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SECONDARY SUCCESSION OF THE VEGETATION IN THE YOUNG SHELTERBELT (TUREW AREA, WESTERN POLAND)

ABSTRACT: Plant succession (herb and tree species) in newly planted midfield shelterbelt (0.63 ha of area) was investigated during eight years. Changes of vegetation were found to be similar to the succession on abandoned fields. During first years simple plant communities, consisted by common and very common species, dominated by one species, like: *Arthemisia absyntium* and *Chenopodium album, Conyza canadiensis* or *Apera spica-venti,* substituted year by year. The number of species reached maximal value (48) three years after shelterbelt planting. Among all trees forming the shelterbelt the fastest growing were the species of early succession stages (having light seeds) like: poplar, birch, larch and pine. Those trees form the canopy layer already after four years of succession. That process increased the rate of succession to forest community. Maximum biomass of herb plants (347.84 g dry wt. m^{-2}) was noted in fifth year of succession. Litter biomass increased during all study period. Corridor effect of shelterbelt for plants wasn't evidenced. Introduction of the forest and clear-cutting species is relatively slow and proceeds from the forest adjacent to the shelterbelt.

KEY WORDS: secondary plant succession, canopy formation, midfield shelterbelts

1. INTRODUCTION

In studies on secondary succession, two processes focused particular attention: forest regeneration (Christiansen and Peet 1981, Peterson and Carson 1996, Dzwonko and Loster 1997, Hyat and Casper 2000, Woods 2000) and succession on abandoned fields (Egler 1956, Werner and Platt 1976, Adamowski and Knopik 1996, Wilcox 1998). Contrary to classic Clements' theory, a stochastic character of vegetation changes has been demonstrated since the eighties. Success of colonisation in the initial stage of succession seems to be of great importance. The concept of succession as a result of demographic processes concentrated the studies on population dynamics (Tillman 1988, Van der Walk 1992, Van Hulst 1992, Falińska 1991, 1998). Vegetation changes during succession are not, however, totally random. The development of vegetation is accompanied by a definite sequence of functional groups of species. Early stages of succession are dominated by species of light seeds, producing seeds in great numbers, dispersing them on large areas and

fast growing. The species like: *Conyza canadensis* (L.) Chronquist, *Urtica dioica* L, *Calamagrostis epigejos* (L.) Roth. grow in patches and prevent seed germination of other species through both light limitation and allelopathy. Species of heavy seeds, slower growth and longer life span, grow well under a strong competition and at limited nutrient level and dominate in later stages (Rees *et al.* 2001). Moreover, many studies showed similar way of succession of different formerly agricultural ecosystems (old-fields, artificially created field borders and midfield hedgerows) and in different regions (Werner and Platt 1976, Baudry 1988, Burrel and Baudry 1990, Van Hulst 1992, Marshal *et al.* 2002). Fast colonization mainly by common and very common species was observed there.

One may expect that succession in newly planted shelterbelts will resemble that on abandoned fields though artificially introduced trees may accelerate the process towards forest associations (Falińska 1989).

The paper is aimed at estimating the rate of vegetation changes in young shelterbelt. Long-term studies in a selected shelterbelt enabled to follow most important stages in the development of plant communities and stabilisation of species structure during the shelterbelt growth.

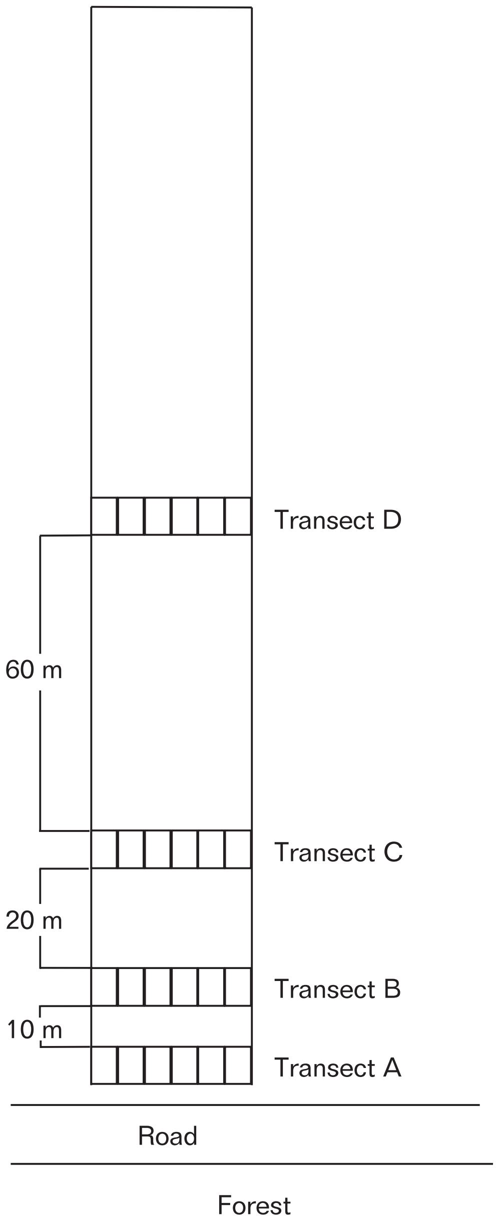

Fig. 1. A scheme of distribution of the plots to study plant succession in young shelterbelt.

