trend. This value is in harmony with the 0.20-0.50 °C per decade rise in the average global temperature (Roberts 1994).

Station	*Average of temperature rise, °C per year*	*T value*	*95% significance level*
Baja	0.011	5.718	yes
Kalocsa	0.011	5.727	yes
Kecskemét	0.011	5.332	yes
Szeged	0.010	4.519	yes

Table 1 *Temperature trends in the Danube-Tisza Interfluve*

These two trends suggest that the average temperature in the Danube - Tisza Interfluve may rise by a 0.5 °C in 20 years and by 1.0 °C in 50 years (Mika 1993). The annual rainfall is expected to decrease to below 500 mm, as compared to the present 550-600 mm, and that will not cover the water demand of the region (Figure 1).

The presented data sequences have direct and indirect ecological consequences. The most significant direct effect is the strong decrease in the water supply coupled with social effects. This will result in increasing aridification and a falling groundwater table (Figure 2). The calculations by Szász (1993) indicate thata 1 °C rise in temperature and a 5% fall in relative humidity will result in a 5-6% decrease in soil humidity (at the beginning of summer, it may even be more), while a 10% decrease in rainfall will cause a 2-4% decrease in soil humidity. The values are higher in spring and are unfavourably affected by the decreasing precipitation primarily in the spring and autumn. All of the above factors result in a decreasing water availability for the soils. The prognoses are based on the continuation and acceleration of this tendency. The other direct effect is the increasing duration of the vegetation period of plants.

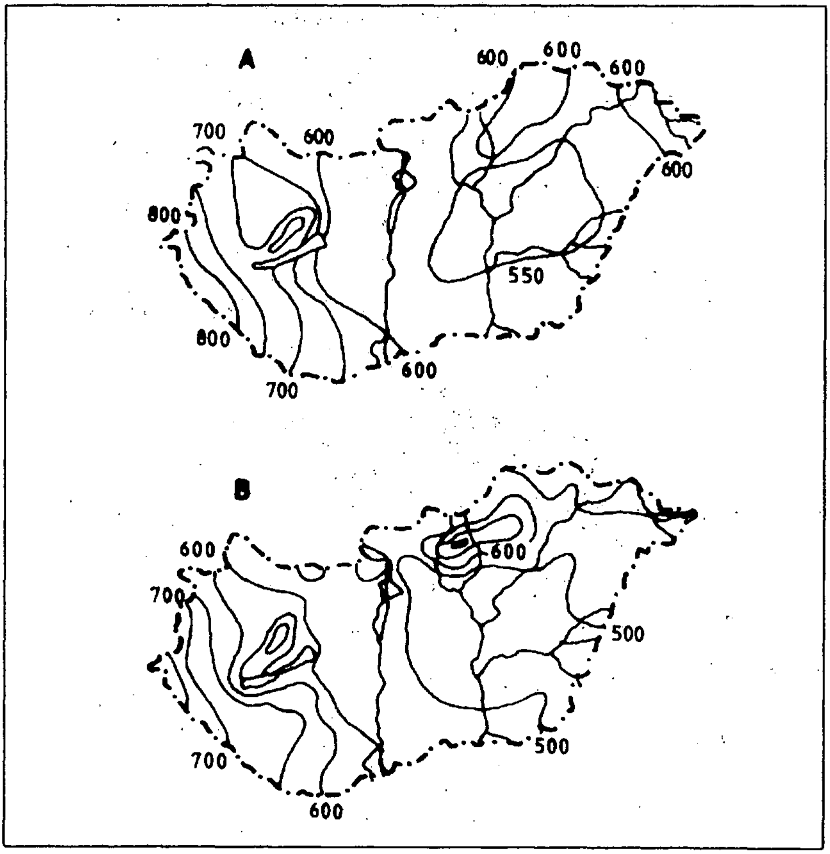

Figure 1 *(A) Distribution of mean annual rainfall (1901-1950).(B) Predicted mean annual rainfall due to 1 mm annual precipitation decrease in Hungary (after Szász 1993)*

The global changes may have favourable side-effects in the Carpathian Basin, besides the changes in the two climatic factors described above. For example, the larger amount of CO_2 will contribute to a greater effectivity of photosynthesis (Acock 1990), accompanied by a decreasing transpiration (which does not mean the decrease of transpiration in the whole of the vegetation).

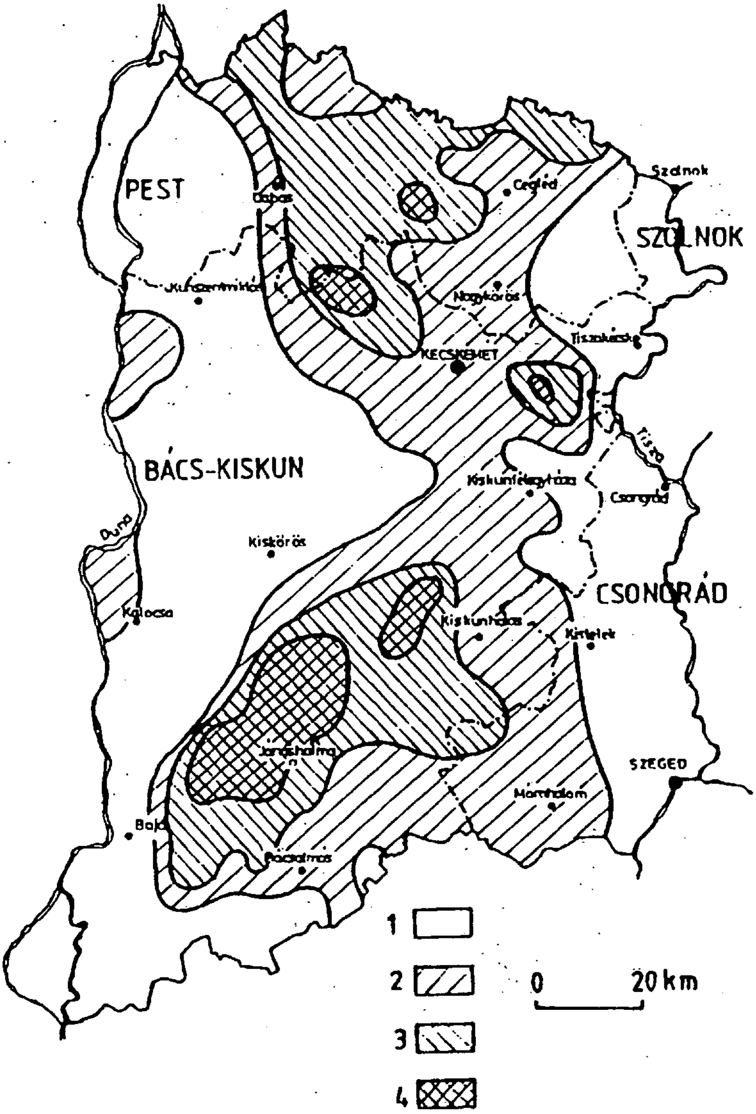

Figure 2 *Average groundwater level in Danube - Tisza Interfluve in early 1990s compared to average annual value from 1956 to 1975 (after Pálfai 1994). (1) < 1 m, (2) 1-2 m, (3) 2-3 m, 4 > 3 m*

Results

A. To elucidate the changed conditions of the ecotopes, we have made a detailed field survey of the the vegetation of the Danube-Tisza Interfluve (1:25,000) and ranked it into 24 vegetation types. A map presenting these in 5 categories (edaphic association groups) is shown in Figure 3. The maturity (the condition achieved in the succession line under the present land cover), the naturality (the association of the vegetation with the ecological capability) and the diversity are shown for each vegetation type. These parameters are then evaluated on a scale from 1 to 5, and the scores are summed. The values obtained in this way are used in landscape ecology as ecological values (Marks et al. 1989). Examination of the ecological values in the Danube - Tisza Interfluve (Figure 4 a) reveals that the highest (best) ranks are assigned to the flat, grove-covered depressions with a good water supply in the Danube Valley and the Danube - Tisza Interfluve; and the lowest values to the pusta associations (Categories II and III) determining the face of the landscape.

