



МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ  
«ЛАНДШАФТНЫЙ ДИЗАЙН ГОРОДА»

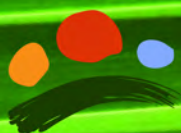
# CONFERENCE PROCEEDINGS

СБОРНИК ТРУДОВ КОНФЕРЕНЦИИ «ЛАНДШАФТНЫЙ ДИЗАЙН ГОРОДА»

Three pillars of landscape architecture: design, planning and management. New vision.

Новое направление в ландшафтной архитектуре (дизайн, планирование и управление).

[WWW.KGAINFO.SPB.RU](http://WWW.KGAINFO.SPB.RU)



Saint-Petersburg State Forest Technical University  
City of Saint-Petersburg

Swedish University of Agricultural Sciences, Sweden  
Uppsala, Sweden

**THREE PILLARS OF LANDSCAPE ARCHITECTURE:  
DESIGN, PLANNING AND MANAGEMENT. NEW VISIONS**

International conference proceedings

7 – 8 June 2017  
Saint-Petersburg, Russia

**НОВОЕ НАПРАВЛЕНИЕ В ЛАНДШАФТНОЙ АРХИТЕКТУРЕ  
(ДИЗАЙН, ПЛАНИРОВАНИЕ И УПРАВЛЕНИЕ)**

Сборник трудов международной конференции

7 – 8 июня 2017 года  
Санкт-Петербург, Россия

Saint-Petersburg State Polytechnic University  
Polytechnic University Publishing House

2017

ББК 85.118.7  
Н74

**Three pillars of landscape architecture: design, planning and management. New visions:** Conference proceedings Eds: Ignatieva M., Melnichuk I., Saint-Petersburg State Polytechnic University, Polytechnic University Publishing House, Saint-Petersburg, 2017. — 168 p.

**Новое направление в ландшафтной архитектуре (дизайн, планирование и управление):** сборник трудов международной конференции. 7 – 8 июня 2017 года. Санкт-Петербург, Россия. – СПб: Изд-во Политехн. ун-та, 2017. – с.

The published proceedings of the conference «Three pillars of landscape architecture: design, planning and management. New visions» comprises selected abstracts in English and Russian. The conference was held in St. Petersburg, Russia on 7 – 8 June 2017, and was an initiative supported by Saint-Petersburg Administration, Saint-Petersburg State Forest Technical University and Swedish University of Agricultural Sciences in Uppsala, Sweden. The abstracts came through the review process organized by the Conference Scientific Committee (Dr. Maria Ignatieva (Sweden) and Dr. Irina Melnichuk (Russia) with help of several reviewers from different European universities.

Сборник трудов конференции «Новое направление в ландшафтной архитектуре (дизайн, планирование и управление)» содержит тезисы, которые прошли процесс рецензирования, организованный М. Игнатъевой и И. Мельничук, с помощью рецензентов из различных европейских университетов. Конференция проводилась в Санкт-Петербурге с 7 по 8 июня 2017 года. Эта конференция была также изначально задумана и поддержана администрацией города Санкт-Петербург, Санкт-Петербургским государственным лесотехническим университетом и Шведским университетом сельскохозяйственных наук в Упсале.

Выпускающий редактор – Лариса Канунникова  
Chief Editor – Larisa Kanunnikova

Редакторы: Мария Игнатъева, Ирина Мельничук  
Editors: Ignatieva Maria, Melnichuk Irina

ISBN 978-5-7422-5780-6

© Saint-Petersburg State Forest Technical University, 2017  
© Swedish University of Agricultural Sciences, Sweden, 2017  
© SPbSTU, 2017

- WHO, 2016. Urban green spaces and health: a review of the evidence, Copenhagen. Available at:  
[http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1](http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1).
- Wilson, E.O. 1986. *Biophilia*, Cambridge: Harvard University Press.
- Xiao, Q. et al. 2000. A new approach to modeling tree rainfall interception. *Journal of Geophysical Research: Atmospheres* 105(D23),29173–29188.
- Yli-Pelkonen, V., Setälä, H. & Viippola, V, 2017. Urban forests near roads do not reduce gaseous air pollutant concentrations but have an impact on particles levels. *Landscape and Urban Planning* 158(2), 39–47.