2. STUDY AREA, MATERIAL AND METHODS

The studies were carried out on the area of Gen. D. Chłapowski Landscape Park, near Turew village (West Poland). The location of the area is 16°45'E to 16°50'E and 52°01'N to 52°06'N (Ryszkowski 1996). Climate and soils of study area were detaily described in separate paper (Ryszkowski *et al.* 2003)

Changes of plant communities were studied in a selected shelterbelt 0.63 ha of area, locally called "Wyskoć" and described in Ryszkowski *et al.* (2003). The studies were performed since 1994 i.e. almost immediately after shelterbelt planting (autumn 1993). Three 3 m wide transects running across the shelterbelt were set up (Fig. 1). The distance of transects from the road separating the shelterbelt from forest was 3, 15 and 40 m for transects A, B and C, respectively. Additional transect D situated in the middle of the shelterbelt, 100 m from its edge, was set up in 1996; growth of the tree seedlings and the development of the storey structure was observed there (Fig. 1). Six plots, each of an area of 9 m^2 (3x3 m), were marked along each transect. Starting from 1994 two series of phytosociological surveys (in spring and summer) were made using a classic Braun-Blanquet method on transects A, B and C. Shannon-Wiener index (H'), based on the cover of individual species (average for transect) was calculated. Twice a year (in spring and in summer) the

biomass of plants and litter in the shelterbelt was determined at a distance of 5, 20 and 45 m from the forest's edge. Five samples were taken from each plot with a square frame of an area of 0.09 m^2. Material was dried for 48 hours at 80°C and weighed with the accuracy of 0.01 g.

3. RESULTS

3.1. Plant cover and species diversity

In spring of the 1st year of succession plant cover in the studied shelterbelt did not exceed 10% of an area. Only several plant species were present, mostly weeds of cereal crops (*Stellaria media* Vill., *Poa annua* L, *Agropyron repens* L, *Apera spica venti* L). In the summer of the same year a phytosociological survey revealed 60–100% plant cover. Dominating species were the weeds of tuber crops, mainly *Echinochloa crus galli* L, *Artemisia absynthium* L and *Chenopodium album* L. In the subsequent years, full (75–100%) coverage was observed in both spring and summer, excluding single patches on transect A (Tables 1–3).

In the 2nd year the herb layer of the shelterbelt was almost exclusively dominated by one species – *Conyza canadensis*. In the next year, in spite of the *C. canadensis* domination, a trend of forming more stable plant associations in parts of the shelterbelt adjacent to the road was observed. Species typical of ruderal habitats, like: *A. repens, Glechoma hederacea* L., and *P. major*, dominated there and *Convolvulus arvensis* L., *Capsella bursa pastoris* (L.) Medik, *Arabidopsis thaliana* (L.) Heynh and *Mentha arvensis* L. were the accompanying species. Some species of the clear-cutting habitats like *Chamomilla suavolens* (Pursh.) Rydb., *Trifolium dubium* Sibht. and *Chamaenerion angustifolium* (L.) Scopp. appeared also. In the farther zones of the shelterbelt an apparent increase of the species number was noted not earlier than in 4th year of succession and dominating *C. canadensis* was replaced by *A. spica-venti*. Since 1998 the herb layer of the shelterbelt showed a more stable species structure with the domination of grasses. Apart from already existing *P. annua* and *A. repens, Agrostis stolonifera* L,. *Lolium perenne* L. and *Setaria viridis* (L.) P.Beauv were numerous. In the 5th and 6th year, apart from dominating grasses, patches of *Cirsium arvense* (L.) Scopp., *Carduus crispus* L. and *Calamagrostis epigejos* (L.) Roth. developed in the central parts of the shelterbelt. Moreover, in all parts of the shelterbelt share of *Taraxacum officinale* F. H. Wigg. in the vegetation cover increased (Tables 1–3).

The plants in the herb layer remained through successive years regardless of changes taking place on adjacent fields. Cereals and tuber crop weeds that invaded shelterbelt in the 1st year (*S. media, E. crus-galli, P. annua*) showed trend to decline during succession, as well as individuals of rye and maize (Tables 1–3).

A rapid increase of the number of species was recorded in the first years of the shelterbelt succession. In 4th year the number achieved its maximum (48 species) to decrease slightly afterwards to 43–46 species (Fig. 2). Until 3rd year the greatest species richness and the highest contribution of species not associated with crops were noted on transect A, closest to the forest. In the subsequent years the number of species remained there at a constant level of 15–20 species. In the remaining transects it increased till 5th year. Contrary to the number of species, Shannon-Wienner index (H') was highest in a transect A (closest to the forest) for four years. On other transects the H' index was lower due to the domination of a single species, like: *C. canadiensis or A. spica-venti* (Fig. 3).

3.2. Development of the storey structure, biomass changes and litter formation

In the first two years biomass of the herb plants did not exceed 200 g dry wt. m^{-2}. Maximum biomass (347.84 g dry wt. m^{-2}) was noted in 5th year of succession after which it significantly decreased (Fig. 4). Litter biomass in the shelterbelt gradually increased until 6th year (Fig. 5). Both trends were statistically significant.