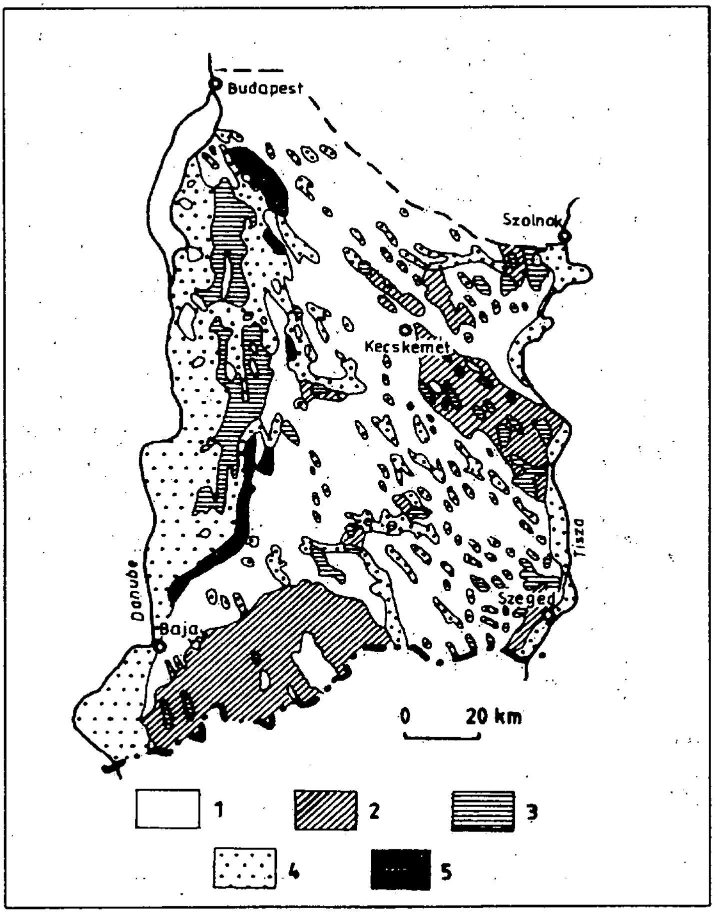

Figure 3 *Map of vegetation types (after Soó 1964). (1) Sandy oak groves and pusta; (2) loessy pusta, (3) alkali associations; (4) floodland gallery forests; (5) boggy meadows*

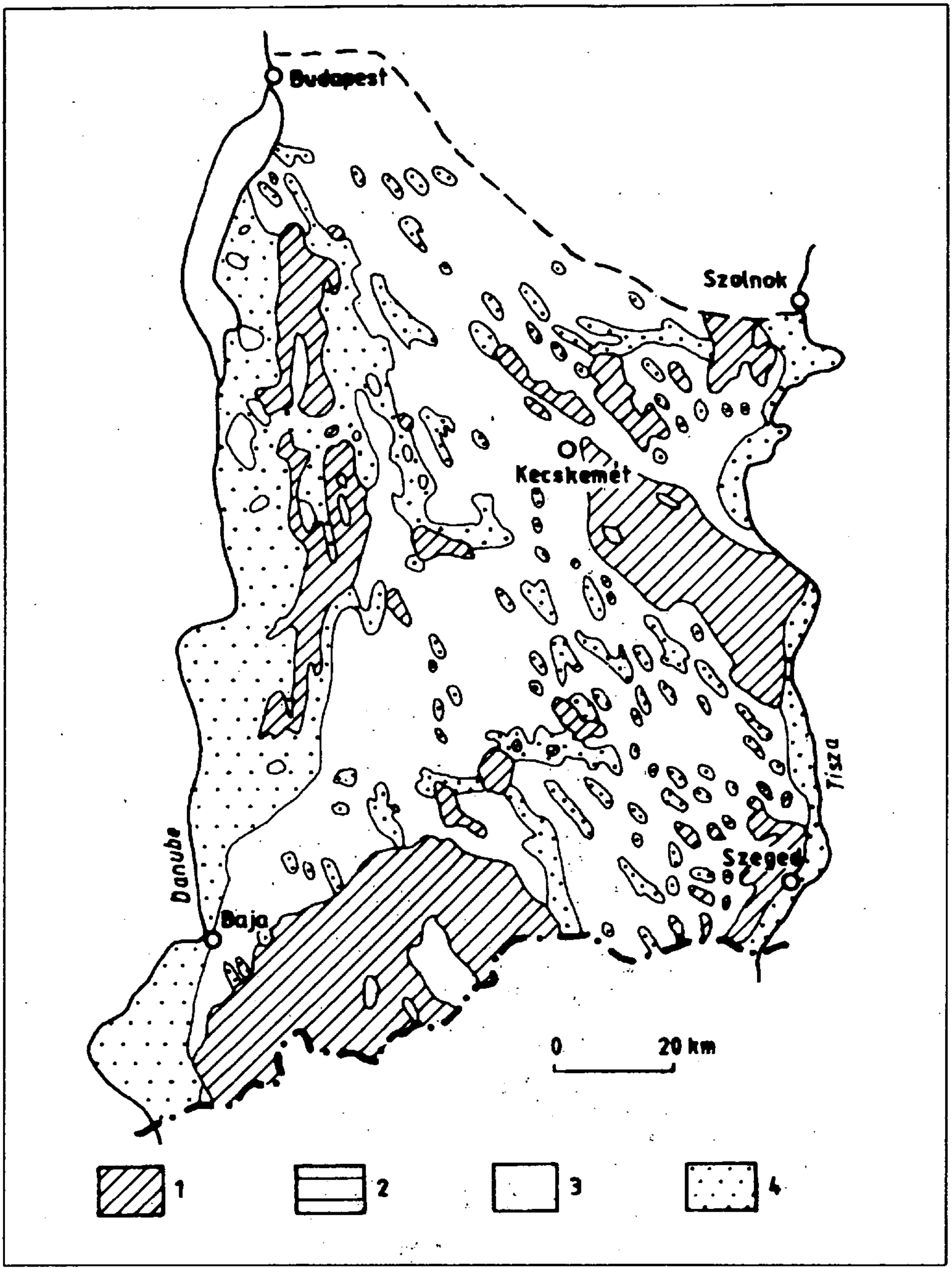

Figure 4a *Present ecological value of Danube - Tisza Interfluve. (1) < 8 points, (2) 8.5-10 points, (3) 0.5-12 points, (4) > 12.5 points*

