UDK 630*5:631.6

THE IMPACT OF CANOPY DENSITY AND LIGHT TRANSMISSION ON THE PROJECTIVE GROUND VEGETATION COVER OF WINDBREAKS

G.O. Lobchenko, *postgraduate student*[*]

The impact of forestry and mensuration indices and light transmission of the canopy on the projective ground vegetation cover are analyzed in the article. It's found out the correlation between projective ground cover and canopy density and light transmission. These relationships are described by the equation of polynomial dependence. According to the modelling results that favorable conditions are formed by canopy density stands above 1,25 (0,9) and light transmission below 8 (16)% were revealed. There are recommendations for species composition of windbreaks for the ensuring conditions of formation forest environments in the line stands.

Windbreaks, ground cover, projective cover, canopy density, light transmission, modeling, reliability approximation index.

Introduction. Stability of the biological community is ensured by the availability and effective interaction of all its components. In particular for the forest as a type of natural complex is characterized by the following main components: stands, understory, underwood, living ground vegetation, forest soil. It is known that environmental conditions and vegetation, which is growing in these conditions, are interrelated and influence each other.

Ground vegetation is the most sensitive to changes in the environment, that's why it is acting as a reliable indicator of site conditions. In addition to abiotic factors, ground vegetation is exposed by influence of higher storey of vegetation: understory, underwood and the main component of forest ecosystems – forest stand. This effect is evident at all stages of forest plantations in different ways [2, 5, 6].

Especially these processes recognized in the windbreaks, which are linear plantings, the formation of which takes place in the harsh conditions of open space [1]. Belgard O.L. in his works (1953, 1956 and 1960) has described the environment-transforming role of forests, which is determined by the time of its effect on the environment and changes with age. That's why he distinguished three

[*]Supervisor – doctor of sciences, professor V.Y.Yukhnovsky

stages in the life of the stand life: stand before the closing of canopy, period of maximum closure of canopy and period of marked thinning. At the young age of the stand herbaceous vegetation acts as a competitor for tree and shrub layer in the struggle for moisture and nutrients. After canopy closure ground vegetation undergoes qualitative changes in the structure and serves as phyto-indicator of conditions that formed in the stands [6].

The aim of the research was to analyzing and modeling the degree of dependence between projective cover ground vegetation and forestry and mensuration indices and light transmission of their canopy.

The object of the research is windbreaks of the Right-Bank Forest-Steppe, where were established 17 sample plots, 7 of which are presented in the Vinnitsa region, 5 – in the Kyiv region and 5 – Cherkassy region (Table 1).

1. Forestry and mensuration characteristic of the sample plots

№ of sample plot	Composition	Age, years	Diameter, cm	Height, м	Cross-sectional area, $m^2 \cdot ha^{-1}$	Canopy density	Light transmission, %	Ground vegetation cover, % (2012)	Ground vegetation cover, % (2013)
Trostyanets district, Vinnitsa region									
1	100 % Quercus robur	54	39,0	24,7	93,3	1,30	4,80	13,48	8,25
2	70% Quercus rubra 30% Tilia cordata	38	16,9	18,1	37,6	0,85	16,45	33,77	12,97
3	100% Quercus robur	50	33,7	25,2	72,6	1,20	8,60	12,63	6,38
4	60% Quercus robur 30% Tilia cordata + Cerasus avium	45	45,5	25,6	86,1	1,10	11,48	6,71	7,81
5	70% Quercus robur 30 % Fraxinus excelsior	35	29,3	22,4	61,4	0,95	16,83	5,41	9,38
6	90% Fraxinus excelsior 10% Acer platanoides + Cerasus avium	50	30,3	21,4	56,8	1,10	10,02	4,28	4,17
7	50% Quercus robur 50% Acer platanoides + Cerasus avium	45	27,2	21,4	41,1	0,80	19,62	23,39	24,88

Continuing of the Table 1.

