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AN ATTEMPT AT ASSESSMENT OF *ALNETUM INCANAE* LÜDI 1921 TRANSFORMATIONS IN THE SKAWICA RIVER VALLEY (THE BESKID ŻYWIECKI MTS)

Abstract: The paper presents an attempt at assessment of *Alnetum incanae* LÜDI 1921 transformations in the Skawica River valley. The field studies were carried out in the whole Skawica valley. On the basis of phytosociological relevés, the participation of species which prefer riparian habitats, the number and cover of anthropophytes, including invasive plants, were analyzed. The presence of synanthropic sites was also taken into consideration. The research demonstrated that in the study area phytocoenoses of the *Alnetum incanae* association have primarily retained natural character, in spite of a noticeable influence of human impact. The results suggested that the vicinity of synanthropic sites does not eliminate natural components of phytocoenosis.

Key words: riparian forests, geobotanical indicators, anthropophytes, invasive plants

1. INTRODUCTION

The Skawica is a typical mountain river. Its sources are situated in the area of the Babia Góra National Park and the Biosphere Reserve of UNESCO. It starts from

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the merging point of two source streams: the Marków and the Jałowiecki (Fig. 1). In the vicinity of Juszczyn, the Skawica flows into the Skawa River. In the distance of about 16 km and in the altitudinal zone between 360-590 m a.s.l., its valley has a diversified character. In the upper river section water course is rapidly flowing along a narrow canyon with steep slopes; in the lower one it reaches a valley-floor which is widening, forming the alluvial terraces favorable to vegetation development. On the one hand, there are fluvial forms, on the other, human activities are noticeable. The Skawica River valley is used as a migration route by native as well as alien species.

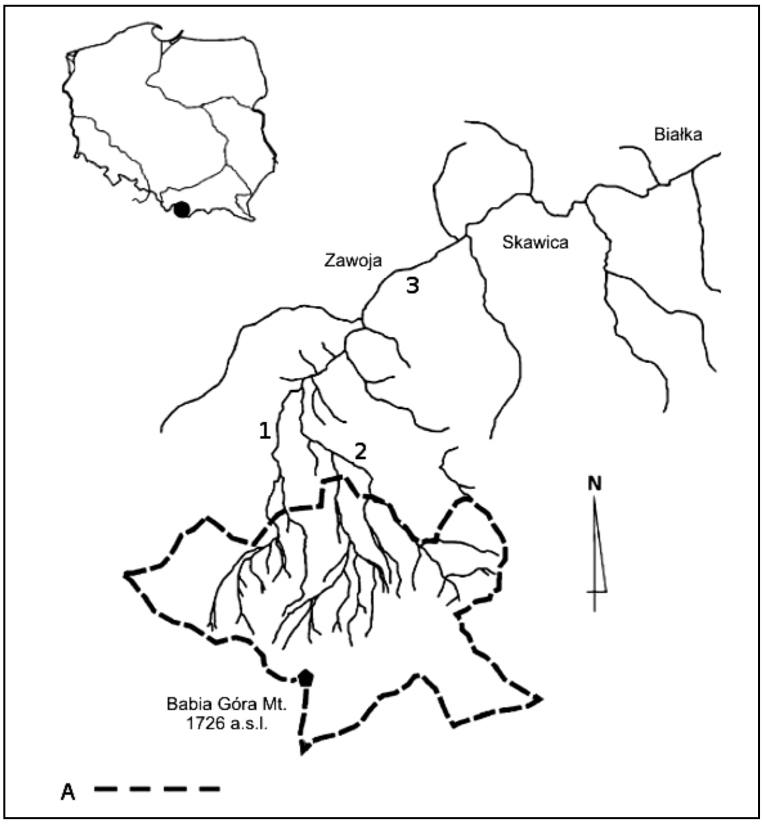

Fig 1. Localization of the investigated area. A – border of the Babia Góra National Park; 1 – the Marków Stream; 2 – the Jałowiecki Stream; 3 – the Skawica River.

Currently, ones of the most valuable plant communities in the Skawica River valley are riparian forests. An alder forest represented by *Alnetum incanae* association is particularly significant element of the valley landscape.

