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INITIAL SCREENING OF SEED BANK OF PHYTOINDICATORS OF TECHNOGENIC PRESSURE ON EDAPHOTOPES IN DONBASS

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Safonov A. I. **Initial screening of seed bank of phytoindicators of technogenic pressure on edaphotopes in Donbass.** – Methodological techniques and significance of research of soil seed bank in technogenically transformed landscapes in Donetsk region have been analyzed. We have defined the spectra of participation of seed material of plants of indicational value set before for retrospective analysis of trend of technogenic pressure onto natural environments.

Key words: seed bank, phytoindication, diagnostics of the environment state, Donbass.

The soil seedbank (seed pool) represents the floristic potential of a given area and an important reservoir of species in restoration efforts [3, 11, 12]. This reservoir may include seeds from taxa presently inhabiting the site in addition to seeds transported into the area by different vectors. Species whose seeds have been incorporated into the seedbank from neighboring areas may have potential for future colonization [15, 17].

The probability that a given plant will become established in a particular area is influenced by the extent to which its seeds are dispersed [1]. The seedbank resulting from this dispersal contributes to ecological and genetic diversity of the area [5-7, 13, 16, 20]. Habitats characterized by frequent disturbance events typically exhibit transient seedbanks [2, 6] with seeds that either die or germinate within a year [10, 15]. Transient seedbanks have little or no influence on established populations because germinating seeds typically germinate within safe-sites where seedling survival may be assured. Consisting primarily of ephemeral species, seeds from this type of seedbank germinate in response to some unpredictable change in habitat characteristics [1, 9, 12]. Persistent seedbanks, in areas less prone to perturbation, consist of seeds that have accumulated over two or more years. The seeds of perennial species are often widespread and are able to germinate under the environmental conditions of the site. Although seedling growth may be somewhat restricted in the presence of the dominant vegetation, removal of the dominant taxa by disturbance is often accompanied by increased growth rates of seedlings within the patch [8, 14, 19].

In this study, we monitored seedlings germinating from soil samples collected from restored and unrestored portions of a Donbass shale barren. The composition of the seedbank was compared with that of the aboveground vegetation.

Data on the state of soil seed bank have fundamental and practical importance. Fundamental and theoretical meaning of information on seeds can be regarded as

- strategic potential of soil horizons,
- retrospective analysis of reproductive sphere of plants,
- defining geochronological sequence,
- transformation of generative sphere of plants.

In the framework of issues under consideration, in Donetsk region plants are mostly used as informative indicators of the state of tecnogenically transformed landscapes, toxic pressure on the environment.

In this aspect soil seed bank has practical importance for

- monitoring research of the state of environment,
- forecast for realization of ecological potential of plants,
- conducting ecological expertise on the territory of industrial objects,
- assessment of population strategies of plants-indicators in industrial region.

Issues of soil seed banks have been considered by many researchers in different countries [1, 4, 6, 9, 10, 13-15, 17].

In the previous publication [18] we have conducted an ecological analysis of the territory of an industrial town on the example of the Donetsk city with the use of bioindicational indices.

According to any parameter reflecting reproductive biology or relationships between a plant and environment, the species form continuum that is reduced to the discrete types because of pragmatic reasons. Continuum of species strategy (behaviour) reflects their relationships to the level of resource supply, biotic factors and disturbances. The last index is basic for analysis of disturbed habitats on the territory of Donbass. Different species adapt to the same environmental factor using different sets of physiological and structural modes. The greater number of such modes, the more successfully species can get over environment resistance. When monitoring landscape changes, the visual landscape should also be considered. This pertains to the information function of ecosystems and landscapes that refers to environmental structure and its function for satisfying needs. Practical means of principally important blocks of integration of industrial indicational botany trends have been grounded. Indices of structural transformation of plants, their fluctuation asymmetry in technogenic and natural ecotopes have been potentialized. Strategies of plants' survival under unfavorable conditions of growth have been taken into consideration [18].

Our scientific programme is aimed at research of seed bank of given ecotopes with various technogenic pressure for assessment of population strategies of plants-indicators in industrial region.