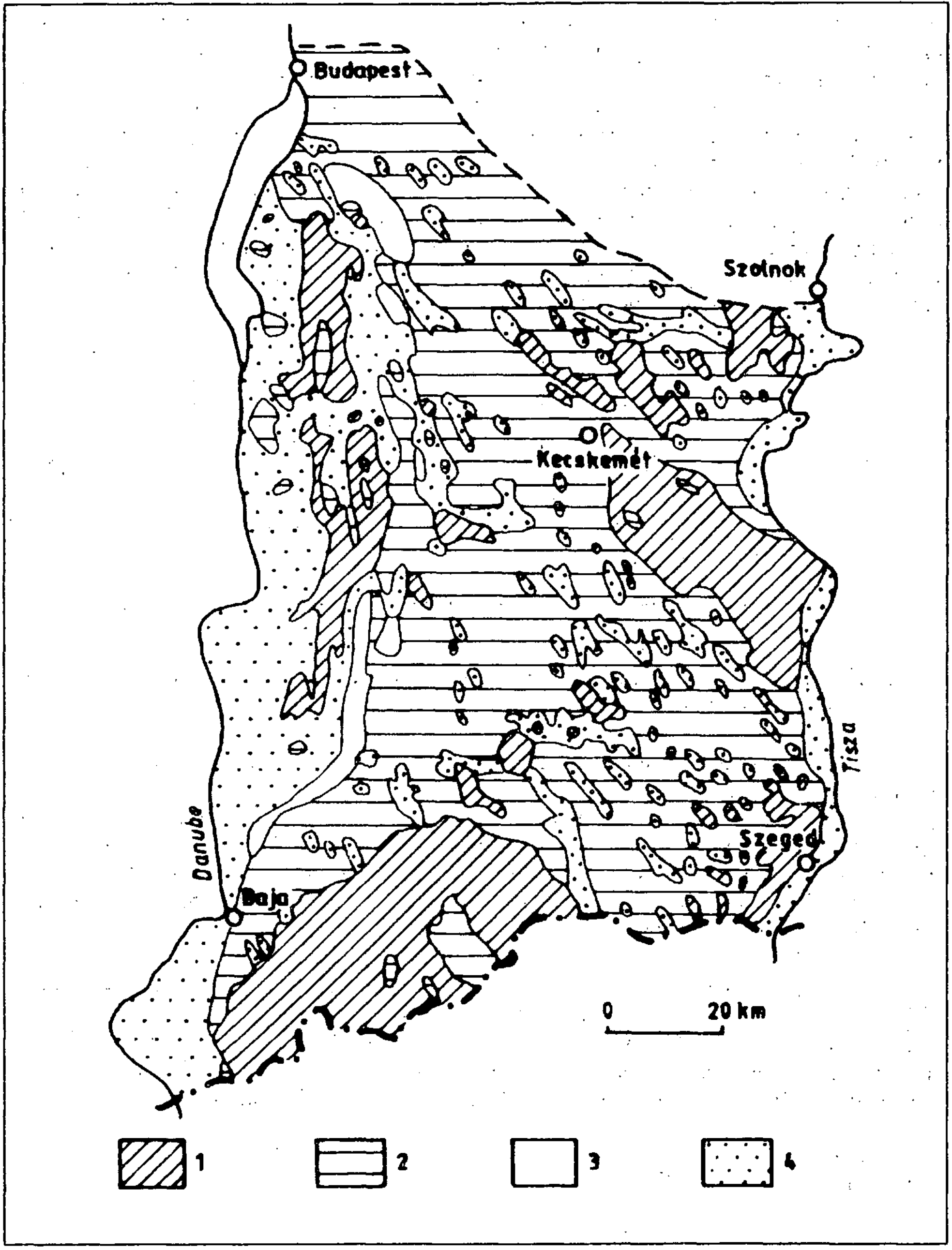

Figure 4b *Estimated ecological value of Danube - Tisza Interfluve. (1) < 8 points, (2) 8.5-10 points, (3) 10.5-12 points, (4) > 12.5 points*

The detailed ecological investigations in the Danube - Tisza Interfluve demonstrated the succession of the vegetation (Figure 5, after Soó 1964). From the estimated precipitation and temperature changes, the probable trend was reconstructed for each vegetation type, and their naturality, maturity and diversity were calculated together with their ecological values. The regional differences are to be seen in Figure 4 b. For the overall region, a slight decrease in the ecological values can be predicted (from 10.0 to 9.5, as in Table 2) in the case of the presumed climatic change. The values in Categories II and III will not actually change, though minor variations, may be expected in the vegetation associations, and the area of the closed sandy pusta steppe may be replaced at some sites by sandy pasture. The values in Category IV will not alter much, though the association will undergo a considerable change: the willow - poplar groves will be replaced by oak - elm growes. In categories I and V, the ecological values will decrease and the inner changes will be considerable.

Vegetation types	*Average ecological value*	
	at present	estimated
I. Sandy oak groves and pusta	10.5	9.0
II..Loessy pusta	7.5	7.5
III. Alkali associations	8.0	7.8
IV. Floodland gallery forests	12.6	12.6
V. Boggy meadows	11.5	10.5
Average	10.0	9.5

Table 2 *Present and predicted ecological value of vegetation types (a higher rank reflects a better ecological condition)*

For verification of the results, the factors limiting the evaluation also have to be considered: the vulnerability of the method is governed by these. The above - used scale is appropriate for an overall analysis of an area of some 10,000 km^2. The longer the forecast, the greater the errors that may occur in the estimation of the data because of the intensity of human activity on the Earth's surface. It therefore pointless to make estimates for a period longer than 50 years. The transformation of the vegetation may also be very variable as regards both dynamics and dimensions.

B. The change in productivity of the landscape can best be expressed in terms of NPP values. The NPP can be regarded as a direct (hard) landscape value. Because of the extent of the investigated area, we could not use the ecological methods devised for site measurements. The Miami Model (Leith 1974) has long been long used to determine the approximate NPP of large regions. In the calculations, we used the formulas

$NPP = 3000\ (1 - e^{-0.000364P})$ and
$NPP = 3000\ (1 - e^{-0.0009695(ET-20)})$,

where

P = annual average rainfall in mm, ET = actual evapotranspiration in mm, and NPP is in expressed g/m^2/year).