Single individuals of poplar (*Populus canadensis*) and larch (*Larix decidua*) achieved the height of the shrub layer already in 2nd year of succession. Maximum number (5) of species, i.e. poplar, larch, birch (*Betula pendula*), pine (*Pinus silvestris*) and elm (*Ulmus campestre*) in that layer was noted in 3rd year of succession. In the subsequent years the species number decreased as a consequence of growing of the mentioned species up to the tree layer. Since 4th year elm was also

Table 1. Changes of vegetation during eight years of succession and species constancy on transect A of the studied shelterbelt. (see Fig. 1)

Year of succession	1st	2nd – 4th	5th – 7th	Trend
Tree layer cover (%)	0	0	0–10	
Ulmus minor Mill.			I	↑
Shrub layer cover (%)	0	0–5	0–5	
Ulmus minor Mill.		I	I	↑
Betula pendula Roth.		I	I	↑
Salix fragilis. L.			I	↑
Herb layer cover (%)	3–80	30–100	75–100	
Weeds of cereals and tuber crops				
Stellaria media Vill.	IV	IV	II	↓
Poa annua L.	IV	IV	IV	—
Apera spica venti L.	II	III	III	↑
Agropyron repens L.	II	IV	IV	↑
Echinochloa crus galli L.	II	I	I	↓
Galinsoga parviflora Cav.		I	I	↑
Myosurus minimus L.			I	↑
Secale cereale L.	III	I	I	↓
Zea mays L.	I			↓
Ruderal plants				
Taraxacum officinale F. H. Wigg.	II	IV	IV	↑
Plantago maior L.	II	II	I	↓
Artemisia absynthium L.	II	I	I	↓
Chenopodium album L.	II	II	I	↓
Conyza Canadensis (L.) Chronquist		I	I	↑
Polygonum persicaria L.	I	II	I	↑↓
Polygonum aviculare L.	II	II	I	↓
Fallopia dumentorum (L.) Hollub		I	I	↑
Polygonum hydropiper L.			I	↑
Convolvulus arvensis L.	I	I	I	—
Capsella bursa pastoris (L.) Medik	I	I	I	—
Arabidopsis thaliana (L.) Heynh	I	I	I	—
Glechoma hederacea L.	I	II	II	↑
Mentha arvensis L.	I	I	I	—
Calamagrostis epigejos (L.) Roth.		I	II	↑
Veronica chamaedrys L.		I	I	↑
Trifolium repens L.		I	I	↑
Achillea millefolium L.		I	I	↑
Galium aparine L.		I	I	↑
Galium verum L.			I	↑
Tusilago farfara L.		I	I	↑
Geum urbanum L.			I	↑
Urtica dioica L.			I	↑
Urtica urens L.			I	↑
Bromus inermis Leyss.			I	↑
Agrostis stolonifera L.			II	↑
Cirsium arvense (L.) Scopp.			I	↑
Carduus crispus L.			I	↑
Rumex acetoza L.			I	↑
Lolium perenne L.			I	↑
Carex sp.			I	↑
Holcus lanatus L.			I	↑
Sonchus arvensis L.			I	↑

Forest and clear-cutting plants				
Chamaenerion angustifolium (L.) Scopp.	I	I	I	↑
Chamomilla suavolens (Pursh.) Rydb.		I	I	↑
Chamomilla recucita (L.) Rauschert		I	II	↑
Trifolium dubium Sibht.		I		↑
Epilobium collinum C. C. Gmell			I	↑
Asarum europeum L.				↑
Ajuga reptans L.				↑
Populus × canadensis. Moench.	II	I		↓
Larix decidua Mill.	I	I		↓
Quercus robur L.	II	I	I	↓
Ulmus minor Mill.	I	I	I	—
Picea abies (L.) H. Karst.	I	I	I	—
Salix fragilis. L.		I	II	↑
Betula pendula Roth.		I	I	↑
Sambucus nigra L.		I		↑↓

Degrees of constancy: I – 0–25%, II – 25–50%, III – 50–75%, IV – 75–100%

Trends ↑ – increasing — – stable ↑↓ – fluctuating ↓ – decreasing

Table 2. Changes of vegetation during eight years of succession and species constancy on transect B of the studied shelterbelt. (see Fig. 1)

Year of succession	1^{st}	2^{nd} – 4^{th}	5^{th} – 7^{th}	Trend
Tree layer cover (%)	0	0	0–15	
Pinus silvestris L.			I	↑
Populus × canadensis. Moench.			I	↑
Larix deciduas Mill.			I	↑
Shrub layer cover (%)	0	0–15	0–20	
Populus × canadensis. Moench.		I	I	↑
Larix deciduas Mill.		I	I	↑
Pinus silvestris L.		I	I	↑
Ulmus minor Mill.			I	↑
Quercus robur L.			I	↑
Herb layer cover (%)	10–95	100	100	
Weeds of cereals and tuber crops				
Stellaria media Vill.	IV	III	II	↓
Apera spica venti L.	II	II	III	—
Poa annua L.	II	II	II	—
Agropyron repens L.		III	IV	↑
Echinochloa crus galli L.	II	I	I	↓
Viola arvensis Murray		I	I	↑
Secale cereale L.	II	I	I	↓
Zea mays L.	I			↓
Ruderal plants				
Taraxacum officinale F. H. Wigg.	I	IV	IV	↑
Plantago maior L.		I	I	↑
Chenopodium album L.	II	II	I	↓
Conyza canadensis (L.) Chronquist		II	I	↑↓
Urtica dioica L.			II	↑
Calamagrostis epigejos (L.) Roth.			I	↑
Cirsium arvense (L.) Scopp.			I	↑
Arabidopsis thaliana (L.) Heynh	I	I	I	—
Polygonum persicaria L.	I	I		↓
Polygonum aviculare L.		I		↑↓
Capsella bursa pastoris (L.) Medik	I	II		↑↓

