Bioindication using Scots pine for assessing environmental pollution

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Abstract. The paper contains information on the fluctuating asymmetry of Scots pine in important recreational areas of the north of St. Petersburg - Sosnovka park, Novoorlovsky zakaznik, Udelny park. A comparative assessment of the quality of the environment in these locations is being carried out.

1 Introduction

Scots pine is widely used as an indicator of the state of the environment [1]. This is due to the wide habitat of Scots pine, the convenience of taking measurements, as well as the simplicity of working with the herbarium (the compactness of the herbarium material and the relative mechanical stability of the needles in comparison with the leaves, the ease of separating the needles from the branches, the ability to straighten the needles during measurements). St. Petersburg is included in the growing area of Scots pine, and many of its forest parks are forest areas that have entered the city's boundaries as it develops. Among such recreational areas in the north of St. Petersburg, it is worth highlighting favorite recreation areas of the townspeople - the public Sosnovka park and Novoorlovsky nature reserve. The purpose of this paper is to study the fluctuating asymmetry of Scots pine at various points in the Sosnovka park, to assess the quality of the environment in these recreational areas, as well as to assess the possibility of using fluctuating asymmetry to assess the degree of ecological well-being of closely located collection points of the herbarium of indicator plants.

2 Materials and methods

The herbarium collection spot in Sosnovka park was limited to a square of 10 by 10 meters due to the fact that the purpose of our study was not to obtain a general picture of the maximum area, but to obtain data on several points for mapping a very compact area of the terrain. In the Novoorlovsky nature reserve, the collection of the herbarium was carried out in the form of an average sample at 10 points evenly distributed over the area of the

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reserve. The coordinates of the collection points of the herbarium were determined by a GPS navigator. Measurements were made with a ruler with a graduation of 0.5 mm. Herbarium collection and measurements were carried out by different researchers.

Calculations of the fluctuating asymmetry were made according to the formula (1) (the ratio of the difference between the lengths of the right and left needles of the paired needles to their average value):

$$As_{fl} = 2 * \frac{L_1 - L_2}{L_1 + L_2}, \tag{1}$$

where: $L_1 -$-left needle length; $L_2 -$ - right needle length.

A sufficient sample size for calculating the index of fluctuating asymmetry was determined based on the dependence of its mean value on the sample size.

3 Results and discussion

Fluctuating asymmetry depends on many factors and cannot be used as an "absolute scale" of ecological well-being [2]. However, we suppose that it can be useful when comparing the degree of pollution of various points characterized by the same growing conditions of the indicator plant, but experiencing different anthropogenic load. In practical terms, this will make it possible to reduce the volume of microbiological manipulations when analyzing soil samples for the presence of destructors of organic pollutants by taking and studying the most promising samples, since, as a rule, isolated crops have a very ordinary activity. Nevertheless, urban soils of megalopolises with a long industrial history can be a source of destructors of organic pollutants, which are not inferior in their activity to crops isolated from toxic waste accumulators [3]. To test this assumption, we selected relatively ecologically clean and highly polluted locations where indicator plants are in the closest possible growing conditions. Sosnovka park and Novoorlovsky nature reserve are essentially the remnants of a forest area absorbed by the city. When choosing points for collecting the herbarium, they were also guided by the maximum similarity of conditions. It is for this reason that samples were not taken in Sosnovka park in places with severe pollution, but samples were taken in clean locations (points 1-4).

Table 1. Fluctuating asymmetry of Scots pine needles at points of herbarium collection (Sosnovka park).

| No.	Coordinates	n	min	max	Mean±1.96*Sx/√n
1	60.012353 30.347352	557	0	0.4466	0.014±0.003
2	60.017532 30.341903	650	0	0.2675	0.015±0.002
3	60.026597 30.363345	550	0	0.3809	0.016±0.003
4	60.018945 30.363789	562	0	0.6829	0.017±0.004

