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VEGETATION TRANSFORMATIONS OF KUJAWY-POMERANIA REGION IN THE LAST TWENTY YEARS PERIOD

Abstract: This paper contents dynamic tendencies analysis results of Kujawy-Pomerania region (N Poland) for a 20-year time period. Acreage changes as well as structure and species composition transformations of forest and shrub vegetation (associations) and non-forest vegetation (alliances) were evaluated. Main factors influencing on regressive and progressive changes were set out. Analysis was relied on results of geobotanical research and observations of selected objects. Regressive changes were noted for i.a. thermophilous oak forests, dry and fresh coniferous forests, aquatic, halophytic, pasture vegetation, vegetation of *Molinion* and *Cnidion* meadows, heaths and xerothermic grasslands. Whereas progressive were observed in case of mixed coniferous forests, mesophytic shrubs, rush and tall herbs vegetation, fresh meadows and some ruderal communities.

Key words: causes of transformations, ecological processes, plant communities, vegetation dynamics

1. INTRODUCTION

Existence of plant cover dynamic tendencies is well-known. Plant species and plant communities reveal dynamics under the influence of various natural factors and diverse, variables in space and time, anthropogenic factors (MICHALIK 1974; OLACZEK 1976, SENDEK 1981; KUCHARSKI 1999; JUTRZENKA-TRZEBIATOWSKI

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1999; FALIŃSKA 2004). Researchers' interests in this matter focus both on species population dynamics (taxons' threats) as well as on transformations of ecosystems and plant communities in a broad sense.

Concluding basis about all vegetation changes constitutes among others a possibility of comparison of current state with the past state. Since in the last few decades in Poland intense phytosociological research were carried out, analyses of vegetation transformations are currently undertaken more often. It concerns both different types of plant communities as well as different regions of our country (KORNAŚ 1987; MICHALIK 1990a, b; KORNAŚ, DUBIEL 1991; ZARZYCKI, KORZENIAK 1992; JAKUBOWSKA-GABARA 1993; KUROWSKI 1993; BARABASZ 1997; ZAŁUSKI 2002; SUGIER, CZARNECKA 2004; BODZIARCZYK, DRAJEWICZ 2007; KAŹMIERCZAKOWA, GRODZIŃSKA 2007; KUROWSKI, MICHALSKA-HEJDUK 2007; MICHALSKA-HEJDUK 2007; WRÓBEL 2007; ZARZYCKI, KAŹMIERCZAKOWA 2007; MATUSZKIEWICZ 2007a, DURAK 2009; GRYNIA *et al.* 2009).

This paper is an attempt of knowledge balancing on the subject of natural and anthropogenic transformations of different vegetation types in Kujawy-Pomerania region. It is an original point of view on plant cover of this region because evaluations thereof dynamic tendencies rely not only on documentation but also on different objects' observations. For a clearer image of vegetation changes a relatively short period of time was adopted – a period of the last 20 years. At the same time, it is a period of other than previously performed forms of nature use resulting from different economic reality.

2. MATERIAL AND METHODS

An analysis of dynamic tendencies of vegetation was carried our for Kujawy-Pomerania province (N Poland) including some of its adjacent areas. It is a non-homogenous area in physicogeographical terms, constituting a part of few macroregions – South Pomeranian Lakeland, Wielkopolska Lakeland, Toruń-Eberswalde Glacial Valley, Lower Vistula Valley and Chełmno-Dobrzyń Lakeland (KONDRACKI 2000). Vegetation transformations analyses were performed for the last twenty years period.

Both, acreage changes and degree of structure species composition transformation of respected vegetation types were evaluated. Main factors influencing on regressive and progressive changes were set out. As a basic unit of forest and shrub vegetation unit an association was adopted, whereas of non-forest vegetation – an alliance. A setout of values and causes of changes was presented in tables.

Syntaxonomical classification of forest, meadow and partially ruderal vegetation was adopted according to MATUSZKIEWICZ (2005), spring vegetation according to HINTERLANG (1992), whereas other non-forest plant communities – according to BRZEG and WOJTERSKA (2001).

The analysis was relied on results of author's research and other authors' research and also on observations of selected, previously geobotanically identified objects. Numerous published and unpublished papers concerning both forest (i.a. KĘPCZYŃSKI, ZIELSKI 1976; ZIELSKI 1978; BERNDT, CEYNOWA-GIEŁDON 1988; ZIELONY 1988; KĘPCZYŃSKI, ZAŁUSKI 1991; CYZMAN, REJEWSKI 1992; BIAŁY, ZAŁUSKI 1994; ZAŁUSKI, GAWENDA 1999; JAGODZIŃSKI, MACIEJEWSKA-RUTKOWSKA 2005, 2008; PASZEK 2005; MATUSZKIEWICZ 2007b; CYZMAN, KANNENBERG 2008; CYZMAN 2009) and non-forest (i.a. WILKOŃ-MICHALSKA 1970; KĘPCZYŃSKI, ZAŁUSKI 1977, 1988; NORYŚKIEWICZ 1978; SAMOSIEJ 1987; KĘPCZYŃSKI, CEYNOWA-GIEŁDON 1988; KRASICKA-KORCZYŃSKA 1996; MARCYSIAK 1999; ZAŁUSKI *et al.* 2005, 2008; EJANKOWSKI, KUNZ 2006; KRASICKA-KORCZYŃSKA *et al.* 2008; RATYŃSKA 2008; WALDON, RAPACKA-GACKOWSKA 2010; KUNZ, NIENARTOWICZ 2010; NIENARTOWICZ *et al.* 2010) vegetation changes were used. For each analyzed syntaxonomical unit documented and observed changes in at least 5 objects were taken into account. A detailed documentation of performed analyses and evaluations is located in Department of Biology and Pharmaceutical Botany, Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń.

