# METHODOLOGY OF ASSESSMENT OF CONSERVATION EFFECTIVENESS OF PROTECTED AREAS AND THEIR REGIONAL SYSTEMS

# INTRODUCTION: PURPOSE AND SCOPE OF THE METHODOLOGY

The proposed methodology is aimed at the evaluation of **conservation effectiveness of protected areas (PAs), their individual conservation functions, and entire regional PA systems**, including **planned ones**, with the purpose of identifying the need, opportunities, and priority areas for the optimization of PAs, their regional systems, and management approaches. Conservation effectiveness is viewed as the degree to what a PA of a regional PA system is successful in fulfilling its conservation objectives arising from its natural peculiarities. Conservation effectiveness depends not only on the management of individual PAs and their systems, but on all other circumstances affecting PAs – their layout, geographic location, surroundings etc.

A mandatory element of the methodology is the evaluation of **conservation value** of both individual PAs and their regional systems. This indicator, used in combination with conservation effectiveness of the respective areas and systems, allows to rank them in terms of their **significance** to the conservation of environmental diversity, maintenance of ecological balance, and support of ecosystem services. For regional PA systems, conservation value and significance are determined not only by the respective parameters of constituent PAs, but also by the system's **completeness** and **integrity**, which are applicable only to a PA system of a certain region and can also be of interest as independent indicators.

In addition to current conservation effectiveness, the methodology also provides for the evaluation of **prospective conservation effectiveness** of individual PAs and their regional systems, i. e. their probable effectiveness in the future with the existing potential threats and possible global environmental changes taken into account. To support that evaluation, such additional parameters of PAs and their systems as their **security** and **resilience** to environmental changes are identified; those parameters can also be of value in their own right. For PA systems, stability of their current integrity is also evaluated.

In all cases when actual indicators produced for PAs and their systems differ from their maximum possible or optimal values, the methodology allows to identify the key factors leading to that difference and opportunities for the improvement. Based on the analysis of those factors, **potential values** in addition to actual ones are calculated for all indicators produced in the process of the assessment. It is assumed that those values can be achieved as a result of more or less feasible optimization measures. Limits to possible optimization of parameters, as well as the most relevant and promising areas for improvement are also identified.

The publication consists of four parts, the first one describes the process of assessment of individual PAs and its conservation functions; it can also be used for a comparative analysis of arbitrary groups of PAs. The second part lays out the approach to assessment of regional PA systems, which requires, as a prerequisite, the assessment of all constituent PAs according to the techniques presented in the first part. The third part deals with assessment of conservation value and effectiveness of planned PA systems, whereas the fourth one is dedicated to the procedure of assessment of conservation effectiveness of PAs and their regional systems.

The methodology is based on expert evaluation of a set of basic indicators, which are scored using a number of proposed point-based scales. Then the scores assigned to those indicators are used to produce a range of derived indicators, including final conservation effectiveness indicators.

## TERMS AND DEFINITIONS

**Relevance of (potential) threats** – a measure of potential exposure of the PA to adverse impacts, which is a function of a range of parameters characterizing potential damage to protected complexes and features of the PA, and the probability of the realization of the respective threats in the future. **Overall (cumulative) relevance of threats** – the sum total of relevance of all threats identified for the PA. **Minimized relevance of threats** – the expected relevance of threats in case of the implementation of feasible prevention measures.

**Security of the PA (= relative security of the PA)** – a quantity opposite to the ratio of the current overall ***relevance of threats*** to the maximum possible relevance of threats (one minus the ratio, or one hundred percent minus the percentage ratio), which characterizes the PA's exposure to both anthropogenic and natural adverse impacts. The security at the moment of assessment is called **current security**. Furthermore, one can define **potential security**, calculated as a quantity opposite to the ratio of the overall ***minimized relevance of threats*** to the maximum possible relevance, which characterizing the level of PA security, which can be achieved by implementing feasible threat prevention measures.

**Security of the PA system** – a measure of exposure of the PA system to both anthropogenic and natural adverse impacts, defined as a quantity opposite to the ratio of the current overall ***relevance of threats*** to all the system's PAs to the maximum possible relevance of threats.



**Favorability of geographic location** – a relative quantity characterizing the degree of possible changes in the PA's environmental complexes in response to significant global environmental changes manifested as shifts of natural zone boundaries, changes in the sea level etc.; it depends on the PA's location relative to *boundaries of climate-determined physiographic divisions, coasts of seas and major inland water bodies, and areas with extreme climate*.

**Favorability of the territory** – a relative quantity characterizing the possibility of the preservation of the currently existing environmental diversity within the PA in case of significant global environmental changes; it depends on the PA's *size* and its *landscape diversity*. **Current favorability of the territory** characterizes such possibility at the moment of the assessment, **whereas potential favorability of the territory** characterizes the possibility of the preservation of the diversity in case of the implementation of feasible PA optimization measures – expansion of the area leading to an increase in its landscape diversity.

**Contrast of the PA with unprotected surroundings** – a quantity characterizing differences between the state of environmental features underpinning the PA's ***conservation functions*** within the PA and that in unprotected areas surrounding it.

**Minimized relevance of threats** – ***see relevance of (potential) threats***.

**Completeness of the PA system** – a relative quantity characterizing the representativeness of the PA systems in terms of environmental diversity of the region and sufficiency of the system for the conservation of that diversity. The completeness encompasses eight aspects, including: *landscape representativeness; representativeness in terms of ecosystems and biocenoses; representativeness in terms of flora and fauna; completeness in terms of rare taxa; completeness in terms of areas of special conservation value; completeness in terms of notable environmental features; the degree of coverage of areas supporting the reproduction of biological resources; the degree of coverage of areas determining the ecological stability of the region and supporting natural process at the landscape and regional levels*. **Potential completeness of the PA system** – expected completeness in case of possible development of the PA system, which may include creation of new PAs and expansion or optimization of existing ones.

**Potential threats** – external and internal adverse impacts of both anthropogenic and natural origin, which may potentially affect PAs in the near future (10–15 years).

**Conservation significance** – a quantity representing the significance of individual ***conservation functions***, their components and subcomponents, and the PA as a whole for the conservation of environmental diversity and/or the preservation and reproduction of natural resources. It is determined by the ***conservation value*** of the PA and the ***current state of components of conservation functions*** of environmental complexes and features underpinning that value. The conservation significance of a system (or any arbitrary group) of PAs is characterized by **overall conservation significance** – the sum total of significances of all PAs comprising the system or the group – and by **specific conservation significance** – the average significance calculated by dividing the overall conservation significance by the number of PAs in the group.

**Conservation function** – a function supporting the conservation of environmental diversity and preservation and reproduction of natural resources, which is determined by the location, size, and specific features of landscapes and environmental complexes of the PA or the PA system. There are five main conservation functions of PAs and their systems: *reference, refugium, reserve, monumental, and ecological stabilization* ones (see Section I.1 for a detailed explanation). Each of the main functions is comprised of **components**, which, in turn, encompass a number of **subcomponents**. For example, components of the refugium function include the conservation of rare and endangered taxa and conservation of rare ecosystems, whereas subcomponents of these components include the conservation of individual taxa and individual types of rare ecosystems, respectively.

**Conservation value** – an indicator reflecting the PA's value for the conservation of the environmental diversity, which encompasses the ***representativeness*** of the PA, determined by such aspects as the diversity of environmental complexes and features, the completeness of their representation within the PA in question, and their rarity on the regional, national, and global scale, as well as the PA's ***contrast with unprotected surroundings***. The latter indicator is taken into account to emphasize the fact that protected environmental complexes or features are more valuable in the situation of anthropogenic isolation than when they are surrounded by similar environmental complexes or comprise an integral part of them. For regional PA system or other groups of protected areas, one can calculate ***overall conservation value*** (the sum total of conservation values of individual PAs) and ***specific conservation value*** (average conservation value of PAs comprising the set).

