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Valuation of ecosystem services of protected areas

Understanding that the environment is more than the resource base of commercial activity was a turning point in the realization of the real value of the environment and the need for evaluation of its quality.

Ecosystem services are the benefits people obtain from ecosystems. We consider ecosystem services as an intermediate link between the processes and phenomena in the environment and human well-being. There are four types of ecosystem services.

- *Provisioning services* are: the products obtained from ecosystems, including, for example, genetic resources, food and fiber, and fresh water
- *Regulating services* are: the benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases
- *Cultural services* are: the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values.
- *Supporting services* are: ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.

As practice shows, ecosystem services are generally admitted, however, are undervalued by mankind. At the present time ecosystems of the planet experience a tremendous anthropogenic burden. Population growth, raising of living standards entail the fact that ecosystems don't have time to self-reproduction. The inability of ecosystems to heal itself in a short time cuts up their basic functions on reproduction of natural resources, regulation of processes in the atmosphere, hydrosphere and biosphere. Exertion in ecosystems is growing, and their capabilities due to degradation reduce. To evaluate the potential of a territory from the standpoint of ensuring maximum flow of ecosystem services is possible only studying areas not affected by human activities. In densely populated regions protected

areas (PAs) can provide such opportunity. Valuation of ecosystem services of protected areas can be the key to solving the problems of the economic growth, both regionally and globally.

For different types of ecosystem services there is its own developed set of methods of their evaluation. The main include the use of direct and indirect market value, the principle of "willingness to pay or willingness to accept compensation"). The paper uses the concept of total economic value, which synthesizes all approaches mentioned above.

Valuation of ecosystem services of protected areas is made on the example of the state natural reserve Pasvik (or Pasvik zapovednik). Pasvik reserve is located in the extreme Northwest of the Kola Peninsula on the border with Norway and Finland. The reserve got its name from the valley of the river Paz (or Pats-joki), along the right bank of which it stretches from North to South by 44 km. The environmental situation in the region is complicated by the functioning of two industrial sites of the Kola mining and metallurgical company 'Nickel' and 'Zapolyarny' mines, which are located in the same named towns Nickel and Zapolyarny of Murmansk Region.

Pasvik reserve has many ecosystem functions aimed at providing the local population with the natural resources, at the maintenance of natural systems of the region in a good conditions, at community health, at satisfaction of research needs of indigenous landscapes of this area, at environmental education and the conservation of cultural and historical heritage of the region.

The purpose of work is to estimate ecosystem services of the Pasvik reserve. To achieve this goal it is necessary to take several steps:

1. To determine the boundaries of the study area.
2. To identify the full range of ecosystem services of the study area.
3. To determine the methods of evaluation (one or more) for each of the services.
4. To calculate the total economic value of the territory.

The first step is defining the territory, which ecosystem services will be assessed. As noted earlier, a key area of research is the territory of the state natural reserve Pasvik. Why we choose the Pasvik? This reserve was chosen for several reasons.

For European Russia this reserve can be used as a reference due to its physiographic and economic-geographical position. It is known that all European territory of Russia has changed by human economic activity, and this process began long time before the establishment of the first protected area in the country. Therefore, contrary to the popular opinion about virgin nature in the protected areas, landscapes of protected areas have been

broken, and now their natural territorial complexes cannot be considered indigenous. Against this background allocated only border areas with low population density areas, which is caused by the processes of centralization and access control visit the territory. Along with the abovementioned factors, the landscapes transformation can be the result of some temporary anthropogenic phenomena (for example, hostilities) or nature phenomena (for example, wildfires). Within the reserve there are traces of the military actions of the Second World War, but these objects are point, that allows speaking about the minimum disturbance area.

In terms of nature the Pasvik reserve is located in the zone of Northern taiga. Northern taiga forests on the territory of the reserve are represented by pine forests with an admixture of birch. Almost one third of the territory is very swampy. About 1% of the reserve area is grassland of secondary origin. Also it has an branching lake-river system, the main artery of which is the Paz river.

