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Ground flora in plantations of three years old short rotation willow coppice

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Abstract. Short rotation willow coppice plantations are widely used for biomass production over the world. However, their effect on local biodiversity has not been fully elucidated. Ground flora cover of willow plantations are functionally diverse and contains high richness of plant species. The vegetation structure depends on soil type, previous land use, management practices (for example herbicide and fertilizer use) and frequency of harvesting. Investigation of ground vegetation and soil analyze were conducted in seven willow SRC plantations in Central Latvia, Skrīveri municipality. The objective of this study was to evaluate the influence of light availability, plantation age, and soil properties on ground vegetation species composition in three years old short rotation willow coppice. Plantations consist of various willow clones, planted in rows. Weed control was carried out during the first year of plantation establishment.
The qualitative and quantitative proportion of species, including species percentage cover and the mean Ellenberg indicator values were calculated. In total, 64 vascular plant species and two tree species were found in the willow coppice ground vegetation layer. Perennial plants dominate in ground vegetation (constitutes 81% of the identified species). For most species, percentage cover was 10–20% within each plot, but percentage cover of *Achillea millefolium* L., *Elytrigia repens* (L.) Nevski and *Agrostis gigantea* Roth was more than 40% in some plots.

Key words: Ellenberg indicator values, ground flora, weed species, willows, plantations.

INTRODUCTION

Short rotation coppice (SRC) plantations on agricultural lands are appropriate for biomass and bioenergy production. However, their effects on local biodiversity have not been fully elucidated (Baum et al., 2012). SRC plantation have been shown to contains high plant species richness and functional diversity (Cunningham et al., 2006; Verheyen et al., 2014), although the plant composition depends largely on the specific growth conditions (Baum et al., 2012), previous land use, management practices and time since establishments (Ledin, 1998; Sage, 1998; Fry & Slater, 2009). The influence of the previous vegetation decreases with plantation age (Stjernquist, 1994; Baum, 2012). In addition to planation age, irradiance and soil nutrient contents influence ground vegetation cover and composition in plantations (Baum et al., 2014). However, some studies indicate that willow biomass can be produced without fertilizer additions during the first rotation (Quaye & Volk, 2013). With increasing age, decrease irradiance reaching through the ground and suppresses growth of the ground vegetation (Wieh, 2009; Baum et al., 2014).

More diverse ground flora and a higher proportion of long-lived perennials characterize plantations established on former grassland instead of former arable land (Cunningham et al., 2006; Baum et al., 2012). Annual plants that germinate from the seed bank dominated immediately after the establishment of plantations, but over the time, there is an increase in the proportion of invasive and long-lived perennials (Fry & Slater, 2009).

Some researchers also argue that the vegetation communities closer to the edge of plantation are strongly influenced by the plant species from the surrounding landscape (Verheyen et al., 2014) accordingly ground vegetation cover and number of species are higher at the edges than in the inside of plantations (Cunningham et al., 2004; Cunningham et al., 2006). However, the edge effect has not been studied during this research.

It also should be mentioned that many perennial species characteristic for SRC plantations are typical for disturbed areas and anthropogenic environments. The vegetation cover consisting of a few species with high share, including predominantly grass species. Most species reported in SRC plantations are common, but rare plant species have be identified in young plantations (Baum, 2012).

There are several environmental factors influencing plant growth and geographic distribution in SRC, for example sunlight – essential for any crop, soil structure, composition, fertility, pH, water content etc. (Caslin et al., 2010). Species composition in plantations depends heavily on light intensity. Light intensity is higher in youngest plantations before full canopy closer (Baum et al., 2009; Baum, 2012) and also depends on the planted tree species. Light demanding species which includes a large proportion of annual species, usually colonize plantations in the early stage, with increasing plantation age there is a replacement with more shade-tolerant, perennial species (Cunningham et al., 2004; Cunningham et al., 2006; Archaux et al., 2010). Investigations of Sage & Tucker (1998) have shown that during the growing season photoactive radiation is reduced by between 98% and 88% within uncut willow plantation, thereby may have an impact on successful growth of the plant species within plantations. As radiation and temperature decrease with increasing canopy coverage, ruderal and pioneer species are replaced with woodland species (Baum et al., 2009) and annual species to perennial species (Cunningham et al., 2004; Cunningham et al., 2006). Usually, short-lived species being replaced by long-lived species in the vegetation succession process (Baum et al., 2009).

