Influence of recreation on vegetation and the soil in the conditions megalopolis

V.A.Kuznetsov, I.M.Ryzhova, G.V.Stoma
Moscow State University, Moscow, Russia
xts089@gmail.com

Forest parks play an important role in the maintenance of favorable ecological environment in cities. The recreational load increases with the growth of the cities that negatively influences forest parks. In the conditions of megalopolis the forest parks are exposed to atmotechnogenic deposition as well as to recreation. Quantitative data on the change of the main characteristics of various components in forest ecosystems at different levels of recreational load is necessary for forecasting the dynamics of the condition of forest parks and the choice of optimum control.

The purpose of this work is to comprehensively and quantitatively assess the change of indicators of vegetation, mesofauna, characteristics of ground litter and the change of physical, chemical and biological properties soils of forest parks in Moscow depending on the level of recreational influence. The research was conducted in the territory of two large Moscow forest parks: "Losinii ostrov" and "Bitsevskii forest", actively used for recreation. Fir-tree linden-forest on sod-podzolic sandy loam soils and oak-linden forest on sod-podzolic easy and medium loamy soils were respectively studied in "Losinii ostrov" in "Bitsevskii forest" (Album Retisols on WRB, 2014).

5 plots (25×25м) corresponding to the 5 levels of the recreational load determined by the area of footpath network were put in each forest park in the same geomorphological conditions in the watershed, in accordance with OST 56-100-95. At each plot geobotanical description of all tiers of the wood by traditional techniques was performed. For the characteristic of the trees condition the complex indicators by E.G.Mozolevskoy was used (2004). Illumination was defined by the photo-electric light meter Yu-117 at the level of the soil surface and at the height of 1.5 m with 36 multiple frequency at each trial square. The integral stability indicator of development small-leaved linden (PSRL) was determined by the size of the fluctuating asymmetry of lamina (Zakharov, Chubinishvili, 2001). Tackling of ground litter and soils (samples were selected from layers of 0-5, 5-10 and 10-20 cm) was carried out taking into account their biogeocenose space variability and irregularity of distribution of recreational load within the trial areas. Slightly disturbed "core" of forest ecosystems at the I digression stage (DS) was selected as the background. The characteristics of the ground litter, properties of soil and the condition indicators of soil invertebrates were determined by the conventional techniques in soil science. The statistical analysis of data was carried out on the basis of the "stratified sampling" made taking into account ratio of the areas of footpaths, near footpaths zones and the least disturbed core in each DS. Data processing was carried out in STATISTICA package. The chosen level of significance was 0.05.

According to the obtained data in the studied forest parks indicators of condition of the main components of the forest ecosystems depending on the recreational load level change the similar way. Distinctions in the character of vegetation and particle size distribution in the soils influence the extent of change of the studied parameters.

The changes in the condition of vegetation. The recreation impacts all the tiers of vegetation mantle. With the growth of its level (to the V DS) by 4-5 times the share of trees in the good condition decreases. In oak and linden forest of "Bitsevskii forest" more than a half of trees are in the good condition up to the IV digression stage, and in fir-tree linden-forest "Losinii ostrov" already at the III stage their share makes only 44%. It is attributed to the smaller resistance to recreation of coniferous breeds compared to deciduous breeds. The indicator of stability of development of linden is the highly sensitive indicator of change ecological conditions. It increases from 0,028-0,030 for the I stage of digression to 0,039-0,045 for the V digression stage. All stages of digression statistically significantly differ on average values of this indicator. As a result of deterioration in condition of the forest stand crown density of the trees decreases (from 70-80% to 20-30%). It leads to the increase in illumination which increases in forest parks by more than 30 times at the V digression stage. Its change affects the number of undergrowth and species diversity of herbs.

The abundance of underbrush at the digression stages I-IV is rather constant, and to V - sharply decreases (by 3-4 times). At the same time shade-enduring types disappear and filbert bushes expand. The abundance of shoots and undergrowth of trees increases (twice) at the average levels of recreational load, and at the high levels – sharply decreases for the mechanical damage.

At weak recreational load 9-11 species of the plants related generally to forest ecologo-cenotic group are allocated in herbaceous layer. At its average level owing to increase in variety of habitat conditions at average loading species diversity of herbs increases. This can be explained by the implementation of forest-meadow, meadow and weed types. The maximum quantity of species of herbs (23) is noted at illumination of 25%: in "Losinii ostrov" on III stage, and in "Bitsevskii forest" on the IV stage DS. Further increase in loading leads to decrease in species diversity of herbs.

The changes in condition of complex of soil invertebrates. Soil invertebrates form a very vulnerable component of forest ecosystems. Under recreation conditions, they are exposed to both direct influence, which is expressed in their mechanical destruction, and to mediated – as a result of change of habitat factors. On background sites the complex of soil invertebrates in the studied parks is characterized by close values of the main indicators. The density and the biomass are respectively 430-490 pieces/m^2 and 150-170 g/m^2 as an average. These indicators decrease by 2-2,5 times for the digression stage V. Especially strong oppression is experienced by litter mesofauna where the number and biomass decreases twice, already at the III stage, and at the V – by 4-7 times. Increasing the recreational load leads to decrease of the variety of soil invertebrates. In their structure the share of oligochaetes increases from 17-22 to 53-77% and the share of myriapods and insects decreases by 2-3 times.

