DISTRIBUTION OF WOODY VEGETATION ON THE SLOPES OF REGULATED STREAMS

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Abstract

The paper presents the study material and analysis of the distribution of woody vegetation of regulated streams in southeast Lithuania. The studies were carried out in 110 randomly selected slope strips of regulated streams in the Neris river basin in the Baltic Highland within the period of 2005 to 2006. During the studies 32 species of woody vegetation were found, from which 14 species of trees and 18 species of bushes. In regulated streams different species of willows are most common. However their distribution on channel slopes is different. For most species of woody vegetation the conditions are most favorable in the lower and middle part of slopes. Here their density is highest (0.34 ± 0.89 and 0.73 ± 0.139 units m^{-2} respectively), the frequency is 0.56 and 0.64 respectively. As it was determined, the frequency of woody vegetation on slope strips of regulated streams is $n_a = 0.61$. On the slope the lower overgrowth limit of woody vegetation is $r_a = 1.58 \pm 0.16$ m, the upper limit is $r_v = 4.13 \pm 0.22$ m. In southeast Lithuania, in discharge network of drainage systems there are more possibilities for planning of ecological means, when trees and bushes are allowed to grow on slopes.

Keywords: regulated streams, overgrowth of slopes, woody vegetation.

Introduction

Except for protective channels (there are about 10 thousand km of them) in Lithuania there are about 53 thousand km of land reclamation channels. Most of those channels are former natural, now regulated water flows. The purpose of a drainage channel is to collect and discharge water from draining areas on time (Lamsodis, 2001). When selecting maintenance ways for water recipients of drainage systems and adapting them to natural processes occurring in channels, it is important to determine the suitability of the state of channels for the performance of functions of water recipients. The main purpose is the conductivity of the channel. Vegetation – trees, bushes, grass – reduce the conductivity of the channel (regulated stream) (Rimkus and Vaikasas, 1998). Many researchers have investigated the resistance of trees and bushes to water flow, the influence of their shadows on the development of grass vegetation, as well as the hydraulic conductivity of the channel (Rimkus et al., 2002; Šukys and Poškus, 1998). Naturally, every additional obstacle (trees, bushes and grass vegetation) increase the resistance to the flow within a flow profile and thus reduce the hydraulic conductivity. As the study results show, the hydraulic conductivity in overgrown channels is most affected by the central part of channels, and flood water is often collected in the bed; moreover, the lower strip of the channel is less overgrown with trees, and in the zone of shadow grass vegetation is choked naturally. Higher density of trees makes more significant impact on the vegetation.

Having carried out land reclamation works, also having eliminated sprouts, bushes and other perennial vegetation from slopes, the morphological structure of landscape has changed and become less different. Natural components were replaced by many morphological anthropogenic components. When the amount of vegetation decreases in draining areas, the conditions become favorable for wind erosion, pollution of water bodies, specific changes of fauna and changes of local microclimate. The studies carried out in the Vardas stream basin in southeast Lithuania (Šileika et al., 1998) have shown that the protective belt arranged around the streams may effectively retain and remove nutrients and sediment. Trees and bushes growing on the protective belt significantly reduce nitrate concentration in water flowing from adjacent arable land plots.

Having regulated the stream, woody vegetation does not grow on its slopes. During the changes of grass vegetation in channels, woody plants start growing here. Most often these include deciduous trees and bushes. Having investigated woody vegetation in the Nevėžis Plain in Middle Lithuania (Lamsodis, 2002; Lamsodis, 1999), 32 species of woody vegetation were observed. It was determined that the highest specific composition, frequency and density of woody vegetation is observed in channels arranged in the forest, at the outskirts or near the forest. Thus the forest and outskirts of forest are places where drainage channels are most naturalized from the dendrology point of view. In field channels single plants are prevailing. Here the lower and upper parts of channels are overgrown most intensively. In channels located near the forest, in outskirts of forest or in the forest the middle and upper parts of slopes are overgrown most intensively. This implies that the distribution of plants more depends on the forest; on slopes of field channels the distribution of vegetation more depends on different moisture conditions on the upper and lower parts of slopes. The overgrowth of channel slopes also depends on the exposition of the channel. As it was determined (Lamsodis, 1999; Survilaitė and Šaulys, 2006), field channels facing west, northwest, north and northeast tend to overgrown with vegetation more intensively.

Thus, the overgrowth process of the discharge network of drainage systems with trees has a positive impact on the environment, as well as reduces the hydraulic conductivity of the channel, which is particularly important for the principle draining function to perform. Detailed investigations about the overgrowth of channel bed and slopes with woody vegetation, its specific composition and expansion were performed in the region of intensive agriculture in the Nevėžis river basin located in the Middle Lithuania (Lamsodis, 2001; Lamsodis, 2002). Meanwhile, no any similar investigations are performed in southeast Lithuania. The objective of this work was to investigate quantitative and qualitative peculiarities of the overgrowth of regulated streams with woody vegetation, and evaluate the future possibilities to plan the naturalization of regulated streams of southeast highlands.