3. RESULTS AND DISCUSSION

Dynamic tendencies analysis of deciduous forests (Tab. 1) revealed that few plant communities from different phytosociological classes undergo distinct transformations.

Forest plant communities revealing regressive tendencies comprise eutrophic swamp forests *Ribeso nigri-Alnetum*, riparian poplar forests *Populetum albae*, higrophilous elm forests (*Ficario-Ulmetum minoris*, *Violo odoratae-Ulmetum*), oak-linden-hornbeam forests (*Tilio-Carpinetum*, *Galio-Carpinetum*) and thermophilous oak forests *Potentillo albae-Quercetum* (Tab. 1). About regressive tendencies of *Ribeso nigri-Alnetum*, including transformations of this plant community towards wet alder riparian forests *Fraxino-Alnetum*, decides mainly lowering from many years ground water level (cf. CYZMAN 2009). Riparian poplar forests *Populetum albae* have larger share of geographically alien species (i.a. *Acer negundo*, *Solidago gigantea*) and reveal transformations towards higrophilous elm forests *Ficario-Ulmetum minoris*. Higrophilous elm forests (*Ficario-Ulmetum minoris*, *Violo odoratae-Ulmetum*) reveal regression as a result of inundations which leads to changes towards oak-linden-hornbeam forest (cf. JAGODZIŃSKI, MACIEJEWSKA-RUTKOWSKA 2005, 2008; CYZMAN, KANNENBERG 2008). Oak-linden-hornbeam forests (*Tilio-Carpinetum*, *Galio-Carpinetum*) undergo degeneration (pinetization) as a result of coniferous trees introduction, which is a well-known process (OLACZEK 1974; ZIELSKI 1978; ZIELONY 1988; CYZMAN 1991). They also reveal gradual transformations as a result of abundant development of different deciduous trees or shrubs, which is a cause of strong shadowing of herb layer. Furthermore, they are exposed to danger of kenophytes' penetration (e.g. *Impatiens parviflora*). Heliophilous and thermophilous oak forests *Potentillo albae-Quercetum*, which can be acknowledged as the most endangered forest community (cf. JAKUBOWSKA-GABARA 1993), undergo analogical transformations. Changes occurring in their phytocoenoses are very clear and follow generally in a quick pace.

Table 1. Transformations of deciduous forest vegetation. Changes of area: –1 - small decrease; –2 - distinct decrease; 0 - lack of changes or small changes; +1 - small increase; +2 - distinct increase; ? – disputable assessment. Changes of structure and species composition: ↓ - small changes due to regression/degeneration; ↓↓ - distinct changes due to regression/degeneration; ↔ - lack of changes or small changes; ↑ - small changes due to succession/regeneration; ↑↑ - distinct changes due to succession/regeneration; ? - disputable assessment. Main causes: aff - afforestation; asexp - alien species expansion; asint - alien species introduction; bua - built-up areas; csint - coniferous species introduction; eh - eutrophication of habitats; fe - fishpond establishment; ff - forest felling; fl - floods; freg - forest regeneration; gwld - ground water level decrease; nrp - natural regression processes; nsp - natural succession processes; saf - shadowing by adjacent forests; ssuccu - secondary succession due to cessation of use; ssw - secondary swamping; tbulb - technical building up of lake banks; tburb - technical building up of river banks; tm - treestand monotypization; tr - trampling; tru - tourist and recreation use.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Alnetea glutinosae Br.-Bl. et R. Tx. 1943; *Alnion glutinosae* (Malc. 1929) Meij. Drees. 1936				
Ribeso nigri-Alnetum Sol.-Górn. (1975) 1987	–2, 0, +1	↓↓↔↑	bua, fe, ff, gwld, nrp	freg, nsp, ssuccu, ssw
Sphagno squarrosi-Alnetum Sol-Górn. (1975) 1987	–1, 0, +1	↓↔↑	eh, gwld	freg, nsp
Cardamino-Alnetum (Meij. Drees. 1936) Pass. 1968	–1, 0	↔	fe	
Thelypterido-Betuletum pubescentis Czerw. 1972	–1, 0, +1	↓↔↑	eh, fe, gwld	freg, nsp, ssuccu, ssw
Salicetea purpureae Moor 1958; *Salicion albae* R. Tx. 1955				
Salicetum albo-fragilis R. Tx. 1955	–1, 0, +1	↓↔↑ ?	asexp, gwld, nrp, tburb	fl, nsp, ssuccu, ssw
Populetum albae Br.-Bl. 1931	–1, 0, +1	↓↓↔↑	asexp, asint, gwld, nrp, tm	fl, freg, nsp
Querco-Fagetea Br.-Bl. et Vlieg. 1937 ; *Alno-Ulmion* Br.-Bl. et R. Tx. 1943				
Fraxino-Alnetum W. Mat. 1952	–1, 0, +2	↓↔↑↑	asexp, bua, fe, ff, gwld, ssw, tbulb, tm, tru	aff, freg, nsp, ssuccu
Carici remotae-Fraxinetum W. Koch 1926 ex Faber 1936	–1, 0	↔	fe	
Astrantio-Fraxinetum Oberd. 1953	0 ?	↔ ?		

