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Transformation and Features of Plant Successions of the Taman Peninsula in Case of Technogenic Impact

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Abstract: The impact of technogenic objects on the plant communities of the Taman Peninsula is considered. Technogenic transformations lead to destabilization of the balance in plant communities and landscapes of the Taman Peninsula. Anthropogenic successions are manifested differently in different types of ecosystems. The speed and nature of these processes usually determine the resistance of individual populations to the action of new environmental factors on them. When the vegetation cover is destroyed, the succession will focus on the formation of a ruderal community. When the sand-shell substrate was replaced with cement blocks in the littoral zone, the succession began to form linear synanthropic communities.

Keywords: Taman peninsula, steppe communities, littoral communities, technogenic impact.

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Ecological, botanical and landscape studies are carried out in the area of anthropogenic impact in order to obtain reliable information that could adequately reflect the current state of ecosystems and the anthropogenic impact on the state of the plant component of ecosystems and the abiotic environment. The Taman Peninsula is a young formation. The study of historical documents shows that it was a system of islands with mud volcanoes, there is an abundance of water channels, straits, lakes, the shores of which were covered with forest floodplain communities. There are forests in the form of "khmerechs" that have been preserved to this day: on the Duboviy Rynok Mountain, on the hills near the village of Golubitskaya, Ilyich khutor, to the south of the ancient settlement of Fanagoria, along the old Kuban riverbed, on the hills along the shore of the Vityazevsky estuary and near the village of Dzhighinka, etc. [*Litvinskaya*, 2021]

The vegetation of the Taman Peninsula of the pre-agricultural period is considered as herb bunchgrass steppe with copses of tree species, grass bunchgrass steppe and grass bunchgrass shrub steppe. Currently, the steppes of the Taman Peninsula belong to a special provincial subzone of the Azov-Black Sea, grass bunchgrass shrub steppe with elements of the Mediterranean flora [*Litvinskaya*, 2018]. Stable communities have been preserved in some beam and coastal areas. The steppes of the Taman Peninsula have experienced prolonged anthropogenic pressure [*Litvinskaya*, 2020].

The main historical environmental management associated with agriculture [*Litvinskaya and Bochko*, 2019], viticulture, pasture animal husbandry contributed to the destruction of tree and shrubbery renewal. Constant military operations and domestic needs required the use of wood. All this gradually led to the change of the climax community of the shrub steppe by herb bunchgrass steppe. Moreover, the sod base was formed very quickly by feather-grasses due to the features of growth.

The object of research is a plant component. Steppe (Taman port) and littoral (Verbnaya Spit) plant communities were studied. Generally accepted geobotanical research

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methods were used in our studies such as: the method of sample areas, cenotic description according to geobotanical forms for meadow communities, the method of analysis and the method of mapping communities.

The territory of the Taman Peninsula is characterized by increased environmental sensitivity as a territory marked by the occurrence of dangerous natural processes and phenomena. An increased seismicity of the area and mud volcanism of the endogenous dangerous geological processes should be noted. Currently, technological impact has increased on the ecosystems of the Taman Peninsula, which is accompanied by certain environmental risks. First of all, there is ecological risk of habitat disturbance for biota, which leads to the loss and degradation of natural steppe ecosystems.

Grass bunchgrass steppe communities are widespread on the territory of the surroundings of the technogenic facility "Port Taman". Presumably, the steppe communities between the capes of Panagia and the Iron Horn are secondary, but long-existing, having formed stable more or less stable biogeocenoses corresponding to specific abiotic environmental conditions of the Pre-Caucasian steppe zone [*Litvinskaya*, 2018].

