Environmental and floristic analysis of undesired plants on the railway formation canvas

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Abstract. Negative effects caused by the vegetation of unwanted plants on the railway track skeleton have been studied. The ballast prism is shown to be a potentially areal for a vegetation of specific plants under particular effects of biotic and abiotic factors. The phytoindication technique was used to estimate the plants vegetation in the railroads with different volumes of traffic. The typical plants species and the average degree of the manifestation in the photoautotroph areal have been determined. To improve efficiency of the weed control measures, various forms of herbicides have been tested. The paper reports techniques for the environmental and floristic analysis of unwanted plants that grow in the tie cribs and provides recommendations on how to avoid an appearance of those plants. These measures ensure a stable operation of the railway infrastructure.

1. Introduction

The photoautotrophs are both undesired and natural elements of the biocenos process that has the track skeleton of the railway formation. The photoautotrophs can negatively affect the technical parameters of the railway tracks and the railway operation.

For example, the following negative effects are possible: distorting the results of diagnostics and monitoring of the railway tracks, and GPS sensors; overlapping the train markers and sidelights; decreasing the special equipment efficiency; degradation of the drainage and carrying capacities of the railway canvas; accelerating the corrosion and bio-corrosion of the track elements, and others.

Any linear technospheric object is a potential areal of biota that is typical of soils and climate of current region.

The railway track consists of a sand sub-ballast, broken-stone ballast, spring-actuated rail fastening, sleepers and rails.

The broken-stone ballast contains no plant food required for producers. However, the railway tracks receive various organic and mineral substances due to the train traffic.

A lack of the water availability might limit the growth of photoautotrophs on the railway track. However, a set of the local plants includes the drought-resistant crops that can form producers for local biocoenosis.

The syntaxonomical approach is the important tool for bioenvironmental estimations.

For environmental and floristics classification, Russian phytocenology school widely uses Braun-
Blanquet method [1, 2]. Some authors [3, 4] criticize this method. However, we support and use Braun-Blanquet method.

The phytointication-based method is a universally valid technique that can be used for studying the phytocenosis state.

### 2. Materials and methods

Presently, some physical and chemical methods are used for eliminating unwanted plants. These methods are expensive and environmentally destructive.

The following questions are actual: populating the railway track skeleton with photoautotrophs, studying their species composition, and methods for preventing their reproduction.

For studying the species composition of photoautotrophs and estimating the zones of presence of their Biodestructor-producers on the tie cribs, we selected three test sites: constantly operated railroads, rarely operated railroads, and abandoned railroads (see Table 1).

The area of each site is about 100 m². In our paper, we use the species composition as described in [5, 6], and Ellenberg indicator [6, 7].

### Table 1. Biology characteristics of investigated phytocenosis

| Species                      | Braun-Blanquet cover-abundance score | Requirements for illumination $(L)$ | Requirements for soil moisture $(F)$ | Soil reaction $(R)$ | Mineral nitrogen availability $(N)$ | Areal type according to Meusel et al., $(TA)$ |
|------------------------------|-------------------------------------|------------------------------------|-------------------------------------|--------------------|-------------------------------------|-----------------------------------------------|
| Achillea millefolium         | 2                                   | 8                                  | 4                                   | $\times$           | 5                                   | Ews                                           |
| Geranium robertianum         | 2                                   | 4                                  | $\times$                           | $\times$           | 7                                   | Ea                                            |
| Bromopsis inermis            | 3                                   | 8                                  | 4                                   | 8                  | 5                                   | Cir                                           |
| Calamagrostis epigeios       | 3                                   | 7                                  | $\times$                           | $\times$           | 6                                   | Ea                                            |
| Site No. 2 Rarely operated railroads |                          |                                    |                                     |                    |                                     |                                               |
| Site No. 3 Abandoned railroads |                                    |                                    |                                     |                    |                                     |                                               |
| Rubus idaeus                 | 3                                   | 7                                  | 5                                   | 6                  | 4                                   | Ea                                            |
| Fragaria vesca               | 4                                   | 7                                  | 5                                   | $\times$           | 6                                   | Cir                                           |

### 3. Results and discussion

**3.1. Studies of phytocenosis on the sleeper box for railroads with different operation levels**

The maximum number of species 24 (twenty-four) was found in Site No. 3 (abandoned railroads). These results might be caused by intensive successional processes, an accumulation of organic substances by photoautotrophs, and absence of the weed control measures. The minimum number of species 7 (seven) was found in Site No. 1 (constantly operated railroads). These results are because of the wide use of herbicides, and intense impact from trains and special equipment.

