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Vegetation of Külső-Somogy in Hungary I Regional diversity and pattern of woody habitats at landscape scale

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Abstract: In this study occurrence, proportion and landscape pattern of woodlands are analysed in Külső-Somogy based on MÉTA method at landscape scale. Relative importance of woody habitat types represent more than the half of the total number of habitats listed for Hungary in this region. Semi-natural woodlands have the relative greatest area, among them riverine swamp and mesic woodlands are dominating (J+K+P habitat types) in the central and western part of the region. Dry woody habitat types are in subordinated position in the central-northern and south-eastern parts (L habitat types), shrubs are concomitants or substituents of semi-natural habitat patches (P habitat types). In landscape elements which are poor in woodlands uncharacteristic woody habitats and dry woodland fringes (R and M habitat types) are significant. Regional land and forest management ought to have preserve actual condition of woodlands in Külső-Somogy.

Keywords: GIS database, MÉTA method, habitat patches, woodlands, landscape ecology

Introduction

Külső-Somogy is a characteristic hilly landscape in the middle of Transdanubia belonging to Kaposense and Somogyicum phytogeographical regions of Hungary. This landscape is the least revealed and documented area in Transdanubia according to its flora and vegetation. Published botanical data of species of (semi-)natural vegetation stands are sporadic (HORVÁT 1943, KEVEY and HORVÁT 1986, KEVEY 1988, 1989, 1993, 1995, 2001). Reference points for the southern and western zones of Külső-Somogy region are basic or correspondent vegetation descriptions and analyses of the sorrounding areas (e.g. Zselic, Belső-Somogy e.g. Borhidi 1984, Juhász 2005). Results of complex botanical mapping and research started in the last decade (BARTHA et al 2002) would be presented as reference verifying and finding new occurrences of plant species (e.g. KIRÁLY 2007) or as corresponding analyses of semi-natural vegetation. In our work, as a first study of a landscape series, we present and evaluate characteristic woody habitat types and groups, their patches with areal data and spatial patterns in Külső-Somogy region at landscape scale. Analyses are implemented with MÉTA method and mapping

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(GIS database for Hungarian Habitats, Magyarországi Élőhelyek Térképi Adatbázisa, HORVÁTH et al. 2008) based on a landscape ecology oriented protocol fitted to the whole territory of Hungary (BÖLÖNI et al. 2003, 2007, MOLNÁR et al. 2007).

Material and method

Külső-Somogy region (Fig. 1) is located south from Lake Balaton, bordered by Kapos river, Sió channel and Pogány valley in the territory of Somogy and Tolna counties. Its total extension is 3000 km^2, mean altitude is 186 m a.s.l., 200-300 m a.s.l. especially on the ridges of the hills. The bedrock is limestone covered by loess on the surfaces of the crests trended to north-south direction. In the western part of the area (Nyugat-Külső-Somogy) the ridges of the hills are exposed to erosion and derasion. The eastern part of the region (Kelet-Külső-Somogy) is dissected with valleys parallel to Lake Balaton and the south part of it (Dél-Külső-Somogy) is a horizontal loess plateau with moderate slope to Kapos river. Running through the main north-south valleys, Jaba stream and Koppány stream flow from west to east. According to the data of meteorological stations (Szabadhídvég, Kaposvár) mean temperature is -2.5 C° in January, +20.5 C° in July, sum of precipitation is 650 mm per year. There are some cities and many small villages, so Külső-Somogy is not a frequent region from economical point of view (MAROSI and SOMOGYI 1990). On the basis of drought-sensitivity index some vegetation types existing in south-eastern part of the region could be endangered in climatically dry periods (NÉMETH et al. 2004).

Mesophilous and riverine forest vegetation types in Külső-Somogy were widely distributed in the last centuries. Stands of lowland oak-hornbeam woodlands (e.g. *Fraxino pannonicae-Carpinetum* Soó & Borhidi in Soó 1962), oak-hornbeam woodlands (e.g.