Weed species have been found to affect the development of plantation crops by competing for moisture, nutrients and light (Sage, 1998; Aguilar et al., 2003). Therefore perennial weeds, with developed root system have to be removed completely before planting willows (Verwijst et al., 2013). Missed or failed weed control or lack of soil preparation can lead to plantation extintion in the first growing season. However once established willow shoots inhibit the growth of weeds and ground cover consists of shade-tolerant species in spaces between rows (Lazdiņa & Lazdiņš, 2011). For example, *Salix dasyclados* has a dense crown and broad leaves providing shade and reducing ground vegetation (weed) competition (Lazdiņa & Lazdiņš, 2011). Weed management is therefore needed only during the establishment of the plantation (Wieh, 2009).

The changes in ground flora could have impacts on ecosystem processes and services. The increased ground cover may also help to reduce soil erosion and improve water quality (Rowe et al., 2009). Vegetation diversity could be beneficial for soil organism diversity, and may affect decomposition rates (Hattenschwiler et al., 2005) and may positively effects primary production (Hooper et al., 2005; Duffy et al., 2007). Ground vegetation of plantations can improve the soil structure, landscape value and provide a habitat for the natural agents of pest control (Sage, 1995; Cunningham et al., 2006).

As is well known, willow plantations are an important renewable energy resource. Willow growth and development may be affected by various factors, several of which are described above. The aim of this study is to inventory ground flora in willow short rotation coppice. Species of ground vegetation level were determined, species occurrence due to different ecological requirements (Ellenberg values), soil parametres as well as previous land use and of the plantation management activities were assessed during the research.

MATERIALS AND METHODS

Location and brief territory description

Ground vegetation surveys were conducted on four study sites located in central part of Latvia, Skrīveri municipality (56.691438, 25.133457). Short rotation willow coppice plantations were planted in 2012. Flora cover estimated in all plot 20 x 24 m as whole and graded to persents of the coverage.

Plantations were established using mixtures of genus *Salix* clones (Sven, Klara, Inger, Gudrun, Lisa, Tora, Stina, Biminalis, Swerini, Burjatica, Purpurea, Tordis). Cutings had been planted in double row system 1.5 x 0.75 x 1.5 m (Table 1). Those are comercial and candidate clones for commercial use. They need similar growth conditions. This *Salix* varieties are field-tested and have high disease and insect resistance are suitable for growing in different soils (Lazdiņa et al., 2014; Salix Energy, 2016).

In plantation was carried out weeding and line spacing mowing in the first year and only mowing in the second year. Separate plots of willow plantations were fertilized with ashes and sewage, but flora investigations were carried out in plots without fertilisers. Nearby plots were fertilized in strips (Table 1). Information about fertilizers used and fertilization regimes as well soil analysis results are published by Bārdule et al. (2013). Control plots (control–K and control–D) were selected for ground flora analysis. Names of sample plots formed using field block numbers (1–4). Control D plots – it was planned to use the digestate as fertiliser, but fertilizer was no applicated because of lacking of material) (1K; 1D; 2K, 2D, 3K, 3D, 4D).

Different forecrops were grown in sample plots before willow plantation establishment: rape (*Brassica napus* L. s.l.), timothy (*Phleum pratense* L.), perennial ryegrass (*Lolium perenne* L.), meadow fescue (*Festuca pratensis* Huds.), red clover (*Trifolium pratense* L.), common barley (*Hordeum vulgare* L. s.l.), buckwheat (*Fagopyrum esculentum* Moench) and Italian rye-grass (*Lolium multiflorum* Lam.).

Table 1. Location scheme of *Salix* clones in plantation

	1 – 'block'				2 – 'block'				3 – 'block'				4 – 'block'			
	Control - K	*ash*	*sludge*	*Control - D*	*Control -K*	*sludge*	*Control - D*	*ash*	*Control - K*	*Control - D*	*ash*	*Sludge*	Control - K	Control - D	*sludge*	*ash*
2,20 m between double rows of each clone	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Sv	Different species and trees from our road sides	Sv	Sv	Sv
	K	K	K	K	K	K	K	K	K	K	K	K		K	K	K
	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I
	G	G	G	G	G	G	G	G	G	G	G	G		G	G	G
	L	L	L	L	L	L	L	L	L	L	L	L		L	L	L
	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T
	St	St	St	St	St	St	St	St	St	St	St	St		St	St	St
	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi		Bi	Bi	Bi
	Sw	Sw	Sw	Sw	Sw	Sw	Sw	Sw	Sw	Sw	Sw	Sw		Sw	Sw	Sw
	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B
	P	P	P	P	P	P	P	P	P	P	P	P		To	To	To
20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m	20 m
Fore-crops	Rape 2007 Timothy 2008–2010 (104 m)				Perennial ryegrass 2007–2010 (56 m)			Meadow fescue 2007–2010 (56 m)			Red clover 2007–2009 Common barley 2010 (48 m)		Red clover 2007–2008 Fallow land 2009. Buckwheat 2010. (42 m)		Timothy 2007–2008 Fallow land 2009 Italian rye-grass 2010 (52 m)	

Abbreviations: Sv – Sven; K – Klara; I – Inger; G – Gudrun; L – Lisa; T – Tora; St – Stina; Bi – Biminalis; Sw – Swerini; B – Burjatica; P – Purpurea; To – Tordis.