**Conservation effectiveness of the PA** – an indicator, expressed in relative terms, that reflects the degree of the fulfillment of the PA's key conservation objectives, determined by its status and natural peculiarities. **Current conservation effectiveness** of individual conservation functions of the PA, their components and subcomponents, as well as the PA as a whole is determined by the ***current state*** of the environmental complexes and features underpinning conservation functions relative to their best possible state. **Potential current conservation effectiveness** is defined as current conservation effectiveness in case of full or partial removal of ***incompleteness factors of conservation effectiveness***. Potential current conservation effectiveness corresponding to the removal of factors, associated with PA management deficiencies only, is the **minimum potential current effectiveness**, whereas the effectiveness in case of the removal of all incompleteness factors except for effects of irresistible forces is the **maximum potential current effectiveness**. **Prospective conservation effectiveness** is an indicator characterizing probable conservation effectiveness in the future; it is determined by the PA's current conservation effectiveness and ***security*** (when relatively stable conditions are expected in the future), or by the PA's current effectiveness, security, and ***resilience to long-term environmental changes*** (in case of significant environmental changes expected in the future). In addition to prospective conservation effectiveness estimated on the basis of the current conservation effectiveness, one can calculate **potential prospective effectiveness** based on potential current conservation effectiveness. For planned PAs, one can speak of their **projected conservation effectiveness**.

**Conservation effectiveness of the PA system** – a relative quantity reflecting the degree of the fulfillment of the system's objectives with regard to the conservation of the region's environmental diversity and reproduction of its natural resources. This indicator is determined by the average ***conservation effectiveness*** of individual PAs comprising the system in question, as well as the ***completeness*** and ***integrity*** of the system as a whole. As in case of individual PAs, one can distinguish between current, potential current, prospective, and potential prospective effectiveness of the system (with regard to a planned system, it is preferable to speak of «projected effectiveness»).

**Diversity of extrazonal and relic elements** – a relative quantity characterizing potential ability of the PA to support, on the basis of its own biodiversity, natural changes, including changes of the biocenotic cover, in response to significant global environmental changes.

**Representativeness** – an indicator characterizing individual components and subcomponents of conservation functions. In most cases it reflects the presence and completeness of representation of environmental complexes and features underpinning those functions (with the PA's significance for their conservation taken into account), as well as relative conservation significance of these complexes and features. Some exceptions are associated with such components of the reference function as non-native and synanthropic species, non-native communities, as well as disturbed and transformed ecosystems. The absence of such elements implies better representativeness of the PA.

**Connectivity with undisturbed and less-disturbed areas** – a relative indicator characterizing the probability of the natural course of changes in the biocenotic cover due to migration of species, complexes and entire communities in response to significant global environmental changes. In addition to current connectivity, one can estimate **expected connectivity** incorporating likely changes over the next 20–25 years, and **potential connectivity** – expected connectivity in case of the implementation of all possible optimization measures.

**Subcomponents of components of conservation function** – see ***conservation function***.

**Stability of the lithogenic base** – a relative quantity characterizing the probability of significant transformations of the lithogenic base of the PA's landscapes in case of significant changes in the global climate.

**Stability of the current integrity of the PA system** – an indicator characterizing the degree of the preservation of the observed ***integrity of the PA system*** in the near future without the establishment of new PAs or expansion of existing ones.

**Current state of components of conservation functions** – an indicator characterizing the contemporary status of the environmental complexes or features underpinning the components of conservation functions being evaluated, which is manifested through certain trends in their state. It is the focus on trends that makes this indicator substantially different from ***representativeness***. For example, in case of endangered species the representativeness reflects the PA's role in their conservation and is based on relative population size, whereas the current state indicator reflects the degree of well-being and viability of the respective populations, as well as observed trends in their status. Equally representative populations may be characterized by different current states: one population may be in a stable state or show a growing trend, while another one may show signs of degradation. Conversely, two populations substantially different in terms of their representativeness may be in the same current state: both a large significant population and a small insignificant one may be equally viable and in equally good state.

**Resilience of the PA (to long-term environmental changes)** – a relative quantity characterizing the probability of the PA to retain its conservation value in case of significant long-term environmental changes due to the preservation of its existing environmental diversity (**conservation resilience**) and/or expected natural changes in the biocenotic cover (**dynamic resilience**). The conservation resilience is determined by *favorability of geographic location, favorability of the territory, and stability of the lithogenic base*, whereas the dynamic resilience is determined by *diversity of extrazonal and relic elements, and connectivity of the PA with undisturbed and less-disturbed areas*. The **overall resilience of the PA** is defined as the average of the conservation and the dynamic resilience.

**Potential resilience of the PA** – resilience in case of the implementation of all feasible measures to improve favorability of the area, diversity of extrazonal and relic elements, and connectivity with undisturbed and less-disturbed areas.

**Factors of incompleteness of conservation effectiveness** – factors preventing the conservation effectiveness of the PA's conservation functions, their individual components and subcomponents, as well as the PA as a whole from reaching the maximum possible value (100%). There are 6 main groups of such factors: *deficiencies of PA management; correctable deficiencies of PA planning; external anthropogenic impacts originating from within the region; external anthropogenic impacts originating from outside the region; natural factors of irresistible force; uncorrectable deficiencies of PA planning*.

**Integrity of the PA system** – a relative quantity characterizing the PA system's capacity to support: natural lifecycles of species undertaking longtime nomadic or other migrations; populations of large animals, whose continued existence within a PA requires regular exchange of individuals with other areas; natural course of regional physiographic processes supporting connectivity between the region's PAs; restoration of disturbed or destroyed environmental complexes within a PA through in-migration of species and communities from other areas; natural changes in the biota and ecosystems in response to cyclic or directional changes of the physiographic environment manifested as shifts of boundaries of zonal divisions. **Potential integrity** – integrity of the PA system in case of expected changes in the system and the implementation of measures to prevent degradation of the integrity.

# I. ASSESSMENT OF CONSERVATION VALUE, SIGNIFICANCE, AND EFFECTIVENESS OF INDIVIDUAL PROTECTED AREAS

**Conservation effectiveness** of a protected area (PA) can be defined as a parameter, expressed in relative terms, that reflects the degree of the fulfillment of the PA's key conservation objectives, stemming from its status and natural peculiarities of the territory. One should distinguish between *current conservation effectiveness* of a PA, which reflects the degree of the fulfillment of its objectives under the existing conditions, and *prospective conservation effectiveness* reflecting that completeness under expected changes, including the realization of existing potential threats and/or global environmental changes.

**Current conservation effectiveness** is determined by the ***current state*** of protected environmental complexes relative to their best possible state. The latter implies optimal conditions conducive to conservation without taking into account possible limitations arising from the location, size, and other features of the PA. Thus, the notion of conservation effectiveness reflects not only the effectiveness of the PA's activities in terms of the conservation of environmental complexes and features, but also whether the size, location, and other natural features of the area are optimal in terms of the conservation.

At the same time, a high conservation effectiveness of a protected area does not necessarily mean that it is more valuable in terms of the conservation of environmental diversity compared to other areas having a lower effectiveness, since the conservation effectiveness is unrelated to the diversity of environmental complexes and features of the protected area and their relative conservation value.

The latter two aspects necessary for an analysis of the effectiveness of PA systems can be accounted for by another indicator – **conservation value** of a PA. This indicator reflects a) ***representativeness*** of the PA, which characterizes the diversity of environmental complexes and features of the PA, as well as the completeness of their representation within the PA in question and the degree of their rarity on the regional, national, and global scale; b) ***contrast with unprotected surroundings***. The latter aspect is introduced to emphasize the fact that protected environmental complexes or features (e.g. animal populations) in the situation of «anthropogenic isolation» are more valuable than those surrounded by similar complexes or being an integral part of them.



The conservation value of a PA characterizes its potential significance for the preservation of environmental diversity; however, even an area of a high conservation value may have a low significance, if its conservation effectiveness is low. Therefore, to characterize the current significance of a PA for the conservation of environmental diversity, which is also of importance for the analysis of PA systems, another indicator – **conservation significance of the PA** – can be used. This indicator is determined by the conservation value and current conservation effectiveness of the PA, being proportional to these two parameters.

When characterizing **prospective conservation effectiveness** of a PA, one should take into account, in addition to the current effectiveness of the area, the **security of the PA**, determined by the magnitude of various potential threats and the probability of their realization, and the PA's **resilience to long-term changes in the natural environment** (primarily climatic changes) determined by its geographic location, specific features of the territory, its landscape and biological diversity, surroundings etc.

A general scheme of all abovementioned indicators and relations between them is presented in Figure 1.