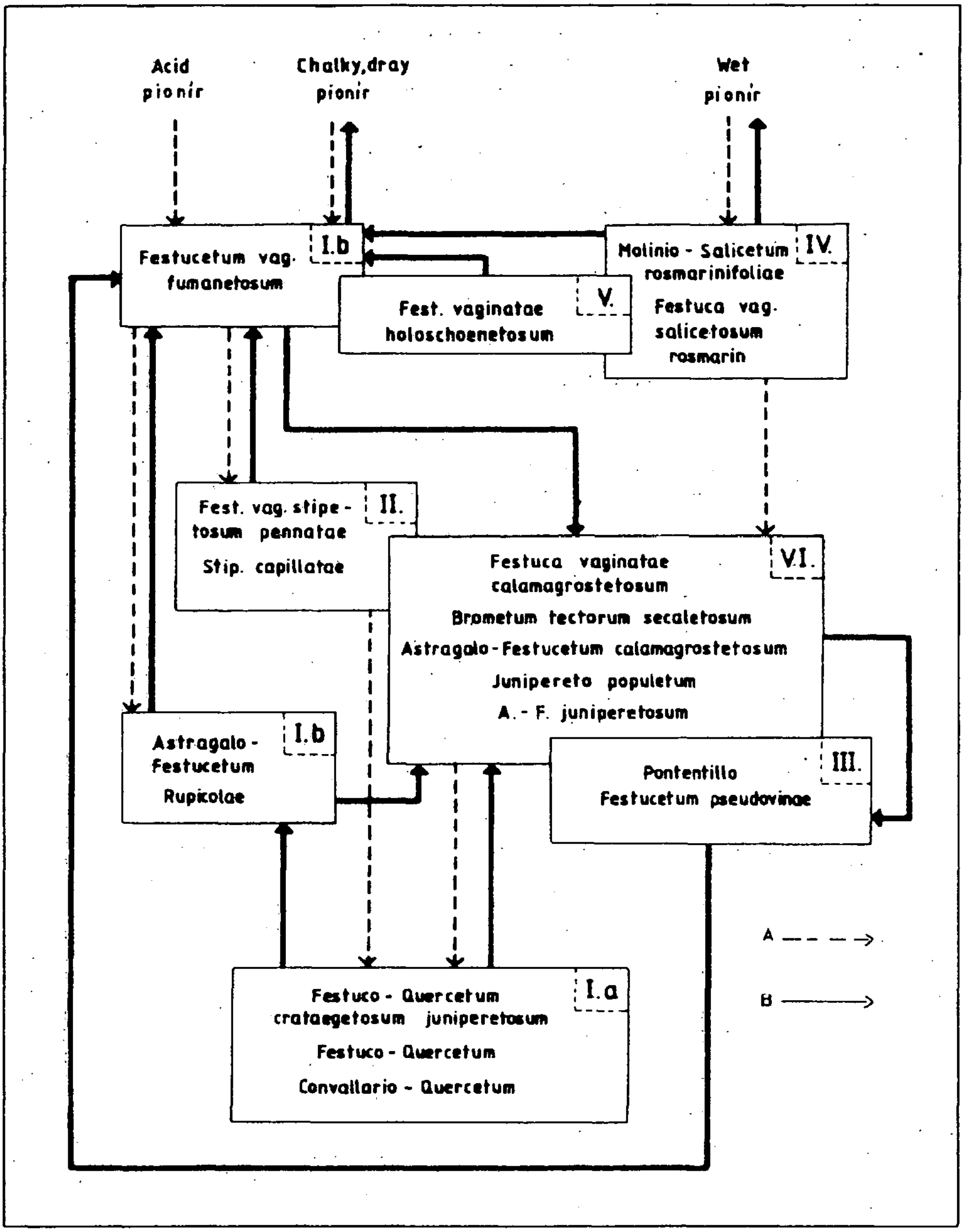

Figure 5 *Vegetation changes caused by climatic fluctuations and human effects in Danube - Tisza Interfluve (A) Normal succession, (B) succession with degradation trend: (Ia) sandy oaks, (Ib) sandy pusta, (II) loessy pusta, (III) alkali association, (IV) floodland and wet association, (V) boggy meadows, (VI) sandy grass with junipers*

There are various empirical formulas for the expression of NPP, involving both precipitation, and measured evapotranspiration. In our experiment, the different models yielded contradictory results: of the predicted climatic changes, the decreasing rainfall will cause a 10% drop in the NPP, while the rising temperature will result in a 2-3% increase. Thus, these models can be used for such a "small" region to give general information. What can be concluded from the calculations is that the natural productivity of the region is decreasing and the overall changes will cause a 6-8% NPP loss, wich may be doubled when the indirect NPP loss due to the fall in soil humidity is also considered.

C. Aridity, the main factor modifying the **use value**, is chiefly caused by the changing features of the climate, water utilization and drainage, and land use. If these factors are analysed separately, false results may be obtained. The development of land use is the most reliable aspect from which changes in use value can be checked (Figure 6). Ecological and economic changes are jointly responsible for the modifications, and thus an inaccurate record would be obtained if an attempt were made to establish the exact ecological change rate brought about by privatization, for example. Ecological factors automatically involve changes in utilization, which induce further processes. If the changes in the system of land utilization - albedo - groundwater are analysed, it can be concluded that the numerous factors modify the use value both positively and negatively. Tab.3 presents the modification in the rate of land use.

	1855	*1895*	*1935*	*1964*	*1985*	*1993*	*suggestion I*	*suggestion II*
Municipal areas	0.6	1.1	2.0	2.6	3.4	3.6	3-4	3-4
Forests	4.5	6.1	5.2	9.1	17.3	17.6	15-17	16-18
Arable land	37.9	53.5	58.8	64.1	62.2	63.3	30-55	38-52
Kitchen,gardens, vineyards,orchards	2.3	3.5	6.5	7.2	7.4	7.3	6-8	8-12
Meadows, pastures	39.8	29.0	21.2	16.0	9.7	8.2	20-30	20-30
Fallow	14.9	6.8	6.0	n.a.	n.a.	n.a.	5-20	
Albedo*100	22.5	21.7	21.6	20.6	19.6	18.7	20.6	22.1

n.a. = not available

Table 3 *Changes in land use and albedo rates in Danube-Tisza Interfluve*

Field measurements (Marosi-Somogyi 1991) and Landsat TM 4,5,3 (RGB) composites from 1993 were applied to differentiate the most important land use types, and revealed that large-scale social changes decreased the albedo, the ecological diversity and also the naturality. The decreasing albedo does not induce, but rather intensifies the aridity process produced for the above-mentioned reasons. We had believed that the expansion of the forests between 1855 and 1895, and between 1950 and 1985 also led to aridity, regardless of the fact that pines with a low water demand were planted in this region. Particularly the meadows and pastures were first affected by such changes in land use, which may have influenced the aridity process. After 1945, mostly arable land was afforested and thus aridity due to a"well-effect" cannot be proved. From the 1960s, melioration and dramatic changes in the water management of the interdune depressions (the local name is *semlye)* influenced the water supply to a larger extent. This resulted in subsequent setbacks such as the current fall in the water table and land alkalization (Kevei-Bárány 1988).