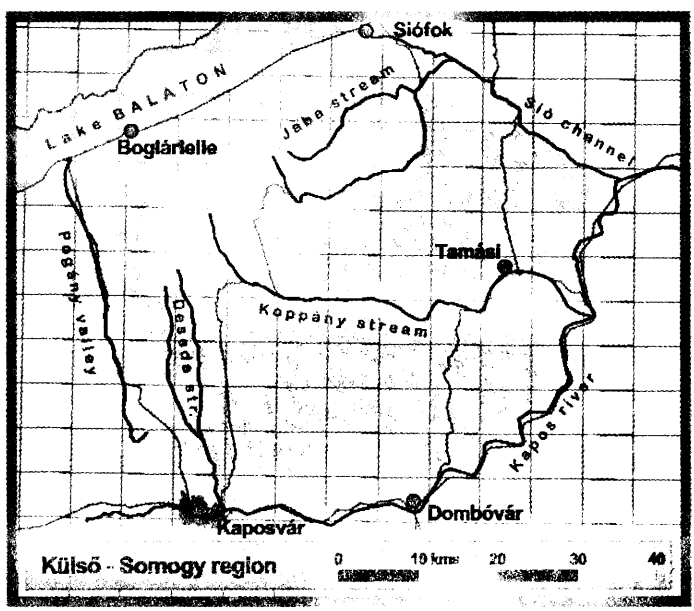

Fig. 1. Territory, settlements, geographical and hydrological elements of Külső-Somogy

Helleboro dumetorum-Carpinetum Soó & Borhidi in Soó 1962) and riverine oak-elm-ash woodlands (e.g. *Knautio drymeiae-Ulmetum* Borhidi & Kevey 1996) were the most frequent. Riverine ash-alder woodlands and alder galleries (e.g. *Carici elongatae-Alnetum* Koch 1926, *Carici brizoidis-Alnetum* Horv. 1938 em. Oberdf. 1953), swamp woodlands (e.g. *Angelico sylvestris-Alnetum* Borhidi in Borhidi & Kevey 1996) were characteristic along the rivers and the streams. Several patches of beechwoods existed in extrazonal position (e.g. Vicio oroboidi-Fagetum Pócs & Borhidi 1960). The main vegetation type of dry continental woodlands was the turkey oak woodland (e.g. *Potentillo micranthae-Quercetum dalechampii* Horvát A.O. 1981). Nowadays most of woodland patches are fragmented and poor in species, they are transitional stands between the vegetation of the sourrounded Zselic, the Great Hungarian Plain and Mecsek mountains (BORHIDI 1984, 2003, 2006).

The woodlands of Külső-Somogy region belong to the State Forestry of Szántód (Sefag Rt.). Managed woodland patches have great species richness in different status of naturalness due to traditional intensive land use and reforestration. The main natural woody species are oaks (*Quercus cerris, Q. petraea, Q. robur, Q. pubescens*), beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), limes (*Tilia tomentosa, T. platyphyllos*), maples (*Acer campestre, A. platanoides, A. pseudo-platanus*), ashes (*Fraxinus ornus, F. excelsior*), elms (*Ulmus minor*), common alder (*Alnus glutinosa*), willows (e.g. *Salix alba*). Frequent non-natural or introduced species are black locust (*Robinia pseudo-acacia*), pines (*Pinus sylvestris, P. nigra, Picea abies, Larix decidua*), poplars (*Populus* spp.), walnut (*Juglans nigra*), red oak (*Q. rubra*), maple (*Acer negundo*) and tree-of-heaven (*Ailanthus altissima*) (www.sefag.hu).

Data collection

Field data collection was executed between 2003-2006 as a grid-based, satellite-image supported (SPOT4), multi-attributed, large-scale mapping method so called MÉTA (Molnár et al. 2007). It is based on Á-NÉR2003 mapping and habitat guides (MOLNÁR 2003, BÖLÖNI et al. 2003). The goals were: 1) collecting data of all natural and semi-natural habitat types in Hungary 2) creating maps of semi-natural vegetation patches and 3) evaluating landscapes with vegetation types and their attributes as well. The database is constructed on a hexagon grid system of 35 hectars covering the whole area of Hungary as mapping units (HORVÁTH et al. 2008). Approximately 100 hexagons are associated into a quadrat at landscape scale. In hexagons habitat types, roughly estimated areas and vegetation attributes are listed (e.g. naturalness, neighbourhood, land use). This database is suitable to determine natural-based habitat quality and to compose the prognosis of future changes for vegetation and landscape. See MOLNÁR et al. (2007) for more details.