In many discrete and density-dependent models of annual plant population dynamics there is a parameter that measures the probability that a seed will germinate and become established the following year [4, 10], or a compound parameter of fecundity times a probability of seed germination and establishment [4, 13, 14]. Seed germination in such models is generally assumed to occur the following year without considering a seed bank, or alternatively, assumed to be a measure of the probability of germination from a seed bank in equilibrium, irrespective of when germination occurs. However, the presence of a seed bank is an effective strategy for preventing local extinction due to catastrophic environmental events, and this strategy is an important component in the life history of most plant species. Consequently, it is important to understand the effect of a seed bank on the dynamics and equilibrium conditions in the abovementioned discrete and density-dependent plant population models.

It is possible explicitly to model the dynamics of the seed bank in stage-structured models, where the effect of delayed germination and seed mortality is included in the models. However, this makes the ecological models more complicated, and if seedbank dynamics are not the main focus of the investigated model, e.g. in the study of multi-species dynamics, most ecological modelers tend to simplify their models and assume the absence of any seed bank. However, this model simplification poses a problem in the possible testing of the models by more empirically oriented plant ecologists. If the studied plant species have a seed bank, which almost all plants species do, it is not straightforward to apply the plant ecological data to a published model without a seed bank. Therefore, it would be useful to be able to correct the simpler, unstructured population dynamic models for the possible effects of a seed bank.

Here, the effect of a seed bank is investigated for an annual plant population. Throughout, it is assumed that the plant population is at ecological equilibrium. The main issue that is investigated is the importance of ignoring a seed bank in the class of discrete and density dependent models of unstructured plant populations. A formula that corrects the probability of germination and establishment in unstructured population models of annual plants for the effect of a seed bank is derived.

In the plant ecological literature there seems to be a division between theoretically oriented and empirically oriented plant ecologists, and this division may partly be due to the fact that the parameters in the theoretical plant ecological models do not correspond to observable quantities that may be estimated in plant ecological studies. Since the probabilities of seed germination and establishment typically are estimated from single-year observations, it will in most cases be necessary to correct the probabilities of seed germination and establishment in order to apply the simple unstructured theoretical models to real data.

If delayed germination is an important life-history strategy and seed mortality in the seed bank is relatively low, it has been demonstrated here that it is important to take the effect of the seed bank into account.

A seedbank may include seeds of species presently inhabiting a site as well as seeds from species that do not presently occur on the site nor within the local area. In greenhouse studies, there also exists the possibility that not all of the seeds from the seedbank will germinate. Year to year variation in seedbank composition is dependent on the summation of the number of germinating seeds of which the seedlings reach sexual maturity, the number of seeds produced by those plants, and the fraction of seeds lost to decay, predation, and inviability.

Studies, based solely on seed germination from soil samples, might not reveal all of the taxa that actually occur on a given site. Not all of the seeds may be viable, some seeds may have been removed by predation prior to the time of sampling, or the conditions in the research facility may not be sufficient for the seeds to break dormancy.

The dominant taxa represented a mix of species from disturbed habitats (i.e. Asteraceae, Brassicaceae, Lamiaceae, Poaceae), as well as shale barrens (i.e. Poaceae, Asteraceae, Brassicaceae, Lamiaceae, Fabaceae, Chenopodiaceae, Rosaceae, Polygonaceae, Caryophyllaceae).

In an attempt to provide a reliable estimate of the annual seed rain, sampling was conducted with three different types of seed traps. On each of the 40 plots, a sticky trap, a funnel trap and a pot trap were disposed in the 1 m^2 used to sample vegetation in order to assess their similarity. The sticky trap consisted of a clear plexiglas plate (15 x 15 cm) fixed on a metal pole (fig. l a).