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Ground-vegetation studies

Ground-level vegetation share in each sample plot were visually assessed using values 1, 2, 3 and 4. Braun-Blanquet method where not used, because flora were conted in all the plot not in small sampling places 1x1m. Later for grading are adapted to %, respectively 0–10%, 11–20%, 20–40% and above 60%.

Soil measurements

Soil samples were collected at different depths of 0–20, 20–40, 40–60, 60–80 cm. Soil samples were prepared for analyses according to LVS ISO 11464 Standard (LVS ISO 11464, 2006). Soil pH was measured following LVS ISO 10390 standard (LVS ISO 10390, 2006) using a glass electrode in a 1:5 suspension of soil in water (pH in H_20), in 0.01 mol^{-1} calcium chloride solution (pH in $CaCl_2$), total nitrogen ($N_{tot.}$) according to LVS ISO 11261 – Modified Kjeldahl method – (LVS ISO 11261, 2002).

Statistical Data Processing

The arithmetic mean of of Ellenberg indicator values (Ellenberg et al., 1992) for nitrogen (N), soil reaction (R), moisture (F), light (L), continentality (C) and temperature (T) of all plots were calculated. According to values plants were ordered along a nine point scale: closer value to nine, it is more connected to this indicator.

The qualitative and quantitative proportion of species, including species percentage cover was calculated. The classification of species by life expectancy was done according to Priedītis (2015).

Statistical analysis of obtained data realized using Microsoft Excel 2010, SPSS 22 software tools. Phytosociological descriptions of ground-level vegetation plant communities of seven sampling plots were stored in the TURBOVEG data base (Hennekens, 1995). The further analysis and data grouping was carried out using the Two-way indicator species analysis (TWINSPAN). Ecological analysis of vegetation in each sample plot was done using detrended correspondence analysis (DCA) and program PC ORD 4.0. The numerical significance values of ecological gradients and the relationship between axes were obtained in PC ORD program using tool (Correlations with second matrix –∑2), correlation coefficients obtained (Table 3). Ellenberg indicator values were used as main gradients.

RESULTS AND DISCUSSION

In total, 64 vascular plant species and two tree species (*Betula pendula* Roth and *Populus sp*.) were found during the analysis of vegetation in willow coppice ground vegetation layer

The most frequently identified species were *Agrostis gigantea* Roth (black bent), *Artemisia vulgaris* L. (mugwort), *Cirsium arvense* (L.) Scop. (creeping thistle), *Epilobium montanum* L. (broad-leaved willowherb), *Hypericum perforatum* L. (perforate St John's-wort), *Matricaria perforata* Mérat (scentless mayweed), *Mentha arvensis* L. (corn mint), *Vicia cracca* L. (tufted vetch) and *Betula pendula* Roth (silver birch), found on all seven plots. *Elytrigia repens* (L.) Nevski (common couch), *Hieracium spp*. (hawkweeds), *Myosotis sylvatica* Ehrh. e1 Hoffm. (wood forget-me-not), *Phleum pratense* L. (timothy), *Sonchus arvensis* L. (perennial sow-thistle), *Taraxacum officinale* F.H.Wigg. s.l. (common dandelion), *Trifolium hybridum* L. (alsike clover), *Trifolium pratense* L. (red clover) and *Tussilago farfara* L. (colt's-foot) at six sites. 39% of species found at only one or two sites (26 species) (Table 2).