# Using space syntax measures to assess the human impact on ground cover plant communities in recreational forests

Alexander Kryukovskiy\*, Irina Melnichuk, Victor Smertin

Landscape Architecture Department, St.-Petersburg State Forest Technical University,  
St.-Petersburg, Russia

\*Corresponding author: alexander.kryukovskiy@lta-landscape.com

## Introduction

The main difference between recreational forest and undisturbed forest is that the spatial structure of the former is designed and made by humans. The main spatial structure of recreational forest is its road network, which is the main factor determining the spatial distribution of visitors. Visitors have a significant impact on forest ecosystems, mainly through trampling, which is an immediate result of visitor movements. The most appropriate and widely used indicators of trampling are parameters of ground cover, forest litter and upper soil layers.

In forestry, there is no method to predict the trampling impact by the use of road network measures. Therefore we tested the use of space syntax theory for this purpose. Before this method could be developed, we had to determine whether there is a relationship between space syntax measures and indicators of trampling and then to test this relationship. We also had to identify which space syntax concepts and measures and which case study methods of forestry can be used to reveal the relationship, if it exists.

A fundamental proposition in space syntax is that, with some exceptions, the configuration of the urban street network is in itself a major determinant of movement flows. The theory shows that topological and geometric complexity are critically involved in how people navigate urban grids (Hillier et al. 1993). The background to the theory is graph theory and computing technologies.

## Methods of research and data analysis

For our research, we needed methods that could show the changes caused entirely by trampling, in all local types of landscapes, independent of local conditions (such as type of soil, type of forest ecosystem etc.).

Based on the main criteria proposed by Melluma and others (1982), we selected three parameters of ground cover which could be used as indicators of trampling impact:

- Projective degree of coverage by the ecological group of typical forest species
- Degree of dominance by the ecological group of typical forest species
- Total percentage of forest litter not covered with projections of ground cover plants and soil with denuded upper horizons (total percentage of 'dead' ground cover).

Thus, the indicators of changes caused by trampling were defined as follows:

- Decreases in projective degree of coverage by typical forest species
- Decrease in degree of dominance by typical forest species
- Increase in total percentage of dead ground cover.

Trampling causes an decrease in the degree of dominance and projective cover by forest plants because in this case the share of rural and meadow plants (usually weeds) increases. Within the territory of a recreational forest, there could be at least two types of zone: with higher trampling impact and with

lower trampling impact. We assumed that these zones could be defined topologically, by applying one of the space syntax measures. Based on the concept of through-movement (Hillier et al. 1993), we also assumed that the intensity of movement on a forest road can correlate with the choice measure. The ground cover parameters can then be calculated for each of these two zones. We assumed that if these two zones really represent a significant difference in recreational usage, the differences between ground cover parameters should correspond to the indicators of trampling impact.

Therefore, our main hypothesis was that if space syntax theory can actually be used to predict the recreational impact on natural forest ecosystems, the difference between parameters of ground cover within the two zones should indicate changes caused by recreation. To prove this, the following main assumption (research question) needed to be verified: ground cover parameters of the zone (area) characterised by the high choice measure should show greater trampling impact than parameters of the zone (area) characterised by the lower choice measure.

We assumed that trampling impact, in the general case, can be described as follows:

- A visitor prefers to move on the most appropriate pathways for walking and the most preferable ways are used most intensively and frequently
- The most appropriate pathway is a designed road
- Spontaneous paths are much less comfortable because they are not specially designed for movement and are the result of trampling
- The need to go outside the road is lower the more appropriate the road network is for moving from one point of interest to another. Theoretically, there could be no need to move outside the road
- The greater the distance from the road border, the lower the trampling impact.

We considered only recreational usage and excluded visiting the forest to gather berries or mushrooms. The most efficient way to represent a road network is to use road centre lines to construct a model for angular segment analysis (ASA) (Turner 2004, 2007). The completed model of the road network is a set of straight lines and does not represent any information about plant communities or any other properties of the recreational forest or landscape. The description of the ground cover could be carried out either on a sample plot or on a transect.

We used the transect method to describe ground cover for two reasons:

- The possibility to associate a transect directly with a certain line segment
- The possibility to describe continuous changes in ground cover with increasing distance from the road border.

