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Simple scale for assessing anthropogenic pressure on the environment

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Abstract. The article describes a new simple author five-point scale of assessing anthropogenic pressure on the environment, based on the conducted investigations in various parts of the urban and suburban landscapes which were changed to various degrees by human activity. A feature of this method is a simple and quick estimation of the degree of anthropogenic transformation, on the basis of the visual observations (expert estimation) without the use of sophisticated specialized laboratory equipment and methods. There are some main criteria used in the process of performance of estimation of the environmental conditions according to the proposed methodology. The most advisable usage of the scale in the conditions of urban natural communities (urbosystems) and suburban areas (on the studying of which it was designed) during the environmental and biological investigations by schoolchildren, students and also postgraduate students and scientists.

1. Introduction

The development of human society proceeded in proportion to its impact on the environment. The scope of the modern environmental impact is so great that there are calls to designate our current geological period as *the Anthropocene* of the new *Technozoic Era*.

There are many different methods of environmental impact assessment, but at the moment there is no single point of view on the implementation of such measures. At different times, a number of authors have created and proposed various methods for assessing anthropogenic impact on a territory, based on measuring the threshold limit value (TLV) of toxic substances in environment or on bioindication (using living organisms as criteria for assessing the state of the environment). Nevertheless, most of them involve access to scientific laboratories to obtain the results of measurements of harmful chemicals in water, soil and air [1], and do not take into account (or take it partly) garbage, human-built objects and other factors. Sometimes such assessments require deep knowledge of ecology [2]. This circumstance is absolutely unacceptable in the case when a researcher (who may not be an ecologist) does not have an access to special equipment but needs to conduct a sufficiently accurate and quick assessment of the state of the environment on the ground.

The main task in assessing the degree of environmental impact is to highlight *the anthropogenic components in the natural communities*: areas of crop plants, changes of soil properties and fertility, changes in surface runoff, groundwater regime, windbreaks, gardens, roads (including railroads),



reservoirs, industrial facilities, quarries, dumps, landfills, city blocks, etc. All these elements here are *separate landscape units*.

We can divide the transformations by its scope into *local* (changes of the dominant plant or animal species, structure of the vegetation cover, ecotone properties; fragmentation of natural communities etc.) and *regional* (invasions of species, land use changes, creation of agricultural areas etc.).

Characteristics of environmental impacts can be divided into several groups: *type of impact* (direct, indirect, secondary); *impact reversibility* (reversible, irreversible); *level of changes* (low, medium, high); *impact duration* (constant, temporary); *scope of impact* (local, regional); *terms of duration* (short-term, mid-term, long-term); *cumulation* (cumulative, non-cumulative).

The most convenient method for determining the degree of anthropogenic (agricultural, rural, industrial, urban, recreational and other types of landscape changes) transformation of a territory is the use of specially developed scales. Often, authors create scales taking into account the specifics of the territory. For example, scales have been developed to assess the anthropogenic impact on forest landscapes, agricultural and transformed landscapes [3, 4]. Separate scales are based on assessing the degree of change in soil and plant groups (also bioindication) or the conditions of surface runoff of river basins [5, 6] and human-built objects [7]. Scales were also created to determine the degree of anthropogenic transformation of landscapes in specially protected natural areas.

Recently, most of such studies related to assessing the degree of human impact on the environment can be carried out by remote methods — *distant observations* (satellite images, Google Earth Pro, unmanned aerial vehicles (UAV), geographic information systems (GIS) etc.) [8].

The proposed method for assessing the anthropogenic impact on the territory was developed and tested during long-term zoological research on the territory of the city of Biysk and its surroundings. It involves a quick assessment of the degree of anthropogenic transformation of natural landscapes based on visual observations, the presence or absence of the listed below criteria. The described scale is relevant when conducting environmental research and practice by schoolchildren and students, as well as doctorate students and scientists.

2. Materials and methods

This scale was originally designed for the longitudinal study of the beetle fauna of the city of Biysk and its surroundings (Altai Krai). The uniqueness of the territory lies in the fact that Biysk is a large industrial city where nature has been significantly influenced by humans, but at the same time, especially in the suburbs, unique, little-changed natural communities have been preserved [9, 10]. Any faunistic or ecological research is associated with assessing the level of anthropogenic transformation of the environment in various regions and habitats in the studied area. During the development of the scale we analyzed such different territories as river terraces, floodplain areas of rivers, islands, ravines, valleys, gullies, industrial and park zones, quarries for the mining of sand and clay (artificially desertified landscapes), residential areas (the most densely populated areas), garden associations, coniferous and deciduous forests, windbreaks, agricultural areas and vast spaces covered with meadow and meadow-steppe vegetation. The variety of habitats, natural and anthropogenic conditions made it possible to work out as much as possible the methodology for assessing the degree of anthropogenic transformation of the territory and to highlight the most significant and easily visible criteria directly on the ground.

3. Results

The developed *scale for assessing the level of anthropogenic transformation of the territory* is based on observing the presence of such human factors of influence on natural landscapes as *garbage* and *unauthorized dumps* of various sizes, *recreational pressure*, *unpaved (dirt)* and *asphalt roads*, *garden communities*, *residential areas* (low-rise and multi-storey buildings), *artificial landforms*, *industrial facilities*, *parks*, *agricultural lands*, etc.

The scale ranks the degree of anthropogenic pressure into 5 levels: *weak*, *moderate*, *medium*, *strong* and *very strong* (table 1).

Table 1. Scale of the degree of anthropogenic impact on the territory.