The steppe ecosystem had been developing for a long time in relatively stable climatic and soil conditions, which led to the development of stability of their structure and saturation with floral components of a close ecology and to the development of stenobiont in steppe species, including assemblers. But it is also characterized by the abundance of steppe grasses, the presence of species of different ecology, in particular steppe-meadow (*Medicago romanica* Prodan, *Filipendula vulgaris* Moench, *Fragaria viridis* Duch., *Inula culus-christi* L., *Achillea setacea* Waldst.et Kit., *Salvia tesquicola* Klok. et Pobed.et al.), an insufficiently strong sod base, but they had been developing in relatively stable conditions for a long time (Figure 1).

The technogenic impact of the Port of Taman and the occurrence of an unfavorable environmental background (air pollution, dust emissions, etc.) will cause disturbances of the existing equilibrium in the formed steppe ecosystem. These disturbances may exceed the regenerative capacity of the steppe ecosystem. If the intensity of the impact goes beyond these possibilities, the initially stable, species-rich community of the forb feather-grass steppe will gradually degrade.

(a) Crimean-wormwood monodominant

(b) Solonechnikov-forb

(c) Fescue – solonechnikov

(d) Forb-fescue-feather grass

Figure 1. The formed stable steppe ecosystems of the Port of Taman.

The steppe ecosystem disturbance leads to disruption of the normal functioning of many organisms. *Festuca sulcata* L. and *Artemisia taurica* Willd have the greatest resilience and tolerance in extreme conditions due to their ecological individuality. They can survive a period of unfavorable conditions and produce seeds and then the edifiers will gradually but slowly recover under favorable conditions, and the succession will gradually lead to the filling of the cenosis in quantitative terms. The succession will strive for a sustainable ecosystem but this process is long. Most likely, the Crimean-wormwood monodominant community, which has a wider area of tolerance, will be restored.

The smallest range of tolerance has forb-fescue-feather grass community. It is characterized by high floral saturation, a complex vertical structure, the presence of rare species belonging to stenobiont organisms that exist only with small deviations of the factor from the optimal value, which makes these communities sensitive to disturbance. *Stipa capillata* is the most tolerant from feather grasses. Feather grass prefers well-drained, loose, non-acidic soils, which indicates a fairly low diversity of possible habitats by the factor of soil moisture.

The most important environmental factors for normal functioning are light, temperature, and water. The disturbance of the coherence of the action of abiotic factors occurs upon technogenic impact and the edaphotope, the regime of water and mineral nutrition change and pollution is introduced into the environment. First of all, during the construction of facilities, the main impact falls on the edaphic factor and then on plants. In case of soil disturbance, the nutrients become physiologically inaccessible. The least tolerant species (ephemera and ephemeroids, juveniles) will drop out of the community. When the vegetation cover is destroyed, the succession will be directed to the formation of a ruderal community. The first species to appear will be those whose seeds are carried by the wind, some of them will fall with moving transport (on wheels, in building material). The nature of the developing vegetation will depend on the properties of the substrate, the degree of its disturbance, the remoteness of the territories from which the soil or construction material is taken. Populations of synanthropic species more resistant to the changed environment such as: *Elytrigia repens* (L.) Nevski, *Cynodon dactylon* (L.) Pers., *Hordeum leporinum* Link, *Echinochloa crus-galli* (L.) Beauv., species of the genus *Amaranthus*, *Xanthium srumarium* L., etc. will be expanded. Some plants will expand the ecological niche and will use the slightest opportunities for germination in places of soil accumulation.

A reduction in the species richness of plants will lead to a reduction in insects, whose food base has decreased. Insect life will occur in a disturbed environment (Figure 2).

Figure 2. Insect life in a disturbed environment.