### *Modelling the road network*

The road network was drawn in Autocad, including all paths with artificial pavement and excluding spontaneous paths. The spontaneous paths were excluded because our goal was to research only pathways specifically designed as part of the master plan. We assumed that every movement on the path in the general case begins from the road, and therefore the network of spontaneous paths emerges from the road network and grows from it.

The road network was modified into a set of straight lines drawn along the central axial line of the road. The completed model of the road network was saved in .dxf format and imported into UCL Depthmap application. We used embedded Depthmap tools to construct an angular segment map. We then used embedded options of Depthmap to calculate a T1024Choice measure. The range of its values is relatively wide. We tried to make it more easy to handle by using the natural logarithm of choice, called "LNchoice". Since there is as yet no special scale for values of LNchoice, we decided to use two simple ranges. In the first range (called zone0), we included all values less than the mean value of

LNchoice, while all other values were included in the other range (called zone 1). The mean value of the LNchoice measure was calculated automatically by Depthmap.

Based on our main hypothesis, we assumed that the greater the LNchoice measure, the more frequently the road segment would be used for moving and the more frequently the visitor would move outside the road segment (off artificial pavement), and the higher the trampling impact.

To prove our main hypothesis, the following main assumption needed to be verified: the ground cover parameters of zone 1 would show a higher trampling impact than the parameters of zone 0.

#### *Field study of ground cover*

For the field observations of ground cover, we applied the transect method. Where possible, we laid out three transects per road segment between its end points. The transect consisted of 1 m x 1 m squares each with two shared edges with adjacent squares and with no less 20 squares in total. The axis of the transect was perpendicular to the road border (see Fig. 10).

The transects were laid only in forest areas with closed canopy (with crop density greater than 0.3), while forest areas with open canopy, marsh and meadow areas were excluded.

There were 202 transects, with a total of 6233 squares. In each square, the following measures of ground cover were recorded:

- Projective degree of coverage by the ecological group of typical forest species
- Projective degree of coverage by the ecological group of meadow species
- Projective degree of coverage by the ecological group of rural species
- Percentage of forest litter and/or denuded soil horizon not covered with plant projections.

For the projective degree of coverage, we used integer values ranging from 0 to 7 in accordance with a modified Braun-Blanquet scale (see Table 1).

Table 1. Scale of ground cover projective cover

Degree	Description	Projective cover percentage
0	No individuals	0%
1	One individual	less than 1%
2	Very few individuals	less than 1%
3	Rarely	1...3%
4	Abundant	3...25%
5	Quite abundant	25...50%
6	Very abundant	50...75%
7	Completely covered	75...100%

The ecological groups of species were defined using available data for the territory of St. Petersburg suburbs.

#### *Research areas*

There were three research areas:

- Pesotchny forest park (214 ha, surveyed length of road network 31 km) (see Fig. 1)
- Osinovaya Roscha park (236 ha, surveyed length of road network 8 km) (see Fig. 2)
- Yunki forest park (270 ha, surveyed length of road network 12 km) (see Fig. 3)

All three parks are in public recreation usage. Osinovaya Roscha is an abandoned park with a large proportion of natural forest.





Fig. 1. Angular segment model of the Pesotchny forest park study area. Segments where  $LN(\text{choice}) \geq \text{Avg}(LN\text{choice})$  are represented with solid lines, segments where  $LN(\text{choice}) < \text{Avg}(LN\text{choice})$  are represented with dashed lines.



Fig. 2. Angular segment model of the Osinovaya Roscha forest park study area. Segments where  $LN(\text{choice}) \geq \text{Avg}(LN\text{choice})$  are represented with solid lines, segments where  $LN(\text{choice}) < \text{Avg}(LN\text{choice})$  are represented with dashed lines.





Fig. 3. Angular segment model of the Yukki forest park study area. Segments where  $LN(choice) \geq Avg(LNchoice)$  are represented with solid lines, segments where  $LN(choice) < Avg(LNchoice)$  are represented with dashed lines.

#### Analysis of data

We associated the field study data with line segments included in topological zones defined by LNchoice values, e.g. if a transect was laid on segment which was included in zone 0, we associated this transect with zone 0. In this way, all transects and ground cover descriptions were divided into two sets, called zone 0 and zone 1. To verify the main assumption of the research, we had to calculate the parameters of ground cover, define the difference between the same parameters in the two different zones and find the relationship between the indicators of trampling impact and space syntax measures.