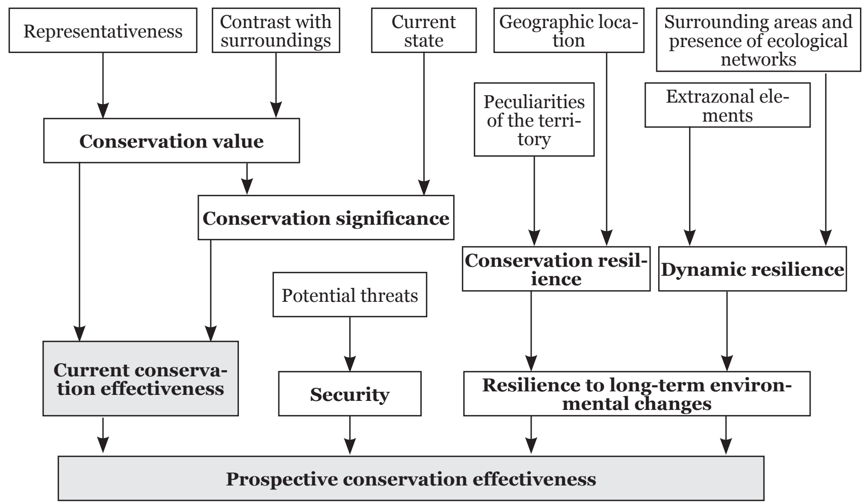


**Figure 1.** A system of key indicators characterizing conservation value, significance, and effectiveness of protected areas

The incompleteness of current and prospective conservation effectiveness (i.e. their being different from 100%) may result from different factors including, among others, those that can be removed through efforts of the PA itself or certain activities at the regional, national, or international level. Therefore, by estimating the contribution of these factors to the observed incompleteness of conservation effectiveness, one can produce estimates of **potential** current and prospective conservation effectiveness, i. e. their possible values in case of removal of all adverse factors that can be controlled or prevented. Such an analysis, among other outcomes, helps identify priority areas of activities for the enhancement of the PA's conservation activities.

# 1. EVALUATION OF CONSERVATION VALUE, CURRENT CONSERVATION EFFECTIVENESS, AND CONSERVATION SIGNIFICANCE OF PROTECTED AREAS

The indicators characterizing overall conservation value and current conservation effectiveness of an individual PA are based on a number of scores representing value and significance of the PA for the realization of its basic ***conservation functions***. These functions are determined both by goals and objectives of PAs specified by the respective regulations on the establishment of protected areas and statutes of individual PAs, and by PAs' potential for the conservation of environmental diversity and maintenance of regional ecological balance, stemming from natural features of the areas regardless of their formal objectives.

## Evaluated conservation functions and their components

There are 5 main conservation functions of a PA, each of which is determined by several components, which, in their turn, encompass a broader or narrower range of subcomponents (or 2nd order components). The PA's conservation value and current conservation effectiveness with regard to each function are underpinned by respective indicators for its components, which, in turn, are based on similar indicators for their subcomponents. Even if a given function for each PA is underpinned by the same set of components, the number and the range of subcomponents being analyzed can be different for each component. In some cases (when components correspond to some generic indicators), the same set of subcomponents can be used for all PAs, while in other cases (when components encompass a range of individual species and ecosystems) they can be specific to each area. Provided below is a description of the main conservation functions with lists of their relevant components and subcomponents:

**1. Reference function** implies the conservation, within the protected area, of undisturbed and less-disturbed environmental complexes, typical to the respective natural region, with the internal diversity and species assemblages peculiar to them. The function is characterized by the following four components:

**Environmental diversity**, whose subcomponents include: a) ***species diversity***; b) ***landscape diversity.*** The former subcomponent is evaluated relative to the local levels of animal and plant species richness typical to the respective natural zone (subzone) and physiographic region (province), whereas the second one reflects the completeness of the representation of the region's typical landscapes and intra-landscape divisions within the PA.

Presence and significance of **non-native and synanthropic elements** found in the biota and biocenotic cover of the area, i. e.: a) ***synanthropic species and the species non-native to natural ecosystems of the PA***; b) ***the communities non-native to the PA***. Non-native species are species not found in the PA's ecosystems in their natural state. Their presence within the PA is directly or indirectly related to economic activities, being a result of deliberate introduction or a side effect of other processes, including unintentional introduction or movement, facilitation of the species' spread by anthropogenic transformation of the natural environment etc., as well as more or less natural movement of the species from the areas of deliberate or unintentional introduction or acclimatization, to which the species also were originally non-native. This category does not include the species, whose populations existed in the area earlier and then have been restored by means of re-introduction, as well as those that have moved naturally from their natural ranges as a result of, among other factors, changes in the natural environment or natural intra-population processes. The *synanthropic* species include the species more or less typical to the PA's surroundings, but typically absent or being of insignificant abundance in natural ecosystems of the region in question in the absence of anthropogenic transformation. *Non-native communities* are the communities, whose edifiers are non-native or synanthropic species. They can be either similar to typical communities of other regions or newly formed ones.

Representation and state of **reference ecosystems**, which include undisturbed and less-disturbed ecosystems typical to the respective region. To support the evaluation of this component, one compiles a list of main types of reference ecosystems represented within the PA well enough to ensure, in principle, their conservation. Such lists are created for each PA in question on an individual basis. They include the following three categories of ecosystems:

a) ecosystems, the most typical to the respective physiographic region and found the most often within its natural landscapes, with particular emphasis on zonal ecosystems;

b) ecosystems, which play a secondary role in the formation of the natural landscape cover, but are specific to the natural zone or the physiographic region where the PA is located;

c) ecosystems more typical to other regions or equally typical to several or many physiographic divisions, which do not occupy large areas in the natural landscapes of the region in question, but are found within the PA in the ideal, or close to the ideal, state characterized by the presence of all typical elements, the absence of significant disturbances etc.

Each ecosystem type included in the list is then evaluated individually, as a separate subcomponent of this component of the reference function.

**1.4.** Occurrence and state of ecosystems **disturbed or transformed as a result of anthropogenic impacts**, which include all ecosystem types clearly distinct in terms of their significant and/or physiognomic characteristics from natural systems, which used to exist in the same location prior to human impacts. The following three main categories of disturbed or transformed ecosystems are considered in the methodology:

a) disturbed ecosystems, which do not experience anthropogenic impacts at the moment and are capable of natural recovery (burned areas from human-induced fires, forest clear-cuts surrounded by natural vegetation etc.);

b) disturbed or transformed ecosystems, which do not experience anthropogenic impacts at the moment but are incapable of natural recovery (or such recovery would require an extremely long time) and therefore require remediation (fallows in the steppe zone isolated from natural steppe vegetation; open-pit mines, waste rock dumps etc.);

c) transformed ecosystems currently under anthropogenic impacts, which are essential for maintaining their current state (fields, meadows, reservoirs and their inundation areas etc.).

This component is characterized by a single value for the entire PA or the PA system based on the frequency of occurrence and the state of disturbed or transformed ecosystems, with the presence of the three categories mentioned above and their relative size taken into account.

Thus, evaluation of the reference function involves evaluating a total of 5 + ***n*** subcomponents, where ***n*** is the number of reference ecosystems included in the evaluation list produced for each PA on an individual basis. The indicators common to all PAs include species richness, landscape diversity, significance of non-native and synanthropic species in the biota and biocenotic cover, and occurrence and state of disturbed and transformed ecosystems.

**2. <u>Refugium function</u>** implies the conservation of rare and endangered taxa, communities and ecosystems, and is evaluated on the basis of two components:



**2.1.** The PA's role in the conservation of **rare and endangered taxa** (species, subspecies, and populations) of plants and animals. The score for this component is based on the scores for individual taxa belonging to the following categories:

a) endemic and subendemic taxa, included in the Red Book of the Russian Federation, and narrowly endemic taxa;

b) taxa included in the Red Book of the Russian Federation, which are well represented outside Russia; taxa included in «monitoring lists» of the federal Red Book; taxa included in regional Red Books and lists of specially protected plant and animal species due to the reduction of their abundance as a result of anthropogenic activities; and regional endemic species with a low abundance;

c) taxa included in regional Red Books and lists of specially protected plant and animal species due to proximity of their populations to boundaries of their natural ranges.