Table 2. A list of vegetation species observed in the short rotation willow coppice during research. Species division by life span, frequency and cover in sample plots

Species name	Life span	Species cover in sample plots							The incidence (number of plots)
		1K	1D	2K	2D	3K	3D	4D	
Achillea millefolium L.	perennial	2	*	3	4	2	3	*	5
Agrostis gigantea Roth	perennial	1	2	3	3	3	3	2	7
Agrostis stolonifera L.	perennial	*	*	*	3	1	3	1	4
Agrostis tenuis Sibth.	perennial	2	*	1	2	*	*	*	3
Alchemilla vulgaris L. s.l.	perennial	*	1	*	*	*	*	*	1
Anthriscus sylvestris (L.) Hoffm.	perennial	1	*	*	*	*	*	*	1
Artemisia vulgaris L.	perennial	2	1	1	2	2	2	2	7
Betula pendula Roth	tree	1	1	1	1	1	1	2	7
Calamagrostis epigeios (L.) Roth	perennial	1	*	*	*	*	*	*	1
Campanula patula L.	perennial	*	*	1	1	1	1	*	4
Centaurea diffusa Lam.	annual	*	*	*	*	2	*	*	1
Cerastium holosteoides Fr.	perennial	*	*	1	1	3	1	*	4
Cirsium arvense (L.) Scop.	perennial	1	1	1	2	4	2	2	7
Convolvulus arvensis L.	perennial	1	*	*	*	1	*	*	2
Elytrigia repens (L.) Nevski	perennial	4	4	3	*	2	4	1	6
Epilobium montanum L.	perennial	1	1	1	1	2	1	1	7
Equisetum arvense L.	perennial	2	2	4	*	2	2	*	5
Erigeron acris L.	perennial	*	*	*	*	2	*	*	1
Erigeron annuus (L.) Pers.	biennial	*	*	*	2	*	1	*	2
Erigeron canadensis L.	annual	1	*	*	*	*	*	1	2
Festuca arundinacea Schreb.	biennial	*	*	*	*	1	*	*	1
Galeopsis bifida Boenn.	annual	1	1	1	1	1	*	*	5
Gnaphalium sylvaticum L.	perennial	*	*	1	1	*	1	1	4
Hieracium spp.	perennial	1	1	1	*	2	3	1	6
Hypericum perforatum L.	perennial	1	1	1	3	1	1	2	7

Table 2 (continued)

Juncus conglomeratus L.	perennial	*	*	1	*	*	*	*	1
Juncus effusus L.	perennial	*	*	*	2	1	*	2	3
Lapsana communis L.	annual	*	*	*	2	1	1	1	4
Leucanthemum vulgare Lam.	perennial	*	*	1	1	1	1	3	5
Lotus corniculatus L. s.str.	perennial	*	*	*	1	*	*	*	1
Luzula multiflora (Ehrh.) Lej.	perennial	*	1	1	*	*	*	*	2
Matricaria perforata Mérat	annual	1	1	1	1	1	1	1	7
Medicago lupulina L.	perennial	*	*	*	*	*	1	3	2
Melampyrum nemorosum L.	annual	*	*	*	*	*	*	1	1
Melandrium album (Mill.) Garcke	perennial	*	1	*	*	*	1	1	3
Melilotus albus Medik.	biennial	*	*	*	*	*	1	1	2
Mentha arvensis L.	biennial	1	2	2	2	1	1	1	7
Myosotis sylvatica Ehrh. e1 Hoffm.	perennial	1	1	1	*	1	1	1	6
Phleum pratense L.	perennial	4	4	3	*	1	1	4	6
Plantago lanceolata L.	perennial	*	*	*	*	1	1	1	3
Plantago major L.	perennial	1	*	*	1	*	1	*	3
Populus sp.	tree	*	*	*	*	1	*	*	1
Potentilla anserina L.	perennial	*	2	4	2	*	*	*	3
Potentilla erecta (L.) Raeusch.	perennial	*	*	*	*	1	*	*	1
Potentilla reptans L.	perennial	*	*	2	*	2	4	1	4
Prunella vulgaris L.	perennial	1	*	*	*	*	*	*	1
Ranunculus acris L.	perennial	1	*	*	*	1	1	*	3
Raphanus raphanistrum L.	annual	*	1	*	*	*	*	1	2
Rumex acetosa L.	perennial	*	*	2	2	1	1	2	5
Rumex confertus Willd.	perennial	*	*	*	*	*	*	1	1
Rumex thyrsiflorus Fingerh.	perennial	*	*	*	*	1	*	*	1
Senecio jacobaea L.	perennial	*	*	*	*	*	*	1	1
Solidago canadensis L. s.l.	perennial	*	*	*	1	*	1	1	3
Sonchus arvensis L.	perennial	2	3	2	*	3	2	2	6

Table 2 (continued)