The changes of ground litter and soils. Maximum load within plots is accounted for footpath soils. The load weakens when removing from them to "core". Therefore for correct evaluation of properties of soils at different digression stages stratified samples were compared. The results are shown in the Table 1.

The increase of load changes the ground litter type. At the first two digression stages they are humified, at the later stages – destructive. Litter stocks decrease by 1.4-1.5 time for the IV-V DS. In its particle size distribution as a result of crushing and mastication when trampling the share of active fraction decreases by 1.7-2 times, and the share of crushed fraction increases by 3.5-7 times.

The most noticeable changes of properties of soils are traced in upper mineral 0-5 cm layer. When the recreational load rises up to the digression stages III-V density, hardness, concentration of Corg, pH of water, electroconductivity the substrate-induced respiration of soils increase and the structure coefficient decreases. Going deeper, at the depth of 5-20 cm the influence of recreation on properties of soils is weakened.

Table 1. Characteristics of laying and property of soils at different stages of digression

Digression stage	I	II	III	IV	V
«Losinii ostrov»					
Sample size (n)	18	22	24	29	54
Underlayer					
Forest ground litter reserve, kg/m^2	1,31±0,19	1,66±0,45	1,47±0,42	**0,94±0,2**	**0,88±0,08**
Crushed fraction (< 1cm)., %	5,6±4,0	9,7±5,0	13,4±4,5	**15,2±3,3**	**19,1±2,8**
Active fractions, %	73,1±9,1	65,2±9,6	**55,9±8,0**	**51,5±6,6**	**43,6±5,9**
0-5 cm soil layer					
Density, g/cm^3	0,97±0,05	1,02±0,05	1,07±0,07	**1,18±0,06**	**1,25±0,05**
Hardness, MPa	1,10±0,33	1,80±0,36	**2,51±0,28**	**2,61±0,29**	**2,92±0,23**
Structure coefficient	3,92±0,38	**2,71±0,43**	**1,52±0,29**	**1,12±0,24**	**0,95±0,22**
Concentration of Corg, %	1,77±0,25	1,92±0,29	**2,56±0,39**	**2,62±0,26**	**2,92±0,38**
pHwater	4,26±0,16	**4,66±0,15**	**4,66±0,14**	**4,95±0,14**	**5,05±0,11**
Electroconductivity, mSm/cm	0,28±0,03	0,35±0,04	0,37±0,07	**0,46±0,08**	**0,56±0,1**

Substrate-induced respiration, μg C-CO₂/ml*h	7,95±0,89	8,42±1,59	8,44±1,87	9,63±1,07	**9,88±1,0**

Substrate-induced respiration, µg C-CO_2/ml*h: 7,95±0,89 | 8,42±1,59 | 8,44±1,87 | 9,63±1,07 | **9,88±1,0**

«Bitsevskii forest»					
Sample size (n)	17	21	22	31	42
Underlayer					
Forest ground litter reserve, kg/m²	1,05±0,15	1,18±0,29	1,15±0,18	0,95±0,15	**0,78±0,1**
Crushed fraction (< 1cm)., %	3,4±2,5	**13,0±3,5**	**13,5±4,1**	**15,3±3,6**	**23,9±4,4**
Active fractions, %	81,9±6,2	**60,1±7,4**	**59,3±7,5**	**56,7±7,3**	**38,9±9,3**
0-5 cm soil layer					
Density, g/cm³	1,08±0,05	1,09±0,06	1,11±0,06	1,16±0,05	**1,29±0,05**
Hardness, MPa	1,8±0,37	2,50±0,33	**2,66±0,38**	**2,85±0,32**	**3,80±0,31**
Structure coefficient	4,88±0,45	**3,29±0,44**	**3,13±0,43**	**2,07±0,24**	**1,02±0,22**
Concentration of Corg, %	2,01±0,25	2,45±0,30	**2,73±0,22**	**3,1±0,40**	**3,29±0,41**
pHwater	5,2±0,09	5,26±0,10	5,33±0,12	5,37±0,10	**5,62±0,10**
Electroconductivity, mSm/cm	0,20±0,02	0,22±0,03	0,23±0,03	0,33±0,12	**0,48±0,12**
Substrate-induced respiration, µg C-CO₂/ml*h	5,62±0,77	5,99±1,17	6,47±0,96	**7,4±0,97**	**8,92±1,04**

*Note: **fat** - averages statistically significantly different from background (α=0,05).*

The obtained data confirm various sensitivity of soil properties to recreational load. As shown by the results of the step-by-step discriminant analysis the soils at different digression stages most greatly differ in the coefficient of degree of structure. Single influences of the other variables are small. Only their total contribution is important when soil discrimination for stages of recreational digression is considered. Instead five-step scheme we propose three-stage scheme to characterize the changes in the properties of soils parks under the influence of recreational load is proposed, since in latter case the proportion of correct classification for independent data increases to 75%.