In Figure 1 (the picture was taken during the period when there are no leaves), it can be seen that the growing conditions at the point of maximum pollution are different - deciduous trees prevail. The measurement results (Table 1), as expected, almost do not differ from each other. There are no outliers (values of the fluctuating asymmetry index are greater than 0.7), mean values stabilize at a sample size of about 500 units (Figures 2-5). Since, according to [4], the territory of the Novoorlovsky nature reserve is almost completely and fairly uniformly polluted, the coefficient of fluctuating asymmetry was calculated from an average sample collected at 10 points (200 pairs of needles, 2000 pairs of needles in total). The results are shown in Figure 7. The dependence of the mean value of the fluctuating asymmetry coefficient on the sample size illustrates the presence of a large, about ten, number of outliers that give jumps in the mean value, but the mean itself eventually stabilizes near a value that almost coincides with that for clean locations (0.017

$\pm$ 0.004). Thus, the use of the fluctuating asymmetry coefficient of the Scots pine needles does not allow us to reliably identify the priority points of selection. The value of the coefficient of fluctuating asymmetry of Scots pine needles almost coincides for clean locations of the Sosnovka park and the highly polluted Novoorlovsky nature reserve. However, in the case of the Novoorlovsky nature reserve, a large number of outliers are observed (Figure 8), the quantity and value of which can be used to assess the degree of ecological well-being of one or another location.

To verify this statement, a herbarium was collected in a location with minimal anthropogenic impact (transport accessible) - Kharlus rural settlement, Pitkyaranta district, Republic of Karelia, Russia (coordinates 61.752805, 30.866513). There were no statistical outliers in the herbarium collected at this point.
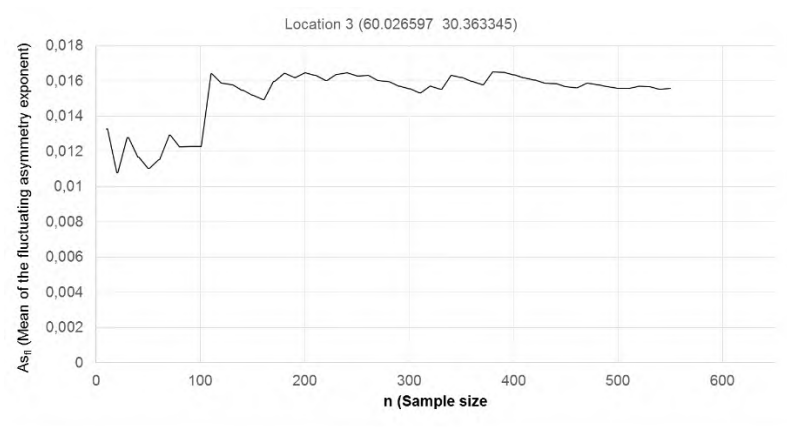