Data analysis

In our work we present landscape characteristics and habitat types of woodland vegetation in Külső-Somogy region. On the basis of MÉTA method a non-statistical quantitative analysis and evaluation was carried out on one hand, spatial thematic maps were constructed for displaying the actual semi-natural habitats and their spatial patterns at broad (landscape) scale on the other. Occurrence and relative areal proportion of woody habitat types and habitat groups were calculated and compared to each other. Habitat diversity was defined as the number of habitats or the occurrence of their landscape patches. Associated habitat groups were displayed on GIS thematic maps with additional layers (settlements, hydrological and geographical elements) using ESRI ArcView 3.3 program from valid hexagons of 99 quadrats. Habitat types in hexagons of 6 quadrats were estimated by the aerial photo owing to missing data.

Basic woody habitat types and their abbreviations: J1a: Salix cinerea mires, J2: Alder and ash swamp woodlands, J5: Riverine ash-alder woodlands, J6: Riverine oak-elm-ash woodlands, K1a: Lowland oak-hornbeam woodlands, K2: Oak-hornbeam woodlands, K5: Beech woodlands, L1: Closed termophilous oak woodlands, L2a: Turkey oak-sessile oak woodlands, L2b: Turkey oak-pedunculate oak woodlands, L2x: Closed and mixed steppe oak woodlands on foothills, L5: Closed lowland steppe oak woodlands, Ly1: Ravine woodlands, M2: Open loess steppe oak woodlands with openings, M8: Thermophilous woodland fringes, P2a: Mesic shrub vegetation, P2b: Dry shrub vegetation with Crataegus, Prunus spinosa and Juniperus, P45: Wooded pastures and sweet chestnut woodlands, P7: Extensive orchards with ancient cultivars, 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 in accordance with MÉTA guide (Bölöni et al. 2007). Habitat groups and their abbreviations are: J-group: J1a + J2 + J5 + J6, K-group: K1a + K2 + K5, L-group: L1 + L2a + L2b + L2x + L5 + Ly1, M-group: M2 + M8, P-group: P2a + P2b + P5 + P7, R-group: RA + RB + RC + RD. Finally we introduced a new habitat variable 'associated habitat group' forming riverine, swamp and mesic woodlands: J-group + K-group, dry or/and rocky woodlands: L-group, (semi)-natural bush vegetation: P2a + P2b, uncharacteristic woody habitats: R-group.

Taxonomical nomenclature is by SIMON (2000), syntaxonomical nomenclature is by BORHIDI (2003), habitat nomenclature is by BÖLÖNI et al. (2007).

Results

Habitat types and diversity

Totally 48 habitat types are identified in Külső-Somogy region, together they represent more than the half of the total number of habitats listed for Hungary (55,8%). Among them 23 types are attached to the stands of woodlands and shrubs, so the relative importance of woody habitat types is high (47,9%). Summarized area of woody habitat types compared to the geographical area of the region is 11,2%, divided into 10,4% for the woodlands and 0,8 % for the shrubs. Participation of woodlands in sum of vegetation cover is 76,8%, divided into 71,7% for the forests and 5,1 % for the connecting shrubs.

The total area of woodlands is 32500 hectares, including shrub habitat types that is less than a tenth part of the sum (7%). The greater part of woody vegetation stands represent semi-natural woody habitat types attached to J, K, L, M habitat groups (55%). It could be divided into two additional parts: associated groups of mesic and dry woody habitats with their appropriate shrub habitats. Between them mesic woody habitats attached to J, K and P2a habitat types are dominating (44%), the associated group of dry habitats attached to L and P2b habitat types is in subordinate position (17%). The lesser part of habitats is the associated habitat group attached to R and M habitat types represent non-natural woody vegetation patches and plantations (38%). It is concluded that vegetation stands of mesic, semi-natural habitat types are the most important in the region (Table 1).

Analysing and comparing woody habitat types and groups (Fig. 2) oak and ash woods dominated mesic woodlands have the greatest area proportion (30%). In K habitat group oak-hornbeam woodlands (K2, 8957 ha, 21%) and lowland oak-hornbeam woodlands (K1a, 3648 ha, 9%) occur with the largest percentage. Ratio of beech woodland stands