As a rule, the taxa and communities used for the evaluation of this function include the ones whose current status is a result of the decrease in their abundance and/or range caused by natural changes or human impacts, the only exception being narrowly endemic species. In all cases, the taxa lists used for the evaluation of this component should include only the taxa whose conservation is or could be facilitated by the PA in question to a more or less significant extent. Therefore the lists should include only the taxa permanently living within the PA of using it at a certain stage of their lifecycle on a regular basis. All «a» category taxa are included in the list, including those whose population's extinction within the PA in question would not result in a serious damage to their global population. Of «b» category taxa, the list should include only those for whose conservation the PA in question is of substantial significance, i. e. the extinction of the local population will lead to a serious or a critical damage to the national population. Of «c» category taxa, the list should include only those for whose conservation the PA is of critical significance, i. e. the extinction of the respective populations will make the conservation of the taxon in the region impossible or unlikely. The taxa characterized by sporadic sightings within the PA, entering the area only occasionally etc. are not included in the evaluation list.

**2.2.** The PA's role in the conservation of **rare, endangered, and endemic communities and ecosystems**. As in the previous case, the score for this component is based on the scores for individual communities and ecosystems belonging to the following categories:

a) communities and ecosystems, rare or endangered at the global scale as well as narrowly endemic communities found only within the PA in question or in the immediately adjacent areas;

b) communities and ecosystems, rare or endangered at the national scale, as well as rare communities endemic to the region;

c) communities and ecosystems, rare or endangered at the regional scale.

For each PA, a permanent list of communities and ecosystems is produced on an individual basis. The list includes all types of category «a» communities and ecosystems; category «b» communities and ecosystems, for which the PA in question is the only one or one of the few such areas in the country, or one of the few areas, where those communities and ecosystems are more or less common; category «c» communities and ecosystems, for which the PA in question is the only or one of the few such areas in the region.

Thus, the refugium function is characterized by a range of indicators, specific to each PA and representing individual scores for rare and endangered taxa, represented within the area, as well as communities and ecosystems meeting the criteria listed above.

**3. Reserve function** is determined by the PA's role as a reproductive area for plant and animal taxa of economic value, and as a significant area for the preservation of large gatherings of animals, particularly vulnerable at certain stages of their lifecycle due to their forming such gatherings, which determine the state of their populations across more or less extensive areas. The function is evaluated on the basis of three main components:

**3.1.** The PA's role in the reproduction of **hunting and commercial animal species**. The overall score for the component is determined based on scores for individual groups of species, the list of the groups being the same for all protected areas:

a) ungulates**;**

b) large predators (bear, wolf, lynx, wolverine);

c) small and medium-sized predators;

d) rodents and lagomorphs;

e) waterfowl and shore birds;

f) galliformes;

g) commercial fish species**.**

The number of taxa of each group, which are abundant enough within the PA in question, is also taken into account when scoring the respective subcomponents.

**3.2.** The PA's role in the preservation of **large gatherings of animals**, including rare and commercial specials. The overall score for the component is based on scores for individual gathering types identified according to the following list of taxa groups, which is the same for all protected areas:



a) rookeries of marine mammals;

b) gatherings of ungulates during the fawning season;

c) seabird colonies;

d) intracontinental colonies of waterfowl and shore birds;

e) molting gatherings of the anseriformes;

f) migration and wintering gatherings of large bird species;

g) large spawning sites of commercial fish species.

For each gathering type, the number of the most abundant taxa forming the respective gatherings (collectively accounting for at least 90% of the total number of animals) is taken into account.

**3.3.** The PA's role in supporting **populations of plants having utilitarian value** and their reproduction. As in the previous cases, the total score for the component is based on scores for individual groups of plant species according to the following list, which is the same for all PAs:

a) medicinal plants;

b) valuable food plants;

c) decorative plants being actively gathered, except for those included in the federal and regional Red Books;

d) wild relatives of cultivated plants.

As in the previous cases, the number of species of each group, more or less common within the PA in question, is also taken into account.

Thus, the overall score for the reserve function is underpinned by a range of scores specific to each PA, their number being equal to the number of groups of plant and animal species having economic value plus the number of types of large animal gatherings, identified according to the lists provided above.

**4. Monumental function** is determined by the presence, within the PA in question, of particularly notable natural features, which can be considered «exceptional natural phenomena», as well as areas of «exceptional natural beauty and aesthetic value» or «exceptional scientific and educational value». Thus, the function is evaluated based on two components:

**4.1.** The PA's role in the preservation of **natural features having outstanding conservation or scientific and educational value**, which include *geological-geomorphological, hydrological, and glaciological features*, unique or extremely rare on the regional, national, or global scale in terms of their type or key characteristics; as well similar *biological* features, whose uniqueness and rarity stems not from the loss of their range, but from unique or specific conditions in which they are found, or their development history.

The score for the entire component is based on individual scores for each feature; the list of relevant features is compiled for each PA on an individual basis.

**4.2.** The PA's role in the preservation of **landscapes having outstanding scientific and educational or aesthetic value**, which include landscapes unique on the regional, national, or global scale in terms of the respective characteristics. As in the previous case, the overall component score is based on specific scores determined for each such landscape within the PA in question; a list of such landscapes is compiled for each PA.

Thus, the number of individual scores underpinning the overall score for the monumental function is specific to each PA, being equal to the number of listed natural features and landscapes, unique or rare at the regional of higher level.

**5.** **Ecosystem stabilization function** implies support by the PA of various ***ecosystem services***, significant to the adjacent and/or more remote areas. The key ecosystem services supported by PAs include:

a) mitigation of the effects of climate change and changes in the composition of the atmosphere;

b) prevention of soil erosion and degradation;

c) bank protection and flood prevention;

d) maintenance of water reserves and water quality;

e) reproduction of the key and economically valuable taxa (except for those taken into account in the evaluation of the reserve function).

The ecosystem services are assessed based on the presence and state of natural features and complexes underpinning those services (e. g., major glaciers and sources of large river support the service of ensuring water reserves and quality etc.).

The full list of conservation function components and subcomponents included in the analysis is presented in Table 1. The last column contains immediately evaluated subcomponents, whose scores (basic indicators) are aggregated to produce scores for components and functions as a whole. The number of subcomponents evaluated varies between PAs and includes 28 generic subcomponents common to all protected areas plus the number of evaluated reference ecosystems; rare and endangered taxa; rare and endangered communities and ecosystems; natural features and landscapes of outstanding conservation value. Lists of subcomponents specific to each PA are compiled in the process of the assessment.



**Table 1.**

*Scored components and subcomponents of conservation functions of PAs*

| ***Conservation functions of protected areas*** | ***Components of conservation functions*** | ***Scored subcomponents of conservation functions*** |
|---|---|---|
| **1. REFERENCE FUNCTION** | **1.1. Environmental diversity** | a) species diversity |
| | | b) landscape diversity |
| | **1.2. Non-native and synanthropic elements** | a) non-native and synanthropic species |
| | | b) non-native communities and ecosystems |
| | **1.3. Reference ecosystems** | *Reference systems meeting the established criteria (see the text)* |
| | **1.4. Ecosystems disturbed or transformed as a result of anthropogenic impacts** | |
| **2. REFUGIUM FUNCTION** | **2.1. Rare, endangered, and endemic taxa** | *Taxa meeting the established criteria (see the text)* |
| | **2.2. Rare, endangered, and endemic communities and ecosystems** | *Communities and ecosystems meeting the established criteria (see the text)* |
| **3. RESERVE FUNCTION** | **3.1. Hunting and commercial animal species** | a) ungulates |
| | | b) large predators |
| | | c) small and medium-sized predators |
| | | d) rodents and lagomorphs |
| | | e) waterfowl and shore birds |
| | | f) galliformes |
| | | g) commercial fish species |
| | **3.2. Large gatherings of animals** | a) rookeries of marine mammals |
| | | b) gatherings of ungulates during the fawning season |
| | | c) seabird colonies |
| | | d) intracontinental colonies of waterfowl and shore birds |
| | | e) molting gatherings of the anseriformes |
| | | f) migration and wintering gatherings of large bird species |
| | | g) large spawning sites of commercial fish species |
| | **3.3. Plants having utilitarian value** | a) medicinal plants |
| | | b) valuable food plants |
| | | c) decorative plants being actively gathered |
| | | d) wild relatives of cultivated plants |
| **4. MONUMENTAL FUNCTION** | **4.1. Natural features of outstanding conservation or scientific and educational value** | *Natural features meeting the established criteria (see the text)* |
| | **4.2. Landscapes of outstanding scientific and educational or aesthetic value** | *Landscapes meeting the established criteria (see the text)* |

| | |
|---|---|
| **5. ECOSYSTEM STABILIZATION FUNCTION** | a) mitigation of the effects of climate change and changes in the composition of the atmosphere |
| | b) prevention of soil erosion and degradation |
| | c) bank protection and flood prevention |
| | d) maintenance of water reserves and water quality |
| | e) reproduction of the key and economically valuable taxa |