Materials and Methods

The studies were carried out in the Neris river basin, in the Baltic highlands (the so-called Baltiškais mountain range) located in the south and east of Lithuania within the period of 2005 –to 2006. Form the point of soils regionalism, the territory corresponds to the districts of South and East Lithuanian Highlands, and its larger part. Soils prevailing here include sand, loam and sandy loam rock-forming soils. Widely expanded sand and sandy loam soils permeable to water absorb snow thaw and precipitation water. Due to their fast infiltration, those waters contribute to the subsurface water stock that gradually is transported to rivers during the abatement period. Annual subsurface runoff of rivers of the study area reaches 5.0 l s^{-1} km^{-2}, which is nearly 10 times higher than that of rivers of Middle Lithuania (0.5 l s^{-1} km^{-2}) where soils of heavy-textured soils of low conductivity are prevailing. The region is distinct for hilly relief, large areas of eroded land and high danger of erosion. The average precipitation amount in southeast Lithuania reaches 700 mm per year. Their distribution is uneven due to the non-homogeneity of spread hills, abundance of water bodies and other reasons. The average annual air temperature is 5.7 °C, the amplitude of yearly air temperature, the index of which is

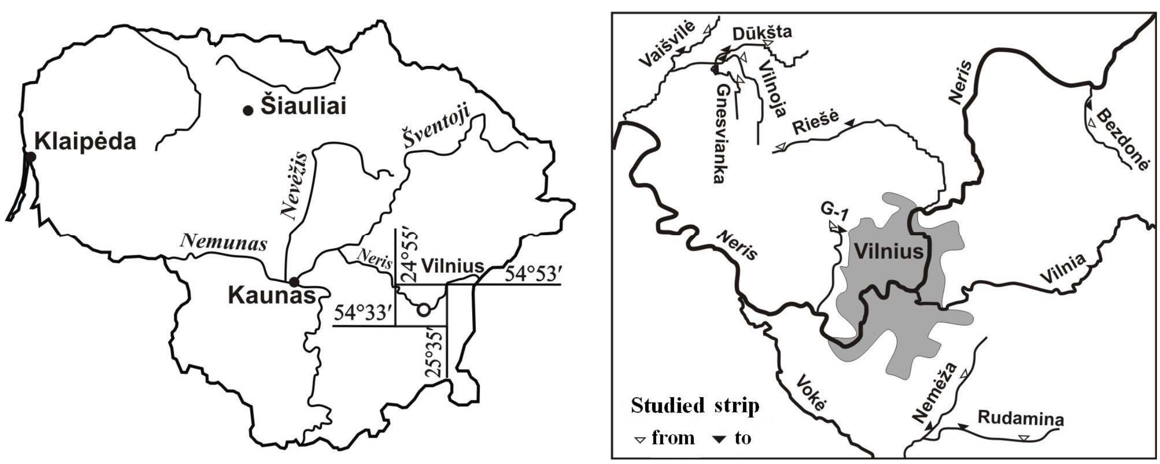

Figure 1. Location of the study area.

the difference between average temperatures of July and January, reaches 23.0-23.5 °C (Gailiušis et al., 2001). Forest density is middle in the region (about 28%). Here small forests, mostly pinewoods, fir woods, birch woods, alder woods and asp woods are prevailing without any large forest areas (Kuliešis et al., 1997). River network is sparse (on the average 0.75 km km^{-2}), because apart from rivers, the territory is drained by lakes and marshes (Baltrušaitienė et al., 1975).

The studies were carried out in strips of the following regulated streams: the Bezdonė, the Dūkšta, the Gnesvianka, G-1, the Neměža, the Riežė, the Rudamina, the Vaišvilė and the Vilnoja. Scheme of the study area is given in Figure 1.

The length of all investigated stream strips reaches 12.7 km, the one of slope strips is 112 km. The average strip length was selected to be 10 meters. In the most representative place of the strip one profile under analysis was distinguished, where morphometric measurements of the stream bed profile were made. The lower border (r_a) of slope overgrowth with woody vegetation was determined – i.e., the distance upwards the slope, from the foot of the slope until the edge of vegetation. Also the upper border (r_v) of slope overgrowth with woody vegetation was determined – i.e., the distance upwards the slope from the foot of the slope until the edge where no vegetation is observed. The width of the overgrown strip of the slope (L_a) is expressed by the difference between overgrowth of upper and lower edges of the slope with woody vegetation.