Herpetofauna stations will be reduced. Lizards and steppe vipers are characterized by the principle of station loyalty. With the territorial reduction of the steppe ecosystem among the herpetofauna, the effect of crowding from overpopulation may manifest itself. With overpopulation of the environment, its quality deteriorates sharply: excrement, metabolic products are accumulated, growth and development of organisms are delayed, the timing of puberty, the rate of reproduction, cannibalism may take place. In the presence of competition, none of the populations can achieve such a number and density that would be possible in its absence. As a result of interspecific competition, ecological successions are manifested: the change of less competitive species to more competitive ones, as well as the narrowing of the ecological niche of the species. Thus, *Elaphe sauromates* prefer open steppe landscapes, often adhere to colonies of small rodents whose burrows are used as shelters. The species is characterized by two-peak daily activity. The species is rare for the steppes of the Taman Peninsula and with anthropogenic disturbance of the steppe ecosystem, the species will not withstand the competition of the steppe viper. New cenoses are being formed that are completely different from the original ones. At the same time, a significant part of the native flora and fauna is lost due to accidental or intentional acclimatization of new plant and animal species, pathogenic, parasites and predators. Seeds, bulbs, rhizomes and native species can remain in the substrate and even go through the full stages of vegetation with reduced vitality during the first 1-2 years. They will completely leave the environment later. Secondary succession will not lead to the restoration of the natural steppe cenosis. Along with the change in vegetation, the fauna of the territory subject to succession will also change. The animal population largely changes its composition. Due to the fact that all changes are related to human activity, we deal with ecological successions that occur under the influence of human activity. In this case, it is a constantly acting external factor, and we deal with an anthropogenically altered landscape. Usually, allogeneic successions manifest themselves in gradual destruction (digression) ecosystems. As a result, some group of eurytopic species, maximally adapted to specific conditions, will remain on the territory of the Port of Taman. In these conditions, the study of the vital state of plants as structural units of cenopopulations is of great importance for assessing the impact of the complex on the natural environment. With the repetition of technogenic disturbances, the further development of anthropogenic successions is suspended for an indefinite period of time and the stages of relatively stable low-component secondary "communities" are formed. It is difficult to call them communities but it is a complex of species of a monotonous set of biomorphs with the structure of a derived ruderal community with insignificant floral saturation, limited composition of dominants, changing abundance and mosaic. Seed sources cease to supply diasporas with further irreversible changes in environmental conditions, and succession stops at the stage of community death. Moreover, the main "blow" is inflicted on the plant component, animals can leave this habitat or switch to a more favorable biotope. Nevertheless, there will be fragmentation of habitats of terrestrial, especially small animals, migration routes to forage resources, mating and breeding sites will change and new anthropogenic biotopes will appear, which may lead to a change in the composition and abundance of animal species. Rare species are particularly sensitive. In the area of Cape Panaghia, there are pied wheatear, little grebe, collared bushchat (first recorded in 2003 [*Belik et al.*, 2009]) and crows, blue pigeon and green cormorant nest.

Anthropogenic successions have the most unexpected nature, they are difficult to predict and manifest themselves in different ways in different types of ecosystems. The speed and nature of these processes usually determine the resistance of individual populations to the action of new unexpected factors for them.

The studies of successions under technogenic impact (construction of the drilling station site) on littoral communities were carried out during the studies of the Azov coastal zone. Plant communities not affected by anthropogenic disturbances were distinguished by the presence of characteristic species, higher projective coverage, pronounced structure, as evidenced by the mapped transect (area 8 × 20 m) (Figure 3)