## Indicators and evaluation process

The core process of assessment of **the conservation value and current conservation effectiveness** of a PA includes 7 stages (see Figure 2):

### *1. Preparatory stage*

At the preparatory stage, a list of evaluated subcomponents of conservation functions is compiled for the PA in question. This means that, in addition to 28 subcomponents common to all PAs, lists of the following features are created based on the criteria outlined above: a) ***reference ecosystems*** (1.3); b) ***rare, endangered, or endemic taxa*** (2.1); c) ***rare, endangered, or endemic communities and ecosystems*** (2.2); d) ***natural features of outstanding conservation or scientific and educational value*** (4.1); e) ***landscapes of outstanding scientific and educations or aesthetic value*** (4.2).

Furthermore, lists of significant (taken into account in the assessment process) taxa are created for each of the following groups: a) *hunting and commercial animal species* (3.1); b) *large gatherings of animals* (3.2); c) *plants having utilitarian value* (3.3); d) *natural features supporting the ecosystem stabilization function* (5).

### *2. Evaluation of basic indicators*

For each subcomponent of the conservation functions, listed in the last column of Table 1, the following three basic indicators are determined: *representativeness* (***r***)*, contrast with surroundings* (***d***), and *current state* (***c***).

**Representativeness** (***r***) characterizes the original potential of the PA in question for the realization of the given conservation function subcomponent. In most cases, it reflects the presence and



completeness of representation of environmental complexes and features underpinning the respective conservation function, as well as the PA's significance for the preservation of those complexes and features (with their relative conservation value taken into account). Some exceptions in this regard include such subcomponents of the reference function as non-native and synanthropic species, non-native communities, as well as disturbed and transformed ecosystems, their absence implying better representativeness of the PA.

The representativeness is evaluated using a four-point scale (from 0 to 3) with different grading criteria for different subcomponents (see Table 2). The only exception is the component «plants having utilitarian value», whose subcomponents are scored on a scale from 0 to 2, which helps ensure more adequate representation of the significance of this component relative to other components of the reserve function. Reduced scales with the maximum values of 2 or 1 are also used for certain types of reference ecosystems, rare, endangered, or endemic taxa, as well as rare, endangered, or endemic communities (see Table 1), whose representativeness scores take into account their relative conservation value, associated with their rarity, uniqueness etc.

The representativeness score «0» is not used for certain subcomponents of the component «reference ecosystems» and subcomponents of all components of the refuguim and monumental functions, since the subcomponents whose state corresponds to that value (i. e. subcomponents not present within the PA) are not included in evaluation lists. At a higher aggregation level, the overall representativeness score «0» for the respective components means that the PA does not have environmental features meeting the criteria of inclusion in the respective lists.

***All subcomponents scored «0» in terms of representativeness are not evaluated in terms of other indicators and are excluded from the subsequent analysis.***

**Contrast with surroundings** (***d***) characterizes differences in the state of environmental features, which underpin components of the PA's conservation functions, between the PA and its surrounding areas. The indicator is used for a more comprehensive assessment of the PA's conservation value, which would take into account the difference between the state of protected environmental features found within the PA and in its surroundings (it is assumed that a PA is more valuable when there are more positive differences in the state of environmental features protected within the area and similar features outside it). For example, a protected forest fully surrounded by cleared areas or arable farmland is deemed to have a higher conservation value than a forest in the same condition surrounded by similar forests.

The contrast is evaluated using a four-point scale from –1 to +2, with the score «0» corresponding to the absence of significant differences between the PA and its surroundings in terms of environmental features underpinning the subcomponent evaluated. The scores «1» and «2» represent different degrees of the positive contrast, when the respective features within the PA are in a better state, whereas the score «–1» corresponds to negative differences, when the state and condition of protected environmental features is better outside the PA. The scoring criteria for all subcomponents are presented in Table 3.

**Current state (*c*)** characterizes the contemporary status of the environmental complexes or features underpinning the components of conservation functions, which is manifested through certain trends in their state. It is the focus on trends that makes this indicator substantially different from representativeness. For example, in case of endangered species the representativeness reflects the PA's role in their conservation and is based on relative population size, whereas the current state indicator reflects the degree of well-being and viability of the respective populations, as well as observed trends in their status. Equally representative populations may be characterized by different current state scores: one population may be in a stable state or show a growing trend, while another one may show signs of degradation. Conversely, two populations substantially different in terms of their representativeness may have equal current state scores: both a large significant population and a small insignificant one may be equally viable and in equally good state.

The current state is evaluated on a scale which has three levels: 0, 2 и 4. The scoring criteria for all subcomponents of conservation functions are listed in Table 4. In general, the current state is scored «4» when environmental features underpinning the respective conservation function are in the optimal condition or close to it, or show a positive trend (recovery etc.). The score «2» corresponds to a relatively stable condition of those features with their significant parameters being different from optimal levels (incompleteness of ecosystems, low level of population degradation etc.). The score «0» represents continued degradation of the respective environmental features.



**Table 2.**

*Scales for the scoring of representativeness for different components of core conservation functions of PAs*

| ***Components and subcomponents of conservation functions*** | | | ***Representativeness score (r)*** | | | |
|---|---|---|---|---|---|---|
| | | | **3** | **2** | **1** | **0** |
| **1. REFERENCE FUNCTION** | **1.1. Environmental diversity** | **a) species richness** | Potential (original) species richness of vascular plants and vertebrate animals is substantially higher than the average richness of local floras and faunas of the respective natural zone and natural region | Potential (original) species richness of vascular plants and vertebrate animals is close to the average richness of local floras and faunas of the respective natural zone and natural region | Potential (original) species richness of vascular plants and vertebrate animals is substantially lower than the average richness of local floras and faunas of the respective natural zone and natural region; however, it is still within the natural limits | Potential (original) species richness is much lower than the natural levels for the respective natural zone and natural region |
| | | **b) landscape diversity** | The PA has the complete or almost complete range of landscape elements and intra-landscape divisions, and most of them preserve their natural (non-transformed) state | The PA has a significant portion of elements typical to its landscapes, including all background elements, or all or almost all landscape elements with some of them transformed as a result of anthropogenic factors | The PA has only some of typical landscape elements, or most of the elements present have been transformed as a result of anthropogenic factors | The PA does not have landscape elements or intra-landscape divisions not transformed as a result of anthropogenic factors |
| | **1.2. Non-native and synanthropic elements** | **a) non-native and synanthropic species** | At the moment of PA establishment, there were no non-native species within it, while abundance of synanthropic species did not exceed the level typical to natural ecosystems | At the moment of PA establishment, there were individual non-native species within it, which did not have significant adverse impact on the native fauna and flora; while abundance of synanthropic species might exceed the level typical to natural ecosystems, their populations also did not have significant adverse impact on local ecosystems or their components | At the moment of PA establishment, there were non-native species diverse and/or abundant enough, living within it, and/or there were abundant synanthropic species, with caused adverse impacts on the native biota or local ecosystems | At the moment of PA establishment, non-native elements or synanthropic species played a key role in local communities and ecosystems |
| | | **b) non-native communities and ecosystems** | At the moment of PA establishment, there were virtually no non-native communities within it | At the moment of PA establishment, there were non-native communities within it, but they did not occupy a significant portion of the area | At the moment of PA establishment, a significant portion of the area was occupied by non-native communities | Non-native communities were absolutely dominating within the PA |