Table 1. *(Continued)*

Ficario-Ulmetum minoris Knapp 1942 em. J. Mat. 1976	–1, 0, +1	↓↓↔↑	csint, nrp, tm	aff, freg, nsp
Violo odoratae-Ulmetum minoris (Weevers 1940) Doing 1962	–1, 0, +1	↓↓↔↑	asint, csint, nrp, tm	freg, nsp
Carpinion betuli Issler 1931 em. Oberd. 1953				
Tilio cordatae-Carpinetum betuli Tracz. 1962	–1, 0, +1	↓↓↔↑	asexp, asint, csint, nrp, tru	aff, freg, nsp
Galio sylvatici-Carpinetum betuli Oberd. 1957	–1, 0, +1	↓↓↔↑	asexp, asint, csint, nrp, tru	aff, freg, nsp
Acer platanoides-Tilia cordata Jutrz.-Trzeb. 1995	0	↓↔	asexp, tr	
Fagion sylvaticae R. Tx. et Diem. 1936				
Luzulo pilosae-Fagetum W. Mat. et A. Mat. 1973	0, +1	↓↔↑	csint, saf, tru	freg, nsp
Galio odorati-Fagetum Rübel 1930 ex Sougnez et Thill 1959	0, +1	↔↑	csint, tru	freg, nsp
Potentillo albae-Quercion petraeae Zól. et Jakucs n.nov. Jakucs 1967				
Potentillo albae-Quercetum petraeae Libb. 1933 n.inv.	–2, 0	↓↓↔↑	asexp, asint, csint, nrp, saf, tm	ff, freg, nsp

Whereas into group of forest plant communities which reveal progressive tendencies alder riparian forests *Fraxino-Alnetum* and beech forests can be reckoned (Tab. 1). Communities of a wet alder riparian forests *Fraxino-Alnetum* character develop in areas of drained swamp forests *Ribeso nigri-Alnetum* and as a consequence of spontaneous or conscious afforestation of wet meadows. Whereas gradual yet more distinct share increase of beech forests (*Luzulo pilosae-Fagetum*, *Galio odorati-Fagetum*) in some forest complexes results from natural and anthropogenic share increase of beech *Fagus sylvatica* in deciduous and mixed coniferous forests' treestands.

Other deciduous forest associations (Tab. 1) are relatively stable on account of occupied area as well as structure and species composition, while undergoing changes in many observed phytocoenoses are not distinct. Particularly stable vegetation units are some plant communities of wet forests, mainly spring forests (*Cardamino-Alnetum*, *Carici remotae-Fraxinetum*, *Astrantio-Fraxinetum*) and slope maple-linden forest *Acer platanoides-Tilia cordata*. About stable character of this communities decide both natural stability of habitats and low availability for human management.

A setout of dynamic tendencies of coniferous and mixed coniferous forests vegetation (Tab. 2) depicts a specific regularity. It is and area shrinking and disappearing of individual features of phytocoenoses of oligotrophic dry and fresh pine coniferous forests (*Cladonio-Pinetum, Peucedano-Pinetum, Leucobryo-Pinetum*), while progressive tendencies for mixed coniferous forests (*Querco roboris-Pinetum, Serratulo-Pinetum*), typical for mesotrophic habitats. This direction of changes was documented in examined area (KĘPCZYŃSKI, ZAŁUSKI 1991; PASZEK 2005) and in other regions of Poland (MATUSZKIEWICZ 2007c). Changes mentioned above are generated both by natural factors, i.e. regeneration and succession processes on mesotrophic habitats, as well as supported by anthropogenic actions, mainly by preferring deciduous trees (*Quercus* spp.) in accordance with principles of contemporary forest management. Very clear disappearing tendencies of acid oak forests (*Calamagrostio arundinaceae-Quercetum petraeae*), barely noted in examined region should be underlined.

Analysis of changes of shrub and clearing vegetation (Tab. 3) revealed generally high variability of dynamic tendencies of respective phytocoenoses. Few plant associations reveal progressive tendencies (*Salicetum pentandro-cinereae, Euonymo-Prunetum spinosae, Aegopodio-Sambucetum nigrae, Agrostio-Populetum tremulae, Rubo plicati-Sarothamnetum*), which is an effect of extensive forms of use and lack of use of meadows and grasslands. Disappearing communities – *Betuletum humilis* and *Prunetum fruticosae*, of which dominants are strongly endangered species were also noted (cf. ZARZYCKI, SZELĄG 2006).

Regressive tendencies of many groups of aquatic vegetations were demonstrated (Tab. 4), which is conditioned by gradual natural or anthropogenic eutrophication of water bodies and thereby a water transparency decrease (cf. REJEWSKI 1981). Disappearing are also silt-covered ground communities of *Isoëto-Juncetea bufonii* class, which is mostly connected with developing and edge regulation of small, mid-field water bodies and lakes.