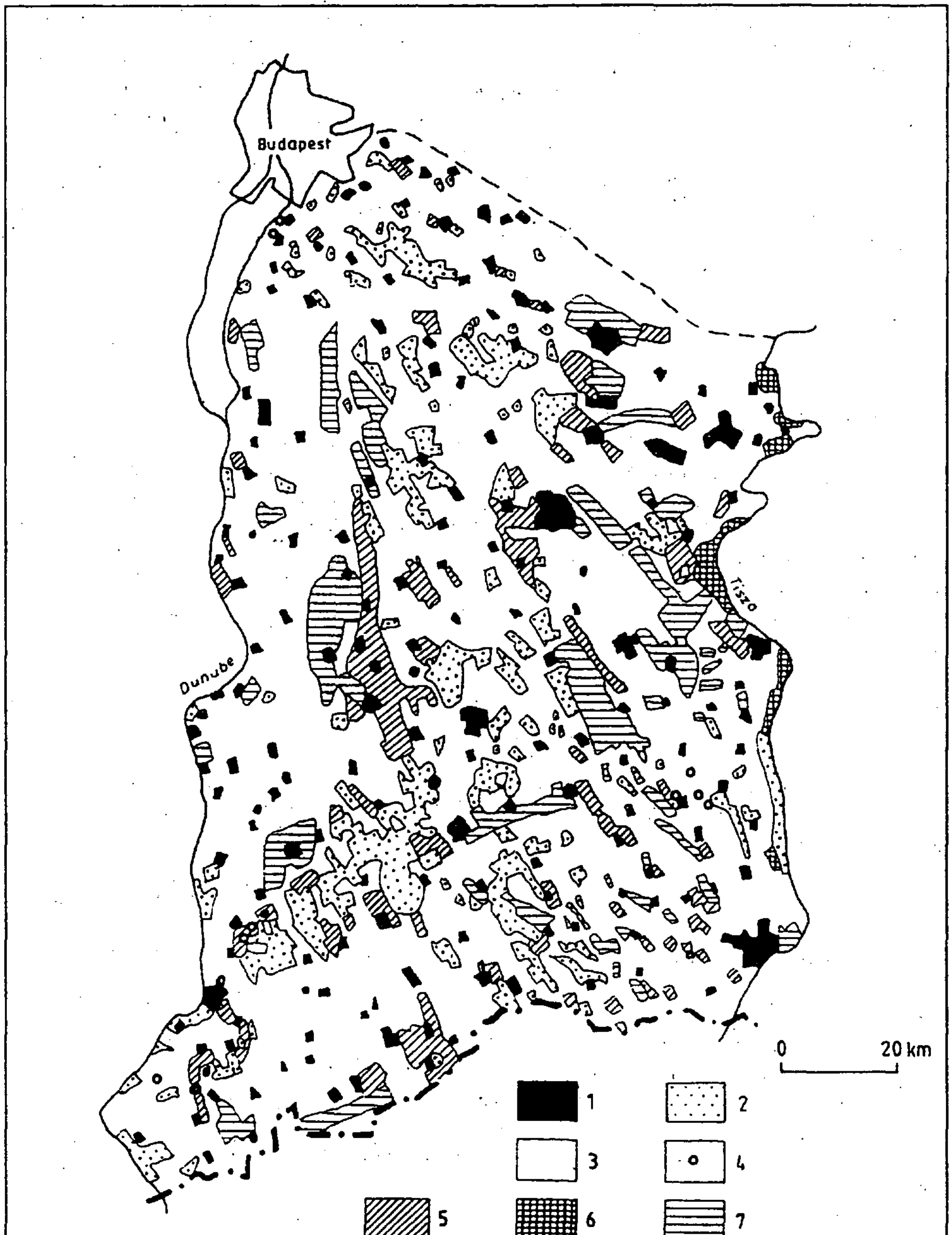

Figure 6 *Present land use of Danube - Tisza Interfluve. (1) Municipal areas; (2) forests, (3) arable land, (4) kitchen-gardens, (5) vineyards, orchards, (6) meadows, pastures; (7) alkali dry pasture*

From an ecological point of view the changes in land use have not been favourable. Grassplots, which carry natural vegetation best, have reduced significantly. This and arable land, which tends towards monoculturs, led to decline in the environmental structure, already sensitive because of the aridity. Larger plots of land predominantly understate ownership have caused increasing wind erosion (privatization has only led to a decreased plot size in a few places). Nowadays, more effective grassland farming (Table 3, suggestion II) and fallow-farming (Table 3, suggestion I) are emphasized.

The above factors influence the use value differently but often cumulatively within different areas. Figure 7 shows the distribution of the predicted change in the use value from an ecological aspect.

Discussion

The appearance of the Hungarian Pusta landscape after 30-50 years will depend mostly on man. If the currently estimated physical processes continue to prevail on the Pusta, we can expect the natural vegetation to transform into rather dry associations: weeds indicating diminishing diversity will become more widespread, as will the juniper at the expense of the oak - hornbeam groves. The competitiveness and acclimatization of the species will also change. The total ecological value of the vegetation cover will decrease. Some species will die out even within the areas of the national parks. Agriculture must be prepared for drier conditions than today. Especially the summer rainfall decrease will result in a need for drought - resistant species.

To summarizie the results of the climatic changes, it may be concluded in general that

a) certain species of plants will disappear due to their insufficient competitive ability and adaptability, while others will take over; still existing plants will be transformed genetically, and the proportion of weeds will increase;

b) because of the increasing danger of drought (the present frequency of droughty months will rise by 60%), agrotechnology must utilize the changing conditions of soil moisture, and this must be reflected in the crop structure, e.g. potato growing will reach a critical situation, while viniculture will improve (Mika 1993);

c) the resistance of the vegetation against environmental risks must be improved: this involves biodiversity, as well as irrigation, melioration and changes of species of trees;
d)it is most important to consider the different consequences of a value-oriented planning strategy and one based on principles of equity; the former is based on a modern value judgement system, and the latter on a projected one, with the aim of ensuring the maintenance of development.