Equisetum arvense L.		I	II	↑
Vicia cracca L		I	I	↑↓
Agrostis stolonifera L.		I	I	↑
Trifolium repens L.		I		↑↓
Cirsium vulgare (Savi) Ten.		I	I	↑
Cirsium oleraceum (L.) Scopp.			I	↑
Cirsium (popłocholistny)			I	↑
Plantago media L.			I	↑
Carduus crispus L.		I	II	↑
Senecio vulgaris L.		I		↑↓
Myosotis arvensis (L.) Hill.		I		↑↓
Galium aparine L.		I	I	↑
Veronica sp.		I		↑↓
Galium verum L.			I	↑
Sonchus arvensis L.			I	↑
Geum urbanum L.			I	↑
Juncus effuses L.			I	↑
Hieracium lachenalii C. C. Gmel.			I	↑
Convolvulus arvensis L.				↑
Forest and clear-cutting plants				
Chamaenerion angustifolium (L.) Scopp.			II	↑
Chamomilla suavolens (Pursh.) Rydb.		I		↑↓
Epilobium collinum C. C. Gmell		I	I	↑
Ajuga reptans L.			I	↑
Torylis japonica (Houtt.) D C			I	↑
Populus × canadensis. Moench.	II	II		↓
Larix deciduas Mill.	I	I		↓
Quercus robur L.	II	I	II	↑↓
Ulmus minor Mill.	I	I	I	—
Pinus silvestris L.	I	I	I	—
Picea abies (L.) H. Karst.	I	I	I	—
Betula pendula Roth.	I	I	II	↑
Sorbus aria (L.) Crantz	I	I	I	—
Rosa canina L.		I	I	↑
Salix fragilis. L.			I	↑

Degrees of constancy: see Table 1.

Trends ↑ – increasing — – stable ↑↓ – fluctuating ↓ – decreasing

Table 3. Changes of vegetation during eight years of succession and species constancy on transect C of the studied shelterbelt. (see Fig. 1)

Year of succession	1st	2nd – 4th	5th – 7th	Trend
Tree layer cover (%)	0	0	0–15	
Populus × canadensis. Moench.			I	↑
Larix deciduas Mill.			I	↑
Pinus silvestris L.			I	↑
Shrub layer cover (%)	0	0	0–10	
Acer pseudoplatanus L.		I	I	↑
Pinus silvestris L.		I	I	↑
Sorbus intermwdia			I	↑
Quercus robur L.			I	↑
Populus × canadensis. Moench.		I	I	↑
Betula pendula Roth.			I	↑
Herb layer cover (%)	5–10	75–100	50–100	
Weeds of cereals and tuber crops				

Stellaria media Vill.	III	III	I	↓
Apera spica venti L.	II	II	II	—
Poa annua L.	II	II	I	↓
Agropyron repens L.		II	III	↑
Echinochloa crus galli L.	II	I	I	↓
Viola arvensis Murray	I	I	I	—
Secale cereale L.	III	II	I	↓
Ruderal plants				
Taraxacum officinale F. H. Wigg.	I	III	III	↑
Chenopodium album L.	II	II	I	↓
Conyza canadensis (L.) Chronquist		III	II	↑↓
Urtica dioica L.		I	I	↑
Arabidopsis thaliana (L.) Heynh		I	II	↑
Capsella bursa pastoris (L.) Medik		I		↑↓
Agrostis capillaris L.		II	II	↑
Festuca pratense Huds.		I		↑
Polygonum persicaria L.		II		↑↓
Polygonum aviculare L.		I		↑↓
Vicia cracca L		I		↑↓
Myosotis arvensis (L.) Hill.		I		↑↓
Carduus crispus L.		I	II	↑
Sonchus arvensis L.		I	I	↑
Convolvulus arvensis L.		I	I	↑
Calamagrostis epigejos (L.) Roth.		I	I	↑
Setaria viridis (L.) P. Beauv.		I	I	↑
Crepis bienis L.		I		↑↓
Rumex acetoza L.		I	I	↑
Veronica verna L.			I	↑
Hieracium lachenalii C. C. Gmel.			I	↑
Cerastium arvense L. s. s.			I	↑
Artemisia absinthium .L.			I	↑
Phleum pratense L.			I	↑
Achillea millefolium L.			I	↑
Rumex acetoza L.			I	↑
Equisetum arvense L.			I	↑
Pteridium aquilinum (L.) Kuhn			I	↑
Geum urbanum L.			I	↑
Galium aparine L.			I	↑
Lolium perenne L.			I	↑
Cardaminopsis arenosa (L.) Hayek			I	↑
Forest and clear-cutting plants				
Chamomilla suavolens (Pursh.) Rydb.	I			↓
Epilobium collinum C. C. Gmell		I	II	↑
Chamaenerion angustifolium (L.) Scopp.			I	↑
Rubus caesius L.			I	↑
Populus × canadensis. Moench.	III	II	I	↓
Larix deciduas Mill.	II	I		↓
Quercus robur L.	I	I	I	—
Ulmus minor Mill.	I	I	I	—
Betula pendula Roth.			I	↑
Pinus silvestris L.	I	I	I	—
Acer pseudoplatanus L.	I	I	I	—
Acer platanoides L.			I	↑
Sorbus aria (L.) Crantz	II	II	I	↓
Sorbus aucuparia L.e.m. Hedh.			I	↑
Padus serotina (Ehrh.) Borkh.			I	↑

Degrees of constancy: see Table 1.