The alder forest has a limited importance in terms of occurrence of protected and rare plant species. However, it plays a crucial role in reducing the damaging effects of flooding, helping to control sediment and erosion as well as in stabilizing stream banks. All of this is especially important in the mountain area (FABIJANOWSKI 1954, after STASZKIEWICZ 1964).

The vegetation of a given area can be an indicator of phenomena and processes occurring as a result of different forms of human impact and natural processes. In the studies on natural environment transformations geobotanical indicators are often used. They regard the indication of both the state and changes of abiotic factors of the environment and, especially, the state and changes of vegetation. Populations of particular plant species or their groups which have common adaptive traits and similar ecological requirements, as well as phytocoenoses formed by these species and responding, by structural and dynamic changes, to the presence or intensity of a factor or to a complex of environmental conditions can be the geobotanical indicators (ROO-ZIELIŃSKA *et al*. 2007).

In this paper the floristic and quantitative analysis based on phytosociological relevés is proposed as a tool for making an assessment of *Alnnetum incanae* transformations in the Skawica River valley.

The aims of this study are: (i) to attempt an assessment of *Alnnetum incanae* transformations in the Skawica River valley, (ii) to verify the hypothesis that the vicinity of synanthropic sites favours elimination of natural components of forest phytocoenosis and encourage the penetration of alien invasive plants, (iii) to determine if the participation of species which prefer a given habitat enhance the penetration of anthropophytes, including invasive plants.

2. MATERIALS AND METHODS

The field survey was carried out between 2006 and 2008 in the entire valley of the Skawica River (in the area of the villages Zawoja, Skawica and Białka). Phytosociological relevés were made in the riverside zone of 15-20 m in width with the use of the Braun-Blanquet's method. Only species noted in the studied forest phytocoenoses were included in the analysis. The name of plant community and its affiliation to the phytosociological units were adopted after MATUSZKIEWICZ W. (2005). The names of vascular plants follow MIREK *et al*. (2002). Archaeophytes were adopted in accordance with ZAJĄC (1979), kenophytes and invasive alien plants after TOKARSKA-GUZIK (2005). Species preferring a riparian habitat are cited according to MATUSZKIEWICZ J.M. (1976, 2002), MATUSZKIEWICZ W. (2005) and ZARZYCKI *et al*. (2002). The set of these species was based on the detailed analyses of the species lists of the following syntaxonomical units: *Alnetum incanae*, *Alnenion glutinoso-incanae*, *Alno-Ulmion*, *Salicetea purpureae*, *Molinietalia*, *Trifolio fragiferae-Agrostietalia stoloniferae*, *Phragmitetea*, *Bidentetea tripartiti*, *Convolvuletalia sepium*, *Glechometalia hederaceae*, *Galio-Urticenea*, *Adenostylion alliariae*, *Betulo-Adenostyletea*.

The assessment of *Alnetum incanae* transformations was based on the following data: (i) the participation of species associated with the dynamic circle of riparian forests, in other words, all herb plants confined to this kind of habitat (e.g. moist meadows, natural and semi-natural nitrophilous edge communities), (ii) the immediate proximity of synanthropic sites (wild rubbish dumps, croplands, roads), (iii) the cover of anhtropophytes, including invasive plants. The values of cover coefficients follow PAWŁOWSKI, WALAS (1949, after DZWONKO 2007). The cover of species which occurred both, in herb and bush layer, was analysed in total. On the basis of phytosociological relevés the collective participation of species associated with riparian habitats in a total number of species was calculated. The collective participation of species group (G) was calculated according to the formula from MEDWECKA-KORNAŚ *et al*. (1972):

$$G = \frac{g}{t} \cdot 100$$

g – a total of occurrences of species from a given group in a table,
t – a total of occurrences of all species in a table.

On the basis of the proposed criteria all vegetation patches were divided into three groups: with large (above 70%), medium (60-70%) and small (below 60%) participation of riparian species.