Table 1. Area and relative proportion of woody habitat types in Külső-Somogy. *Shrub habitat types are excluded, **related shrub habitat type is included

associated habitat type	sum of woody habitats	semi-natural woody habitats	disturbed woody habitats	shrub habitats	mesic semi-natural woody habitats	dry semi-natural woody habitats
habitat group(s)	J+K+L+M+P+R	J+K+L *	R+M *	P	J+K+P **	L+P **
area (ha)	32500	17881	12457	2172	14288	5611
proportion (%)	100	55	38	7	44	17

are scattered in the land (K5, 332 ha, 0,8%). Uncharacteristic woody habitats have the second greater proportion (R habitat group, 12455 ha, 29%), containing several habitat types with native, non-native and cultivated tree species. Among them uncharacteristic hardwood woodlands and plantations have the greatest ratio (RC, 5493 ha, 13%), similar to uncharacteristic woodlands and plantations mixed with non-native tree species (RD, 4944 ha, 12%). Scattered native trees or narrow tree lines (RA, 275 ha, 0,7%) and the uncharacteristic (often pioneer) softwood woodlands and plantations (RB, 1743 ha, 4%) have insignificant contribution to R habitat group. The third important habitat group is the dry, light-rich decidous and rocky woodlands (4542 ha, 11%). In L habitat group turkey oak-sessile oak woodlands (L2a, 3565 ha, 8%) occur with the largest percentage. The second most important habitat type is turkey oak-pedunculate oak woodland (L2b, 745 ha, 1,8%). Thirdly the closed termophilous oak woodlands (L1, 136 ha, 0,3%) have only some little fragmented patches on the southern slopes. Special and rare habitat types are the closed and mixed steppe oak woodlands on foothills (L2x, 90 ha, 0,2%), the closed lowland steppe oak woodlands (L5, 4 ha) and the relict stands of ravine woodlands (LY1, 1,75 ha). The fourth habitat group is the shrub types in various sites (P group, 2172 ha, 6,7%), containing several types of shrubs from forest edges to extensive plantations or woody pastures. The two largest habitats in this group are the mesic shrub vegetation (P2a, 1084 ha, 2,6%) accompanying or substituting mesic and riverine woodlands and dry shrub vegetation with *Crataegus, Prunus spinosa* and *Juniperus* species

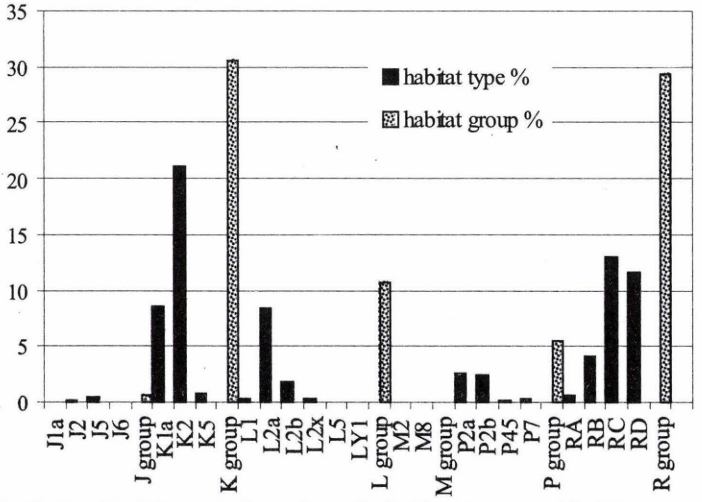

Fig. 2. Territorial proportion of woody habitat types and habitat groups in sum of vegetation cover in Külső-Somogy region

(P2b, 1068 ha, 2,5%) as a secondary habitat type. Wooded pastures and sweet chestnut woodlands (P45, 48 ha, 0,1%) and extensive orchards with ancient cultivars (P7, 86 ha, 0,2%) are included in P habitat group as habitat fragments with small extensions. Swamp and riverine woodlands influenced by permanent water table have very small proportion in spite of their importance in potential vegetation (J habitat group, 281 ha, 0,7%). The main habitat types in the group are riverine ash-alder woodlands (J5, 200 ha, 0,5%), in small extension alder and ash swamp woodlands (J2, 43 ha, 0,1%), Salix cinerea mires (J1a, 14 ha) and riverine oak-elm-ash woodlands (J6, 23 ha) are occured in Külső-Somogy region.