№ of sample plot	Composition	Age, years	Diameter, cm	Height, м	Cross-sectional area, $m^2 \cdot ha^{-1}$	Canopy density	Light transmission, %	Ground vegetation cover, % (2012)	Ground vegetation cover, % (2013)
Vasylkiv district, Kyiv region									
8	70% Fraxinus excelsior 30% Quercus robur	45	31,4	21,1	49,5	1,20	13,53	4,00	3,11
9	40% Acer platanoides 20 % Salix alba 20% Acer negundo 10% Populus alba)	45	35,6	11,9	114,2	1,30	8,90	0,00	0
10	70% Quercus robur 30% Acer platanoides	45	33,5	22,5	53,7	0,75	18,04	22,25	31,87
11	100% Acer platanoides	45	24,7	16,1	55,4	0,85	14,50	10,19	9,57
12	70% Populus alba) 30% Ulmusglabra	45	41,9	25,6	96,4	0,90	15,38	1,51	50,13
Lysyanska district, Cherkassy region									
16	40 % Quercus robur 60 % Tilia cordata	50	25,0	17,0	57,8	1,2	14,77	-	1,90
17	30 % Quercus robur 40 % Tilia cordata 20 % Cerasus avium 10 % Betula pendula+ Acer platanoides	60	29,6	20,0	73,9	1,3	11,18	-	12,16
18	60 % Betula pendula 30 % Acer platanoides 10 % Fraxinus excelsior	40	18,5	15,7	65,9	1,25	13,19	-	0,64
19	100 % Quercus robur	60	34,4	22,8	40,0	0,95	7,47	-	1,46
20	90 % Quercus robur 10 % Acer platanoides+ Tilia cordata	70	29,0	22,7	46,1	1,15	8,91	-	1,08

Investigated windbreaks are characterized with IV-VII classes ages, different species composition, because among them there are both mixed (oak-linden, ash-maple, oak-maple, birch-maple etc.) and pure oak stands. All windbreaks have high closed canopy, which is associated with growth of outskirts lines of stands.

Materials and methods of research. Forestry and mensuration indices (composition, age, diameter, cross-sectional area and average height) were determined by the conventional method in forestry and forest inventory.

Stand canopy density was defined by the results of a detailed mapping of the horizontal projection of the stands crowns.

Light transmission of stands' canopies were determined using Illuminometer U-16 as the ratio of the illumination on the surface of the soil under the canopy of forest (measured under cloudless weather in midday in 10 locations in space between the rows in the 10-fold repetition of each) to the number of lux of illumination on the open space.

Projective cover was determined on the basis of a detailed inspection of 10 m^2 of ground vegetation on each sample plot in 2012 and 2013, using the Ramenskii's grid. For its evaluation used unequal-distance scale B.M. Mirkin, with assigning to points degrees of coverage: no – + (1%), very weak – 1 point (5%), moderate – 2 points (5-15 %), medium – 3 points (15-25 %), high – 4 points (25-50 %), very high – 5 points (50-100 %).

Results. The formation of ground vegetation is affected by the composition of stand, its mensuration indices and microclimatic conditions that have emerged in the course of life of the stand.

For determination of the relationship between the studied indices was constructed correlation matrix (Table 2).

Data of correlation matrix indicate that the degree of the projective cover in 2012 and 2013 is depending on parameters such as light transmission and canopy density of stands. Between these indices there is a direct and inverse nonlinear correlation.

To find models that describe the data correlations, were build schedules of pair correlation between degree projective cover and light transmission (Fig. 1) and canopy density of the stands (Fig. 2).