| | | | | | | |
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| | **1.3. Reference ecosystems** | **category «a»** | Ecosystems are represented by sites having all significant elements and capable of self-sustaining and natural dynamics | Due to the lack of certain significant elements, ecosystems require special measures to support their natural state and natural dynamics | *Not used* | *Not applied to individual ecosystems; the component as a whole is scored «0» when the PA does not have ecosystems meeting the criteria for the inclusion into evaluation list* |
| | | **category «b»** | *Not used* | Ecosystems are represented by sites having all significant elements and capable of self-sustaining and natural dynamics | Due to the lack of certain significant elements, ecosystems require special measures to support their natural state and natural dynamics | |
| | | **category «c»** | *Not used* | *Not used* | Ecosystems are represented by sites having all significant elements and capable of self-sustaining and natural dynamics | |
| | **1.4. Ecosystems disturbed or transformed as a result of anthropogenic impacts** | | There are no ecosystems disturbed or transformed as a result of anthropogenic impacts within the PA, or their area is insignificant | Ecosystems disturbed or transformed as a result of anthropogenic impacts occupy significant areas within the PA; however, the latter is dominated by ecosystems not exposed to anthropogenic pressure at the moment and capable of self-recovery | Ecosystems disturbed or transformed as a result of anthropogenic impacts occupy significant areas within the PA, with the share of transformed ecosystems which continue to be exposed to anthropogenic pressure, or are free of it but not capable of self-recovery also being significant | The entire or almost the entire PA has been disturbed or transformed as a result of anthropogenic impacts; at present, it is dominated by ecosystems, which continue to be exposed to anthropogenic pressure, or are free of it but not capable of self-recovery |
| **2. REFUGIUM FUNCTION** | **2.1. Rare, endangered, and endemic taxa** | **«a» category** | The PA plays a key role in the conservation of the taxon | The PA plays an important role in the conservation of the taxon, supporting the preservation of a significant part of its global population, whose loss will result in a serious, though not irreversible, damage to the global population | The PA does not play a particularly important role in the conservation of the taxon, supporting the preservation of only an insignificant part of its global population, whose loss would not result in a serious damage to the global population | *Not applied to individual taxa; the component as a whole is scored «0» when the PA does not have taxa meeting the criteria for the inclusion into evaluation list* |
| | | **«b» category** | *Not used* | The PA plays a key role in the conservation of the taxon in the country, supporting the preservation of an essential part of the national population, whose loss will result in the extinction of the national population | The PA plays an important role in the conservation of the taxon in the country, supporting the preservation of a significant part of its national population, whose loss will result in a serious, though not irreversible, damage to the national population | |
| | | **«c» category** | *Not used* | *Not used* | The PA plays an key role in the conservation of the taxon in the region, supporting the preservation of an essential part of the regional population, whose loss will result in the extinction of the regional population | |
| | **2.2. Rare, endangered, and endemic communities and ecosystems** | **«a» category** | The PA plays a key role in the conservation of the given type of communities or ecosystems on the global scale, being the only or one of the few areas where they are found | The PA plays a significant but not unique role in the conservation of the given type of communities or ecosystems on the global scale, being one of the areas where such communities (ecosystems) are relatively common | The PA plays a secondary role in the conservation of the given type of communities or ecosystems on the global scale, being one of many areas where such communities (ecosystems) are found, and where they may be rare enough or represented by individual fragments | *Not applied to individual communities and ecosystems; the component as a whole is scored «0» when the PA does not have communities and ecosystems meeting the criteria for the inclusion into evaluation list* |
| | | **«b» category** | *Not used* | The PA plays a key role in the conservation of the given type of communities or ecosystems in the country, being the only one or one of the few areas where they are found | The PA plays a significant but not unique role in the conservation of the given type of communities or ecosystems in the country, being one of the areas where such communities (ecosystems) are relatively common | |
| | | **«c» category** | *Not used* | *Not used* | The PA plays a key role in the conservation of the given type of communities or ecosystems in the region, being the only one or one of the few areas where they are found | |

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| **3. RESERVE FUNCTION** | **3.1. Hunting and commercial animal species** | **species groups** (*see the text*) | The PA is associated with particularly large reproduction (fawning, spawning) or feeding sites, as well as migration and other gatherings of one or several species of the given group, having at least regional significance | One or several species of the given group have the maximum population density possible under the given conditions within the PA, or the PA contains reproduction (fawning, spawning) sites, as well as sites of feeding, molting, or migration gatherings determining the state of the respective populations in the PA's surroundings | The PA has sustainable viable populations of one or several species of the given group, which do not have particularly significant influence on the state of the species' populations outside the PA | The group is not found within the PA, or the abundance of its representatives is low |
| | **3.2. Large animal gatherings** | **gathering types** (*see the text*) | The PA is associated with animal gatherings of the given type, which are among the largest in the world and have global significance | The PA is associated with animal gatherings of the given type, which are among the largest in the country and have national significance | The PA is associated with animal gatherings of the given type, which have regional significance | There are no gatherings of the given type within the PA |
| | **3.3. Plants having ilitarian value** | **species groups** (*see the text*) | *Not used* | The PA is characterized by a high diversity of the group species and a high abundance of certain representatives of the group | The PA is characterized by a high abundance of certain representatives of the group, or a high diversity and a low abundance of the group species | The group is not found within the PA, or the abundance of its representatives is low |
| **4. MONUMENTAL FUNCTION** | **4.1. Natural features of outstanding conservation or scientific and educational value** | | The feature is unique at the global scale | The feature is unique to the country | The feature is unique to the region | *Not applied to individual features; the component as a whole is scored «0» when the PA does not have features of the given type* |
| | **4.2. Landscapes of outstanding scientific and educational or aesthetic value** | | The landscape is unique at the global scale in terms of its scientific and educational or aesthetic value | The landscape is unique to the country in terms of its scientific and educational or aesthetic value | The landscape is unique to the region in terms of its scientific and educational or aesthetic value | *Not applied to individual landscapes; the component as a whole is scored «0» when the PA does not have landscapes of the given type* |
| **5. ECOSISTEM STABILIZATION FUNCTION** | | **types of ecosystem services** (*see the text*) | The ecosystem services of the given type provided by the PA make substantial contribution to the stabilization of the environmental situation in the region and are of some significance beyond its boundaries | The ecosystem services of the given type provided by the PA make substantial contribution to the stabilization of the environmental situation in the PA's surroundings and are of some significance at the regional level | The ecosystem services of the given type provided by the PA are significant to the PA's immediate surroundings | The PA does not provide significant ecosystem services of the given type |

**Table 3.**

*Scales for the scoring of contrast with surroundings for different components of core conservation functions of PAs*