Considering the moisture conditions for plants, the slopes of investigated strips were divided into three parts – upper, middle and lower (the foot of slope). In every part of the stream slope (habitat) the dispersion of woody vegetation was determined in respect of quantitative and qualitative characteristics of different species, communities and their whole. The habitat of woody vegetation is considered to be the stream bed profile where individual species or their communities are present.

The number of woody vegetation species (R_{sk}) in habitats (distinguishing upper, middle and lower parts of slope) was determined on the basis of the Guidebook for the recognition of Lithuanian plants (Lekavičius, 1989; Snarskis, 1968).

The frequency of separate species of woody vegetation (D) in habitats was determined as ratio of bed slopes or their sample of parts in which this spice was found (upper, middle and lower part of slope) and the number of researched bed profiles.

The density of woody vegetation (T) in habitats was determined as a total number of stems and forms (a bush of one species was considered as a unit) falling for 1 m^2 of the area of the whole bed slope as well as parts of slopes (i.e., the number of stems and forms falling for 1 m^2 of the area of upper, middle and lower part of slope).

The data of the spread of woody vegetation in the regulated stream beds was processed by the methods of mathematical statistics (was estimated mean value, standard deviation, coefficient of variation, standard error of the mean value) (Čekanavičius and Murauskas, 2000; Čekanavičius and Murauskas, 2002).

Results and Discussion

Different trees and bushes grow on the slopes of regulated streams. Having made the investigations in streams of southeast Lithuania (Fig. 1), 32 species of woody vegetation were found, from which 14 species of trees and 18 species of bushes. Within the study area the following tree species were most dominant: sallow (*Salix caprea*) observed in 25 habitats, white alder (*Alnus incana*) and black alder (*Alnus glutinosa*) observed in 22 and 16 habitats respectively. From all bushes, the most popular was grey osier (*Salix cineria*) observed even in 47 habitats.

When analyzing the overgrowth of regulated stream slopes with woody vegetation it is obvious that its distribution on channel slopes is different. For most species of woody vegetation the conditions are most favorable on the lower and middle parts of the slope. Here its frequency and density is highest (Fig. 2). Frequency of woody vegetation on the middle part of the slope and on the foot of the slope is 0.64 and 0.56 respectively. Frequency on the foot of the slope is 0.45 less. The changes of density of woody vegetation are similar in different parts of the slope. The highest density is observed on the middle part of the slope (0.73 ± 0.139 units m^{-2}) and on the foot of the slope (0.34 ± 0.089 units m^{-2}). The least density and frequency of woody vegetation are observed on the upper part of the slope.

Changeable growing conditions on the slope resulted in scarce woody vegetation due to moisture excess on the lower part of the channel slope (the most frequent spot of the contact of depression curve with the slope) (Table 1). The lower edge of the overgrowth of slope with woody vegetation is $r_a = 1.58$ m. In each case the variety of different conditions is expressed by a rather high variation coefficient (84%). On the

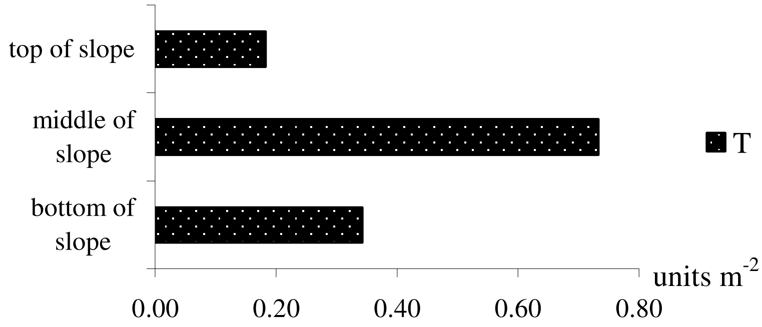

Figure 2. Distribution T of woody vegetation.
(T - density (units m^{-2})).

upper part of the channel slope (nearly always above the depression curve) the amount of woody vegetation is also less due to the lack of moisture. The upper edge of the overgrowth of slope with woody vegetation is $r_v = 4.13$ m, or 2.02 m from the upper part of the slope (variation coefficient is 43%). As the best conditions for plant growing are observed on the middle part of the slope, here woody vegetation is most abundant. In this part of the slope the width of overgrown strip is $L_a = 2.55$ m, variation coefficient is 77%.

As it was determined, the lower edge of the overgrowth of slope with woody vegetation is $r_a = 1.58$ m, which is 1.76 times more than the overgrowth of the lower edge (0.90 m) determined in the Middle Lowland of Lithuania In southeast Lithuania, sand and sandy loam soils are prevailing, and here the coefficients of channels of trapezium-shaped profile are higher (m = 2.0) than in the Middle Lowland of Lithuania (m = 1.5) where loam and clay soils are dominant. Therefore here the water depth in the channel bed increases 1.42 times and the width of the flow increases 2.23 times until the edge of woody vegetation strip. When the hydraulic roughness and other morphometric parameters of the lower part of profile are similar, the hydraulic conductivity of regulated streams overgrown with woody vegetation is more than 2 times higher in southeast Lithuania compared to those in the Middle Lowland of Lithuania. From this point of view, in southeast Lithuania there are more possibilities to plan ecological means in the discharge network of drainage systems, allowing trees and bushes to grow on the slopes.