On the next phase a full range of ecosystem services of reserve reveals. Based on the theoretical developments of this issue mainly by foreign scientists, we had a list of ecosystem services of the reserve. This list was adapted by taking into account the terminology used in the Russian scientific school, and the availability of primary statistical data, which is easy to use on the Russian territory. The list of ecosystem services is given according to the concept of total economic value (table 1).

Table 1. The total economic value of ecosystem services of Pasvik Zapovednik

| Use value | | | Non-use value |
|---|---|---|---|
| Direct use value | Indirect use value | Option value | Value of existence |
| <ul style="list-style-type: none"> • gathering, and hunting of wild animals • fishing • fresh water • medicinal plants • non-food fibres of vegetable and animal origin • decorative resources • genetic resources • aesthetic value (natural and cultural landscape) • historical heritage • religious and spiritual value (virgin nature, sacred places and animals) • educational value (information and knowledge) • scientific value • recreation, tourism • improvement | <ul style="list-style-type: none"> • flow regulation, treatment and storage of water • sedimentation • flood protection • protection from erosion • protection from UV rays • climate regulation at the global level (including the carbon balance) and on the regional level • regulation of gases in the atmosphere (maintenance of air quality) • the water cycle • soil formation and maintenance of soil quality • maintenance of the life cycle and protection of habitats (pollination and spreading of seeds) • biological control (protection of plants from pests, disease control) • preservation of the gene pool (protection of refugia and habitats) • assimilation of wastes, emissions, discharges | <p>Unstudied species of living organisms, and also features of functioning of natural complexes, which will be received in the future</p> | <p>Benefit from the existence of the GEA Pasvik for the population of other regions, which do not use his services directly, consisting of biodiversity conservation and availability cultural heritage</p> |

| | | | |
|---|---|--|--|
| <ul style="list-style-type: none"> • watch animals - birdwatching etc. • hunting, fishing, collecting • biofuel plant origin • energy, water, sun | (thinning, filtering, removal and removals) <ul style="list-style-type: none"> • bioremediation (using plants and microorganisms) • nutrient Cycling • production of primary products | | |
|---|---|--|--|

There is no unique correspondence between natural territorial complexes and ecosystem services. Each type natural territorial complex has certain ecosystem services in a certain amount. There are some unique ecosystem services provided by specific type of natural territorial complexes. And there are common services provided by many types of natural territorial complexes. After analyzing the landscape structure of the Pasvik nature reserve and a set of ecosystem services provided by protected area, we can make a matrix of ecosystem services reserve, estimated in the framework of research (table 2).

Table 2. Matrix of ecosystem services of Pasvik zapovednik

| Ecosystem services | Natural territorial complexes | | | | | |
|-------------------------------------|-------------------------------|-----------------------|--------------|-------------------------------|----------|-------------------|
| | Pine forest lichenous | Pine forest sphagnous | Birch forest | Grassland of secondary origin | Wetlands | Lake-river system |
| Wood forest products | + | + | + | | + | |
| Non-timber forest product | + | + | + | | + | |
| Medicinal plants | + | + | + | + | + | |
| Flow regulation | | | | | + | + |
| Accumulation and water purification | | | | | + | |
| Carbon sequestration | + | + | + | + | + | |
| The energy of water | | | | | | + |
| The aesthetic value | + | + | + | + | + | + |
| Historical and cultural heritage | + | + | + | + | + | + |
| The educational value | + | + | + | + | + | + |
| Scientific value | + | + | + | + | + | + |
| Recreation and tourism | + | + | + | + | + | + |

Matrix of Pasvik ecosystem services illustrates the correlation between natural territorial complex and ecosystem services. It is necessary to note that on the reserve territory there is a unique ecosystem service (the energy of water) which is provided only by one type of ecosystems (lake-river system). An interesting feature of cultural and scientific ecosystem services is that they match to all, without exception, natural complexes. It means that all natural territorial complexes have educational and scientific value, aesthetic and historical

value, and also attractive for recreation and tourism. Considering natural territorial complexes, we can notice the difference in their value, which is expressed in the number of provided services. So, at first glance, it seems that grasslands and lake-river ecosystems have fewer ecosystem services in comparison with different types of forest. And wetlands, on the contrary, are leaders in the number of services. It should be noted that the diversity of services is not always outweigh their quality, which will be evaluated later.