In order to detect the relationships between the participation of species associated with the dynamic circle of riparian forests and the cover of anthropophytes, including invasive plants, the Spearman's rank correlation coefficient (Łomnicki 2003; Stanisz 2006) was calculated. To verify the hypothesis that the synanthropic sites proximity influences the species composition detrended correlation analysis (DCA) was performed based on cover data (medians of percentage intervals). Next, differences in mean and range of site scores along two first axes of DCA were examined by Mann–Whitney *U* test (Łomnicki 2003; Stanisz 2006) between two groups of relevés. The same test was performed to falsify hypothesis whether presence of synanthropic site affects the natural character of the patch's floristic composition by encouraging penetration of anthropophytes, including invasive plants. For this purpose differences in the mean cover between particular groups of relevés were studied. The statistic and ordination analyses were carried out using MS Statistica version 8.0 software and CANOCO for Windows 4.5 respectively.

3. RESULTS

The analysis of species noted in the studied vegetation patches revealed the presence of 188 species of vascular plants, 13 of which are anthropophytes, including 8 kenophytes (6 invasive plants) and 5 archaeophytes (Tab. 1). The species which achieved the highest cover in the studied patches are *Reynoutria japonica* (0.5 – 55), *Aster x salignus, Hesperis matronalis* and *Solidago canadensis* (0.5 – 17.5). Other plant species appeared as a small admixture in the herb layer, or as single specimens (Tab. 2). *Impatiens parviflora, Reynoutria japonica, I. glandulifera, Solidago canadensis* and *Aster x salignus*, qualified as invasive species, were the most frequent.

Table 1. Anthropophytes found in *Alnetum incanae* patches in the Skawica River valley. Explanations: ane – anemochory, antr – antropochory, aut – autochory, egz – egzochory, end – endochory, hyd – hydrochory, myr – myrmecochory, * after Tokarska-Guzik (2005) and Frank, Klotz (1988).

Succesive No.	Name of species	Status	Family	The way of spread *	Invasiveness	No of sites	Min. and max. cover
1	*Amaranthus sp.*	kenophyte	*Amaranthaceae*	ane egz	-	1	0.5
2	*Aster x salignus*	kenophyte	*Asteraceae*	ane egz antr	+	4	0.5-17.5
3	*Geranium dissectum*	archaeophyte	*Geraniaceae*	ane	-	2	0.5
4	*Hesperis matronalis*	kenophyte	*Brassicaceae*	ane	-	3	0.5-17.5
5	*Impatiens glandulifera*	kenophyte	*Balsaminaceae*	aut ane end hyd	+	5	0.5-5
6	*Impatiens parviflora*	kenophyte	*Balsaminaceae*	aut ane end hyd	+	14	0.5-5
7	*Lamium album*	archaeophyte	*Lamiaceae*	myr aut	-	2	0.5
8	*Matricaria maritima*	archaeophyte	*Asteraceae*	ane myr egz	-	1	0.5
9	*Melilotus alba*	archaeophyte	*Fabaceae*	aut	-	2	0.5
10	*Reynoutria japonica*	kenophyte	*Polygonaceae*	ane egz myr hyd antr	+	7	0.5-55
11	*Robinia pseudoacacia*	kenophyte	*Fabaceae*	end ane antr	+	1	43.5
12	*Solidago canadensis*	kenophyte	*Asteraceae*	ane egz myr	+	5	0.5-17.5
13	*Torilis japonica*	archaeophyte	*Apiaceae*	egz	-	1	5

The DCA carried out on the species abundances data from 35 relevés produced two axes with eigenvalues (0.3424, 0.2602) lengths of gradient (2.5572, 2.2560) and cumulative percentage of variance, which accounted for DCA1 (11.4%) and DCA2 (20.01%) respectively. There are no statistical differences in mean scores for DCA1 (p=0.067) and DCA2 (p=0.96) between the group of relevés with the synanthropic site in the vicinity and group of relevés without it.

The analysis of the contribution of species associated with riparian habitats shows that 11 (31%) from among 35 relevés were marked by the large participation of these plants, 17 (48%) – medium and 7 (20%) – small. The vicinity of synanthropic sites was noted in the case of 12 patches. Here, the mean participation of riparian species is 61.9% and it does not statistically differ from the mean

Table 2. Comparison of the participation of species associated with the dynamic circle of riparian forests, cover of anthropophytes as well as invasive plants and the proximity of synanthropic sites in individual relevés, * (herb layer + bush layer).