Table 2. Transformations of coniferous and mixed forest vegetation. Changes of area: explanations in Table 1. Changes of structure and species composition: explanations in Table 1. Main causes: aff - afforestation; asexp - alien species expansion; asint - alien species introduction; csint - coniferous species introduction; eh - eutrophication of habitats; ff - forest felling; freg - forest regeneration; gwld - ground water level decrease; nrp - natural regression processes; nsp - natural succession processes; saf - shadowing by adjacent forests; tm - treestand monotypization; tru - tourist and recreation use; tu – turfing.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Quercetea robori-petraeae Br.-Bl. et R. Tx. 1943 ; *Quercion robori-petraeae* Br.-Bl. 1932				
Calamagrostio arundinaceae-Quercetum petraeae (Hartm. 1934) Scam. et Pass. 1959	–2	↓↓ ?	csint, nrp, tm	
Vaccinio-Piceetea Br.-Bl. in Br.-Bl. et al. 1939; *Dicrano-Pinion* (Libb. 1933) W. Mat. 1962				
Cladonio-Pinetum Juraszek 1927	–2, 0, +1	↓↓↔↑	asint, eh, nrp, saf	aff, ff, freg, nsp
Peucedano-Pinetum (W. Mat. 1962) W. Mat. et J. Mat. 1973	–2, 0, +1	↓↓↔↑	asexp, asint, eh, ff, nrp, saf, tru, tu	aff, freg, nsp
Leucobryo-Pinetum (W. Mat. 1962) W. Mat. et J. Mat. 1973	–2, 0, +1	↓↓↔↑	asexp, asint, eh, ff, nrp, tru, tu	aff, freg, nsp
Molinio (caeruleae)-Pinetum W. Mat et J. Mat. 1973	0 ?	↓↔ ?	asexp, asint, tu	
Querco roboris-Pinetum (W. Mat 1981) J. Mat. 1988	–1, 0, +2	↓↔↑↑	asexp, asint, csint, nrp, tm, tru, tu	aff, freg, nsp
Serratulo-Pinetum (W. Mat 1981) J. Mat. 1988	–1, 0, +2	↓↔↑	asexp, asint, csint, nrp, tm, tru	freg, nsp
Vaccinio uliginosi-Betuletum pubescentis Libb.1933	–1, 0, +1	↓↔↑	asexp, csint, gwld, nrp	freg, nsp
Vaccinio uliginosi-Pinetum Kleist 1929	0, +1	↓↔↑	eh, gwld	nsp
Vaccinio-Piceenion Oberd. 1957				
Querco-Piceetum (W. Mat. 1952) W. Mat. et Pol. 1955	0 ?	↓↔↑	csint, nrp	aff, nsp

Table 3. Transformations of shrub and clearing vegetation. Changes of area: see explanations in Table 1. Changes of structure and species composition: see explanations in Table 1. Main causes: asexp - alien species expansion; bua - built-up areas; cfag - conversion into farmlands or allotment gardens; eg - establishment of greenway; eh - eutrophication of habitats; fe - fishpond establishment; ff - forest felling; fl - floods; freg - forest regeneration; gwld - ground water level decrease; le - lawn establishment; lr - levelling of roadsides; nrp - natural regression processes; nsp - natural succession processes; p - plantings; saf - shadowing by adjacent forests; ssuccu - secondary succession due to cessation of use; ssw - secondary swamping; tburb - technical building up of river banks; we - wastelands elimination.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Alnetea glutinosae Br.-Bl. et R. Tx. 1943; *Salicion cinereae* (Malc. 1929) Meij. Drees. 1936				
Salicetum pentandro-cinereae (Almq. 1929) Pass. 1961	–1, 0, +2	↓↔↑	asexp, fe, gwld, nrp, ssw, we	nsp, ssuccu
Salicetum auritae Jonas 1935 em. Oberd. 1964	–1, 0, +1	↓↔↑	eh, gwld, nrp	nsp
Betuletum humilis Steffen 1931	–2, 0	↓↓↔	gwld, nrp	
Salicetea purpureae Moor 1958; *Salicion albae* R. Tx. 1955				
Salicetum triandro-viminalis Lohm. 1952	–1, 0, +2	↓↔↑	asexp, nrp, tburb	fl, nsp
Rhamno-Prunetea Rivas-Goday et Carb. 1961 ex R. Tx. 1962; *Carpino-Prunion spinosae* R. Tx. 1952 em. Weber 1974				
Euonymo-Prunetum spinosae (Hueck 1931) Pass. in Pass. et Hofm. 1968	–1, 0, +2	↓↔↑	lr, nrp, we	nsp, ssuccu
Euonymo-Coryletum Pass. in Pass. et Hofm. 1968	–1, +1	↓↔↑	lr, nrp	nsp, ssuccu
Berberidion Br.-Bl. 1950 ex R. Tx. 1952				
Pruno-Ligustretum R. Tx. 1952 nom.inv.	–1, 0, +1	↓↔↑	nrp, we	nsp, ssuccu
Prunion fruticosae R. Tx. 1952				
Prunetum fruticosae Dziubałtowski 1926	–1	↓↓↔	nrp	
Arctio-Sambucion nigrae Doing 1962				
Aegopodio-Sambucetum nigrae Doing 1962 em. M. Wojt. 1990	–1, 0, +2	↓↔↑	asexp, bua, cfag, lr, we	eh, nsp, ssuccu
Chelidonio-Robinietum Jurko 1963	–1, 0, +1	↓↔↑	bua, eg, le, lr, we	p, asexp
Agrostio capillaris-Frangulion Pass. in Pass. et Hofm. 1968 em. Brzeg et M. Wojt. 2001				
Molinio-Franguletum Pass. in Pass. et Hofm. 1968 em. Brzeg et M. Wojt. 2001	–1, 0, +1	↔↑ ?	nrp, we	nsp, ssuccu
Agrostio-Populetum tremulae Pass. in Pass. et Hofm. 1968	–1, 0, +2	↓↔↑↑	bua, cfag, we	nsp, ssuccu
Rubo plicati-Sarothamnetum Weber 1977	–1, 0, +2	↓↔↑	cfag, freg, lr, nrp, saf, we	ff, nsp, ssuccu