#### Calculation of parameters

The road network parameters were calculated for the zone as a whole (one single parameter for each of two zones of given area), and also for a generalised transect of a zone (a set of 20 values for each transect square, 20 values for zone 0 and 20 values for zone 1, in total 40 values per research area) (see Fig.4).

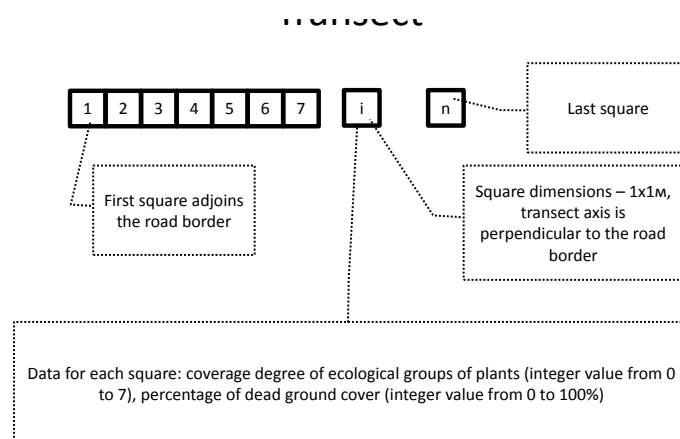


Fig. 10-4. Transect for field observations.

The parameter "Projective degree of coverage by the ecological group of typical forest species" was calculated using the initial data from the field research and only for the generalised transect as:

$$CDt(i) = \frac{Sum\{CDsq(i)\}}{TNs(i)} * 100 \quad (1)$$

where  $CDt(i)$  is average projective degree of coverage in all squares  $i$ ;  $CDsq(i)$  is the projective degree of coverage value for each square  $i$ ; and  $TNsq(i)$  is total number of squares.

To emphasise the continuous change in projective degree of coverage within a given transect, we calculated the median value for transect intervals,  $M(i)$ , and allocated it to square  $i$ . For example,  $M(12)$  is the median value of projective degree of coverage for squares 1 to 12 and was assigned to square 12. The values of  $M(i)$  were used to calculate  $CDt(i)$  values in accordance with equation (1), but in this case we replaced  $CDsq(i)$  with  $M(i)$ .

The parameter "Degree of dominance by the ecological group of typical forest species" for a zone as a whole was calculated as:

$$DDz = Nf / TN * 100 \quad (2)$$

Where  $DDz$  is degree of dominance in a zone, %;  $Nf$  is number of squares where the degree of dominance of the forest species is greater than that of both meadow and rural species; and  $TN$  is total number of squares within a zone;

The parameter "Degree of dominance by typical forest species" for a square of a generalised transect of a zone was calculated as:

$$DDt(i) = Nfsq(i) / TNs(i) * 100 \quad (3)$$

where  $DDt(i)$  is degree of dominance in all squares  $i$ , %;  $Nfsq(i)$  is number of squares  $i$  where the degree of dominance of the forest species is greater than that of both meadow and rural species; and  $TNsq(i)$  total number of squares  $i$ .

The parameter "Total percentage of dead ground cover" was calculated for a zone as a whole and for a generalised transect of a zone in accordance with the equations used for projective degree of coverage (equations 1, 2).

#### *Calculation of the difference between parameter values*

We calculated the absolute difference and relative difference between parameter values. The absolute difference was calculated by simple subtraction of the value of zone 1 from the value of zone 0. The relative difference was calculated as:

$$RD = (P(\text{zone 0}) - P(\text{zone 1})) / P(\text{zone 0}) * 100 \quad (4)$$

where  $RD$  is relative difference, %;  $P(\text{zone 0})$  is value of the parameter for zone 0; and  $P(\text{zone 1})$  is value of the parameter for zone 1.

#### *Determining the indicators of trampling impact*

Based on our main assumption and trampling impact indicators, the projective degree of coverage by typical forest plants and of dominance by typical forest plants should be greater in zone 0. Therefore, the difference for these two parameters should be greater than zero. Percentage of dead ground cover should be greater in zone 1, and the difference for other parameters should be less than zero.