Roughly estimated area of habitat types or groups and occurrences of them could give information about vegetation patch statistics for 99 quadrats and average occurence per quadrat (Fig. 3). In the database 5341 occurrences were recorded for 23 woody habitat types exsisting at least with one case in every valid quadrat. In the first series we could analyse the occurrence percentage for the habitats and groups. The most distinct and related vegetation patches are revealed in case of R habitat group (2501 cases, 47%) especially. The number of occurrences and their proportion decreases in order to RD (811 cases, 15%), RB (706 cases, 13%), RC (678 cases, 13%) and RA (306 cases, 5,7%). The second large ocurrence and percentage of habitat patches have in mesic woodlands (1147 cases, 21%) with oak-hornbeam woodlands (K2) which have the greatest occurrence number and proportion (761 cases, 21%). Calculated data of P habitat group are comparable to the statistics of K group (1104 cases, 21%) with the largest occurrence proportion of mesic shrub vegetation (P2a, 698 cases, 13%). Occurrence proportion of dry deciduous woodlands habitat group is less than 10% (492 cases) with the greatest occurence percentage of turkey oak-sessile oak woodlands (L2a, 379 cases, 7%). Patches proportion of J and M habitat groups are not remarkable. In the second series average number of patches per quadrat for valid stands could be compared among habitat types and groups. Among habitat groups K, R and P have the largest occurrence number per quadrat (11,4; 10,8; 5,7), M habitat types (2,4) have the lowest one. Between

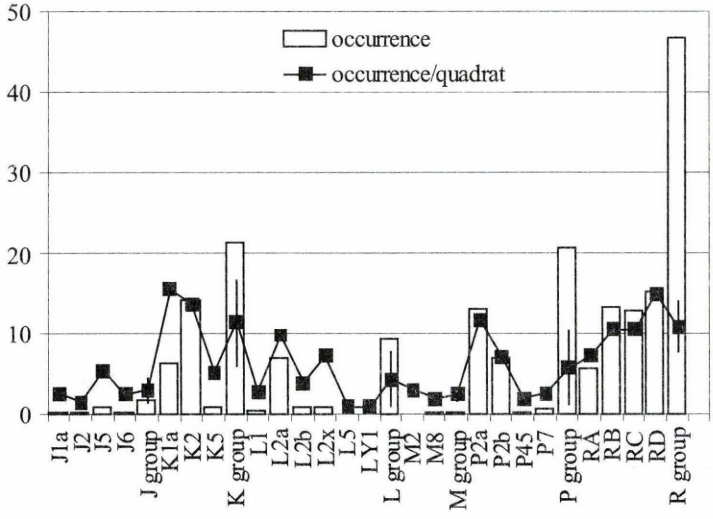

Fig. 3. Patches distribution of woody habitat types and habitat groups in Külső-Somogy. Occurrence: percentage of cases in 99 quadrats, occurrence/quadrat: mean number of patches per valid quadrats with standard deviation in habitat groups

habitat types K1a, RD, K2 and P2a have the greatest occurrence number per quadrat in the region (15,4; 15; 13,6; 11,6).

Spatial patterns at landscape scale

In order to display main features of habitat types and habitat groups (e.g. occurrence, spatial distribution) thematic maps were constructed. These maps emphasize spatial variation of one or a small number of series of target attributes. In the first step quality and territorial extension of habitat types and groups were calculated on a previously standardized consensus scale (<2 ha, 2-15 ha, 15-200 ha, 200-500 ha, >500 ha). Data calculation was based on valid hexagons, spatial habitat maps were displayed at quadrat level referred to a GIS database. According to the map of significant associated habitat groups were constructed which could visualize the variability of woody habitat types and groups classed among: 1) riverine, swamp and mesic woodlands, 2) dry and rocky woodlands, 3) uncharacteristic woody habitats.

In the first map the three main associated habitat groups are displayed in connection with managing and land-use types: the semi-natural woodlands and uncharacteristic plantations (Fig. 4). Distribution of regional woodland habitats is uneven, the majority of vegetation patches are found in central and western part of Külső-Somogy. Riverine, swamp and mesic woodlands are the dominating habitats all over the quadrats which have medium or large cover of woody habitats, especially along the Koppány stream. In the quadrats including small woody patches the proportion of uncharacteristic woody habitat types is the most important. Occurrence of dry and mesic woodlands is considerable in the central-northern and south-eastern parts of the region.