Trends ↑ – increasing — – stable ↑↓ – fluctuating ↓ – decreasing

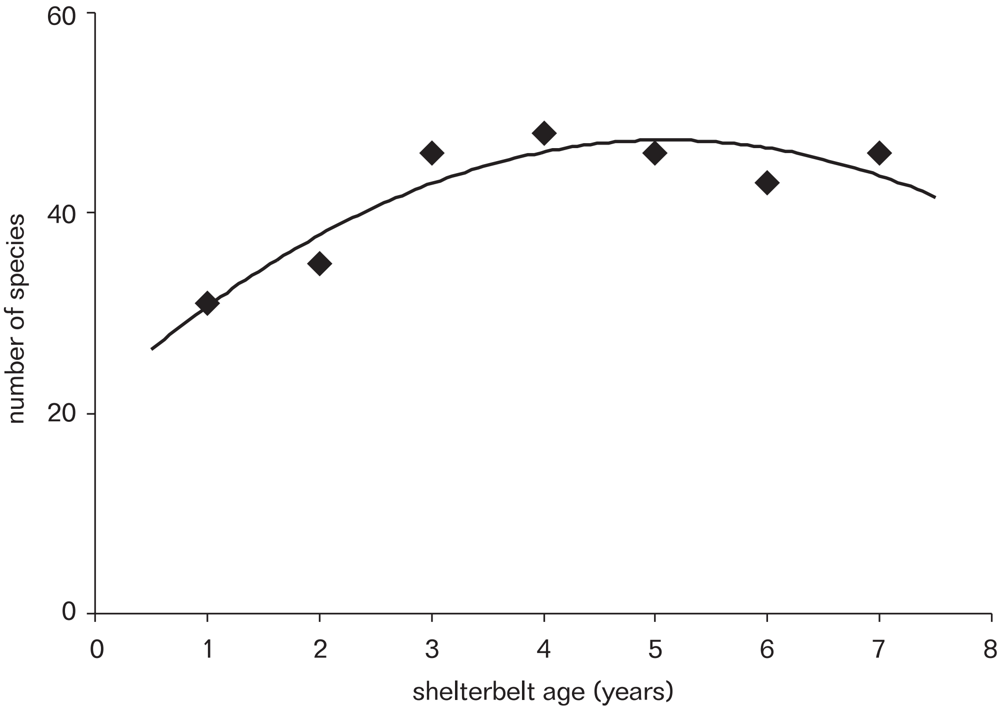

Fig. 2. Number of herb ad tree species (total for all transects – see Fig. 1.) observed in studied shelterbelt during 7 years of its development (1994–2000).

noted in the shrub layer. In 7th year the number of species in the shrub layer increased again as a result of growing of young tree seedlings (Fig. 6). Percent of cover (crown density) by the tree layer did not exceed 15% in 5th year of succession. Later it was differentiated among various shelterbelt zones and depended primarily on species composition of the wood stand. The highest cover (up to 50%) was recorded in the larch patches (Tables 1–3).

Species composition of trees changed due to a different sensibility of tree species to rubbing and phloem destruction by roe-deer (Karg 1999). The least resistance to grazing by roe-deer was found in oak, sycamore maple and beech, which during the whole study period remained in the herb layer. A good survivorship was shown by spruce but, due to its slow growth, it did not play an important role in the canopy formation. The least sensible were pine and larch.

During the first four years, when tree crowns did not achieve the shrub layer, *C. canadensis* and *A. spica-venti* growing in patches dominated the whole shelterbelt. Later on, monospecific patches of *C. arvense, U. dioica* and *C. epigeios* were formed only in places planted with slow growing and sensible for grazing trees (oak, beech). Fast growing tree species, mainly birch and larch, did not allow for creating monospecific patches

Table 4. The impact of trees on species composition of the herb layer in the studied shelterbelt (planted in 1993).

Plants dominating on areas with undeveloped tree stand	Plants growing only on areas with developed tree stand
Artemisia vulgaris	*Pinus silvestris*
Cerastium arvensis	*Rosa canina*
Chamaenerion angustifolium	*Sorbus aucuparia*
Cirsium oleraceum	
Urtica dioica	
Viola arvensis	

Table 5. Indices of diversity (Shannon-Wiener index – H') of herb layer on areas of different tree crown density in the studied shelterbelt, eight years after planting (planted in 1993).

	Number of species	H'
1 areas of undeveloped tree layer	8	1.99
2 areas of crown density < 15%)	10	2.23
3 areas of crown density > 15%)	8	1.94

Significance of difference ($P < 0.01$) between 1–2, 2–3, for species number as well as for H' values