For the parameters which were calculated for a zone as whole, there was one single value, i.e. the absolute value, and relative difference. For the parameters which were calculated for a generalised transect of a zone, there were 20 values of absolute and relative difference. When there were several positive and negative difference values, the assumption could be true on condition that this distribution of difference values is not random. We verified this cases using chi-square criterion.

If the sign of all the difference values of a transect agreed with the main assumption, we considered it as true without additional verification. For data processing, we selected the first 20 m of each transect (the first 20 squares).

## Results and discussion

### *Projective degree of coverage by the ecological group of forest plants*

For generalised transects of all research areas, the projective degree of coverage by forest plants was greater in zone 0 (see Figs. 5 and 6). Verification of transects which had several negative values of difference showed that the difference was not normally distributed.

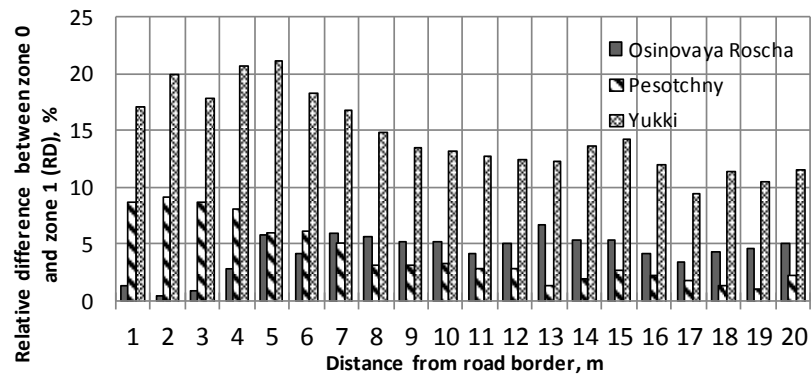


Fig. 5. Parameter "Projective degree of coverage by the ecological group of typical forest plants". Relative difference in  $M(i)$  (median value for intervals of the generalised transect).

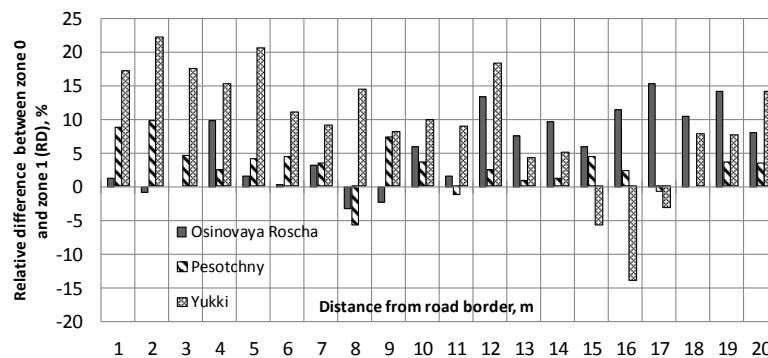


Fig. 6. Parameter "Projective degree of coverage by the ecological group of typical forest plants". Relative difference between arithmetic mean of projective degree of coverage by the ecological group of typical forest plants for square  $i$ .

### *Degree of dominance by the ecological group of forest plants*

For this parameter, the difference values of the generalised transect for the Yukki forest park were distributed normally (see Fig. 7), which contradicts our assumption. However, data for transects of other research areas and for the whole zone areas (see Fig. 9) confirmed our main assumption.

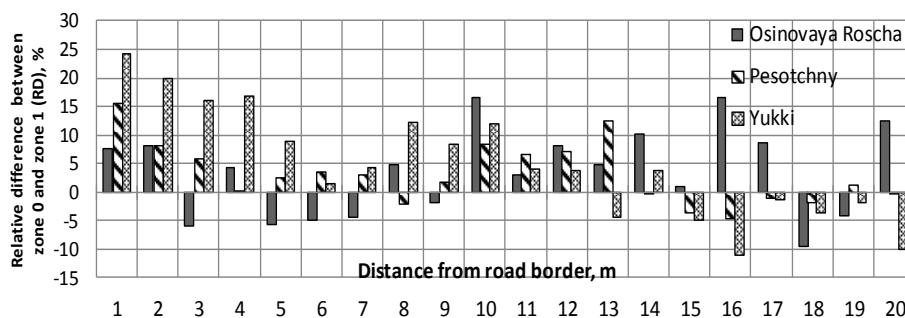


Fig. 7. Parameter "Degree of dominance by the ecological group of typical forest plants". Relative difference between  $DDt(i)$  (number of squares  $i$  where the degree of dominance of the forest species is greater than that of both meadow and rural species) for the generalised transect.

