Monitoring research and care for nature technologies in biosphere reserves UNESCO

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Abstract. In biosphere reserves UNESCO, we propose to distinguish scientific research studying the unknown qualities of the biota from technological design aimed at restoring and caring for the ecosystems of a reserve. In primary or climax ecosystems, we propose to use technological methods that prevent anthropogenic transformation. In secondary and degraded ecosystems at different levels, we propose artificial restoring of the lost functions of ecosystems. Examples of monitoring studies in ecosystems with varying degrees of disturbance in the Middle-Volga Integrated Biosphere Reserve are considered.

1. Introduction

The idea of a biosphere reserve as a reference area demonstrating sustainable development and almost unchanged biodiversity has existed for more than 30 years [1, 2]. During this time, the most recognized are two ways of the management of biosphere reserves:

- regular monitoring and evaluating of the territory;
- taking advantage of concentric zoning of reserves.

To implement the idea of a biosphere reserve in scientific publications and collective documents, it is logical and effective to use functional zones in terms of the level and the quality of permissible changes in ecosystems. The first inner zone is usually designated as a site with minimal human impact (the core zone of a biosphere reserve). The second (buffer) and third (transitional) zones represent a series of areas with increasing human pressure. The transitional zone is recognized as a site or plots with the maximal permissible level of human impact for a biosphere reserve UNESCO [3].

In recent years, the authority of biosphere reserves has grown rapidly. The network of such territories is expanding, numbering more than 700 biosphere reserves all over the world. Many conservationists and ecologists consider this network to be an important international tool for moving the biosphere towards “sustainable development” and “sustainable biodiversity” [4]. The idea is popular among specialists: in case of successful operation of the network of biosphere reserves, the severity of many global environmental problems will decrease and humanity will come closer to entering a new historical stage. We consider this approach to be a simplification of the situation. The number of global problems in the territory of biosphere reserves is increasing every year. Some of them are following:

- determination of the optimal size of the reserve;
- the impact of climate change;
- disappearance of traditional knowledge and customs of local communities;
• lack of quality education and training of specialists for biosphere reserves.

In this work, we analyzed some human activity in the ecosystems of the natural-historical complex Samarskaya Luka. This territory is located in the Samara Oblast (Russian Federation) in the middle flow of the Volga River.

2. Materials and Methods
The article is an analysis of studies conducted in the territory of the natural-territorial complex Samarskaya Luka since 1961. The Samarskaya Luka is the peninsula formed by a bend of the Volga River in its middle reach (53°25′N, 49°42′E). The Zhiguli Mountains are located in the northern part of the Samarskaya Luka. It is a barrier, which makes the old broad-leaved forests still intact here, although the majority of woods were exposed to logging operations in the past. Most of the Samarskaya Luka peninsula is protected territory. The principal vegetation of Samarskaya Luka is lime (Tilia cordata Mill.)-oak (Quercus robur L.) forest with some maple (Acer platanoides L.) and elm (Ulmus glabra Huds.). Pine (Pinus sylvestris L.) and mixed broad-leaved-coniferous (Pinus sylvestris L., Quercus robur L., Tilia cordata Mill., Corylus avellana L.) forests occur in small patches on the slopes and crests of the mountains. Also aspen (Populus tremula L.) and birch (Betula pendula Roth.) forests of secondary origin with different admixtures grow on Samarskaya Luka. The main type of undergrowth is hazel (Corylus avellana L.), sometimes hazel and maple.

Data on the dynamics of forest felling were published earlier in the paper by Yu K Roshchevskiy [5]. Data on the number of the edible dormouse (Glis glis L., 1766) were obtained using live trap census. The indicator of number was the amount of individuals caught per 100 trap-nights [6]. Data on the abundance dynamics of bats were obtained by the method of annual total census in the galleries of the villages Shiryaevo and Bogatyr’ [7, 8]. Data on the methods of census for different groups of living organisms near a technogenic object are given in the book "Apple ravine" [9].

3. Results and Discussion
The Samarskaya Luka is a natural-historical territorial complex (about 160 thousand hectares) surrounded by an ancient (about 360 million years old) bend of the Volga River. It includes floodplain, ridge-flat, low-mountain (the Zhiguli Mountains) and cultural landscapes. Terrestrial ecosystems have not undergone dramatic changes since the last ice age (about 11 thousand years ago). As a result, biodiversity is very rich here. Fauna and flora include a large number of endemics and relics. Since the middle of the 16th century, local communities have developed peacefully and relatively isolated from other areas of Russia. The local population is distinguished by mentality, features of character and the existence of unusual folklore images. The complex Samarskaya Luka is the main functional part of the Middle-Volga Integrated Biosphere Reserve created in 2006 with a total area of 443.93 ha (figure 1). The most valuable natural and cultural objects of the reserve are located in the I.I. Sprygin Zhiguli State Nature Biosphere Reserve (23,157 ha) and the National Park "Samarskaya Luka" (127,186 ha).

The territory of UNESCO biosphere reserves includes plots with varying degrees of anthropogenic pressure. Most of them require at least two research approaches:
• scientific work aimed at identifying unknown peculiarities of biota and landscapes;
• technological work aimed at the design, treatment and restoration of biota and landscapes.