Stachys palustris L.	perennial	1	*	*	*	*	*	*	1
Stellaria graminea L.	perennial	*	1	3	2	1	1	*	5
Taraxacum officinale F.H.Wigg. s.l.	perennial	*	2	2	2	2	2	1	6
Trifolium hybridum L.	perennial	*	1	1	1	2	1	2	6
Trifolium medium L.	perennial	*	*	*	*	*	*	1	1
Trifolium pratense L.	perennial	1	1	*	1	2	1	2	6
Trifolium repens L.	perennial	1	2	2	*	2	2	*	5
Tussilago farfara L.	perennial	1	2	1	4	2	*	2	6
Urtica dioica L.	perennial	*	*	*	1	*	*	*	1
Valeriana officinalis L.	perennial	1	*	*	*	1	1	2	4
Vicia cracca L.	perennial	1	1	4	2	1	1	2	7
Viola arvensis Murray	annual	*	*	*	1	*	*	*	1

* species was not established in sample plot.

Data obtained during research show that perennials are particularly dominant in willow plantation ground flora level with 81.3% proportion of the total number of vascular plant species in plantations, annuals – seven species (10.9%), biennials – five species (7.8%) (Fig. 1). Total species number per plot varied from 27 to 41.

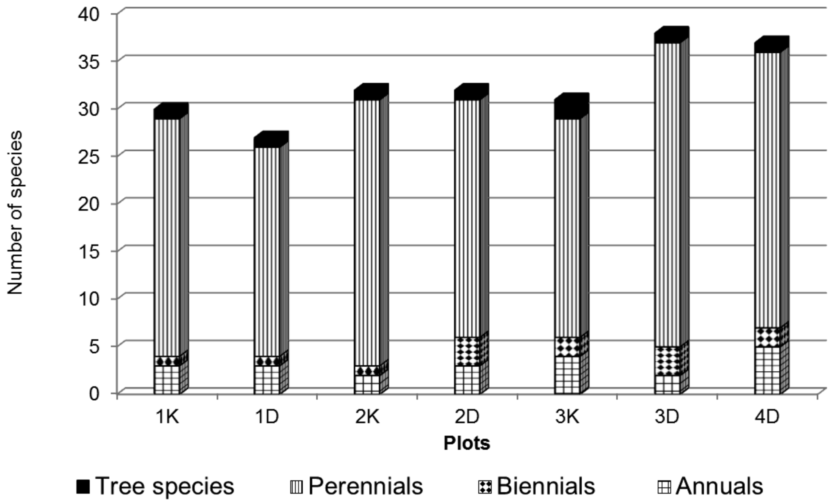

Figure 1. Ground-level vegetation groups by life span.

Similar studies in Sweden show that *Taraxacum officinale, Betula pendula*, *Dactylis glomerata* (orchard grass) and *Geum urbanum* (wood avens) are very common plants in willow plantations (Baum et al., 2013). However, in plots located in Skrīveri *D. glomerata and G. urbanum* were not detected at all. Ligh and soil nutrients The main factors could be key factors for *G. Urbanum* distribution. Mean Ellenberg indicator value for light in sample plots is 7, but this plant are shade tollerant (Ellenberg indicator value for light = 4), and also associated with nutrient-rich soils (Ellenberg indicator value = 7), but average in plots is 5.4. It were former arable land no abandoned grasland which is ussualy turned to SRC plantations to minimize agricultural activities necesary for some product growing up.

On average, for most species (48.5%), cover takes up to 10% per sample plots. Species average cover within one plot also is similar and takes about 15–20%. Percentage cover of *Achillea millefolium* L. (yarrow), *Elytrigia repens* (L.) Nevski and *Agrostis gigantea* Roth in average takes more than 40% in some plots.

Invasive species

According to list of invasive species in Latvia (Anon, 2014), two potentially invasive (*Erigeron canadensis* L., *Myosotis sylvatica* Ehrh. e1 Hoffm.) and three invasive species (*Populus* species, *Rumex confertus* Willd. and *Solidago canadensis* L. s.l.) were found. However, the total covers of these plants in plots were only about 10% and characterized by a small number of invaded plots (*Populus sp*. and *R.confertus* – one, *E.canadensis* – two, *S.canadensis* – three and *M. sylvatica* – six). It is need to take into account fact that *Populus* species are characterized as fast-growing plants and species coverage may increase in the coming years. Relatively wide range of distribution of *M. sylvatica* could relate with plant ecology – tolerate a variety of soils, full sun to full shade and prefers rich-moist soils. Numbers of plants are limited because during management they are going to cut down before seed production, probably seeds were bringing by animals from abandoned fields.

Occurrence of weed species

Several weed species typical for vegetation of Latvia were also found in plots (weed species evaluation based on State Plant Protection Service database about weed species in Latvia) (State Plant Protection Service, 2016). Weed species, which found in all plots: *Artemisia vulgaris* L., *Cirsium arvense* (L.) Scop., *Matricaria perforata* Mérat, *Mentha arvensis* L. and *Vicia cracca* L.