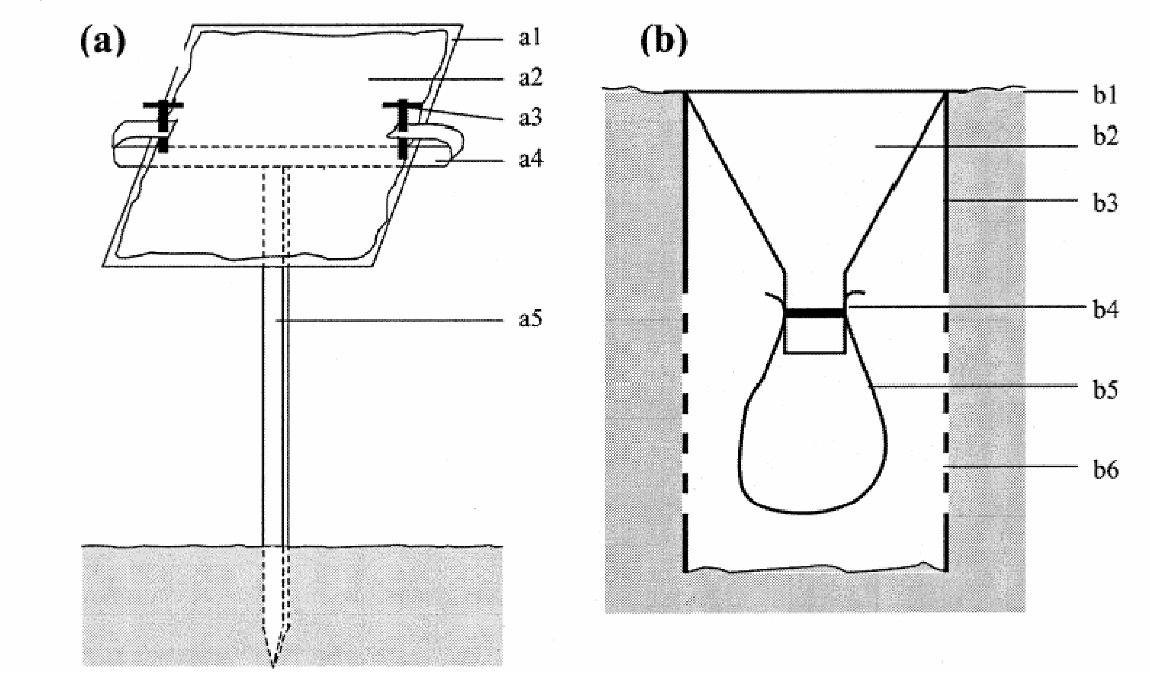

Fig. 1. (a) Sticky trap and (b) funnel trap [according to 3, 6, 10, 13]: a 1 – clear plexiglas plate; a 2 – sticky grease; a 3 – screw fixing the plate; a 4 – metallic plate support; a 5 – metallic pole; b l – ground level; b 2 – PVC plastic funnel; b 3 – grey PVC pipe; b 4 – elastic band; b 5 – gauze bag of 0,1mm mesh size; b 6 – bore holes (1 cm diameter).

The plexiglas plate was situated 15 cm above ground, facing the main wind direction and sloping at an angle of 45^0. The characteristics of the sticky trap were chosen to feature the optimum design to record seed rain principally of anemochorous species. Monthly, from March 2009 to March 2010 the sticky plates were exchanged and all material from each trap was examined under a dissecting microscope (10 x 90). All seeds, including those inside multi-seeded diaspores, were counted if they were whole and apparently un damaged. Unidentifiable seeds were planted into trays containing sterile soil and grown until identification was possible (*Artemisia* L., *Euphorbia* L., *Amaranthus* L., *Centaurea* L., *Chenopodium* L., *Atriplex* L., *Carduus* L., *Carex* L., *Epilobium* L., *Galium* L., *Poa* L., *Achillea* L.).