By further detailed analysis of riverine, swamp and mesic woodlands the oak-hornbeam woodlands (K1a+K2 habitat types) have the largest proportion in this associated habitat group (Fig. 5). Great ratio of K2 is generally characteristic in woody-rich land

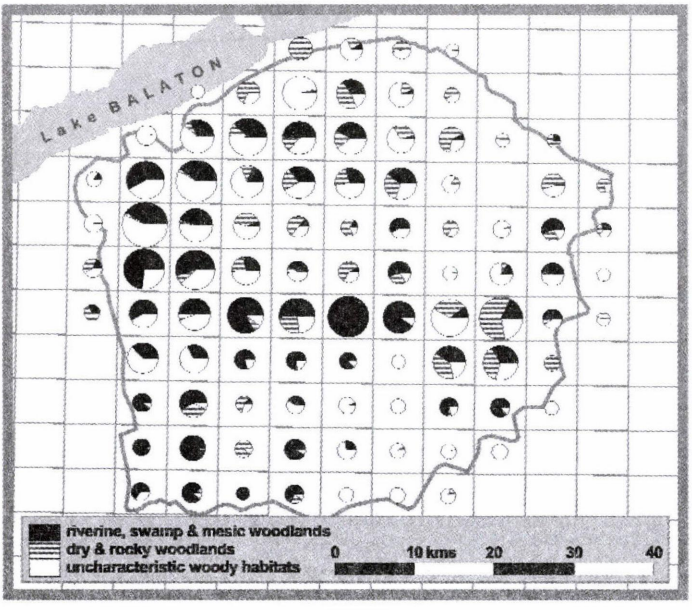

Fig. 4. Territorial extension (circle diameter) and proportion (circle segment) of main associated habitat groups in Külső-Somogy. Related shrub habitat types are excluded

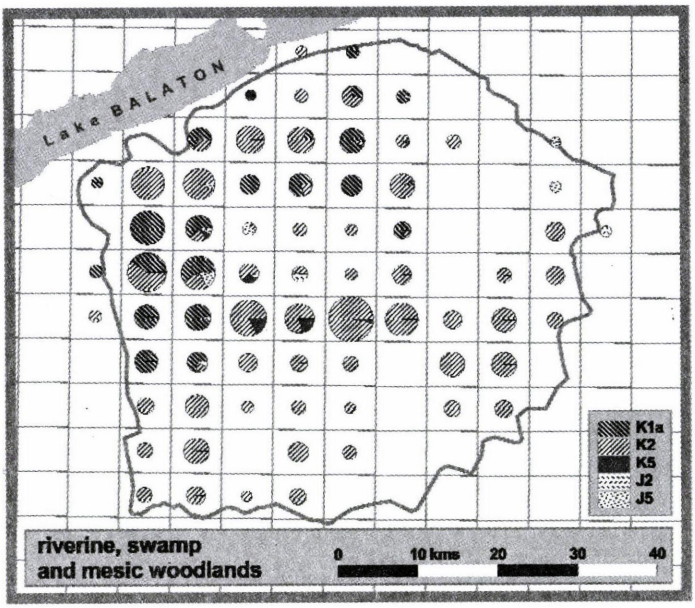

Fig. 5. Territorial extension (circle diameter) and proportion (circle segment) of riverine, swamp and mesic woodland habitats in Külső-Somogy.

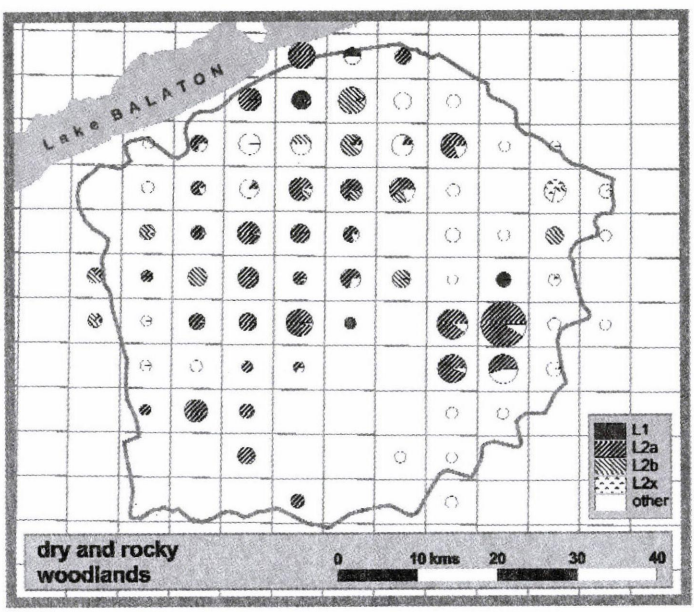

Fig. 6. Territorial extension (circle diameter) and proportion (circle segment) of dry and rocky woodland habitats in Külső-Somogy