| ***Components and subcomponents of conservation functions*** | | | ***Contrast score (d)*** | | | |
|---|---|---|---|---|---|---|
| | | | **2** | **1** | **0** | **−1** |
| **1. REFERENCE FUNCTION** | **1.1. Environmental diversity** | **a) species richness** | Most natural local floras and faunas of the region have much lower species richness; many species are not found in the unprotected areas | Significant fraction of natural local floras and faunas has much lower species richness; some species are not found outside the PA | Species richness of natural local floras and faunas of the region is close to the one within the PA | Species richness of the natural local floras and faunas of the region is on average higher than the one within the PA |
| | | **b) landscape diversity** | The diversity of landscape units preserving their natural state (not transformed by economic activities) is much lower than within the PA; many types and varieties of non-transformed landscape units are not found outside the PA | The diversity of landscape units preserving their natural state (not transformed by economic activities) is somewhat lower than within the PA; certain types and varieties of non-transformed landscape units are not found outside the PA | The landscape diversity within the PA does not differ substantially from the one in the surrounding areas | The areas surrounding the PA are characterized by a much higher diversity of landscape units being in a natural state or close to it |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1.2. Non-native and synanthropic elements | a) non-native and synanthropic species | Across the non-protected areas surrounding the PA, the diversity and abundance of non-native and synanthropic species is much higher, and they cause much more significant adverse impact on the native biota | In the non-protected areas surrounding the PA, the diversity and abundance of non-native and synanthropic species is much higher in some locations, and they cause more significant adverse impact on the native biota | In the non-protected areas surrounding the PA, the diversity and abundance of non-native and synanthropic species is generally close to the ones within the PA | In the non-protected areas, the diversity and abundance of non-native and synanthropic species is lower than within the PA, and they cause less influence on the native biota |
| | | b) non-native communities and ecosystems | Communities non-native to the region are much more common outside the PA | Communities non-native to the region are somewhat more common outside the PA | Communities non-native to the region are equally common within the PA and in the surrounding areas | In the surrounding areas, non-native communities are less common than within the PA |
| | 1.3. Reference ecosystems | ecosystems | The representation, completeness, and condition of the ecosystems within the PA is much better than in the surrounding areas | The representation and/or completeness of the ecosystems in the surrounding areas is on average lower than within the PA, or their condition is generally worse than within the PA | The representation, completeness, and condition of the ecosystems within the PA are similar to the ones outside the PA | In the areas surrounding the PA, the ecosystems are better represented and/or more complete, or are in a better condition than within the PA |
| | 1.4. Ecosystems transformed or disturbed as a result of anthropogenic impacts | | Disturbed or transformed ecosystems occur much more frequently, and the degree of their transformation or disturbance is much higher outside the PA | Disturbed or transformed ecosystems occur somewhat more frequently in the surrounding areas than within the PA, and/or the degree of their transformation or disturbance is somewhat higher | There are no substantial differences between the frequency of occurrence of transformed or disturbed ecosystems within the PA and outside it, and between the degree of their transformation or disturbance | Disturbed or transformed ecosystems occur somewhat less frequently in the surrounding areas than within the PA, and/or the degree of their transformation or disturbance is lower |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2. REFUGIUM FUNCTION | 2.1. Rare, endangered, and endemic taxa | taxa | The taxon is much more common and widespread within the PA compared to the surrounding areas, which play no role or only an insignificant role in its conservation | Representatives of the taxon are somewhat less common or found somewhat less frequently outside the PA, which plays a more important role in its conservation compared to the surrounding areas | There are no significant differences in the condition of the taxon between the PA and the surrounding unprotected areas | The taxon is more common and widespread in the surrounding unprotected areas compared to the PA |
| | 2.2. Rare, endangered, and endemic communities and ecosystems | communities and ecosystems | In the surrounding areas, the communities and ecosystems in question are absent or much worse represented, and are in a much worse condition than within the PA | In the surrounding areas, the communities and ecosystems of the given type are somewhat worse represented and/or are in a worse condition than within the PA | There are no significant differences in the representation of the communities and ecosystems of the given type between unprotected areas of the region and the PA | In the surrounding unprotected areas, the communities and ecosystems of the given type are better represented than within the PA |
| 3. RESERVE FUNCTION | 3.1. Hunting and commercial animal species | species groups (*see the text*) | In the surrounding unprotected areas, no species or the given group are found, or their abundance is much lower and supported by reproduction within the PA | In the surrounding unprotected areas, the abundance of all or some species of the given group is lower than within the PA, and it is supported by reproduction within the PA | There are no significant differences in the state and abundance of species of the given group between the PA and unprotected areas of the region | In unprotected areas of the region, population of species of the given group are in a much better condition than within the PA |
| | 3.2. Large gatherings of animals | gathering types (*see the text*) | In the surrounding unprotected areas, gatherings of animals are found much rarer than within the PA, and their size is much smaller | In the surrounding unprotected areas, animal gatherings are found rarer, or their size is significantly smaller | There are no significant differences in the frequency of occurrence and size of animal gatherings between the PA and its surroundings | Outside the PA, gatherings of animals are found more often and/or their size is significantly larger |
| | 3.3. Plants having utilitarian value | species group (*see the text*) | *Not used* | In the surrounding areas, representatives of the group are less diverse and/or less abundant than within the PA | There are no significant differences in the diversity and abundance of the group's representatives between the PA and the surrounding areas | In the surrounding areas, representatives of the group are more diverse and/or more abundant than within the PA |

| | | | | | | |
|---|---|---|---|---|---|---|
| **4. MONUMENTAL FUNCTION** | **4.1. Natural features of outstanding conservation or scientific and educational value** | **notable natural features** | In the areas surrounding the PA, similar features are not found or are in a much worse condition, and have a much lower conservation or scientific and educational value | In the areas surrounding the PA, similar features have a lower conservation or scientific and educational value, or are in a worse condition | In the areas surrounding the PA, similar features of equal conservation or scientific and educational value are found | In the areas surrounding the PA, similar features are in a better condition, and/or have a higher conservation or scientific and educational value |
| | **4.2. Landscapes of outstanding scientific and educational or aesthetic value** | **landscapes** | In the areas surrounding the PA, similar landscapes are not found, or their scientific and educational or aesthetic value is much lower than within the PA | In the areas surrounding the PA, scientific and educational or aesthetic value of similar landscapes is somewhat lower than within the PA | In the areas surrounding the PA, similar landscapes of equal scientific and educational or aesthetic value are found | In the areas surrounding the PA, similar landscapes of a higher scientific and educational or aesthetic value are found |
| **5. ECOSYSTEM STABILIZATION FUNCTION** | | **types of ecosystem services** (*see the text*) | No features supporting the provision of the given type of ecosystem services are found in the areas surrounding the PA | In the areas surrounding the PA, features supporting the provision of the given type of ecosystem services are found, but their significance is much lower than of those within the PA | There are no substantial differences in the state and significance of natural features supporting the provision of the given type of ecosystem services between the PA and the surrounding areas | In the areas surrounding the PA, the significance of features supporting the provision of the given type of ecosystem services is substantially higher than within the PA, or such features are found in the surrounding areas, but not within the PA |

**Table 4.**

*Scales for the scoring of current state for different components of core conservation functions of PAs*

| ***Components and subcomponents of conservation functions*** | | | ***Current state score* (*c*)** | | |
|---|---|---|---|---|---|
| | | | **4** | **2** | **0** |
| **1. REFERENCE FUNCTION** | **1.1. Environmental diversity** | **a) species richness** | The species richness is preserved at a level close to the maximum possible natural level, or is recovering | The species richness is stable at a level lower than the maximum possible one | The species richness is declining |
| | | **b) landscape diversity** | The natural landscape diversity of the area is preserved at a level close to the maximum possible one, or the recovery of disturbed or transformed landscape units takes place | The landscape diversity is stable at a level lower than the natural one; there are disturbed or transformed landscape units, which are not recovering or recovering at a very slow pace | The landscape diversity is gradually declining as a result of anthropogenic transformation of landscape units |
| | **1.2. Non-native and synanthropic elements** | **a) non-native and synanthropic species** | There are no non-native species, and the abundance of synanthropic species corresponds to typical natural levels, or the abundance and diversity of both categories of species are declining rapidly | The abundance and diversity of non-native and synanthropic species are stable, with the abundance of the latter exceeding typical natural levels | The abundance and diversity of non-native and/or synanthropic species are growing |
| | | **b) non-native communities and ecosystems** | There are no non-native communities, or the area occupied by them is declining | The area occupied by non-native communities is at a stable level | The area occupied by non-native communities is growing |
| | **1.3. Reference ecosystems** | **ecosystems** | The ecosystems fully preserve their natural structure and composition, or rapidly recover after insignificant disturbances, or are evolving in a natural way under the influence of natural environmental factors | The ecosystems are relatively stable and evolving in a natural way under the influence of natural environmental factors, while their structure and/or composition are somewhat disturbed and/or lacking some elements | The ecosystems are gradually degrading as a result of a lack of certain significant elements or under the influence of other adverse factors |
| | **1.4. Ecosystems transformed or disturbed as a result of anthropogenic impacts** | | Generally, there are no disturbed or transformed ecosystems, or they are recovering well | The disturbed and transformed ecosystems are in a relatively stable state, showing neither significant recovery nor further degradation or expansion | The disturbed and transformed ecosystems are further degrading and/or expanding |