Succesive No.	No of relevé	The participation of species from dynamic circle of riparian forests [%]	The synanthropic site proximity	Cover of all anthropophytes (in total)	Cover of invasive plants (in total)	Cover of individual anthropophytes
1	42	77.14	+	18.00	0.50	(17.5) *H. matronalis;* (0.5) *A. x salignus*
2	10	72.09	+	0.50	0.50	*I. parviflora*
3	45	70.97	+	5.50	5.50	(5) *R. japonica*; (0.5) *A. x salignus*
4	46	70.73	+	0.00	-	-
5	67	62.86	+	55.50	55.50	(55) *R. japonica*; (0.5) *A. x salignus*
6	20	62.16	+	0.50	0.50	*I. parviflora*
7	86	61.29	+	18.00	17.50	(17.5) *S. canadensis*; (0.5) *L. album*
8	80	58.54	+	10.50	10.50	(5.5) *R. japonica*; (5) *S. canadensis*
9	51	55.56	+	6.00	5.50	(5) *I. glandulifera;* (0.5); *M. alba, I. parviflora*
10	22	54.00	+	0.00	-	-
11	17	52.63	+	24.50	23.00	(5.0+17.5)* *R. japonica;* (0.5) *H. matronalis, M. maritima, I. parviflora, M. alba*
12	64	45.16	+	2.50	2.50	(1) *R. japonica*; (0.5) *S. canadensis, I. glandulifera, I. parviflora*
13	34	78.79	-	1.00	0.50	(0.5) *S. canadensis, G. dissectum*
14	12	77.78	-	0.00	-	-
15	47	76.67	-	0.00	-	-
16	56	75.00	-	0.00	-	-
17	16	71.88	-	0.00	-	-
18	76	70.59	-	1.00	1.00	(1) *R. japonica*
19	53	70.59	-	0.00	-	-
20	54	68.97	-	0.50	0.50	*I. parviflora*
21	29	68.97	-	0.50	-	*G. dissectum*
22	72	68.57	-	0.00	-	-
23	71	67.65	-	1.00	0.50	(0.5) *Amaranthus sp., I. parviflora*

Table 2. *(Continued)*

24	23	66.67	-	0.00	-	-
25	43	66.67	-	5.50	0.50	(5) *H. matronalis;* (0.5) *R. japonica*
26	61	65.31	-	0.00	-	-
27	36	64.10	-	6.00	5.50	(5) *I. parviflora*; (0.5) *S. canadensis, M. alba*
28	52	63.83	-	0.00	-	-
29	8	62.96	-	1.00	1.00	(0.5) *I. parviflora; I. glandulifera*
30	55	62.71	-	6.00	5.50	(5) *T. japonica;* (0.5) *L. album, I parviflora*
31	25	61.29	-	0.50	0.50	*I. parviflora*
32	24	60.00	-	5.00	5.00	*I. parviflora*
33	28	60.00	-	0.00	-	-
34	18	56.60	-	43.50	43.50	(5.0+37.5)* *R. pseudoacacia;* (0.5) *I. parviflora, I. glandulifera*
35	65	51.92	-	23.00	23.00	(17.5) *A. x salignus. (5) I. glandulifera; (0.5) I. parviflora*

participation of these species in patches without the proximity of synanthropic sites (Tab. 3). There are statistical significant differences between the cover of anthropophytes as well as invasive plants in the patches in the vicinity of synanthropic sites and in the patches not in such vicinity (Tab. 3). *Impatiens parviflora* and *I. glandulifera* are the most frequent invasive plants in the patches where no synanthropic sites were observed.

The statistical analysis reveals a negative medium correlation between the participation of species associated with the dynamic circle of riparian forests and the cover of invasive plant species (Spearman correlation rs = -0.52, p = 0.0012). The negative, mediocre correlation (Spearman correlation rs = -0.43, p = 0.009) was found between the participation of riparian species and the cover of all anthropophytes.

4. DISCUSSION

The vegetation development and transformations occur in response to human activity as well as to natural phenomena. This is the major subject of the contemporary geobotanical research. For that reason, natural and transformed phytocoenoses should be distinguished. Moreover, new methods, which will make it possible to make an assessment of advances and trends of transformations, should be sought out and recommended. From a theoretical point of view, it is certainly important to identify patches of real vegetation objectively, as well as understanding the diversity of current vegetation (OLACZEK 1974).