Urtica dioica L. (common nettle) is relatively widespread weed in Latvia, recorded only in one plot with average cover about 10%, in contrast in Rowe et al., (2011) reported high abundance of *U. dioica* in a study off mature willow SRC in the United Kingdom, but this plant was not most abundant weed in surrounding land-use. The level of plant covers increase with distance into the cultivated area (Rowe et al., 2011). Insufficient soil moisture and nitrogen content probably determine the prevalence of species. According to Taylor (2009) *U.dioica* occurs on almost all soil types, although it prefers moist or damp soils, and also has been described as a nitrophile or nitrophyte found in highly rich fertile conditions (Taylor, 2009).

Occurrence of *Artemisia vulgaris* may indicate about decrease in agricultural activity, but increase in the number of *Mentha arvensis* about changes in the composition of agrobiocenosis and about proliferation of weeds resistant to herbicides, for example *Matricaria perforata* (Priede, 2011; Lapiņš & Oboļeviča*,* 2014).

Albertsson J. (2014) found in his study that from the establishment until the end of the first harvest, annual weed species gradually replaced with the perennials. Another essential feature: more than 60% of the ground was covered by creeping thistle (*C. arvense*). *C. arvense* can reduced growth of plantation crops at the end of the first year by > 90% (Clay & Dixon, 1997). Weed control is necessary when installing willows from cuttings. Its takes time while willow cuttings becomes competitive against weeds (Verwijst et al., 2013).

Taking into account a fact that some weed species and also invasive species with relatively rapid and sometimes even aggressive distribution were found, they can also create a threat to plantations. For example *S.canadensis*, which has spread widely in recent years in Latvia. Seeds are essential for long-distance dispersal and infestation of large territories. *S. canadensis* also spread quickly and is well adapted to a wide range of habitats (Weber, 2000; Priede, 2008). It can take a lot of money to implement limiting measures.

Weed prevalence may affect the future growth of the willow clones and output of biomass yield. Depending on territory, weeds reduced stem biomass yield by between 68 and 94% after the first harvest cycle and also increased plant mortality (Albertsson, 2014). The low plant density restricts the possibility of willow to oppress weeds during the first season (Labrecque et al., 1994). If weeds are not controlled well, they will exceed and suppress the willow plants more than the willow suppresses the weeds (Albertsson, 2014). In order to facilitate decision making about control measures, weeds can be classified according to their life cycle (Lundkvist & Verwijst, 2011).

Ellenberg indicator values:

Identified plant species demands for environmental parameters are summarized in Fig. 2.

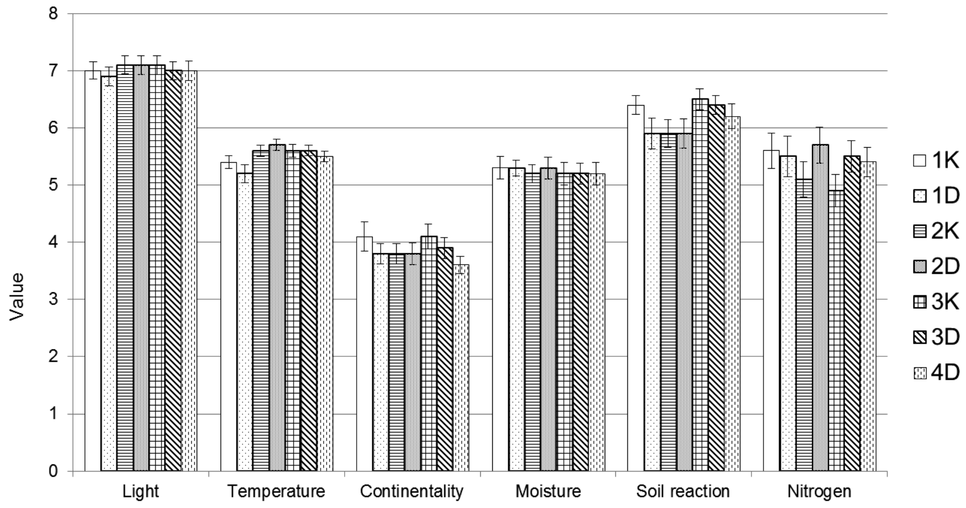

Figure 2. Mean Ellenberg indicator values with standart error bars in sample plots.