Table 3. *(Continued)*

ass. *Rubus plicatus*	–1, 0, +1	↓↔↑	freg, lr, nrp, saf, we	ff, nsp, ssuccu
Epilobietea angustifolii R. Tx. et Prsg 1950; *Sambuco-Salicion capreae* R. Tx. et Neum. in R. Tx. 1950 ex Oberd. 1957				
Salicetum capreae Schreier 1955	–1, 0, +1 ?	↓↔↑ ?	freg, lr, nrp, saf	ff, nsp
Rubetum idaei Malinowski et Dziubałtowski 1914 em. Oberd. 1973	–1, +1	↓↔↑	freg, lr, nrp, saf	ff, nsp
Sambucetum racemosae (Noirf. 1949) Oberd. 1973	–1, +1 ?	↓↔↑ ?	freg, lr, nrp, saf	ff, nsp
Carici piluliferae-Epilobion angustifolii R. Tx. 1950	–1, 0, +1	↓↔↑	freg, lr, nrp	ff, nsp

Distinct progressive tendencies are noted for different rush and tall sedge vegetation (all. *Phragmition, Magnocaricion, Phalaridion*; Tab. 4). On water bodies' edges it is usually an effect of shallowing and eutrophication, whereas in grasslands complexes – an effect of cessation of use and secondary swamping. Clearly spreading plant communities constitute i.a. *Phragmitetum australis* and *Phalaridetum arundinaceae*.

Relatively stable are spring communities (Tab. 4). Pioneer halophytic communities (all. *Salicornion ramosissimae*) and adjacent therophytes (all. *Bidention tripartitae, Chenopodion glauci*), in turn, reveal irregular appearance dependent on water level and soil humidity fluctuations.

Specific plant cover dynamics is observed on peatlands (Tab. 4). More or less boggy peat communities (*Rhynchosporion albae, Caricion lasiocarpae, Sphagnion magellanici*) are currently relatively stable or undergo gradual regression as a result of shrub and forest vegetation succession. The most vulnerable on unfavourable changes (eutrophication and then shrub and forest succession) is however typical to fen vegetation (*Caricion nigrae, C. davallianae*, partially *C. lasiocarpae*), especially moss sedge fen (cf. HERBICHOWA, WOŁEJKO 2004). The least vulnerable are then transformations of phytocoenoses of oligotrophic and strongly bogged habitats.

Table 4. Transformations of aquatic, spring, coastal and peat vegetation. Changes of area: explanations in Table 1. Changes of structure and species composition: explanations in Table 1. Main causes: aff - afforestation; asexp - alien species expansion; del - developing of edge lakes; eh - eutrophication of habitats; fe - fishpond establishment; fl - floods; gwld - ground water level decrease; lr - levelling of roadsides; lssw - limitation of supply with saline water; nrp - natural regression processes; nsp - natural succession processes; saf - shadowing by adjacent forests; ssuccu - secondary succession due to cessation of use; ssw - secondary swamping; swp - surface water pollution; tbulb - technical building up of lake banks; tburb - technical building up of river banks; tr - trampling; tru - tourist and recreation use; tu - turfing; we - wastelands elimination; wld - water level decrease.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Charetea fragilis Fukarek 1961 ex Krausch 1964				
Nitellion flexilis (Corillion 1957) Dąmbska 1966	–1, 0 ?	↓↔	eh, swp, wld	
Charion fragilis (Sauer 1937) Krausch 1964 em. W. Krause 1969	–2, 0	↓↔	eh, swp, tru, wld	
Charion vulgaris Dąmbska 1966 ex W. Krause 1981	–1, 0 ?	↓↔	eh, swp, wld	
Fontinaletea antipyreticae Hb. 1957				
Fontinalion antipyreticae Koch 1936	–1, 0	↓↔	eh, swp	
Littorelletea uniflorae Br.-Bl. et R. Tx. 1943				
Lobelion (Van den Berghen 1944) R. Tx. et Dierss. ap. Dierss. 1972	–2, 0	↓↔	eh, swp, tru	
Eleocharition acicularis Pietsch 1966 em. Dierss. 1975	–1, 0 ?	↓↔	eh, swp	
Utricularietea intermedio-minoris Den Hartog et Segal 1964 em. Pietsch 1965				
Sphagno-Utricularion Müll. et Görs 1960	–1, 0, +1	↓↔↑	eh, nrp, wld	nsp
Lemnetea minoris (R. Tx. 1955) de Bolós et Masclans 1955				
Lemnion minoris (R. Tx. 1955) de Bolós et Masclans 1955	–1, 0, +1	↓↔↑	nrp, swp, wld	eh, nsp, ssw
Hydrocharition morsus-ranae Rübel 1933	–1, 0, +1	↓↔↑	nrp, swp, wld	nsp, ssw
Potametea R.Tx. et Prsg. 1942 ex Oberd. 1957				
Potamion pectinati (W. Koch 1926) Görs 1977	–2, 0, +1	↓↔↑	eh, fl, nrp, swp, wld	nsp
Nymphaeion Oberd. 1957	–1, 0, +1	↓↔↑	nrp, swp, wld	nsp
Ranunculion fluitantis Neuhäusl 1959	–1, 0, +1	↓↔↑	eh, swp	nsp
Montio-Cardaminetea Br.-Bl. et R. Tx. 1943				
Cardamino-Montion Br.-Bl. 1925	–1, 0	↓↔	fe, saf	
Cratoneurion commutati W. Koch 1928	0 ?	↔ ?		
Caricion remotae Kästner 1941	–1, 0	↓↔	fe, saf	