Fig. 1. Herbarium collection points - relatively clean locations of Sosnovka Park.
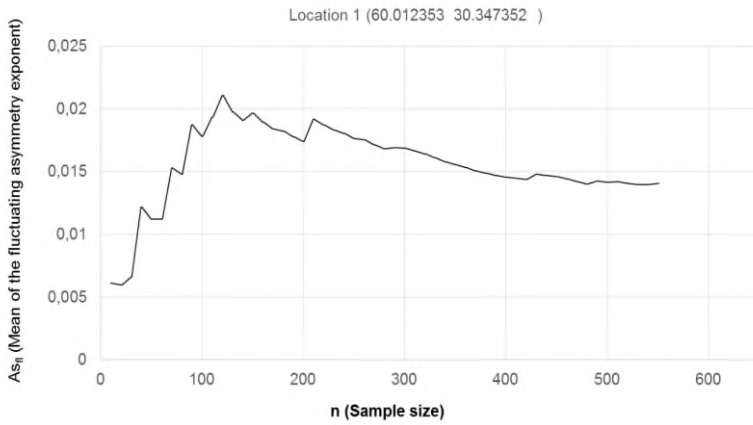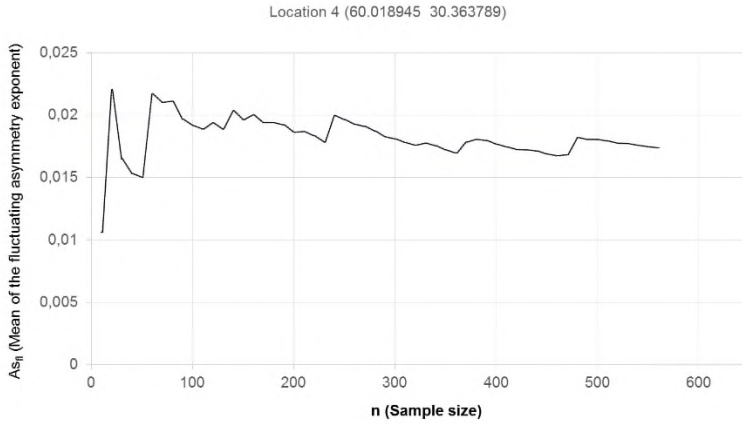
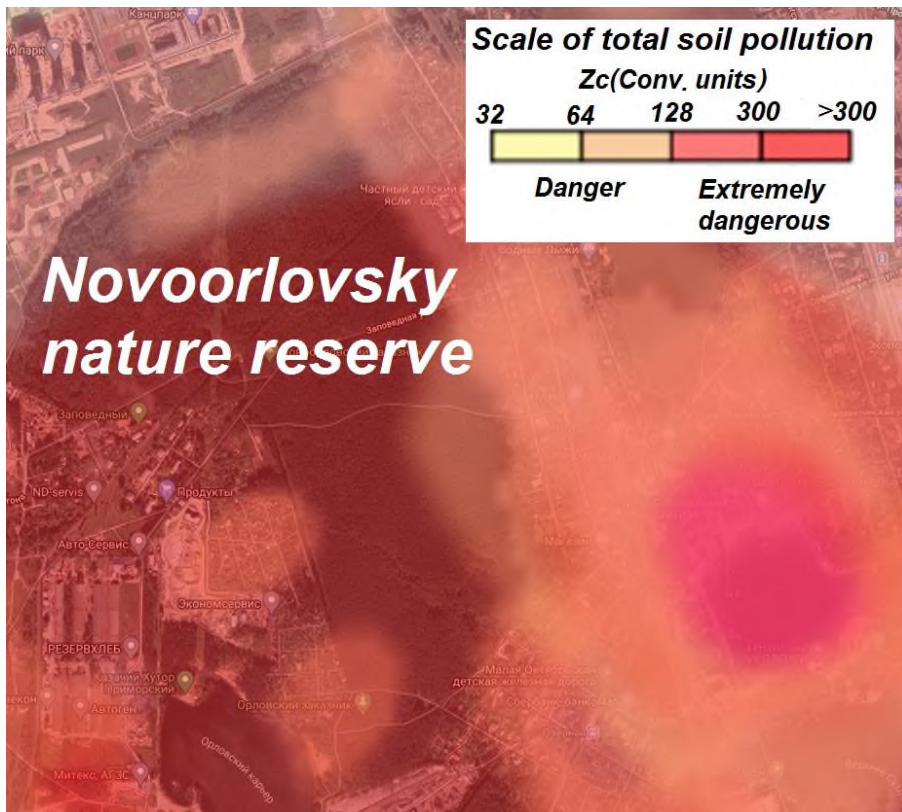**Fig. 2.** Dependence of the value of the index of fluctuating asymmetry on the sample size (location 1).
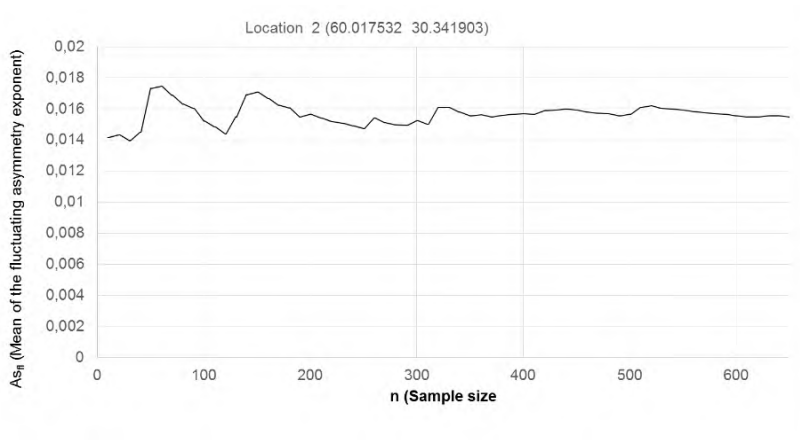
Fig. 3. Dependence of the value of the index of fluctuating asymmetry on the sample size (location 2).
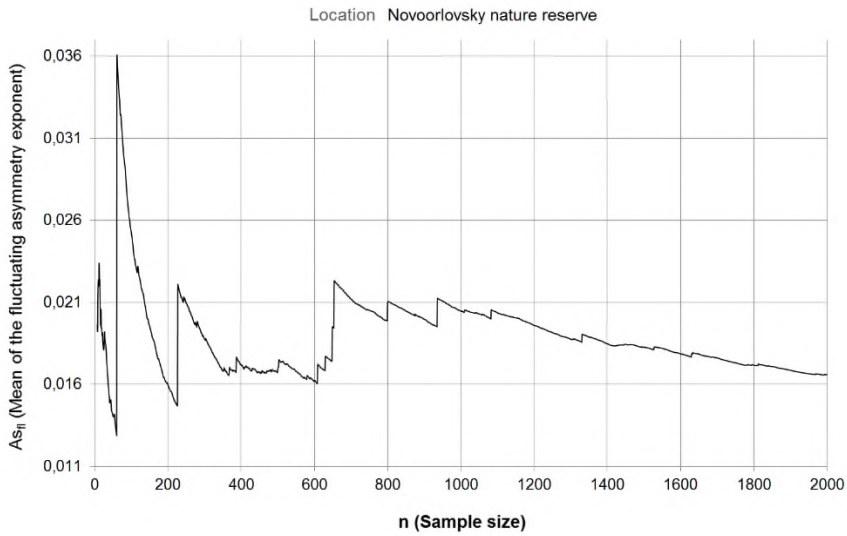