Mean Ellenberg indicator values represents that all species found in seven sample plots have high requirements to **light**. Average value of all plots 7.1 – typical for species which are more appropriate to grow in full or half- light conditions. According to Birmele et al. (2015) light-demanding plant species were dominating SRC plantations at all vegetation research time (2010–2013). Nevertheless their proportion showed a steady deterioration, but the proportion of semi-shade species raised and some shade-tolerant species occurred (Birmele et al., 2015).

Three from observed species have maximum requirements for the light - *Centaurea diffusa* Lam. and *Melilotus albus* Medik. (grows in groups on roadsides and along railways; in dry, sandy wastes in Latvia), *Erigeron acris* L. (in Latvia: different dry habitats). *M.albus* also is typical in dry weedy plant communities. Found only one species *Melampyrum nemorosum* L., with optimal growth conditions in middle shade. Analyzing the spread in Latvia, plant mainly found in dry forests and forest edges, shrubs and roadsides (Priedītis, 2015).

The average **temperature** values (5.5) shows that most species are moderately warm climate species. Two species (*Centaurea diffusa* and *Rumex thyrsiflorus* Fingerh) – warm climate species, one (*Alchemilla vulgaris* L. s.l.) – species characterized for cool climate. *C. diffusa and R. thyrsiflorus* typical to Latvia biotopes (dry and sunny meadows, sunny slopes of riverbanks and along railways) shows not only this plant requirements for the light, but also for the high temperature.

Continentality (average value 4) – species typical for suboceanic climate, which conform to the location of the Latvia.

Requirements for moisture – xeromesophytes (average value 5.1). Six species which haracterized as plants growing in moist and wet conditions (values 7–8) – *Agrostis stolonifera* L., *Festuca arundinacea* Schreb., *Juncus conglomeratus* L., *Juncus effusus* L. and *Mentha arvensis* L. *Juncus sp*. occur a wide range of habitats, usually moist, but not wet. Four species – *Achillea millefolium*, *Centaurea diffusa*, *Melilotus albus* and *Rumex thyrsiflorus* - drought tolerant plants.

Average soil reaction value (6.2) corresponds to plants growing in neutral soils. Four species – *Centaurea diffusa*, *Erigeron acris*, *Medicago lupulina* L., *Tussilago farfara* L. – prefer alkaline soils and *Juncus effusus* L. – acidic soils.

Ellenberg indicator values for **soil nitrogen** concentration show data distribution. Average value 5.1 – indicator of sites of intermediate fertility. Twelve species are within group - more or less infertile sites and five species – with nitrogen extremely rich soils. *U.dioica* have the maximum value of indicator values (9) and was found only in one site (2D). Perhaps it depends on soil conditions, because plant prefers slightly acidic to alkaline soil, moist and rich in nutrients (Ellenberg et al., 1992).

Vascular plants in sample plots are differentiated by ecological conditions. The distribution within the ordination space is explained by DCA Axis 1 with eigenvalue 0.89, DCA Axis 2 with eigenvalue 0.26 and DCA Axis 3 with eigenvalues 0.19.

Between calculated average Ellenberg indicator values moisture and temperature are the major gradients grouping plots into groups (Table 3).

Table 3. Correlation between DCA axes and Ellenberg values

Parameter	DCA Axis 1	DCA Axis 2	DCA Axis 3
Light (L)	-0.74	-0.41	0.38
Temperature (T)	-0.89	-0.20	0.31
Continentality (C)	0.26	-0.51	-0.21
Moisture (M)	0.74	-0.61	0.59
Soil reaction (R)	-0.11	0.18	-0.59
Nutrients (N)	0.40	0.31	0.46

Most of species also are located in the direction of the temperature gradient (Fig. 3).

Taking into account species composition in sample plots and its location between axes, there are differences between sample plots. For example, plot 1D differ with species lower requirements for light and temperature, plot 1K – species with lower temperature requirements.

Optimal or even increased species demand for light and temperature shown in plots 3D, 2D, 3K. The following results can be explained by the fact that the plantation was created only two vegetation seasons ago. Thus, there is no competition between planting material and ground flora for ecological factors (mainly light and water) yet. This is well illustrated by the location of plots 1K and 1D – species listed in these plots have the lowest temperature requirement (Ellenberg indicator values) (Ellenberg et al., 1992).