Table 4. *(Continued)*

Phragmitetea australis (Klika in Klika Novák 1941) R. Tx. et Prsg 1942				
Phragmition australis W. Koch 1926	–1, 0, +2	↓↔↑	del, fe, gwld, nrp, swp, tbulb, tru, we	eh, nsp, ssuccu, ssw
Magnocaricion elatae W. Koch 1926	–1, 0, +2	↓↔↑	fe, gwld, swp, trurb, tru, we	nsp, ssw
Oenanthion aquaticae Hejný ex Neuhäusl 1959	–1, 0, +1	↓↔↑	eh, gwld, swp	nsp, ssw
Sparganio-Glycerion fluitantis Br.-Bl. et Siss. ap. Boer 1942 n.inv.	–1, 0, +1	↓↔↑	swp, wld	nsp
Phalaridion Kopecký 1961	–1, 0, +2	↓↔↑	gwld, swp, tburb	eh, fl, nsp, ssuccu, ssw
Thero-Salicornietea Pign. 1953 em. R. Tx. 1954 in R. Tx. et Oberd. 1958				
Salicornion ramosissimae R. Tx. 1974	–1, 0, +1	↓↔↑	gwld, lssw	nsp
Isoëto durieui-Juncetea bufonii (Br.-Bl. et R. Tx. 1943 ex Westh. et al. 1946) Riv.-Mart. 1988				
Elatino-Eleocharition ovatae Pietsch et Müller-Stoll 1968	–2, +1	↓↑	gwld, del, tburb, tu	wld
Nanocyperion flavescentis W. Koch 1926 ex Aichinger 1933 em. Rivas Goday 1961	–1, +1	↓↑	gwld, del, tbulb, tu	wld
Radiolion linoidis (Rivas-Goday 1961) Pietsch 1973	–2, +1	↓↑	gwld, lr, tu, we	tr
Bidentetea tripartitae R. Tx., Lohm. et Prsg in R. Tx. 1950				
Bidention tripartitae Nordh. 1940 em. R. Tx. in Poli et J. Tx. 1960	–1, +1	↓↑	asexp, del, lr, tburb, tu, we	nsp, ssw, tr
Chenopodion glauci (R. Tx.1960 in Poli et J. Tx. 1960) Hejný 1974	–2, +2	↓↑	asexp, del, tburb, we	fl, nsp
Scheuchzerio-Caricetea nigrae (Nordh. 1936) R. Tx. 1937				
Rhynchosporion albae W. Koch 1926	–1, 0	↓↔	nrp	
Caricion lasiocarpae Vanden Bergh. in Lebrun et all. 1949	–1, 0, +1	↓↓↔↑	aff, eh, gwld, nrp	nsp, ssw
Caricion nigrae W. Koch 1926 em. Klika 1934	–1, 0, +1	↓↔↑	aff, eh, gwld, nrp	ssw
Caricion davallianae Klika 1934	–1, 0, +1	↓↔↑	aff, gwld, nrp	nsp, ssw
Oxycocco-Sphagnetea Br.-Bl. et R. Tx. 1943				
Sphagnion magellanici Kästner et Flössner 1933 em. Dierss. 1975	–1, 0, +1	↓↔↑	gwld, nrp	nsp

Semi-natural meadows, tall herbs, grasslands and forest edges vegetation (Tab. 5) is dependent both on natural and anthropogenic factors. Wet meadows (all. *Molinion*, *Cnidion*) undergo transformations as a result of use intensification or cessation thereof. Fresh pastures (all. *Cynosurion*), halophyte grasslands (all. *Puccinellion maritimae*, *Armerion maritimae*) and xerothermic grasslands (all. *Cirsio-Brachypodion*, *Festuco-Stipion*) are decreasing their share in consequence of grazing cessation. Poor grasslands and heaths (all. *Violion caninae, Calluno-Arctostaphylion*) are disappearing as a result of eutrophication, shadowing or building-up. Progressive tendencies, in turn, reveal tall herbs and nitrophilous edge communities (all. *Filipendulion, Calystegion sepium, Aegopodion podagrariae, Galio-Alliarion*) and fertile fresh meadows (all. *Alopecurion pratensis, Arrhenatherion elatioris*). Particularly significant for the last 20 years period is a secondary tall herbs succession in conditions of wet meadows' cessation of use (cf. KOCHANOWSKA 1997; KRASICKA-KORCZYŃSKA *et al.* 2008).

From group of ruderal and segetal vegetation (Tab. 6) regressive tendencies have very rare phytocoenoses of *Caucalidion lappulae* alliance, whereas progressive tendencies have meso- and thermophilic ruderal communities (all. *Convolvulo-Agropyrion repentis, Onopordion acanthii, Sisymbrion, Eragrostion*).