The most relevant scientific basis for scientific and technological researches in the territory of biosphere reserves is the identification of ecosystems in three stages of ecological transformation: in primary or climax ecosystems; in secondary ecosystems and degraded ecosystems at different levels.
In the coming years, we consider important the following areas of scientific and technological researches and technological design:

- regular monitoring;
- development of projects for the conservation of ecosystems prone to degradation;
- development of principles and norms for the acceptable exploitation of ecosystems;
- regular forecasting of the state of ecosystems.

Let us consider some of the results of testing the biota of the Middle-Volga Integrated Biosphere Reserve, which can be used for technological recommendations, projects, and conclusions.

In the territory where the National Park «Samarskaya Luka» was created in 1985, industrial logging had been carried out for many years. They were finished only in the second year of the park existence (i.e. in 1986). In 1985, a record amount of forest in seven years was cut down: 600 thousand cubic meters of industrial wood. The total area of the cut down forest exceeded 200 hectares that year (figure 2). To restore the forest and maintain its biodiversity, the technology of care for nature was drastically changed. Since 1986, only care felling has been allowed. During the first years of the park’s existence, the volume of cut down industrial wood decreased by 4-5 times. After the creation of the biosphere reserve, the volume of timber from care felling was reduced to 10-20 cubic meters per year. The first changes in the technology of care for the forest stimulated a gradual slow restoration of forest plots getting similar to the state at beginning of the 20th century. Monitoring of forest communities included the control over the age and species diversity of trees [5].

We can use other technological methods based on the results of the census of animal number. In the case of cyclic persistent fluctuations, we can formulate the following technological conclusion: the population of this species is in a state of stable equilibrium and does not require intervention in the natural processes of the community. Such an example of fluctuations was recorded in the population of the edible dormouse (*Glis glis* L., 1766) in primary ecosystems of deciduous forests of the protected area of the biosphere reserve (figure 3) [6].
Another situation was revealed when counting the number of bats in the secondary ecosystem of galleries, in which biotechnical measures were implemented – the creation of artificial lattices from humans (figure 4) [7, 8]. In this group of species, irregular fluctuations of abundance were registered. For a correct technological conclusion, additional research is required to identify the causes of fluctuations.

![Figure 2](image2.png)

**Figure 2.** Felling in the territory of the natural-historical complex Samarskaya Luka [5]

![Figure 3](image3.png)

**Figure 3.** The number of dormice in 2003–2011 [6]
In cases where it is possible to measure any factor distorting the functional state of animals, plants, communities, their biodiversity, it is possible to design effective technological recommendations for the care of contact plots of the reserve zones.

Our observations revealed that the boundaries between the core and the buffer zone, the buffer and transitional zones are not constant and often change their shape. The reserve technologists have to correct constantly the recommendations. Figure 5 shows the situation in the degraded ecosystem of the transitional zone – at the border of the quarry Yablonevyy ravine, where limestone was mined by explosions [9]. The measurements were made in the territory of the national park before the establishment of the Middle-Volga Biosphere Reserve. Dust from calcium carbonate penetrated the broadleaf forest hundreds of meters from the edge of the quarry. Organisms in each ecological niche reacted differently to air pollution. A comprehensive assessment of measuring the abundance of dust, saprophages, predators, phyllophages, and herbaceous plants made it possible to identify several areas in the model space that differ in ecosystem functions. The first site is characterized by the high mortality of organisms and an abundance of saprophages and predators (from 0 to 500 m from the quarry). The second site has a moderate grass layer, a low number of predators and phyllophages, and a high abundance of saprophages (from 500 to 1000 m from the quarry). The third area has low overall mortality of organisms and low abundance of saprophages. A high abundance of herbaceous plants and the maximum abundance of phyllophages and predators (from 1000 to 2000 m from the quarry) were revealed in this area. From these data, it follows that the currently accepted scale of the main zones of biosphere reserves can be measured by indicators of the abundance of ecological groups of organisms by the type of nutrition. Besides, at a certain stage of development of scientific research in the territory of the reserve, it will be possible to create appropriate technologies in each zone and its parts and to determine their quantitative parameters.
Figure 5. Zones of the abundance of ecological groups of organisms near the limestone quarry (Samarskaya Luka) [9]

4. Conclusion
Summarizing the results, biosphere reserves have ecosystems with several degrees of anthropogenic transformation and, accordingly, with different opportunities to restore their primary functions or resist changes. For sustainable development of the entire complex of ecosystems of the reserve, it is proposed to prevent changes in ecosystems and thoroughly calculate all the consequences of changes in the buffer and border zones. We advise developing different management tactics for three types of ecosystem transformation.

In primary or climax ecosystems (core zone of the reserve), we propose to use technological methods that prevent anthropogenic transformation. In secondary and degraded ecosystems at different levels (buffer and transitional zones), we proposed to develop technological methods for restoring the lost functions of the ecosystems. These techniques include restoration of vegetation cover, reintroducing carnivorous species, etc.

For effective management of biosphere reserves, it is proposed to use two research strategies:
1) activities aimed at identifying the unknown qualities of the biota of the reserve (scientific research itself);
2) activities aimed at the restoration of biota (technological design development).

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