2. Correlation matrix

Indices	Age, years	Diameter, cm	Height, м	Cross-sectional area, $m^2 \cdot ha^{-1}$	Canopy density	Light transmission, %	Ground vegetation cover, % (2012)	Ground vegetation cover, % (2013)
Age, year	1,00							
Diameter, cm	0,21	1,00						
Height, м	0,24	0,60	1,00					
Cross-sectional area, $m^2 \cdot ha^{-1}$	-0,09	0,62	-0,03	1,00				
Canopy density	0,34	0,13	-0,18	0,50	1,00			
Light transmission, %	-0,62	-0,39	-0,14	-0,39	-0,69	1,00		
Ground vegetation cover, % (2012)	-0,19	-0,60	0,00	-0,63	**-0,55**	**0,42**	1,00	
Ground vegetation cover, % (2013)	-0,24	0,28	0,39	0,12	**-0,61**	**0,54**	0,18	1,00

In Excel program were described pairwise rows values by different trendlines' equations – logarithmic, linear, exponential and polynomial. According to the value of index of reliability's approximation was chosen model, which is described by polynomial function. Thus, was received the following model to describe the relationship between the degree of the projective cover and light transmission (equation 1):

$$y = 0{,}2235\,x^2 - 4{,}16\,x + 23{,}98. \qquad (1)$$

The graph shows that the minimal projective cover is formed under the conditions of illumination within 9-10%, then with increasing of soil surface illumination increases the value of projective cover of ground vegetation due to the appearance of photophilous non-forest species-indicator (celandine *Chelidonium majus* L., yarrow *Achillea millefolium* L. and sedge-grass vegetation).