Fig. 4. Dependence of the value of the index of fluctuating asymmetry on the sample size (location 3).
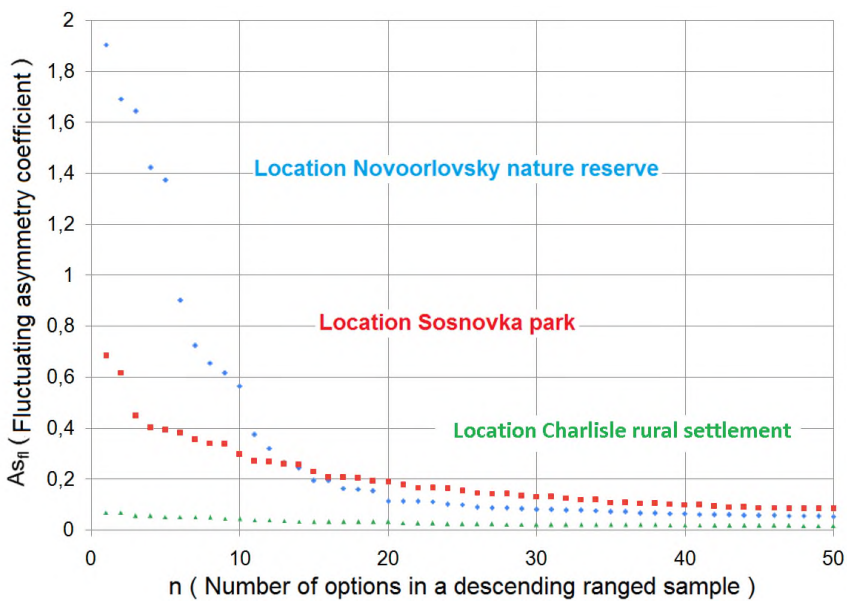
Fig. 5. Dependence of the value of the index of fluctuating asymmetry on the sample size (location 4).

Fig. 6. The total soil pollution of the Novoorlovsky nature reserve (according to [4]).

Fig. 7. Dependence of the value of the fluctuating asymmetry index on the sample size (location - Novoorlovsky nature reserve).

Fig. 8. 50 maximum values of the coefficient of fluctuating asymmetry of Scots pine needles selected in the Sosnovka park (2319 pairs of needles) and Novoorlovsky nature reserve (2000 pairs of needles). Control location Kharlus rural settlement - north of Lake Ladoga.

4 Conclusions

The coefficients of fluctuating asymmetry of Scots pine needles under conditions of weak and strong total pollution in the forest parks of the North-West of St. Petersburg almost coincide. However, in ecologically unfavorable locations, a larger number of outliers is observed.

References

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