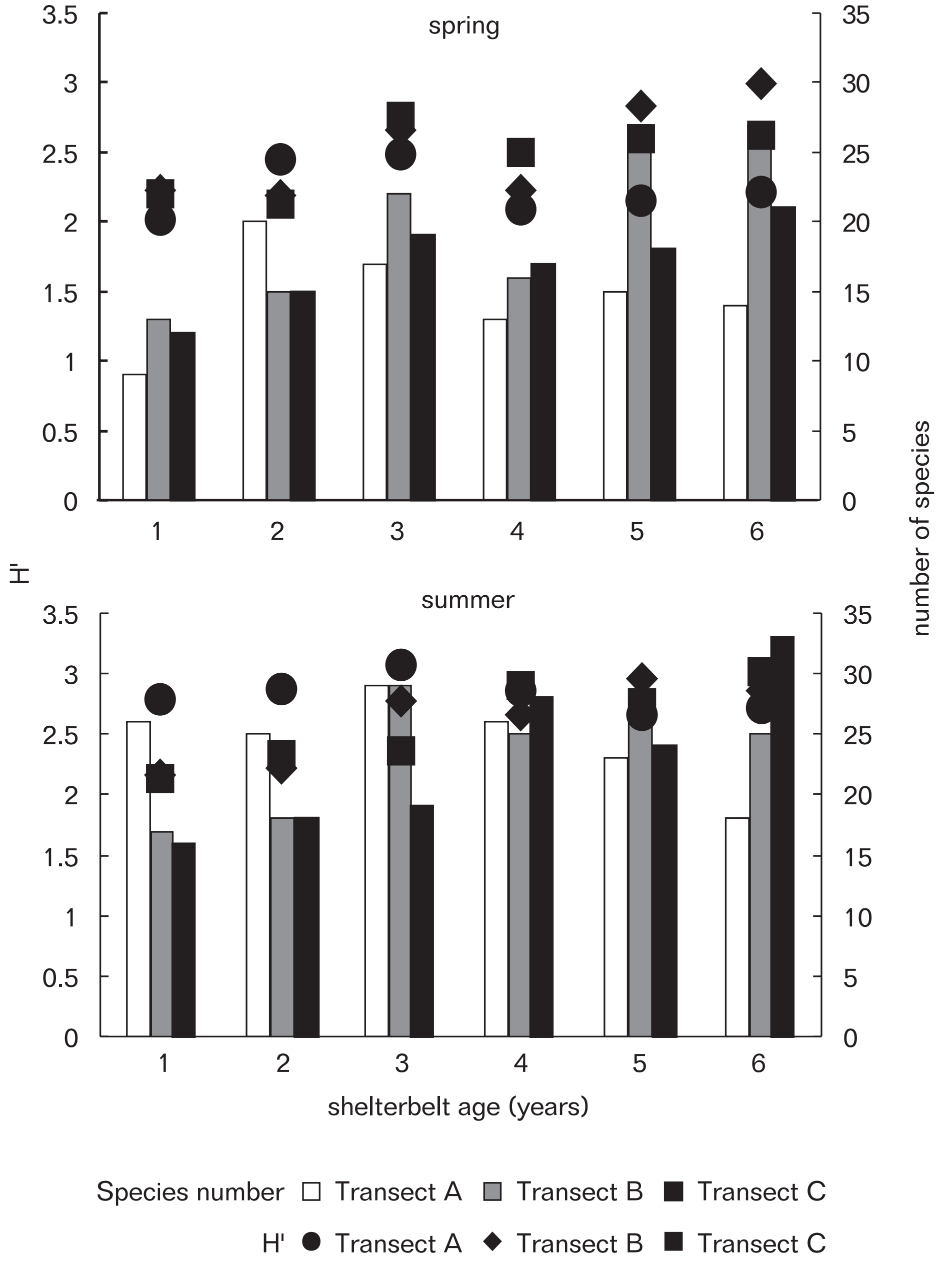

Fig. 3. Changes of species number and species diversity (Shannon Wiener index) – H' on selected tansects (see Fig. 1) in the studied shelterbelt during six years of its development (1994–1999).

under the tree canopy. They inhibited the growth of photophilic species (*U. dioica, A. vulgaris*) and typical weeds (*Cerastium arvensis, Viola arvensis*) thus enabling the development of other species, mainly tree and shrub seedlings (like *Pinus silvestris, Rosa canina, Sorbus aucuparia*) (Table 4). Moreover, a higher number of species and a higher species diversity (H') was recorded on areas of a moderate (up to 15%) tree crown density (Tab. 5). Low diversity under the compact tree canopy resulted from the fact that such

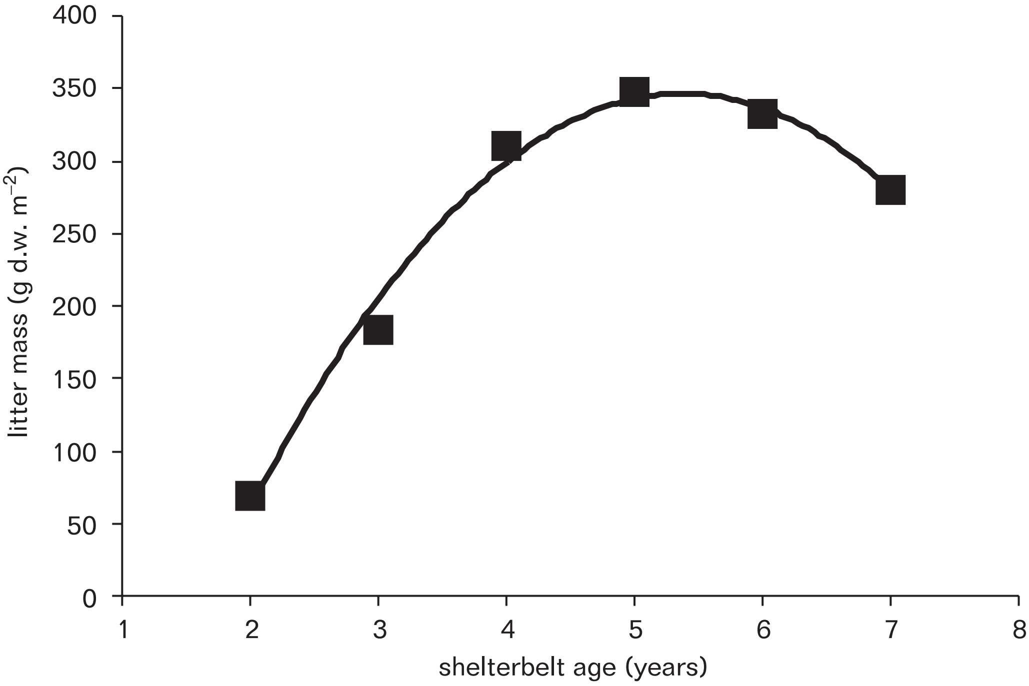

Fig. 4. Changes of the herb plant biomass in studied shelterbelt during 7 years of its development (1994–2000) (average for transects: A, B, C – see Fig. 1); $y = 25.086x^2 + 269.67x - 378.28$.