Table 3. Comparison of mean participation of species associated with the dynamic circle of riparian forests, an average cover of anthropophytes and invasive plants depend on proximity of synanthropic sites.

The proximity of a synanthropic site	Mean± SD	n	P
Participation of species associated with dynamic circle of riparian forests			
not	66.8±6.7	23	0.15
yes	61.9±9.4	12	
Cover of invasive plant species			
not	3.8±10.0	23	0.04
yes	10.3±16.1	12	
Cover of anthropophytes			
not	4.1±9.8	23	0.03
yes	11.8±16.1	12	

It is difficult to find which of the features of the vegetation patch most clearly reflect the reaction to transformations. Phytocoenoses include sets of species which are relatively uniform, relatively constant and instantly recognizable, which can be helpful in attempting an assessment of vegetation transformations. The changes in the floristic composition, but also in the community structure, can function as a main indicator of vegetation transformations (ROO-ZIELIŃSKA *et al.* 2007).

Human activities, on the one hand forest management (ZARZYCKI 1956), logging for specific wood types (grey alder) and pasturage in the past (SURMIŃSKI 1980, after PIĄTEK, PANCER-KOTEJA 2004), on the other, bank reinforcement, wild rubbish dumps, recreational activities or illegal gravel digging at present, have strongly influenced the development of mountain riparian communities. The characteristic feature of riparian communities is the exposure to floodwaters flowing down the mountains. It is recognized as a factor conditioning the existence of this type of vegetation (MATUSZKIEWICZ 2005). What is more, it makes the floristic composition richer and more diversified, due to the fact that the flowing water permits various species to migrate. These migrant species are linked to many kinds of alluvial communities which constitute one of the most changeable circles of vegetation (UZIĘBŁO, CIAPAŁA 2006).

It should be emphasized that none of the processes affects riparian forests in an adverse way. The assessment of transformations occurring within that kind of community should be made on the basis of an objective evaluation of what is normal for the functioning of a community as well as what disturbs its equilibrium (ŁASKA 2001).

In the case of alder forests, the selection of species which are characteristic of a given association as well as of other syntaxonomic units (OLACZEK 1974) can be insufficient to make an assessment of riparian communities transformations. The division of all noted species into two groups, associated and not associated with the dynamic circle of riparian forests, seems to be a better solution.

A number of species associated with alder forests are not considered to be characteristic of riparian associations or higher syntaxonomic units, but typical of other communities, mainly tall herbs, nitrophilous edge communities or ‘veil communities’. Nevertheless, such species can be regarded as natural components of riparian communities. Owing to the analysis of the floristic composition of riparian communities (MATUSZKIEWICZ 1976, Tab. 1), it can be stated that species associated with moist meadows, nitrophilous edge communities or ‘veil communities’, are constant components of riparian phytocoenoses.

Phytocoenoses of *Alnetum incanae* in the Skawica River valley retained the natural character in spite of evident signs of the human impact. On the basis of the results obtained by means of the analyses and field observations, it was stated that the proximity of synanthropic sites both the old ones (e.g. croplands) and the ones whose age cannot be determined (e.g. wild rubbish dumps) does not eliminate natural components from vegetation patches. According to DCA results, the differences in species composition in the vicinity of a synanthropic site are minor, however, it has influenced the penetration of alien species into the patches of alder forest (Tab. 1). In the phytocoenoses in question the herb layer is species-rich, lush and dense. Its structure is diverse, ranging from small perennials (*Galium palustre*) through huge tall herbs species (*Petasites kablikianus*) to creeping ones *(Glechoma hederacea)*, clinging ones *(Galium aparine)* and the ones covering ground surface. Describing the alder communities in the Jaworze mountain range, STASZKIEWICZ (1964) points to the patch with dense, almost natural vegetation, in spite of the fact that it is localized in the vicinity of a railway station and a village.