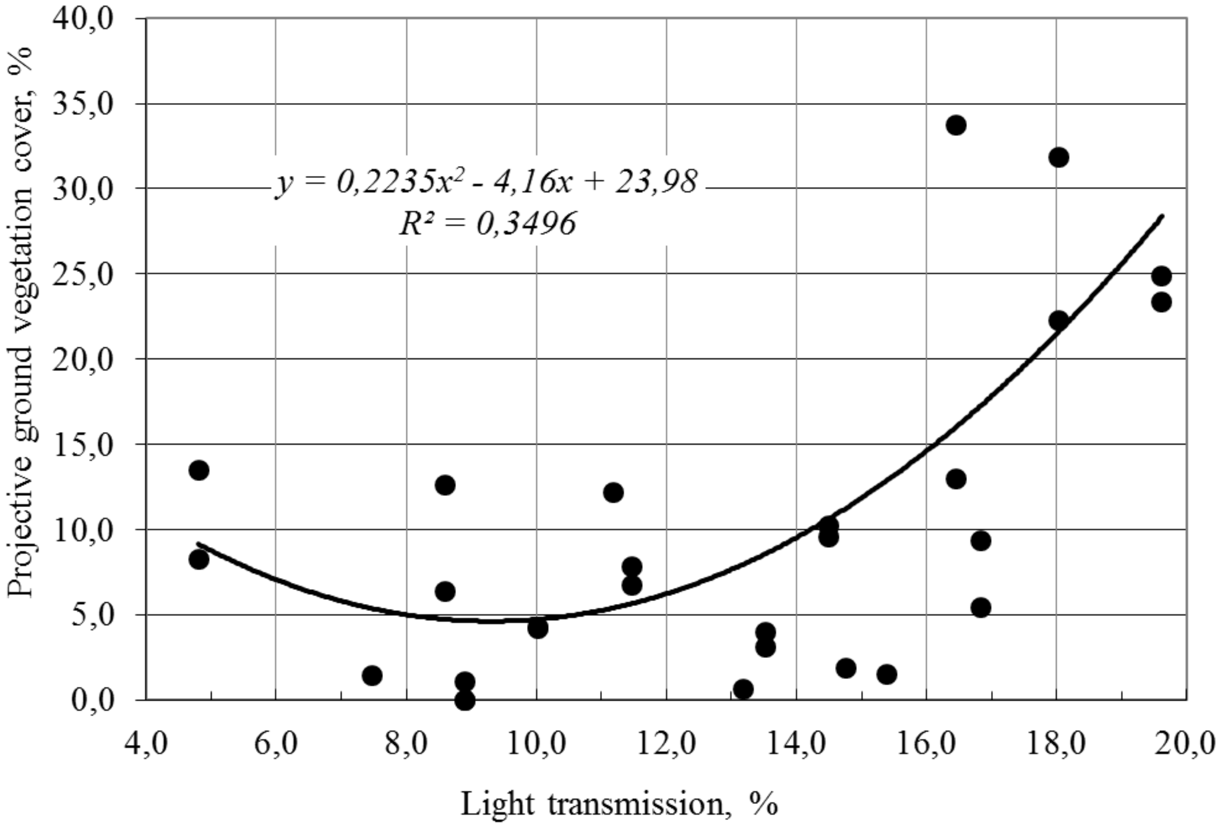

Fig. 1. The dependence between the degree of the projective ground vegetation cover and light transmission of stands' canopy

With the decrease of light transmission of stand's canopy to 8% or lower succession takes place with the participation of more shade-tolerant forest species-indicator (white cinquefoil *Potentilla alba* L., dead-nettle *Lamium maculatum* L., geum *Geum urbanum L.*, cleaver *Galium aparine* L., wood geranium *Geranium sylvaticum* L., bush multiflorous *Polyonatum multiflorum* (L.) All.) [3, 4].

Overall, a very weak degree projective ground vegetation cover appears under the stand's canopy for values of light transmission within 9-10%, moderate – 3-8 % and 11-16 %, average degree – within 0-2% and 17-18 %, high degree – at 19-23 % and very high degree when the luminosity is at over 24 %.

The dependence of the degree of projective ground vegetation cover and canopy density is described by the following function (equation 2):