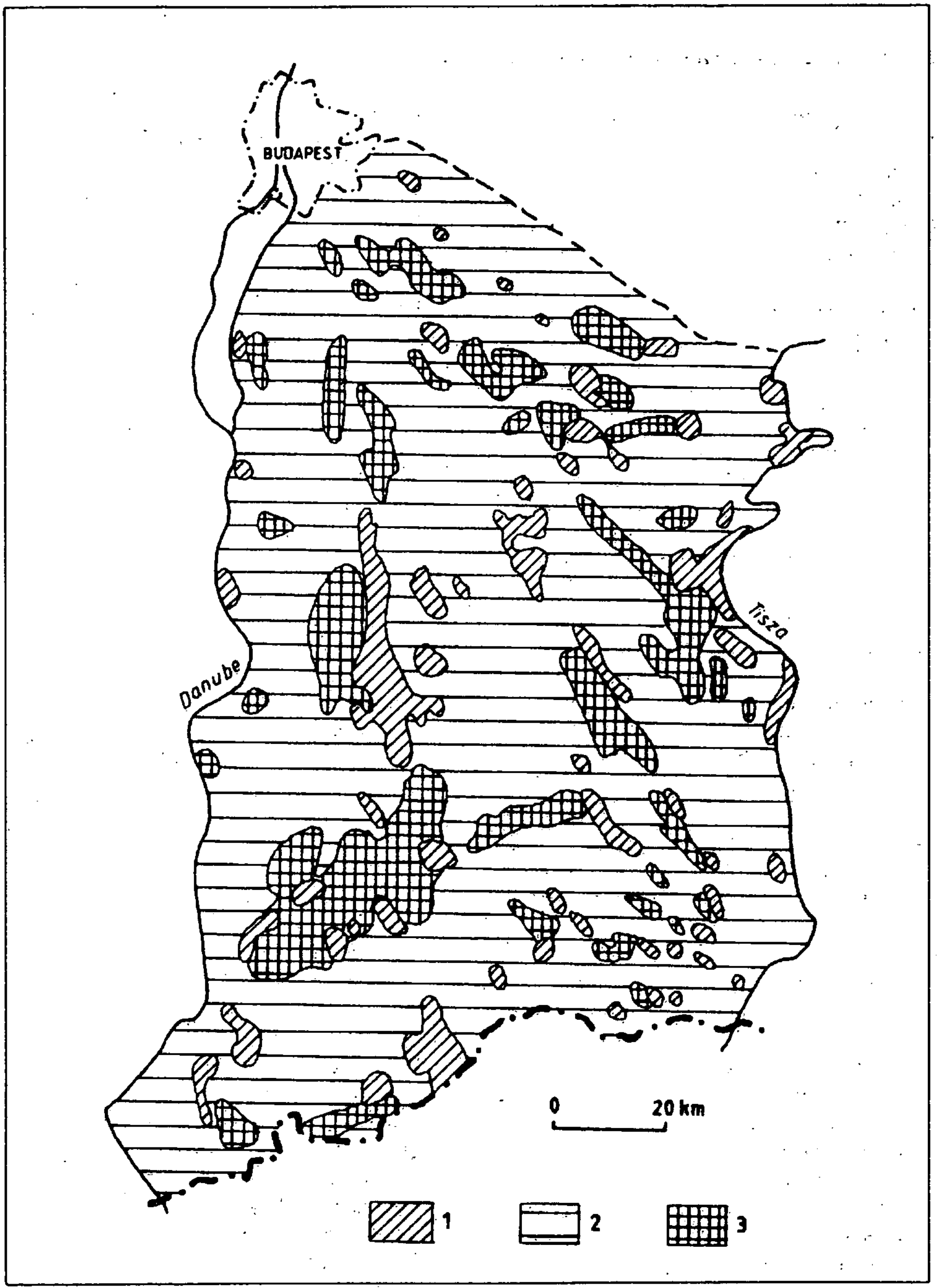

Figure 7 *Esimated change in use value from an ecological aspect in Danube - Tisza Interfluve. (1) Upgrade, (2) no fundamental change, (3) degradation*

APPENDIX

Oak forest with tatar maple on loess (Aceri tatarico - Quercetum pubescenti roboris)

Acer tataricum
A. campestre
Adonis vernalis
Ajuga laxmannii
Amygdalus nana
Anemone sylvestris
Betonica officinalis
Brachypodium pinnatum
B. sylvaticum
Cerasus fruticosa
Crategus monogyna
Dictamnus albus
Doronicum hungaricum
Euonymus verrucosus
Festuca rupicola
F. valesiaca
Filipendula vulgaris
Inula germanica
Iris variegata
Lithospermum purpureo-coeruleum
Melica altissima
muscari botryoides
Nepeta pannonica
Phlomis tuberosa
Polygonatum latifolium
Prunus spinosa
Quercus cerris
Qu. robur
Qu. petrea
Qu. pubescens
Rosa gallica
Thlaspi jankea
Ulmus minor
Vinca herbacea
Viola collina

Opened oak forest on sand (Festuco-Quercetum roboris)

Acer tataricum
Alkanna tinctoria
Allium sphaerocephalon
Amorpha fruticosa
Anemone sylvestris
Anthericum ramosum
Brachypodium sylvaticum
Calamintha clinopodium
Carex praecox
Crocus variegatus
Cornus sanguinea
Corylus avellana
Crategus monogyna
Cynanchum vincetoxicum
Elaeagnus angustifolia
Epipactis atrorubens
Euonymus europaeus
Festuca rupicola
F. vaginata
F. valesiaca
Filipendula vulgaris
Iris humilis ssp. arenaria
I. aphylla ssp. hungarica
Juniperus communis
Ligustrum vulgare
Melica transsylvanica
Peucedanum alsaticum
P. cervaria
Poa angustifolia
Poa nemoralis
Polygonatum odoratum
Populus alba
P. canescens
Pulsatilla hungarica
P. patens
Prunus spinosa
Polygonatum latifolium
Pyrus pyraster
Quercus pubescens
Qu. robur
Qu. cerris
Ranunculus illyricus
Salix rosmarinifolia
Stipa pennata
S.sabulosa

Juniper with poplar (Junipero-Populetum albae)

Rhamnus catharticus
Rubus caesius
Salix rosmarinifolia
Salvia pratensis
Senecio integrifolius
Seseli varium
Silene nutans
S. vulgaris
Solanum dulcamara
Solidago virga-aurea
Stellaria media
Stipa capillata
Taraxacum laevigatum
Teucrium chamaedrys
Thesium ramosum
Thalicrium minus
Thymus glabrescens ssp. subhirsutus
Tragopogon floccosus
Verbascum lychnitis
V. phoeniceum
Veronica spiccata
Vicia angustifolia
V. tetrasperma
Viola rupestris var. arenaria
V. hirta

Floodland forest with oak and ulmus (Fraxino pannonicae - Ulmetum)

Aegopodium podagraria
Allium ursinum
Alnus glutinosa
A. incana
Anemone ranunculoides
Brachypodium sylvaticum
Carex remota
C. strigosa
Cephalanthera rubra
C. longifolia
C. damasonium
Convallaria majalis
Cornus sanguinea
Corydalis cava
Corylus avellana
Crataegus monogyna
Epipactis helleborine
E. microphylla
Equisetum hyemale
Fraxinus angustifolia ssp. pannonica
F. excelsior
Gagea lutea
Galanthus nivalis
Galium odoratum
Hedera felix
Impatiens noli-tangere
Lilium bulbiferum
Lithospermum purpureo-coeruleum
Malus sylvestris
Orchis militaris
O. purpurea
Padus avium
Parietaria erecta
Populus alba
P. canescens
Polygonatum multiflorum
P. latifolium
Pulmonaria officinalis
Quercus robur
Sanicula europaea
Scilla bifolia
Ulmus laevis
U. minor
U. scabra
Viburnum opulus
Vinca minor
Vitis sylvestris

Closed oak forest on sand (Convallario - Quercetum roboris)

Acer campestre
Acer tataricum
Athryum filix-femina
Berberis vulgaris
Betula pendula
Brachypodium sylvaticum
Campanula bononiensis
Carex michelii
Convallaria majalis
Coridalis cava
Cornus sanguinea
Corylus avellana
Crategus monogyna
Dictamnus albas
Doronicum hungaricum
Dryopteris filix-mas
Euonymus europaeus
Ficaria verna
Gladiolus imbricatus
Inula salicina
Iris hungarica
Ligustrum vulgare
Lithospermum purpureo-coeruleum
Muscari botryoides
Ophys insectifera
Orchis purpurea
O. militaris
Platanthera bifolia
Poa nemoralis
Polygonatum latifolium
Populus alba
P. tremula
Pyrus pyraster
Quercus robur
Scilla vindobonensis
Tilia tomentosa
Ulmus minor
Viburnum lantana
Viola hirta