*Percentage of dead ground cover*

The difference values of the generalised transect for OsinovayaRoscha were distributed normally (see Figs. 8 and 10), another contradiction of our assumption. However, data for other research areas and for the whole zone areas confirmed the assumption.

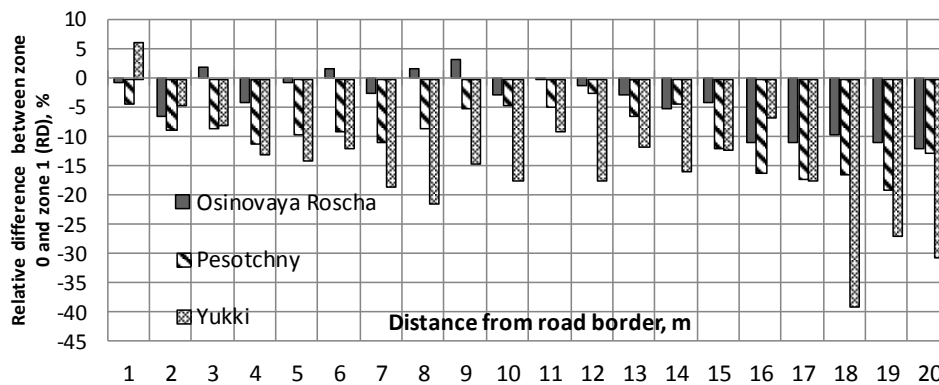


Fig. 8. Parameter "Percentage of dead ground cover" (for generalised transect).

Based on our results, we concluded that there is a valid, essential difference between parts of territory distinguished only by space syntax measures, despite other possible factors and territory attributes, and our main assumption was verified. However some parameters showed inconsistency in the approach. We believe that for each parameter to be valid, there should be a specific range of recreational load intensity. Each parameter has its own sensitivity range.

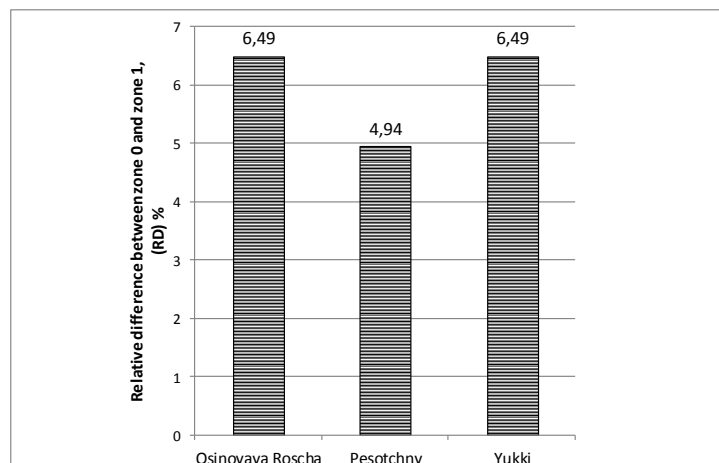


Fig.9. Parameter "Degree of dominance by the ecological group of typical forest plants", whole zone area.

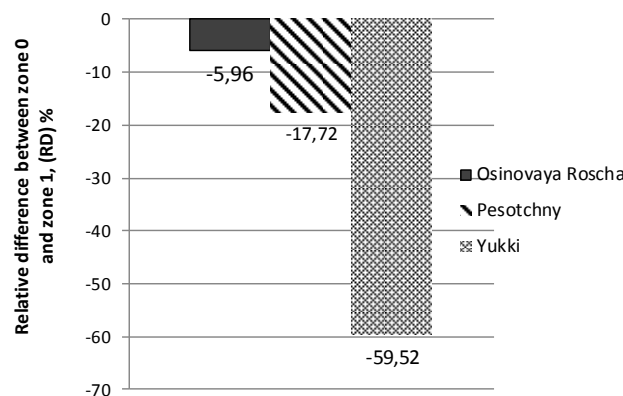


Fig. 10. Parameter "Percentage of dead ground cover", whole zone area.