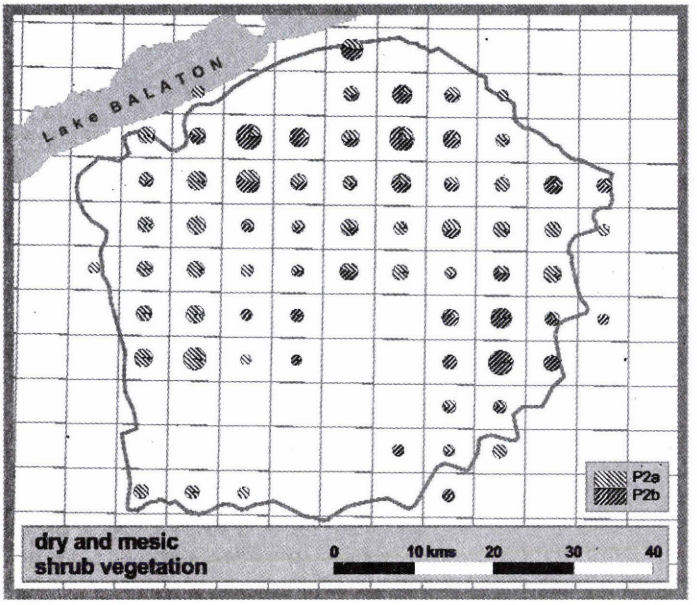

Fig. 7. Territorial extension (circle diameter) and proportion (circle segment) of shrub habitat types in Külső-Somogy.

elements (quadrats). Occurrence of K1a is located along Jaba stream on the northern and by the side of Pogány valley on the western part. Relict stands of beech woodlands (K5 habitat type) are positioned within a small territory along the Koppány stream. Riverine and swamp woodlands (J2+J5 habitat types) influenced by permanent water table are found along the network of small streamlets. Southern and eastern parts of Külső-Somogy region are homogenous according to the diversity of woody habitat types, the central, northern and western parts are more heterogenous by them displaying 2-5 mesic habitat types per quadrat.

As for special and relative rare habitat types and groups of dry and rocky woodlands Külső-Somogy region is diverse according to them (Fig. 6). Pattern of dry woody habitat types concentrate to the central-northern-west and to southern-east parts. The major component of them is the turkey oak-sessile oak woodland (L2a). Quadrats which have medium or large cover of dry or rocky woody habitats are less diverse by habitats, quadrats which include small summarized territories of woody patches are more diverse with 2-5 habitat types per quadrat.

In spatial map of shrub vegetation two types of habitats are distinguished: mesic shrub (P2a) and dry shrub (P2b) (Fig. 7). Their areal distribution pattern could be categorized into three cases. In the western part of Külső-Somogy mesic shrub vegetation patches, in the south-east part dry shrub vegetation and in the central part both of them dominates. Among shrub habitat types dry mesic shrub is spatially stronger connected with landscape pattern of dry and rocky woodlands than mesic shrub habitat type with mesic woodlands.

Discussion

In our study we have discussed the areal proportion, distribution and regional spatial patterns of woody habitat types at landscape scale in Külső-Somogy. Analysing regional extension data, more than a half territory of woodlands is covered by semi-natural woody vegetation, mainly by the mesic woody habitats. Uncharacteristic or disturbed woodlands have the second major areal proportion in the region. Dry semi-natural woody habitat types are in subordinated position principally in the central-northern and south-eastern parts. Shrub habitats are concomitants or substituents of semi-natural habitat patches.

Studying spatial attributes it is established that quadrats with larger summarized territory of woodlands have a larger proportion of semi-natural woody habitat types. Parts having less woodland territories are rich in uncharacteristic woody stands. Habitat diversity is bigger in woody-rich quadrats in the case of mesic woodlands while habitat diversity is smaller in woody-poor quadrats in the case of dry and rocky woodlands. The actual hydrological status is not determining the occurrence of woody habitat types or patches distribution with exception of certain habitat types (e.g. beechwoods). Outside parts along the Sió channel and Kapos river are really poor in any kind of woodlands. Settlements of Külső-Somogy are not seemed to be the hampering or endangering factors for woodland existence or spreading. After all we could presume that spatial patterns of woody habitat types are influenced by not the natural but the human impacts like land use and forest management.

Acknowledgements

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References

BARTHA D., KIRÁLY G. and MOLNÁR ZS. 2002: Magyarország természetes növényzeti örökségének felmérése és összehasonlító értékelése. - In: SALAMON-ALBERT É. (ed.): Magyar botanikai kutatások az ezredfordulón. PTE Növénytani Tanszék, Pécs, pp. 309-342.