Based on the valuation of the different biomes of the Earth by R. Costanzo and identified natural territorial complexes of Pasvik Zapovednik and the most important ecosystem services we can trace the connection between the importance of the biomes of the planet and natural territorial complexes of Pasvik (table. 3).

Table 3. The importance of natural territorial complexes of the Pasvik Zapovednik, obtained on the basis of the calculated values of the biomes of the planet by R. Costanza, USD / ha per year (in prices of 1994).

| Ecosystem functions | Boreal forest | Grassland | Wetland | Lakes and rivers | Total area of the reserve |
|---|---------------|-----------|---------|------------------|---------------------------|
| Regulation gases in the atmosphere | - | 7 | 265 | - | 272 |
| Climate regulation | 88 | 0 | - | - | 88 |
| Regulation disturbances in the atmosphere | - | - | 7240 | - | 7240 |
| Regulation of water | 0 | 3 | 30 | 5445 | 5478 |
| Water supply | - | - | 7600 | 2117 | 9717 |
| The erosion control | - | 29 | - | - | 29 |
| Soil formation | 10 | 1 | - | - | 11 |
| Nutrient Cycling | - | - | - | - | - |
| Disposal | 87 | 87 | 1659 | 665 | 2498 |
| Pollination | - | 25 | - | - | 25 |
| Biological control | 4 | 23 | - | - | 27 |
| Habitat refugium | - | - | 439 | - | 439 |
| Food production | 50 | 67 | 47 | 41 | 205 |
| Raw materials | 25 | - | 49 | - | 74 |

| | | | | | |
|---------------------------------------|-------------------------|------------------|--------------------------|--------------------------|---------------------------|
| Genetic resources | - | 0 | - | - | 0 |
| Recreation | 36 | 2 | 491 | 230 | 759 |
| Cultural | 2 | - | 1761 | - | 1763 |
| The value of 1 ha, USD per year | 302 | 244 | 19581 | 8498 | |
| Area, ha | 7069,23 | 144,27 | 4183,83 | 3029,67 | 14427 |
| TOTAL, USD per year (1994) | 2 134 907,46 | 35 201,88 | 81 923 575,23 | 25 746 135,66 | 109 839 820,23 |

Based on the data of R. Costanza's calculations for 17 biomes of the planet, the value of ecosystem services provided by the area of the Pasvik nature reserve is about 109 839,8 thousand USD per year (in prices of 1994). Biomes and natural territorial complexes of Pasvik are not reciprocation, therefore, this evaluation is approximate, and data in different cells of the table can be both overstated and understated.

Considering the economic value of 1 hectare of various ecosystems we can define a leader – wetlands (19 581 million USD per year in the prices of 1994), then in a gap of about 2.5 times go river-lake complexes (8 498 million USD per year in the prices of 1994). The value of the next order of magnitude have boreal forests (302 USD per year in the prices of 1994) and grassland (244 USD per year in 1994 prices) (Figure 1).