$$y = 131{,}7\,x^2 – 309{,}7\,x + 186{,}5. \qquad (2)$$

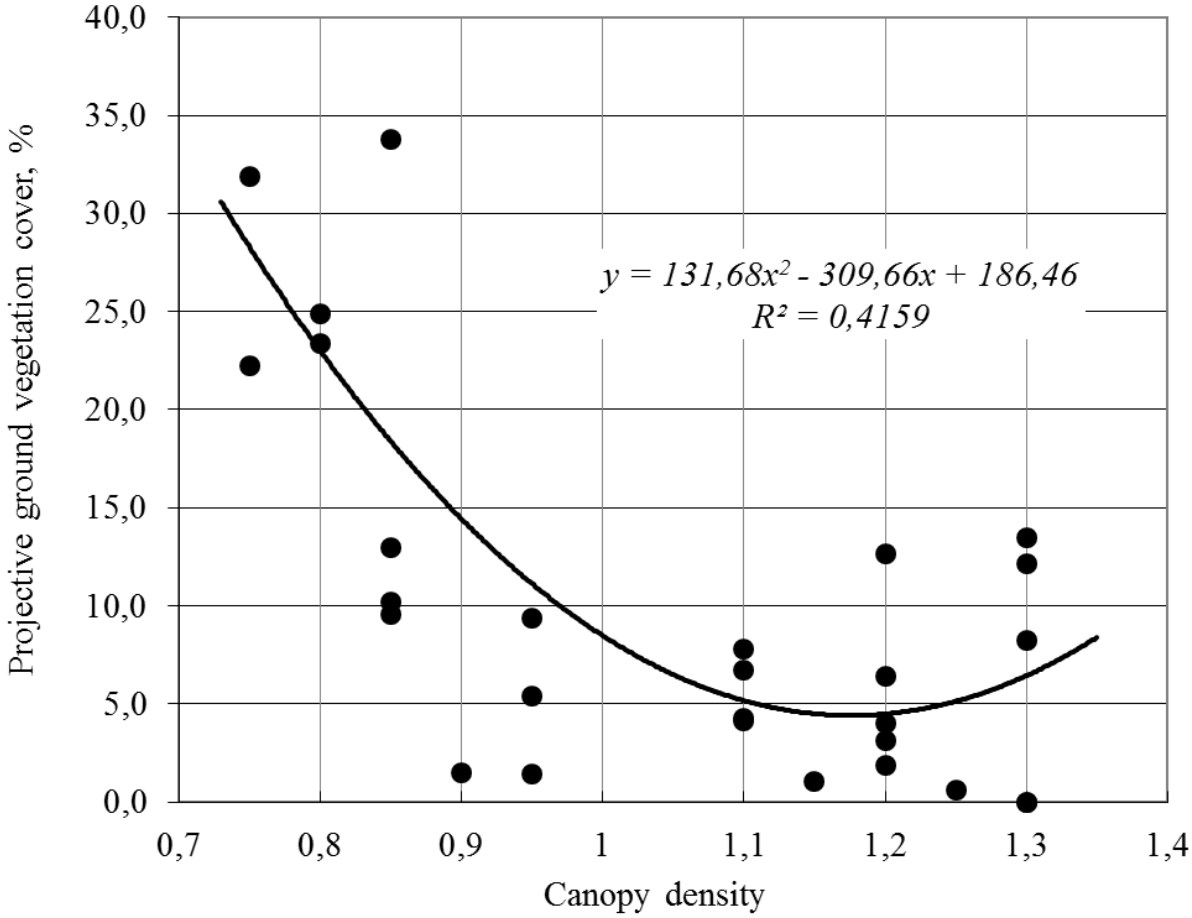

Fig. 2. Effect of the canopy density degree on the distribution of ground vegetation

Limiting the upper limit of canopy density values within 1,3-1,4, according to the model, the projective cover is assessed as very weak at canopy density within 1,15-1,2, weak level – in 0,9-1,1 and 1,25 and above average 0,8-0,85, high – 0,6-0,75 very high – below 0,55. That is, the appearance of forest shade-tolerant herbal vegetation is inherent for stands, which have high canopy density closure due to proliferation of outskirt rows and this compensate for excessive side lighting.

Conclusions

1. Projective cover is one of the important features of the formation of forest surrounding in windbreaks. The degree of ground vegetation distribution is the most depended of canopy density and canopy light transmission, which are also interconnected with each other indicators.

2. The appearance of the typical forest vegetation, which is indicative of the formation in cultural biogeocenosis of windbreaks close to the forest environment, is possible under certain microclimatic conditions. According to the obtained depending

models between the projective ground vegetation cover degree and light transmission and canopy density, favorable conditions are formed when canopy density of stands is above 1,25 (0,9) and light transmission or crown is below 8 (16)%.

3. The optimal values of canopy density and its light transmission in windbreaks are provided by pure oak and mixed stands with advantage of oak, ash, birch and oak-linden and maple-poplar stands.

References

1. Агролісомеліорація. Терміни і визначення понять : ДСТУ ISO 4874:2007. – [Чинний від 01.01.2009]. – К. : Держспоживстандарт України, 2010. – 18 с. – (Національний стандарт України).

2. Голубев И.Ф. Почвоведение с основами геоботаники – 3-е изд., перераб. и доп. / И.Ф. Голубев. – М. : Колос, 1982. – 360 с.

3. Краснов В.П. Атлас рослин-індикаторів і типів лісорослинних умов Українського Полісся. Монографія / В.П. Краснов, О.О. Орлов, М.М. Ведмідь // За ред. В.П. Краснова. – Новоград-Волинський: 2009. – 488 с.

4. Юхновський В.Ю. Атлас фітоіндикаторів типів лісорослинних умов Лісостепу України / В.Ю. Юхновський, С.М. Левандовська, В.М. Хрик. – Біла Церква: Білоцерківдрук, 2013. – 651с.

5. Рысин Л.П. Лесная типология в СССР / Л.П. Рысин. – М.: Наука, 1982. – 216 с.

6. Типологія лісу: Навчальний посібник / [Г.І. Васенков, І.Д. Іванюк, Я.І. Макарчук, О.О. Орлов]; під ред. Г.І. Васенкова. – Житомир: «Полісся», 2013. – 244 с.