BORHIDI A. 1984: A Zselic erdei. - Studia Pannonica (Dunántúli Dolgozatok) (A) Series Historico-Naturalis (Természettudományi Sorozat), ISSN 0139-0805, pp. 1-145.

BORHIDI A. 2003: Magyarország növénytársulásai. - Akadémiai Kiadó, Budapest, p. 610.

BORHIDI A. 2006: Dél-Dunántúl, Külső-Somogy. In: FEKETE G. and VARGA Z. (eds): Magyarország tájainak növényzete és állatvilága. - Magyarország az ezredfordulón, stratégiai tanulmányok a Magyar Tudományos Akadémián, MTA Társadalomkutató Központ, Budapest, pp. 386-387.

BÖLÖNI J., KUN A. and MOLNÁR ZS. 2003: Élőhelyismereti útmutató 1.0. "Magyarország növényzeti örökségének felmérése és összehasonlító értékelése" Adatminőség-ellenőrzési Munkacsoport. MTA ÖBKI Vácrátót, pp. 1-213.

BÖLÖNI, J., MOLNÁR ZS., ILLYÉS E. and KUN A. 2007: A new habitat classification and manual for standardized habitat mapping. - Annali di Botanica (nuova serie) 7: 55-76.

HORVÁT A. O. 1943: Külsősomogy és környékének növényzete. - Borbásia 6: 1-70.

HORVÁTH F., MOLNÁR ZS., BÖLÖNI J., PATAKI ZS., POLGÁR L., RÉVÉSZ A., KRASSER D. and ILLYÉS E. 2008: Fact sheet of the MÉTA Database 1.2. - Acta Botanica Hungarica (in press)

JUHÁSZ M. 2006: A Barcsi Borókás vegetációja és természetes erdőtársulásainak fitocönológiai elemzése. - PhD értekezés, Pécs, p. 96.

KEVEY B. 1988: Adatok Magyarország flórájának és vegetációjának ismeretéhez IV. - Botanikai Közlemények 74-75: 93-100.

KEVEY B. 1989: Adatok Magyarország flórájának és vegetációjának ismeretéhez V. - Botanikai Közlemények 76: 83-96.

KEVEY B. 1993: Adatok Magyarország flórájának és vegetációjának ismeretéhez VI. - Botanikai Közlemények 80: 53-60.

KEVEY B. 1995: Adatok Magyarország flórájának és vegetációjának ismeretéhez VII. - Botanikai Közlemények 82: 45-53.

KEVEY B. 2001: 1989: Adatok Magyarország flórájának és vegetációjának ismeretéhez VIII. - Botanikai Közlemények 88: 95-105.

KIRÁLY G. 2006. Kiegészítések Külső-Somogy edényes flórájának ismeretéhez. - Somogy Megyei Múzeumok Közleményei 17: 31-40.

MAROSI S. and SOMOGYI S. (eds) 1990: Magyarország kistájainak katasztere II. - MTA Földrajztudományi Kutató Intézet, Budapest, 479-513.

MOLNÁR ZS. (ed.) (2003): MÉTA módszertani és adatlapkitöltési útmutató (Guide on the methods of MÉTA and on the completion of the MÉTA datasheets). - MTA ÖBKI, Vácrátót.

MOLNÁR ZS., BARTHA S., SEREGÉLYES T., ILLYÉS E., BOTTA-DUKÁT Z., TÍMÁR G., HORVÁTH F., RÉVÉSZ A., KUN A., BÖLÖNI J., BÍRÓ M., BODONCZI L., DEÁK J. Á., FOGARASI P., HORVÁTH A., ISÉPY I., KARAS L., KECSKÉS F., MOLNÁR CS., ORTMANN-NÉ AJKAI A. and RÉV SZ. 2007: A grid-based, satellite-image suppported, multi-attributed vegetation mapping method (MÉTA). - Folia Geobotanica 42: 225-247.

NÉMETH Á., BELLA SZ. and SZALAI S. 2004: Aszályérzékenység vizsgálata térinformatikai eszközökkel. - http://www.otk.hu/cd03/1szek/Nemet-Bella-Szalai.htm

SIMON T. 2000: A magyarországi edényes flóra határozója, harasztok virágos növények. - Tankönyvkiadó, Budapest, pp. 1-846.