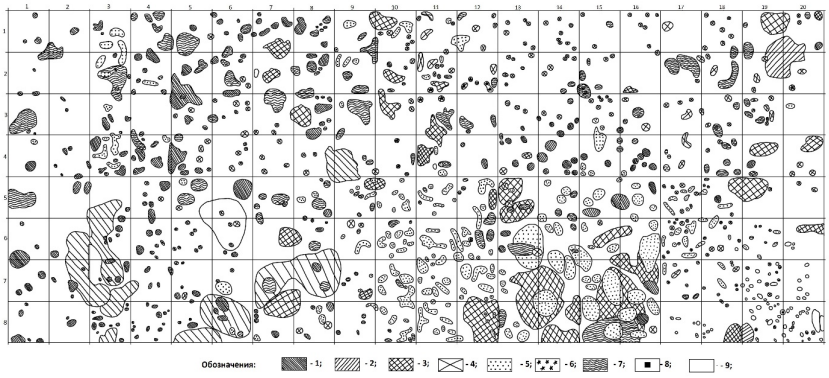

Figure 3. A projection of a community unaffected by anthropogenic impacts.
Notation keys: 1 – *Plantago maritima*; 2 – *Verdascum pinnatifidum*; 3 – *Tribulus terrestris*; 4 – *Plantago arenaria*; 5 – *Cynodon dactylon*; 6 – *Erodium cicutarium*; 7 – *Astragalus onobrychis*; 8 – *Leymus sabulosus*; 9 – *Carex colchica*

During the construction of the technogenic facility, the natural vegetation was completely destroyed and the new substrate was cemented blocks. At the first stages, there was a massive reproduction of the invasive species *Cenchrus longispinus*, which had not previously grown in these biotopes. *Cenchrus longispinus* is an invasive annual species of the *Poaceae* family, spread by prickly fruit systems containing 1–3 spikelets with grain fruits. The fruit systems are easily attached to the wool and skin of animals, clothing, shoes and human skin, by the wheels of cars and spread over long distances from the mother plant. *Cenchrus longispinus* was introduced, apparently, during the construction of a road with transport and was quickly spread. Its new ecological niche is an interplate biotope with soil accumulation. The monodominant communities were formed extremely quickly during two years. Two years later, *Echinochloa crus-galli* began to be introduced. 10 species have been recorded in a community dominated by *Echinochloa crus-galli* with no species from natural littoral communities. Sandbur was only occasionally found in the derived cenoses of the drilling site five years later. *Euphorbia maculata* L., a new invasive species whose homeland is North America, appeared that had not previously grown within the littoral area of the Verbnaya Spit. As a result, the dominance passed to *Euphorbia maculata*.

There was a clear shift in succession towards the dominance of annual and weed species over the years of observations. Littoral species, having mainly powerful root systems, could not grow in conditions covered with cement blocks of the substrate. In the future, the succession followed a more powerful overgrowth of linear ecotopes. The number of species increased slightly but individuals of some species moved from the vegetative state to the flowering and fruiting phase (*Phalacroloma septentrionale* (Fern. et Wiegand) Tzvelev, *Crepis rhoeadifolia* M. Bieb.). The anthropogenic ecological niche was completely populated not only by synanthropic species (*Hordeum geniculatum* All., *Digitaria sanguinalis* (L.) Scop., *Setaria pumila* (Poir.) Roem. et Schult., *Conyza canadensis* (L.) Cronquist, *Ambrosia artemisiifolia* L., *Anthemis ruthenica* M. Bieb.) (Figure 4) but species of natural communities (*Medicago romanica*, *Cacile euxina*) also grew in interplate substrates.

The Taman Peninsula is one of the few territories that has concentrated in its landscapes an unprecedented number of species of biogeocenotic complexes, as well as rare, endangered and protected species. Studies have shown that technogenic transformations lead to destabilization of the balance in plant communities and landscapes of the Taman Peninsula. These impacts belong to the direct category, i.e. there will be a direct destruction of vegetation in different landscapes and a reduction in the number of rare species. The construction of technogenic facilities affects the entire complex of natural landscapes. From the point of view of the impact on the geological environment, the impact is associated with the redevelopment of the relief and the terracing of steep slopes, an increase in the intensity of the development of the processes of planar and linear erosion. The process of

Figure 4. Formation of linear interplate communities on an anthropogenic substrate.

anthropogenic changes in natural complexes is accompanied by many undesirable consequences: reduction of habitats of a number of plant and animal species, general depletion of biota, reduction of genetic diversity of individual species, etc. The most vulnerable elements are usually protected plant species and steppe ecosystems.

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