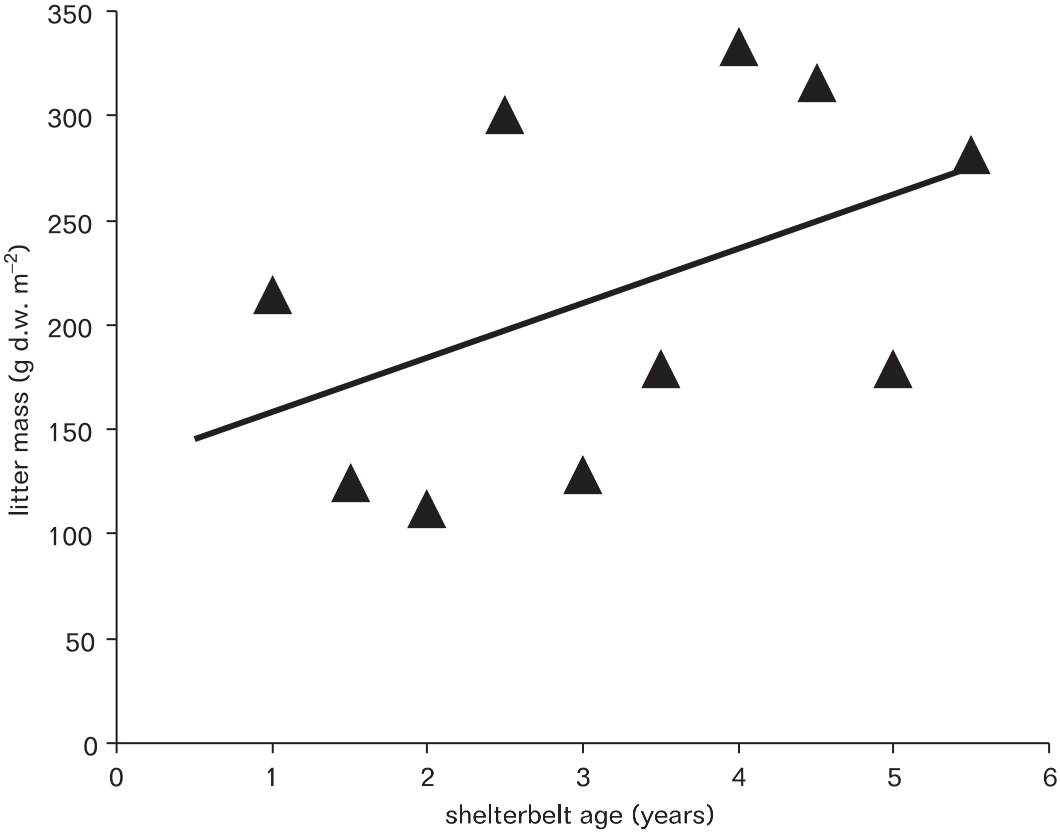

Fig. 5. Changes of litter mass in studied shelterbelt during 6 years of its development (1994–1999) (average for transects: A, B, C – see Fig. 1); $y = 25.986x + 132.16$.

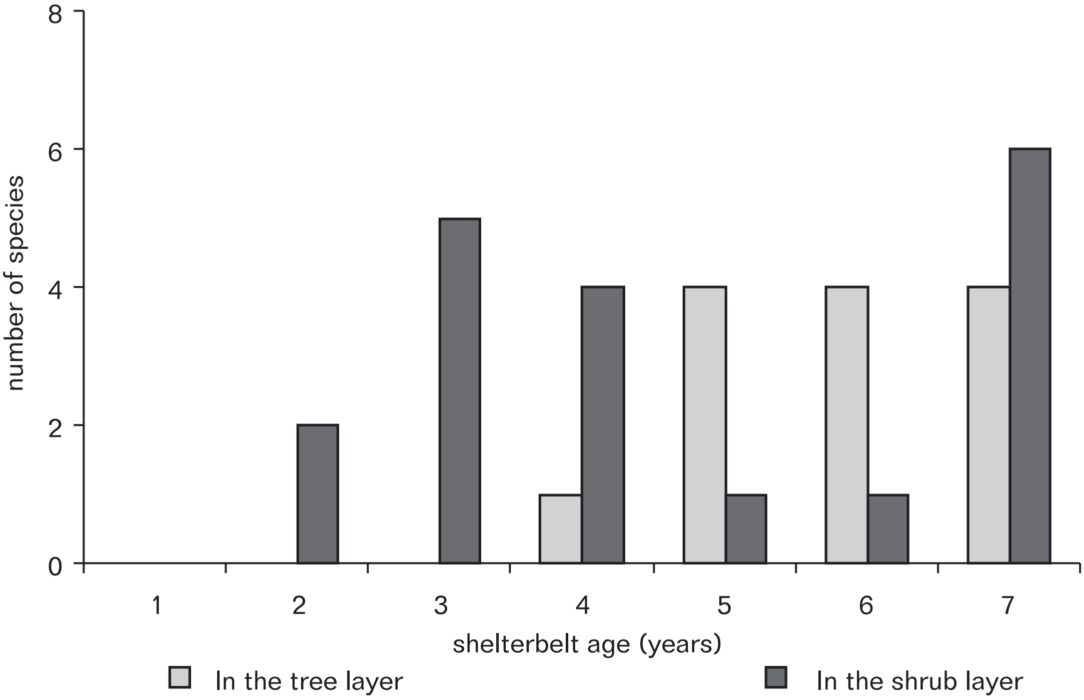

Fig. 6. Development of the storey structure in studied shelterbelt during 6 years of succession (1994–1999) (total for four transects A, B, C, D – see Fig. 1).

an intense cover occurred almost exclusively in the larch patches where shading and fall-out of the litter inhibited development of the undergrowth. Trees seem thus to accelerate plant succession towards forests.