Juniper with poplar (Junipero-Populetum albae)

Achillea millefolium
Ajuga genevensis
Anthriscus cerefolium ssp. trichosperma
Asparagus officinalis
Berberis vulgaris
Brachypodium silvaticum
Bromus sterilis
Calamagrostis epigeios
Carex liparicarpos
C. flacca
Centaurea sadleriana
Cephalanthera rubra
Chondrilla juncea
Colchium arenarium
Conium maculatum
Coronilla varia
Crataegus monogyna
Cynoglossum hungaricum
Echinops ruthenicus
Euonymus verrucosus
Eryngium campestre
Euphorbia cyparissias
Farcaria vulgaris
Festuca rupicola
Fragaria vesca
Galium aparine
G. mollugo
G. verum
Juniperus communis
Koeleria glauca
Ligustrum vulgare
Lithospermum officinale
Lotus corniculatus
Medicago minima
M. falcata
Melandrium album
Muscari racemosum
Onosma arenaria
Phleum phleoides
Pimpinella saxifraga
Poa pratensis
Polygonatum odoratum
Potentilla arenaria
Populus alba
Prunella vulgaris
Prunus spinosa
P. mahaleb
Ranunculus acer

Floodland forest with willow and poplar (Salicetum albae-fragilis)

Agrostis stolonifera
Alnus glutinosa
A. incana
Carex gracilis
C. riparia
C. vesicaria
Galium palustre
Laecojum aestivum
Myosotis palustris
Phalaris arundinacea
Phragmites australis
Poa palustris
Polygonum Mite
Populus nigra
Rorippa amphibia
Rubus caesius
Salix alba
S. fragilis
Stachis palustris
Typhoides arundinacea
Ulmus laevis
Urtica dioica

Alkali sedge field (Agrosti-Caricetum distantis)

Achillea asplenifolia
Agrostis alba
Aster tripolium ssp. pannonicum
Bolboschoenus maritimus
Carex distans
C. paniculata
C. acutiformis
Centaurea pannonica
Cirsium brachycephalum
Dactylis glomerata
Eleocharis palustris ssp. uniglumis
Euphorbia palustris
Festuca arundinacea
Holoschoenus romanus
Inula britannica
Juncus articulatus
Lapidium crassifolium
Linum perenne
Lotus corniculatis ssp. tenuifolius
Ononis spinisa
Orchis laxiflora ssp. palustris
Poa trivialis
Plantago maritima
P. major
Polinia coerulea
Polygala comosa
Potentilla reptans
Ranunculus acer
Rhinanthus glaber
Rorippa silvestris ssp. kerneri
Sanguisorba officinalis
Serratula tinctoria
Taraxacum officinale
T. bessarabicum
Teucrium scordium
Thalictrum simplex var. galioides
Tetragonolobus siliquosus
Trifoliuimfragiferum

Alkali vegetation on solonchak (Lepidio-Camphorosmetum annuae)

Artemisia monogyna
Aster tripolium ssp. pannonicus
Camphorosma annua
Cynodon dactylon
Erophila verna
Festuca pseudovina
Kochia prostata
Lepidium crassifolium
L. cartilagineum
Limonium gmelini
Matricaria chamomilla
Plantago maritima
Polygonum aviculare
Potentilla arenaria
Puccinellia limosa
Sedum saxangulare
Statice gmelini
Suaeda maritima

Alkali vegetation on solonetz (Lepidio-Puccinellietum limosae)

Agrostis alba
Aster tripolium ssp. pannonicus
Bupleurum tenuissimum
Carex distans
Cerastium dubium
Champhorosma annua
Chenopodium glaucum
Cichorium intybus
Crypsis aculeata
Cynodon dactylon
Festuca pseudovina
Juncus compressus
Lepidium crassifolium
L. perfoliatum
Matricaria chamomilla
Nostoc commune
Phragmites communis
Plantago maritima
P. schwarzenbergiana
Puccinellia distans ssp. limosa
Spergularia marginata
Suaeda maritima
Taraxacum bessarabicum
Trifolium fragiferum

Alkali mud assotiation (Suaedetum maritimae hungaricum)

Crypsis aculeata
Chenopodium glaucum
Salicornia ramosissima
Suaeda maritima
S.pannonica

Alkali reedy (Boloboschoeno-Phragmitetum)

Agrostis stolonifera
A. alba
Artemisia maritima
Aster tripolium ssp. pannonicus
Atriplex hastata
Bolboschoenus maritimus
Chenopodium chenopodoides
Eleocharis uniglumis
Heliocharis palustris
Lotus corniculatus ssp. tenuifolius
Phragmites australis
Plantago maritima
Puccinellia distans
Spergularia marginata
Schoenoplectus tabernaemontani
Trifolium fragiferum

One year grassland on sand (Brometum tectorum secaletosum)

Anthriscus cerefolium subs. trichosperma
Arenaria serpyllifolia
Bromus squarrosus
B. sterilis
B. tectorum
Carex liparocarpos
Cynodon dactylon
Equisetum ramosissimum
Kochia laniflora
Medicago minima
Polygonum arenarium
Secale silvestris
Syntrichia ruralis
Tragus racemosus
Tribulus terrestris ssp. orientalis

Closed steppe on sand (Astragalo-Festucetum rupicolae)

Astragalus asper
A. exscapus
Althaea officinalis
Andropogon ischaemum
Carex praecox
Centaureum uliginosum
Chrysopogon gryllus
Cynodon dactylon
Crataegus monogyna
Festuca rupicola
F. pseudovina
Gagea pusilla
Iris humilis ssp. arenaria
Stipa capillata
S. sabulosa
Juniperus communis
Muscari racemosum
Ononis spinosa
Populus alba
Polygala comosa
Salvia pratensis
Veronica prostrata v nemorosa
Verbascum austricum
Verbascum lychnitis

Swamp meadow with Festuca (Festuco rupicolae - Salicetum rosmarinifoliae)

Anthericum silvestris
Anthyllis vulneraria ssp. polyphylla
Arabis recta
Asparagus officinalis
Asperula cynanchica
Astragalus austriacus
A. onobrychis
Botriochloa ischaemum
Bromus squarrosus
Calamagrostis epigeios
Campanula sibirica
Carduus nutans
Carex arenaria ssp. tauscheri
C. liparicarpos
Coronilla varia
Cynanchum vincetoxicum
Erigeron acris
Erophyla verna
Eryngium campestre
Euphorbia cyparissias
E. seguieiriana
Festuca rupicola
F. vaginata
Galium verum
Inula salicia v. denticulata
Iris humilis ssp. arenaria
Linaria genistifolia
Linum austriacum
Onosis spinosa
Medicago falcata
Muscari racemosum
Odontites lutea
Onobrychis aranifera
Phleum phleoides
Poa angustifolia
P. bulbosa
Potentilla arenaria
Salvia pratensis
Saxifraga tridactylites
Scorzonera purpurea
Secale silvestris
Seseli annuum
Stachys recta
Stipa capillata
Syrenia cana
Teucrium chamaedrys
Thesium arvense
Thymus marschallianus
Trogopogon floccosum
Verbascum lychintis
V. phoeniceum
Veronica prostata
Viola kitaibeliana