Level	Criteria	Point
Weak	Almost complete absence of traces of human activity — slightly changed landscapes; lack of garbage and landfills, asphalt or concrete pavement, buildings. Remoteness from the main places of residence of humans and industrial enterprises.	1
Moderate	There is possible insignificant amount of garbage, dirt roads, the use of the territory for recreational purposes and for grazing cattle.	2
Medium	The presence of small illegal dumps, the location of the site near regional highways, garden communities. Cattle grazing.	3
Strong	The presence of large landfills, residential areas, federal highways. Location in the center of cities, which leads to gas pollution of the territory.	4
Very strong	The location of the territory in the immediate proximity of the objects of industrial human activity. City garbage dumps. The territory is located in the immediate vicinity of objects of industrial human activity.	5

A *weak level of anthropogenic transformation (1 point)* is characterized by an almost complete absence of traces of human activity. The landscapes have been slightly changed, there is no garbage or landfills, along with asphalt or concrete pavement, as well as any buildings. As a rule, such places are located far from areas with city blocks or industrial facilities. These are hard-to-reach places in the suburbs or on the outskirts of cities, which makes them unsuitable for economic and recreational purposes — the slopes of large, ancient river terraces, swampy and often flooded areas of river floodplains, islands, forests or meadows (steppes) remote from the city, and abandoned agricultural fields.

A *moderate level of anthropogenic transformation (2 points)* is characterized by the presence of an insignificant amount of debris and dirt roads. The territory may be used for recreational purposes and for grazing cattle. These are relatively accessible places for humans also in the suburban area or on the outskirts of the city — river banks, areas of forests and meadows (steppes) little affected by human activity.

A *medium level of anthropogenic transformation (3 points)* suggests the presence of garbage and small illegal dumps. Such territories are located near regional highways, garden communities (often the gardens themselves have medium level of anthropogenic transformation) and residential areas with low-rise buildings. The area can be used for grazing cattle. Such places are most common in the suburban area, on the outskirts of the city (low-rise buildings, wastelands), in areas not used for economic activity within the city.

A *strong level of anthropogenic transformation (4 points)* presupposes the presence of large amount of garbage and illegal landfills, federal highways and local roads, residential areas with multi-storey buildings, sand and clay mining pits etc. This level also includes parks in the central parts of the city, where, despite the presence of green areas, exhaust gases from internal combustion engines still lead to severe pollution of the atmosphere and the surface layer of the soil. Noise pollution is also significant.

A *very strong level of anthropogenic transformation (5 points)* is characterized by the greatest anthropogenic transformations in natural landscapes. These are places where processes surface (strip) mining or mining with the ingress of toxic substances into the environment, city dumps, dumps of the mining industry (spoil tips), industrial zones of cities. Urban dumps are extremely dangerous — specially designated landfills for the disposal of household and construction waste, where garbage is taken from all parts of the city and, as a rule, is not recycled, poisoning everything around. Often, there are cases of debris ignition (air pollution) and the penetration of toxic substances into the soil and

groundwater (pollution of the hydrosphere and lithosphere), especially during the period of precipitation. Also, a very strong level of anthropogenic impact can manifest itself in the center of large cities, since the surrounding landscapes are so much changed in comparison with natural ones, and traffic is so intense that it leads to pollution comparable to industrial emissions.

4. Discussion

There is no doubt that the number of territories with a low level of anthropogenic impact increases with distance from the city. The distance at which such landscapes can be found depends only on the size of the city and its population. The areas of sites of moderate and medium level of anthropogenic transformation in large cities are insignificant, but in cities such as Biysk (population: $\approx 210\,000$), they occupy rather large areas, largely due to the relief features (the ancient 5th terrace of the Biya river with a height of about 50 m and a developed network of valley-gully and ravine systems) [9, 10]. Gully systems in this respect are of certain interest. On the one hand, the ravines and gullies located within the city are heavily littered — they accumulate *technogenic deposits* over the course of decades. However, as a rule, only some slopes or the top of the ravine are severely affected, while no economic activity is carried out in it, and people visit it extremely rarely. This makes it possible to assess the state of most urban ravines at 2 (moderate level) and 3 points (medium level).

Approximately the same situation is with sand and clay quarries. When mining stops for a long time, desertified landscapes are formed in these places, where many species of animals can settle without fear of being disturbed by humans. Fallows (secondary successions) are generally outwardly often indistinguishable from untouched meadow steppes, as well as windbreaks (artificial plantations).

Strong and very strong levels of anthropogenic transformation of the territory are characteristic for every city of medium and large size. In smaller cities, even in relative proximity to the center, there are areas that are slightly changed by man and his presence there is hardly noticeable. This creates favorable conditions for the existence of many species of plants and animals, but synanthropic species still prevail. This fact suggests that even the medium level of anthropogenic transformation of the territory is not critical and is quite suitable for habitation of many species from the list of local biodiversity. It should also be noted that invasions of alien to the local flora and fauna species most often begin in this zone, while it has moderate level of human intervention and favorable climatic conditions for them. In a short time, they adapt and begin to occupy new territories.

5. Conclusion

The proposed five-point scale does not claim to be used as the main method of environmental impact assessment. It is meant to quickly and accurately determine the degree of human interference in natural landscapes during scientific experiments, school or student practices and to make a preliminary conclusion directly on the ground. In studies where it is necessary to assess the level of anthropogenic pressure on the territory as accurately and comprehensively as possible, this method can be combined with detailed study of the environment (taking samples of air, soil and water) with subsequent analysis in specialized laboratories.

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