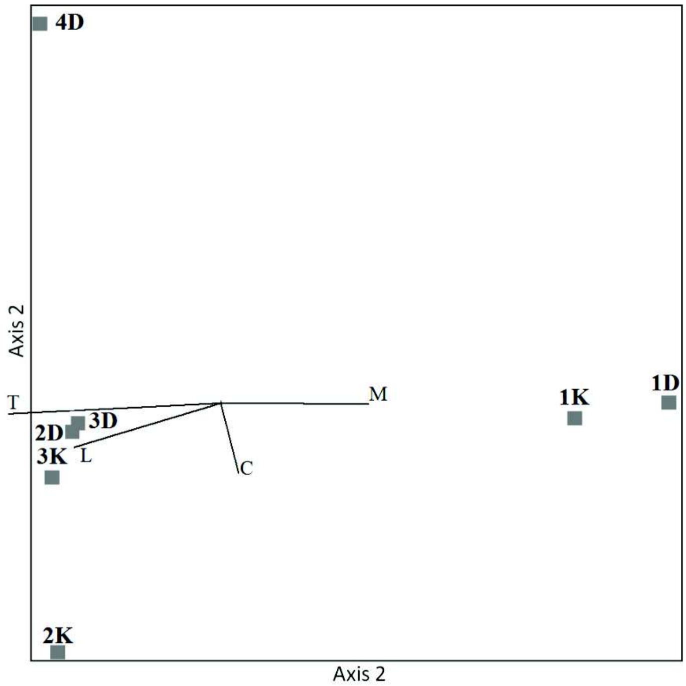

Figure 3. DCA ordination of releves. Sample plots 1K – 4D. T – temperature, L – light, C – continentality, M–moisture.

Soil analyses

In total seven sample plots were investigated and soil parameters were measured (Table 4).

Table 4. The soil parameters of analyzed sample plots of willow short rotation coppice (2011)

	Sample plot						
	1K	1D	2K	2D	3K	3D	4K
pH ($CaCl_2$)	5.9	7.0	6.5	4.5	4.6	5.6	5.1
mg N_{total} * kg	0.8	1.5	3.2	0.6	0.4	0.7	0.3
mg P_{total} *kg	124.6	97.1	88.8	53.8	82.0	59.3	53.1

The pH values ranges from 4.6 to 7.0. The highest pH values were found at 1D and 2K plots, respectively 7.0 and 6.5. The most suitable soils for willows are soils with pH 5.5–7.5 and will provide satisfactory coppice growth. In alkaline soils willows grow more slowly and are more vulnerable to disease (Lazdiņs et al., 2005; Caslin et al., 2015). So it can be concluded, plots 2D and 3K (with acidic soils) not very appropriate for development of willow clones. In addition, the largest number of weed species was counted in these plots, which may further limit the development of willow clones.

Table 4 shows higher concentrations of phosphorus in the plot 1K (124.6 mg kg^{-1}) and also high concentration in plot 1D (97.1 mg kg^{-1}). Phosphorus is an important element in plant growth. The highest concentration of total nitrogen was detected in plot 2K (3.2 mg kg^{-1}). The cultivation of fast-growing trees could reduce nitrate concentrations in the soil solution, because nitrogen is consumed by trees and other ground vegetation. Short rotation plants have ability to use nutrients from deeper soil layers (Līpenīte & Kārkliņš, 2011). Obtained results show that the content of N_{total} decreases towards the deeper soil layers.

Differences in soil conditions on which willow species are being grown for energy purposes, are reflected in weed species diversity (Wrobel et al., 2012).

At the same time the willow clones are expressed response to nutrient supply and the amount of available sunlight (Lazdiņa et al., 2014).

A statistically significant correlation was not found between soil chemical parameters and calculated average Ellenberg indicator values and of soil parameters: reaction and nutrients.

CONCLUSIONS

1. It is difficult to talk about changes in herbaceous species number and proportion in ground-level vegetation in the coming years in this study. Flora assessment should be done for several years (during the first four years since installation) in these plantations. This would allow predicting species, which will spread more intensive and also assess their effects on planted willow clones, as similar studies of other scientists demonstrate.

2. It is considering that plantations of willows on agricultural land can provide higher biodiversity compared with fields of cereals or monoculture plantings, however additional studies of vegetation also should be carried out in cereals other agricultural fields.

3. Perennial plants dominate in plantations, and some species were detected in all plots. This may indicate that, distribution of certain plants develop and stabilize over time and adapt to the specific growing conditions of plantation.

4. On the one hand, presence of invasive and weed species increase the total species diversity in plantation, but on the other hand, may also reflect the negative changes in composition of flora, which may lead to the homogenization of flora.

5. Analysis of Ellenberg values shows, that light and temperature loving plants are dominating in the plantation at the moment of research. However, these parameters likely will change, with increase in plantation age and willow size and may increase the number of shade tolerant plants until current cutting.

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