The second type of seed trap consisted of a PVC plastic funnel 10 cm in diameter, which was put level with the surface into the soil (fig. 1 b). The funnel was fixed on a PVC pipe with lateral bore holes (1 cm) to allow drainage. At the bottom of the funnel the seeds were caught in a filter gauze bag of 0,1 mm mesh size fixed with an elastic band at the base of the funnel. The bags were replaced every second week from March 2009 to March 2010, i.e., a total of 34 sample-dates for the 42 traps. Unidentifiable seeds were planted into trays containing sterile soil and grown until identification was possible (*Cyclachaena xanthiifolia* (Nutt.) Fresen, *Grindelia squarrosa* (Purch) Dunal, *Xanthium albinum* (Widd.) H. Scholz, *Ailanthus altissima* (Mill.), Swingle, *Stenactis annua* Nees, *Reseda lutea* L., *Fallopia convolvulus* (L.) A. Löve, *Rumex crispus* L., *Erucastrum armoracioides* (Czern. ex Turcz.), *Polygonum aviculare* L., *Amaranthus albus* L., *Digitaria sanguinalis* (L.) Scop., *Persicaria maculata* (Rafin.) A. & D. Löve, *Oberna behen* (L.) Ikonn., *Salsola australis* R. Br., *Ambrosia artemisiifolia* L.).

The seeds were identified in the same way as for sticky traps. The third trap type consisted of pots with sterilised soil. The 40 pots with 10 cm diameter were put level with the surface into the soil in the same way as for funnel traps. Pots were left in the field for the same time period as the traps, after which they were placed in an unheated greenhouse and watered twice a week to keep the soil moist. Considered together, however, several of the taxa typify the suite of species frequently found on shale barrens (e.g., *Capsella bursa-pastoris* (L.) Medik., *Echium vulgare* L., *Euphorbia seguieriana* Neck., *Kochia laniflora* (S. G. Gmel.) Borb., *Agrostis stolonifera* L., *Elytrigia repens* (L.) Nevski), *Artemisia absinthium* L., *Anthoxanthum odoratum* L., *Artemisia vulgaris* L., *Convolvulus arvensis* L., *Digitalis purpurea* L., *Eupatorium cannabinum* L., *Chenopodium album* L., *Cirsium arvense* (L.) Scop., *Daucus carota* L., *Berteroa incana* (L.) DC., *Calamagrostis epigeios* (L.) Roth, *Lactuca tatarica* (L.) C. A. Mey, *Amaranthus retroflexus* L., *Dactylis glomerata* L., *Cyclachaena xanthiifolia* (Nutt.) Fresen., *Deschampsia caespitosa* (L.) Beauv., *Galium mollugo* L., *Cynoglossum officinale* L., *Diplotaxis tenuifolia* (L.) DC., *Arrhenaterum elatius* (L.) J. et C. Presl., *Swida alba* Opiz, *Gnaphalium uliginosum* L.

The various and interdependent processes involved in seed rain emphasize the need of using different seed traps and spatial sampling designs to assess the role of seed rain in plant community dynamics. Funnel and sticky traps reveal the qualitative and also quantitative importance of seed rain as a potential source of species regeneration. They reflect the long-term potential for change of the standing vegetation through plant successions. The large quantity of seed input seems to be necessary for seedling establishment in the field because of the effect of the environmental filter. Pot traps indicate that numerous species with a very low number of individuals in standing vegetation are unable to establish in the field. Populations of such species could be doomed to extinction. Thereby, seed rain measured with different methods may contribute to an assessment of population viability analysis of specific plant communities.

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Сафонов А. І. **Первинний скринінг насінного банку фітоіндикаторів техногенних навантажень на едафотопи Донбасу.** – Проаналізовано методологічні прийоми та принципову значущість вивчення насінного банку в ґрунтових горизонтах техногенно трансформованих ландшафтів Донецької області. Визначено спектри участі насінного матеріалу встановлених раніше рослин із індикаційною значущістю для ретроспективного аналізу тренда техногенних навантажень на природні середовища.

Ключові слова: насінний банк, фітоіндикація, діагностика стану довкілля, Донбас.

Сафонов А. И. **Первичный скрининг семенного банка фитоиндикаторов техногенных нагрузок на эдафотопы Донбасса. –** Проанализированы методологические приемы и принципиальная значимость изучения семенного банка в почвенных горизонтах техногенно трансформированных ландшафтов Донецкой области. Выявлены спектры участия семенного материала установленных ранее растений с индикационной значимостью для ретроспективного анализа тренда техногенных нагрузок на природные среды.

Ключевые слова: семенной банк, фитоиндикация, диагностика состояния окружающей среды, Донбасс.