Different moisture demand of the species determined their different distribution on the slope (Table 2). Various trees and bushes require different amounts of water, and thus differently support the lack of moisture.

Table 1

Indices of slopes of regulated streams covered with woody vegetation

Index	slope length, L	lower overgrown limit, r_a	upper overgrown limit, r_v	width of overgrown strip, L_a
total number of strips, N	112			
number of strips when woody vegetation was discovered on slopes, n	68			
frequency of slopes covered with woody vegetation, n_a	0.61			
mean value, $\bar{x}$, m	6.15	1.58	4.13	2.55
standard deviation, S	1.60	1.32	1.78	1.95
coefficient of variation, C_V	26 %	84 %	43 %	77 %
standard error of the mean value, S_X	± 0.19	± 0.16	± 0.22	± 0.24
error of the mean value when reliability is 95%, S_{X95}	± 0.38	± 0.31	± 0.42	± 0.46

Table 2

Spread of species (frequency and density) in different parts of the slope

Species	D$\times 10^{-2}$ (frequency) ratio			T (density) $\times 10^{-2}$ units m^{-2}		
	top	middle	bottom	top	middle	bottom
Alnus glutinosa	0.00	1.82	9.09	0.00±0.000	0.11±0.111	0.79±0.402
Salix triandra	1.82	3.64	7.27	1.09±1.092	1.04±0.875	1.40±0.788
Salix fragilis	3.64	7.27	9.09	1.02±0.835	3.27±1.780	5.08±2.660
Alnus incana	3.64	20.00	18.18	0.18±0.130	4.00±1.480	3.84±1.580
Salix caprea	5.45	18.18	7.27	0.92±0.707	3.63±2.083	2.00±1.753
Salix pentandra	0.00	5.45	1.82	0.00±0.000	4.36±2.783	0.25±0.248
Tilia cordata	1.82	0.00	0.00	0.11±0.108	0.00±0.000	0.00±0.000
Quercus robur	3.64	1.82	0.00	0.46±0.405	0.08±0.081	0.00±0.000
Acer platanoides	7.27	5.45	0.00	1.07±0.821	0.64±0.415	0.00±0.000

For some species, such as black alder (Alnus glutinosa) and crack-willow (*Salix fragilis*), the most favorable growing conditions are observed on the foot of the slope. Here their frequency and density are highest (0.091, 0.0140 units m^{-2} and 0.0508 units m^{-2} respectively). For other species, such as white alder (*Alnus incana*), twig willow (*Salix pentandra*) and sallow (*Salix caprea*), more favorable conditions are found on the middle part of the slope. Oak tree (*Quercus robur*), fir tree (*Picea abies*), European wahoo (*Euonymus euripaea*), small-leave linden (*Tilia cordata*), pear-tree (*Pyrus*) and apple-tree (*Malus*) are found only on the upper part of the slope or on the protective strip. (Lamsodis, 2002) has assigned to this group common black alder (*Frangula alnus*), common filbert (*Corylus avellana*), common maple (*Acer platanoides*), cork elm (*Ulmus suberosa*) (the species are spreading towards the top of the slope). Those species, except for common filbert (*Corylus avellana*), were found very seldom, most often in the forest, therefore it is difficult to decide about their location on the slope.

Conclusions

On the slopes of regulated streams of the Baltic highlands of southeast Lithuania 32 species of woody vegetation were found, from which 14 tree species and 18 bush species. As the study results have shown, the specific composition of woody vegetation and its distribution in regulated streams depend on the place in the landscape (forest, outskirts of forest or field) and on the location on the slope. The study results have also shown that the frequency of the overgrowth of regulated stream slopes with woody vegetation is $n_a = 0.61$ (ratio). The lower and upper edges of the overgrowth of slope with woody vegetation are $r_a = 1.58 \pm 0.16m$ and $r_v = 4.13 \pm 0.22m$ respectively. The width of the slope strip overgrown with woody vegetation is $L_a = 2.55 \pm 0.24m$.

For many species of woody vegetation the most favorable growing conditions were observed on the lower and middle parts of the slope, where the frequency (D) and density (T) of vegetation are D-0.56, T-0.34 $\pm$ 0.089 units m^{-2} and D-0.63, T-0.73 $\pm$ 0.139 units m^{-2} respectively.

According to the distribution of growth on the slope of regulated streams, three types of woody vegetation of streams were distinguished, which has shown that not all species are equally adapted to the growing conditions on different parts of the slope.

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