Seedlings of trees and shrubs appeared spontaneously already in 1st year of succession. Until 4th year their occurrence (except for one individual of the dog rose *R. canina*) was restricted to transect A situated near the forest. These were the seedlings of oak, birch and willow, which usually did not survive longer than a year. The tree seeds were dispersed by trees growing in the nearby forest. In 5th year seedlings of birch, willow and black cherry appeared in transect B. Since 6th year seedlings of various species (common birch, common pear, black cherry, Scots pine, rowan and red oak) appeared in all parts of the shelterbelt (Table 6). Spreading of seedlings of species with heavy seeds was probably associated with the activity of animals, mainly rodents and birds. Colonization of shelterbelt by these animals is described in separate papers (Łęcki 2004, Kujawa 2004).

Table 6. Appearance of tree seedlings in young shelterbelt (planted in 1993) during 7 years.

Year	Species	Transect*
1994	*Quercus robur*	A
1995	*Betula verrucosa*	A
1996	*Salix fragilis.*	A
	Rosa canina	B
1997	*Betula verrucosa*	B
	Pirus communis	D
1998	*Padus serotina*	B
	Pinus silvestris	B
1999	*Pinus silvestris*	B
	Sorbus aucuparia	C
	Quercus rubra	D
2000	*Pinus silvestris*	B
	Pirus communis	D
	Ribes nigrum	D

* see Fig. 1

4. DISCUSSION

Succession in the studied shelterbelt proceeded in a similar way to the abandoned fields. Species appearing during succession are regarded as common or very common. Such reliability is often observed (Wilcox 1988, Van der Walk 1992, Marshal *et al.* 2002). During the first years the herb layer was overgrown by one or two species (*C. canadensis, A. spica-venti*) growing in patches. Similar phenomenon of rapid replacing almost monospecies systems con-

stituted by common species was observed by Werner and Platt (1976), Van der Walk (1992), Wilcox (1998), in the initial stages of secondary succession on abandoned fields, and by Marshal *et al.* (2002) in the artificial field margins. In all those studies as well as in presented paper characteristic sequence of functional groups of species was observed. The species having light seeds, fast growing and forming patches dominate in early stages of succession, but species of heavy seeds, slower growth and longer life span appeared after some years. Such pattern of first stages of succession in different ecosystems and different regions support hypothesis of Rees *at al.* (2001).

In some parts of the shelterbelt, fast growing trees close the canopy of their crowns already four years after planting. In this way they retard the growth of patches of herb species and enable the germination of tree and shrub species. It means that they accelerate the succession towards forest formations. The acceleration of herb plants succession by trees was emphasized by Falińska (1989). Impact of trees, especially different species of birch, on succession course was observed also on heathlands in southern England. In this case the highest species diversity (especially not typical to heathland) was observed on plots with birch (Mitchell *et al*. 1997). Similar relationships were observed in pine and black locust forests in southern Poland (Dzwonko and Loster (1997). However, in present study the decrease of plant diversity under closed canopy of trees (especially larch) was observed. Impact of trees on the changes of herb vegetation differentiates succession in the young shelterbelt from that observed on abandoned fields.

Growth of particular tree species also proceeded according to the pattern described by Rees *et al.* (2001). The tree layer was achieved very soon by the fast growing species of early stages of succession, i.e. having light seeds (poplar, larch, birch, pine). However, slower growing species with heavy seeds (oak, beech, spruce), in spite of being grazed by animals and inhibited by herb plants, remained in the shelterbelt for the whole study period.

The study results proved the relation between species composition of young shelterbelts and the crop on nearby fields only in the first years of their existence. The species of clear-cutting habitats and forest (for example tree seedlings) appeared mainly in part of the shelterbelt adjacent to the forest. The corridor effect of the shelterbelt for plant spreading could not be undoubtedly evidenced because from 6th year the appearance of tree seedlings wasn't dependent on distance from forest. Corridor effect was observed, however, by Loney and Hobbs (1991), who studied plant dispersion in lin-ear ecosystems of Western Australia.

The appearance of tree species with heavy seeds in farther zones of the shelterbelt since 5th year of successon indicates the role of animals for seed dispersion observed also by Barnea *et al.* (1992) and by Debussche and Iseman (1994). Vegetation growth during succession produces a number of ecological niches. The appearance of a given plant species, which is a source of food, is extremely important for insects e.g. for butterflies (Dover 1994) while the development of the storey structure creates new nesting places for birds and rodents (Kujawa 2004, Łęcki 2004) Birds and rodents invading the shelterbelt affect the rate and direction of plant succession through spreading seeds, especially the heavy ones (Barnea *et al.* 1992, Debussche and Iseman 1994).

5. CONCLUSIONS

- Initially the vegetation succession in the shelterbelt resembles that on abandoned fields. Weed communities consisted by common and very common species, typical of open areas, develop there.
- The greatest species richness of the herb plants was observed in the 3rd – 4th year since the shelterbelt planting.
- Until formation of the tree canopy, the shelterbelt is dominated by single plant species growing in patches. In the eighth year, however, due to closing the crown canopy, diversity of plant species increases.
- Among all trees forming the shelterbelt the fastest growing were the species of early succession stages (having light seeds) like: poplar, birch, larch and pine. They achieve the tree layer already after four years of succession.
- Introduction of the forest and clear cutting species is relatively slow and proceeds from the forest adjacent to the shelterbelt.

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