Table 5. Transformations of meadow, grassland and forest edge vegetation. Changes of area: see explanations in Table 1. Changes of structure and species composition: see explanations in Table 1. Main causes: aff - afforestation; asexp - alien species expansion; bua - built-up areas; cfag - conversion into farmlands or allotment gardens; cfu - cessation of farmlands use; eg - establishment of greenway; eh - eutrophication of habitats; ff - forest felling; fl - floods; gcp - green crops ploughing; ges - grass extra sowing; gi - grazing intensification; gl - grazing limitation; gwld - ground water level decrease; le - lawn establishment; lr - levelling of roadsides; lssw - limitation of supply with saline water; mi - mowing intensification; ml - mowing limitation; nrp - natural regression processes; nsp - natural succession processes; o - overfertilization; p - plantings; saf - shadowing by adjacent forests; sge - sand and gravel exploitation; ssuccu - secondary succession due to cessation of use; ssw - secondary swamping; tburb - technical building up of river banks; tr - trampling; tru - tourist and recreation use; we - wastelands elimination.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Molinio-Arrhenatheretea R. Tx. 1937 em. 1970				
Lolio-Plantaginion majoris R. Tx. 1947	–1, 0, +1	↓↔↑	eg, le, lr, we	gi, tr, tru
Agropyro-Rumicion crispi Nordh. 1940 em. R. Tx. 1950	–1, 0, +1	↓↔↑	gwld, nrp, we	gi, ssw
Filipendulion ulmariae Segal 1966	–1, 0, +2	↓↔↑↑	aff, gcp, mi	ssuccu
Molinion caeruleae W. Koch 1926	–2, 0, +1	↓↓↔↑	aff, cfag, eh, gcp,	gwld, ml

Table 5. *(Continued)*

			ges, mi, o, ssuccu	
Calthion palustris R. Tx. 1936 em. Oberd. 1957	–1, 0, +1	↓↓↔↑	aff, gcp, ges, gwld, o, ssuccu	ssw, ml
Cnidion dubii Bal.-Tul. 1966	–1, 0	↓↓↔	gwld, mi, o, ssuccu, ssw	fl, ml
Alopecurion pratensis Pass. 1964	–1, 0, +2	↓↔↑	asexp, aff, bua, cfag, gcp, ges, ssuccu	eh, fl, mi
Arrhenatherion elatioris (Br.-Bl. 1925) Koch 1926	–1, 0, +2	↓↓↔↑	aff, bua, cfag, gcp, ges, gi, lr, o, ssuccu	gl, gwld, mi
Cynosurion R. Tx. 1947	–2, 0, +1	↓↓↔↑	bua, cfag, ges, gl, mi, ssuccu	gi
Asteretea tripolium Westh. at Beeft. ap. Beeft 1962				
Puccinellion maritimae (Christ. 1927) R. Tx. 1937	–2, 0, +1	↓↓↔↑	gl, gwld, lssw, ssuccu	gi, ssw
Armerion maritimae Br.-Bl. et De Leeuw 1936	–2, 0, +1	↓↓↔↑	gl, gwld, lssw, ssuccu	gi, ssw
Koelerio glaucae-Corynephoretea canescentis Klika in Klika et Novák 1941				
Corynephorion canescentis Klika 1934	–1, 0, +1	↓↔↑	aff, bua, nrp, saf, sge, we	cfu, nsp
Thero-Airion R. Tx. 1951 ex Oberd. 1957 em. Brzeg in Brzeg et M. Wojt. 1996	–1, 0, +1 ?	↓↔↑ ?	aff, bua, cfag, nrp, saf, sge, we	cfu, nsp
Koelerion glaucae (Volk 1931) Klika 1934	–1, 0, +1	↓↔↑	aff, bua, cfag, nrp, saf, sge, we	cfu, nsp
Festuco-Brometea Br.-Bl. et R. Tx. 1943				
Cirsio pannonici-Brachypodion pinnati Hadač et Klika in Klika et Hadač 1944 em. Krausch 1961	–2, 0, +1	↓↓↔↑	aff, bua, gi, npr, ssuccu, we	nsp
Festuco-Stipion (Klika 1931) Krausch 1961	–2, 0, +1	↓↓↔↑	aff, bua, gi, lr, npr, ssuccu, we	nsp
Phleion boehmeri Głowacki 1972 ex Celiński et Balcerkiewicz 1973	–1, 0, +1 ?	↓↔↑ ?	aff, bua, cfag, lr, saf, sge, we	cfu, nsp
Alysso alyssoidis-Sedion albi Oberd. et Th. Müll. in Th. Müll. 1961	–1, 0, +1 ?	↓↔↑ ?	lr, p, sge, we	nsp
Trifolio-Geranietea sanguinei Th. Müll. 1962				
Geranion sanguinei R. Tx. in Th. Müll. 1962	–1, 0, +1	↓↔↑	lr, nrp, p, saf	ff, nsp

Table 5. *(Continued)*

Trifolion medii Th. Müll. 1962	–1, 0, +1	↓↔↑	aff, bua, cfag, lr, nrp, p, saf, we	ff, nsp, ssuccu
Melampyrion pratensis Pass. 1967	–1, 0, +1	↓↔↑	lr, nrp, p, saf	ff, nsp
Nardo-Callunetea Prsg 1949				
Violion caninae Schwick. 1944	–2, 0	↓↓↔	aff, bua, eh, gi, o, ssuccu, we	
Calluno-Arctostaphylion R. Tx. et Prsg 1949 ex Faliński 1965	–2, 0	↓↓↔	aff, bua, cfag, eh, saf, we	
Pohlio nutantis-Callunion (Shimwell 1973) Brzeg 1982	–1, 0, +1	↓↔↑	aff, nrp, saf	ff, nsp
Asplenietea trichomanis (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. in Oberd. 1977				
Cymbalario-Asplenion Segal 1969 em. Mucina 1993	0	↔		
Hypno-Polypodion vulgaris Mucina 1993	–1, 0	↔ ?	lr	
Artemisietea vulgaris Lohm., Prsg et R. Tx. in R. Tx. 1950				
Calystegion sepium R. Tx. 1947 em. 1950 1947	–1, 0, +2	↓↔↑↑	asexp, lr, nrp, tburb, we	ml, nsp, ssuccu
Aegopodion podagrariae R. Tx. 1967	–1, 0, +2	↓↔↑	aff, asexp, lr, nrp, saf	ml, nsp, ssuccu
Galio-Alliarion (Oberd. 1962) Lohm. et Oberd. in Oberd. et al. 1967	–1, 0, +2	↓↔↑	asexp, lr, p, saf	ff