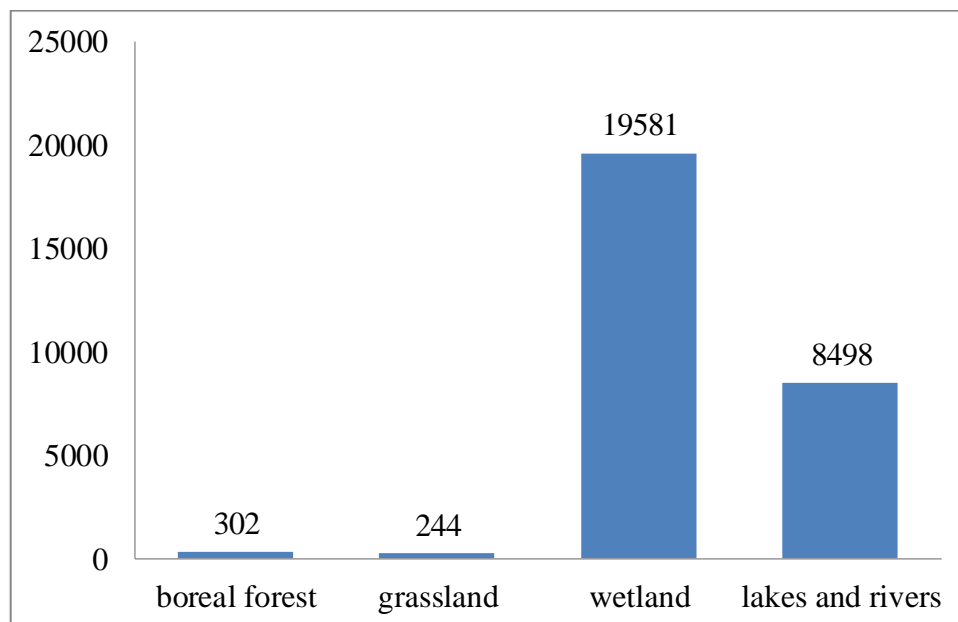


Figure 1. The value of 1 hectare of the different ecosystems of the Pasvik nature reserve, USD per year (in 1994 prices).

Considering the area of each natural complex, the resulting total economic value of protected areas is about 110 million USD per year in the prices of 1994 and it is divided between different ecosystems in the following way (Fig. 2). The most valuable in the context of delivering ecosystem services are the complexes of wetlands, their contribution is almost 82 million USD per year (in 1994 prices). The second best is the lake-river system of the reserve; its value is 25.7 million USD year (in 1994 prices). Next in importance comes the boreal forests, although they occupy almost half of the total area of the reserve. Ecosystem services which are provided by forests estimates at 2.1 million USD (in 1994 prices). The last are grasslands with value 35 thousand USD (price 1994).

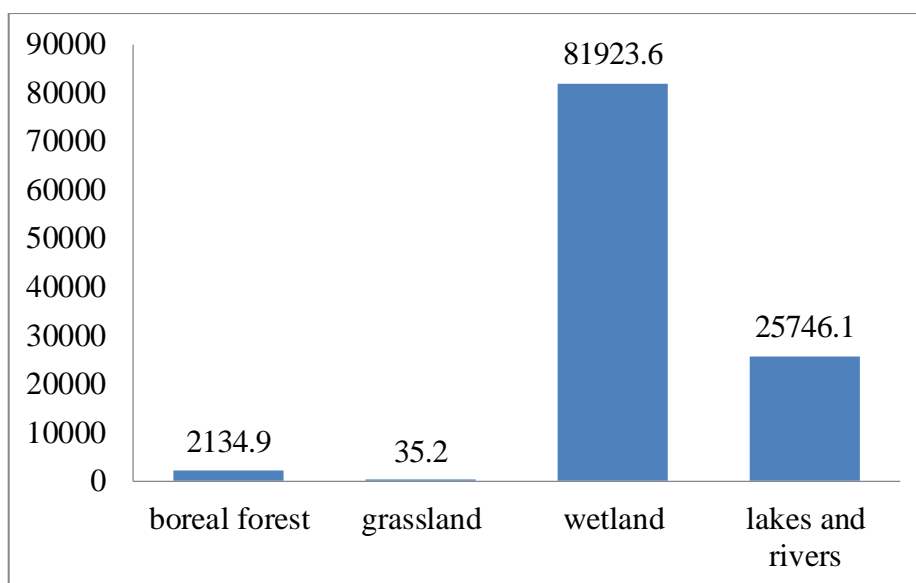


Figure 2. Economic value of ecosystem services which are provided by different types of natural complexes of the reserve, thousand USD per year.

The above calculations of the value of ecosystem services of the reserve Pasvik are approximate. More accurate estimate can be obtained, based on the data of field landscape surveys, on the extended spectrum of data for research and educational activities of the reserve staff and on the socio-economic status of the Pechenga district of the Murmansk region (where Pasvik is situated) and border regions of Finland and Norway.

More accurate assessment of selected ecosystem services will allow optimizing the management mechanism of protected area, elicitation the hidden opportunities of economic growth based on organization of new activities (GRP growth, increasing employment and household incomes, increase tax liabilities). In the case of regional planning (choice from several alternative types of economic activity) it is necessary to note the value equivalent of wilderness area.