The Braun-Blanquet cover-abundance score shows the following most abundant photoautotrophs: Achillea millefolium and Geranium robertianum for Site No.1; Bromopsis inermis and Calamagrostis epigeios for Site No. 2; Rubus idaeus and Fragaria vesca for Site No.3.

The average degree of the manifestation in the areal of Biodestructor-producers is calculated using the following expression:
\[ X = \frac{B_1X_1 + \ldots + B_nX_n}{B_1 + \ldots + B_n}, \] where

- \( X \) – average value of degree of the manifestation;
- \( B_1 \)– Braun-Blanquet cover-abundance scores.

Table 2 illustrates the results of calculations.

**Table 2 – Average degrees of manifestation of the environment factors according to Ellenberg indicators**

| Experimental site | \( \sum X \) | \( \sum KX \) | Average value of degree of manifestation |
|-------------------|-------------|-------------|----------------------------------------|
|                  | \( F \) | \( R \) | \( N \) | \( F \) | \( R \) | \( N \) | \( F \) | \( R \) | \( N \) |
| Site No.1        | 7    | 2    | 7    | 33   | 14   | 54   | 4.7   | 7.0   | 7.7   |
| Site No.2        | 13   | 8    | 13   | 59   | 53   | 70   | 4.5   | 6.6   | 5.4   |
| Site No.3        | 32   | 21   | 35   | 171  | 140  | 211  | 5.3   | 6.7   | 6.0   |

The following results have been obtained for each site:
- Site No. 1: high moisture (\( F=4.7 \)). Weak acid medium (\( R=7.0 \)) with nitrogen enriched (\( N=7.7 \));
- Site No. 2: semi-dry (\( F=4.5 \)). Middle acid medium (\( R=6.6 \)). Poor in nitrogen (\( N=5.4 \));
- Site No. 3: optimum moisture content (\( F=5.3 \)). Middle acid medium (\( R=6.7 \)) with optimum nitrogen content (\( N=6.0 \)).

### 3.2. Estimation of the phytocides efficiency

To estimate an efficiency of the weed control measures conducted in the operated railroads (Site No. 1), we selected four equivalent test areas (\( S=100 \text{ m}^2 \)) that have been exposed to the herbicide impact. Table 3 provides more details on this experiment.

**Table 3** Description of experiments on treating test areas with various herbicides

| Test area | Herbicide tradename | Active ingredient of herbicide, Preparation form | Usage rate |
|-----------|---------------------|-----------------------------------------------|------------|
| I         | Reference area      | -                                             | -          |
| II        | Tornado 500         | Glyphosate isopropylamine salt 500 g/l, water solution | 4.0 l/ha  |
| III       | Magnum              | Metsulfuron-methyl, 600 g/kg, aqua-dispersed granules | 0.3 l/ha  |
| IV        | Grayder             | Imazapyr, 250 g/l, water glycol solution       | 2.5 l/ha  |

Figure 1 illustrates the experimental results that describe killing of weeds in the tie crabs.
Figure 1 - Comparative analysis of the efficiency of various herbicides used in the test areas

Analysis of experimental results proved a high efficiency of all investigated herbicides. The “Greyder” herbicide manifested a maximum efficiency while the “Tornado 500” has a minimum efficiency.

4. Conclusion

1. Probably, the high concentration of mineral nitrogen in the permanent way is caused by an inflow of the organic and mineral substances from several sources: blanket sand and tree leaves; components of trailing loads; wastewater from passenger trains. Saprophytic microorganisms turn those substances into the forms that are easily absorbable for plants.

2. Variations of the water availability of the ballast prism reflect local environmental and geographic features, and accumulation of the organic substances. Different values of the hydrogen index (pH) can be caused by morphological properties of metamorphic rocks that form the broken-stone ballast, and specifics of the railway track pollutants.

3. The environmental estimations of the photoautotrophs species help us develop the efficient phytocide measures. Those measures can be divided into two groups: environment-friendly measures and environment hazards.

   Environment-friendly measures include the activities that suppress the growth and propagation of the photoautotrophs. For example: hermetic sealing the equipment and wagons to avoid the spillage of trailing load, and the leaking of the lubricants, process liquids, and wastewater.

   The following measures might be hazardous for environment: the use herbicides, and removing the weeds with mechanical tools. In addition, those measures might be expensive and labor-consuming.

This paper describes techniques for the environmental and floristic analysis of unwanted plants that grow on the railway canvas. The methods for removing unwanted plants as a way to ensure the stable operation of the railroad transport have been reported.

References

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