Opened grassland on sand (Festucetum vaginatae danubiale)

Achillea ochroleuca
Alkanna tinctoria
Alyssum tortuosum
Arenaria sarpyllifolia
Artemisia campestris
Astragalus varius
Calamagrostis epigeios
Calamintha acynos
Camelina microcarpa
Carex liparicarpos
Centaurea arenaria ssp. tauscheri
Colchium arenarium
consolida regalis
Crepis rhoeadifolia
Cynodon dactylon
Dianthus serotinus
D. pontederae
Echinops ruthenicus
Ephedra distacya
Equisetum ramosissimum
Erophila verna
Eryngium campestre
Euphorbia cyparissias
Festuca vaginata
Fumana procumbens
Galium verum
Gypsophila arenaria
Holoschoenus vulgaris
Iris humilis ssp. arenaria
Koeleria glauca
Linaria genistifolia
Medicago minima
Minuartia glomerata
Odontites lutea
Onosma arenaria
Phleum phleoides
poa angustifolia
Polygonum arenarium
Silene otites ssp. pseudotites
Stipa sabulosa
S. borysthenica
S. capillata
Sedum hillebrandtii
Salix rosmarifolia
Salsola kali ssp. ruthenica
Secale silvestris
Syrenia cana
Teucrium chamaedris
Tragopogon floccosum
Thymus marschallianus
Tragus racemosus
Verbascum lychnitis

Noncalcareous grassland on sand (Festuco-Corynephoretum)

Festuca vaginata
Corynephorus canescens
Kochia laniflora
Jasione montana
Rumex acetosella

Alkali meadow with Puccinella (Puccinellietum limosae)

Agrostis alba
Aster tripolium ssp. pannonicus
Juncus gerardi
Lepidium crassifolium
Plantago tenuiflora
P. maritima
P. schwarzenbergiana
Polygonum aviculare
Puccinela limosa
Scorzonea cana
Taraxacum bessarabicum
Triglochin maritimum

Boggy-sedge with Menyantes (Carici-Menyanthemum)

Agrostis alba
Carex elata
Cirsium palustre
Comarum palustre
Dactylorhiza incarnata
Dianthus superbus
Epipactis palustris
Eriophorum vaginatum
Glycerina maxima
Iris sibirica
lysimachia vulgaris
Menyanthes trifoliata
Phalaris arundinacea
Senecio paludosus
Valeriana officinalis

Whither swamp meadows (Succiso-Molinietum coeruleae)

Agrostis alba
Anacantis pyramidalis
Achillea asplenifolia
Briza media
Carex distans
C. panicea
Cirsium rivulare
C. oleraceum
Dianthus superbus
Festuca arundinacea
Galium boreale
Genista tinctoria
Gentiana pneumonanthe
Leontodon hispidus
Lysimachia vulgaris
Molinia coerulea
Pinguicula vulgaris
Poa trivialis
Potentilla erecta
Ranunculus acris
Sanguisorba officinalis
Serratula tinctoria
Succisa pratensis
Tetragonolobus maritimus

Swamp meadow with Molinia (Molinio-Salicetum rosmarinifolie)

Agrostis alba
Achillea millefolium
Carex flacca
Festuca pseudovina
Galium verum
Holoschoenus vulgaris
Leontodon autumnalis
Molinia coerulea
Ononis spinosa
Potentilla reptans
Salix rosmarinifolia
Schoenus nigricans
Tetragonolobus maritimus

Swamp meadow with Juncus (Juncetum subnodulosi)

Blysmus compressus
Caltha palustris
Carex acutiformis
C. elata
C. hirta
C. lepidocarpa
C. riparia
Deschampsia caespitosa
Euphorbia palustris
Eleocheris palustris
E. quenqueflora
Eriophorum angustifolium
E. latifolium
Equisetum palustre
Galium uliginosum
G. palustre
Gratiola officinalis
Iris pseudacorus
Juncus inflexus
Juncus subnodulosus
Mentha aquatica
M. longifolia

Orchis laxiflora ssp. palustris
Poa trivialis
Ranunculus bulbosus
R. repens
Sanguisorba officinalis
Scutellaria hastifoli
Scorzonera parviflora
Schoenoplectus lacustris
S. tabernaemontani
Taraxacum paludosum
Tatragonolobus maritimus
Thrincia nudicantis
Triglochin maritimum
Typhoides arundinaceaa
Valeriana dioica

Swamp meadow with Schoenus (Schoenetum nigricantis)

Carex flacca
C. lepidocarpa
C. leporina
C. panicea
C. vulpina
Cirsium brachycephalum
Equisetum palustre
E. variegatum
Hypericum tetrapterum
Parnassia palustis
Scorzonera humilis
S. hispanica
S. parviflora
Senecio paludosus var. tomentosus
Schoenus nigricans
Valeriana dioica
Veratrum album
Iris sibirica
Iris spuria
I. pseudocarpus
Orchis laxiflora ssp. palustris
O. incarnata
O. militaris
O. morio
O. coriophora
Phragmites
Potentilla erecta
Polygala comosa

Loess pusta with Achillea (Achilleo-Festucetum pseudovinae)

Achillea collina
A. setacea
Alopecurus pratensis
Artemisia monogyna
Carex ctenophylla
C. praecox
Eryngium campestre
Euphorbia cyparissias
Festuca pseudovina
Inula britanica
Limonium gmelini
Lotus corniculatus
Medicago falcata
M. lupulina
Melandrium viscosum
Mentha pulegium
Ornithogalum gussonei
Poa bulbosa
Ranunculus pedatus
Scorzonera cana
Trifolium campestre
T. dubium
T. retusum
T. striatum
Veronica orchidea

Alkali pusta with Artemisia (Artemisio-Festucetum pseudovinae)

Aster tripolium ssp. pannonicus
Artemisia maritima ssp. monogyna
Achillea collina
Camphorosma annua
Eragrostis pilosa
Festuca pseudovina var. salina
Gypsophila muralis
Hordeum hystrix
Inula britanica
Lepidium crassifolium
Limonium gmelini
Mentha pulegium
Matricaria chamomilla var. salina
Plantago tenuiflora
P. maritima
Poa bulbosa var. vivipara
Puccinellia limosa
Rorippa silvestris ssp. kerneri
Scorzonera cana
Trifolium angulatum
Statice gmelini

Weed assotiation of river-bed (Chenopodium fluviatile)

Ambrosia elatior
Bidens tripartitus
Calystegia sepium
Chenopodium album
Ch. polyspermum
Cyperus fuscus
Echinochloa crusgalli
Equisetum palustre
Matricaria inodora
Polygonum hydropiper
P. lapatifolium
Stachys palustris
Veronica anagalloides
Xanthium strumarium
X. italicum
X.riparium

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