Table 6. Transformations of ruderal and segetal vegetation. Changes of area: explanations in Table 1. Changes of structure and species composition: explanations in Table 1. Main causes: acu - arable cultivation; aff - afforestation; asexp - alien species expansion; bua - built-up areas; cfu - cessation of farmlands use; eh - eutrophication of habitats; ha - herbicide application; le - lawn establishment; lr - levelling of roadsides; o - overfertilization; p - plantings; ssuccu - secondary succession due to cessation of use; tr - trampling; tru - tourist and recreation use; we - wastelands elimination; wf - wastelands formation.

Syntaxonomic units	Changes of area	Changes of structure and species composition	Main causes of regressive changes	Main causes of progressive changes
Polygono arenastri-Poëtea annuae Riv.-Mart. 1975 corr. Riv.-Mart. et al. 1991				
Matricario matricarioidis-Polygonion arenastri Riv.-Mart. 1975 corr. Riv.-Mart. et al. 1991	–1, 0, +1	↓↔↑	bua, eg, le, lr, we	tr, tru
Saginion procumbentis R. Tx. et Ohba 1972 in Géhu et al. 1972	–1, 0, +1	↓↔↑	bua, eg, le, lr, we	tr, tru
Agropyretea intermedio-repentis (Oberd. et all. 1967) Th. Müll. et Görs 1969				
Convolvulo arvensis-Agropyrion repentis Görs 1966	–1, 0, +2	↓↔↑	asexp, aff, bua, eg, le, lr, p, we	eh, cfu, ssuccu
Artemisietea vulgaris Lohm., Prsg et R. Tx. in R. Tx. 1950				
Onopordion acanthii Br.-Bl. 1926 ex Br.-Bl. et al. 1936	–1, 0, +2	↓↔↑	asexp, aff, bua, eg, le, lr, p, we	cfu, eh, wf
Arction lappae R. Tx. 1937 em. Siss. in Westh. et al. 1946	–1, 0, +1	↓↔↑	bua, eg, le, lr, p, we	eh, wf
Stellarietea mediae R. Tx., Lohm. et Prsg in R. Tx. 1950				
Panico-Setarion Siss. in Westh. et al. 1946	–1, 0, +1	↓↔↑	ha, o	acu
Scleranthion annui (Kruseman et Vlieger 1939) Siss. in Westh. et al. 1946	–1, 0, +1	↓↓↔↑	asexp, ha, o	acu
Veronico-Euphorbion Siss. 1942 ex Pass. 1964	–1, 0, +1	↓↔↑	asexp, ha, o	acu
Caucalidion lappulae R. Tx.1950	–1, 0	↓↔	ha, o	acu
Sisymbrion R. Tx., Lohm. et Prsg in R. Tx. 1950	–1, 0, +2	↓↔↑	asexp, eg, le, lr, we	eh, wf
Malvion neglectae (Gutte 1966) Hejný 1978	–1, 0, +1	↓↔↑	eg, le, lr, we	eh, wf
Eragrostion R. Tx. in Slavnić 1944	–1, 0, +2	↓↔↑	asexp, lr, we	eh, wf

4. CONCLUSIONS

- Acreage changes and transformations of different vegetation types of examined region in a period of the last 20 years are both effects of factors existing mainly only in analyzed time period. Into first group regressive changes of wet riparian poplar and elm forests (*Populetum albae, Ficario-Ulmetum minoris*) and gradual overgrowing of xerothermic grasslands of *Festuco-Brometea* class can be reckoned. Whereas to the second group belong i.a. changes resulting from cessation of use of meadows and pastures and frequent mixed coniferous forests regeneration on account of proecological forest management.
- Frequent and drastic plant cover changes of swamp ecosystems as a result of anthropogenic ground water level lowering, which occurred in the middle of the 20th century, are not observed currently. Nowadays even often an overgrowing of drainage ditches and secondary swamping takes place, which is confirmed by progressive dynamic tendencies of rush vegetation. Preserved natural moss bogs undergo gradual overgrowing so they do not belong to strongly endangered plant cover elements of examined area. Also less often an intensive meadow management in grasslands and farmlands is applied. Moreover, greater preferences in forest management have deciduous species than introduced until recently on a large scale pine *Pinus sylvestris*.
- Shown regressive and progressive changes of different vegetation types are, to a larger degree (than in the middle of the 20^{th} century) generated by natural factors rather than anthropogenic factors. Disappearing and transformation of thermophilous oak forests, dry and fresh coniferous forests, halophytic, pasture, meadow, heathery and grassland vegetations result currently most of all from natural
- regeneration processes and secondary succession. At the same time, these factors create progressive changes in case of mixed coniferous forests, mesophytic shrubs, rush and tall herbs vegetation as well as fresh meadows vegetation.

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