The rate of transformations of *Alnetum incanae* phytocoenoses in the Carpathian Mountains area is difficult to follow on the basis of literature. The oldest phytosociological papers usually describe well-developed patches (ZARZYCKI 1955, 1956; STUCHLIK 1968; PANCER-KOTEJA 1965, 1973). In the case of the Pieniny Mts alder forest, authors mention the prolific growth of *Rubus caesius*, which seems to have been caused by clearing away of trees in the past (PANCER-KOTEJA 1973). The descriptions of fragmentary *Alnetum incanae* phytocoenoses transformed by human impact are found in the latest geobotanical studies. Here, due to lack of well-developed patches, more detailed analyses are not carried out.

The anthropogenic transformation of the vegetation is indicated by the presence as well as the cover of alien plants. A small contribution (7%) of anthropophytes to the total species number of the forests prove that alien species currently have a minor influence on the *Alnetum incanae* transformation, however their presence is a cause of concern. *Reynoutria japonica* with the highest cover and with high frequency, as well as two other frequent species *Impatiens parviflora* and *I. glandulifera*, can pose some threat not only to riparian forests in the Skawica River valley, but to the vegetation of the Babia Góra National Park as well. All the species mentioned above are invasive and can spread in many different ways (Tab. 1). The Skawica River valley is used as a migration route by each of these species, which is important for penetration processes, especially for *I. glandulifera* (DAJDOK, ANIOŁ-KWIATKOWSKA 1998; TOKARSKA-GUZIK 2005; TICKNER 2001). However, Himalayan balsam is not considered to be disruptive to phytocoenoses which it penetrates (DRESCHER, PROTS 2002; KASPEREK 2004; HEJDA, PYŠEK 2006).

Impatiens parviflora is the most frequently found, but not abundant, species in the *Alnetum incanae* phytocoenoses in the Skawica River valley. Similarly, PIĄTEK, PANCER-KOTEJA (2004) find individual specimens of this species in virtually every patch of *Alnetum incanae* phytocoenoses in the Pieniny Mts. Individual specimens of *I. parviflora* were observed sporadically in the mountainous alluvial communities in the mid-20th century (STUCHLIKOWA, STUCHLIK 1962; ZARZYCKI 1956). The adverse effect of this plant on the vegetation is still small (even after 50 years from its first occurrence). The strong native competitors, supported by a wet productive habitat, do not leave much space for potential invaders (GRIME 1979; DEL MORAL 1983, after REJMÁNEK 1989). Therefore, small-sized specimens of *I. parviflora* have probably been defeated by large-sized plants associated with alluvial vegetation.

The appearance of *Reynoutria japonica* seems to be of great importance in *Alnetum incanae* transformations. This plant has been quite frequently found in river valleys in Poland especially in the Oder River valley (DAJDOK, KĄCKI 2003; TOKARSKA-GUZIK *et al*. 2007). Forming dense clusters *R. japonica* eliminated other plants (FALIŃSKI 1969). In alder forest of the study area it usually occurs with a large cover. New shoots of this alien plant appear immediately at the beginning of spring and defeat other species, even *Petasites hybridus* and *P. kablikianus*. The species has a tendency to spreading.

In this study we noted negative relationship between native species i.e. species of the dynamic circle of riparian forests and species of alien plants including those which are considered invasive ones. Such relationship was found in many types of vegetation and was reported by numerous authors (REJMÁNEK *et al*. 2005 and cited literature therein). It is also known to be dependent on a plot size (STOHLGREN *et al*. 1999). On a large spatial scale and in some cases e.g. abandoned agricultural land, the positive relationship was detected (MEINERS *et al*. 2004). The negative relationship is said to be a result of biotic resistance or competition ability of invasive species, which lead to the decrease in abundance of native species and finally their replacement. Only observations over time can allow us to answer the question what the trend of changes in vegetation is.

5. CONCLUSIONS

- Phytocoenoses of *Alnetum incanae* in the Skawica River valley primarily retained natural character in spite of apparent signs of human impact.
- The obtained results proved that the proximity of synanthropic sites has a major impact on the process of penetration of alien species into phytocoenoses. However, this proximity does not eliminate the natural components of phytocoenoses.
- Alluvial forest communities characterized by the large participation of species associated with the dynamic circle of riparian forests are more resistant to the penetration of anthropophytes.

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