| | | | | | |
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| **2. REFUGIUM** | **2.1. Rare, endangered, and endemic taxa** | **taxa** | The state of the populations is stable at the optimal level of parameters ensuring their viability, or is improving with those parameters being somewhat different from their optimal levels | The state of the populations is relatively stable but differs from the one optimal for their viability | The state of the populations of the respective taxa is degrading |
| | **2.2. Rare, endangered, and endemic communities and ecosystems** | **communities and ecosystems** | The communities and ecosystems are in a stable state with all significant elements being present and other parameters being optimal for their sustainability and natural development, or in a state which is improving (recovering) with those parameters being different from their optimal levels | The communities and ecosystems are in a relatively stable state with some significant elements being missing and/or other parameters being different from the levels optimal for their sustainability and natural development | Communities and ecosystem gradually degrade and/or their area declines |
| **3. RESERVE FUNCTION** | **3.1. Hunting and commercial animal species** | **species groups** (*see the text*) | The state of the populations of all species of the given group is stable with the optimal level of relevant parameters or is improving | The populations of all species of the given group are in a relatively stable state, or their state is improving for some species while being degrading for others | The state of the populations of most species of the given group is gradually degrading |
| | **3.2. Large gatherings of animals** | **gathering types** (*see the text*) | The gatherings are in a stable state with the maximum possible sizes, or are recovering | The gatherings are in a relatively stable state with their sizes being smaller than the maximum possible ones | The number and/or sizes of the gatherings are declining |
| | **3.3. Plants having utilitarian value** | **species groups** (*see the text*) | The diversity and the abundance of the group are stable at levels close to the maximum possible ones or are increasing (recovering) | The diversity and the abundance of the group are relatively stable at levels lower than the maximum possible ones | The diversity and/or the abundance of the group are declining |



| | | | | | |
|---|---|---|---|---|---|
| **4. MONUMENTAL FUNCTION** | **4.1. Natural features of outstanding conservation or scientific and educational value** | **notable natural features** | The feature is in a stable state without any disturbances, or is recovering | The feature is in a relatively stable state with some insignificant disturbances | The feature is in a significantly disturbed state, or its state is degrading rapidly |
| | **4.2. Landscapes of outstanding scientific and educational or aesthetic value** | **landscapes** | The landscape is in a stable state without any disturbances, or is recovering | The landscape is in a relatively stable state with some insignificant disturbances | The landscape is in a significantly disturbed state, or its state is degrading rapidly |
| **5. ECOSYSTEM STABILIZATION FUNCTION** | | **types of ecosystem services** (*see the text*) | The environmental features and complexes supporting the service in question are in a stable state with their key parameters being optimal, or are recovering after some deviation of those parameters from their optimal levels | The environmental features and complexes supporting the service in question are in a relatively stable state with their key parameters differing from their optimal levels | The environmental features and complexes supporting the service in question are degrading |

### *3. Evaluation of the conservation value, significance, and effectiveness for individual subcomponents of conservation functions*

Using the representativeness, contrast, and current state scores produced in the way described above, three indicators are calculated for each subcomponent of the PA's conservation functions included in the assessment:

**Conservation value** (***V***) reflects the PA's original potential for the conservation of environmental complexes and features underpinning the respective subcomponent of conservation functions. For most subcomponents, conservation value is calculated as the sum of representativeness and contrast with surroundings scores: $V = r + d$. A special case is subcomponents of the reserve function, for with the number of species present in each evaluated group or animal gathering type is also taken into account. For those subcomponents, the indicator is calculated using the formula: $V = n \times (r + d)$, *where* ***n*** is an index of the number of relevant species within the respective group or animal gathering type, expressed on a five-point scale. For commercial animal species and gatherings of animals, the scale is as follows: ***1*** *– at most one relevant species*, ***2***–*2–3 relevant species*, ***3***–*4–5 relevant species*, ***4***–*6–9 relevant species*, ***5***–*10 or more relevant species*. A different scale is used for plants having utilitarian value: ***1***–*5 relevant species or less*, ***2***–*6–25 relevant species*, ***3***–*26–50 relevant species*, ***4***–*51–100 relevant species*, ***5*** *– more than 100 relevant species*.

In all cases, the higher are the representativeness score and the contrast with surroundings score for a given subcomponent, the higher its conservation value associated with that subcomponent. When the contrast is scored negatively with the representativeness being high, the conservation value indicator loses one point but remains high enough. However, when the representativeness is low, the subcomponent may have a zero conservation value.

**Conservation significance** (***I***) represents the PA's current role in the conservation of environmental complexes and features underpinning the subcomponent in question, or the degree to which the PA's conservation potential is realized at the moment. This indicator is calculated using the following formula: $I = V \times (c/c_{max})$, where ***V*** is the conservation vale, **c** – the current state score, $c_{max}$ – the maximum possible current state equal to 4. When environmental features underpinning the evaluated subcomponent and determining its conservation value are in the best possible state, the conservation significance is at the maximum level equal to the conservation value of the respective subcomponent. When the current state is scored at the minimum level, which is equal to 0, the conservation significance is also zero. This means that at the moment of the assessment the PA, regardless of its conservation value, does not contribute to the conservation of environmental complexes and features associated with the respective subcomponent due to degrading trends in their state.

**Conservation effectiveness** (***F***) is a percentage ratio of conservation significance to conservation value. The conservation effectiveness is equal to 100%, when those two indicators are equal, i. e. when environmental features and complexes underpinning the evaluated subcomponent are in the best possible state, and is equal to zero when the conservation significance is scored zero. The third possibility for individual subcomponents is 50%, which means incomplete effectiveness. The connection between all the three indicators is demonstrated by the following formulas: $F = (I \times 100)/V$, but since $I = V \times (c/c_{max})$, than $F = (c/c_{max}) \times 100$. This means that the conservation effectiveness for an individual subcomponent can be evaluated using only the current state score for the respective subcomponent and does not depend on absolute values of conservation value and significance. On the one hand, subcomponents with rather different values of conservation value and significance may have equal conservation effectiveness; on the other hand, subcomponents with similar conservation value or significance may have different conservation effectiveness if the current state score for the respective environmental features is different.

### *4. Evaluation of potential current conservation effectiveness of subcomponents of conservation functions*

For the subcomponents whose conservation effectiveness is lower than 100%, one can evaluate **potential current conservation effectiveness** based on an analysis of the most likely **factors of incompleteness of conservation effectiveness** and possibilities for removing them. The following five groups of such factors can be identified:

a) ***deficiencies of PA management***, which include insufficient effectiveness of PA's measures aimed at the maintenance of a protection regime and the conservation and/or restoration of protected environmental complexes and their components, including actions to combat poaching, other forms of illegal natural resource use, fires, local pollution, and other adverse impacts, which *can be controlled by the PA*, biotechnical and remediation measures etc. Overall, this category includes all factors that are controlled or should be controlled by the PA itself, and can be corrected through improving the effectiveness of the PA management;

b) ***correctable deficiencies of PA planning*** – insufficient size or unfavorable configuration of the PA, incomplete coverage of landscape elements essential for the conservation of certain environmental features or components etc., provided that those deficiencies can in principle be corrected by expanding the PA. Unlike the previous group, these factors are not controlled by the PA itself, and correcting them requires a decision at the regional (for regional and local PAs) or the national (for federal PAs) level;

c) ***external anthropogenic impacts originating from within the region*** – adverse impacts, which cannot be controlled by the PA due to their magnitude and/or remoteness of their source located within the respective region, so that the removal or mitigation of those impacts requires actions at the regional level;

d) ***external anthropogenic impacts originating from outside the region*** – adverse impacts, which cannot be controlled by the PA due to their scale and/or remoteness of their source located outside the respective region (in some cases even outside the country), so that the removal or mitigation of those impacts requires actions at the national or international level;

e) ***natural factors of irresistible force and uncorrectable deficiencies of PA planning*** – natural factors, unfavorable to the protected environmental complexes and features, whose impacts are practically impossible to abate (climate and sea level changes, major natural disasters etc.), as well as planning deficiencies impossible to correct (e. g., when a PA of insufficient size is fully surrounded by landscapes transformed as a result of anthropogenic activities).

For each of the five categories, a score representing its role in constraining the PA's conservation effectiveness with regard to the respective subcomponent is identified. For that purpose, the following scale is used: ***3*** – *factors of this category are of critical significance*; ***2*** – *factors of this category are of substantial but not critical significance*; ***1*** – *factors of this category are of secondary significance*; ***0*** – *factors of this category are insignificant or play no role at all*. For each subcomponent of conservation functions, the score «3» representing critical significance can be assigned to only one group of factors; the score «2» can be assigned to at most two groups when no group is scored «3», or to at most one group when another group is scored «3».

Based on the scores determined in this way, a ***magnitude of impact*** on the conservation effectiveness for each group of factors and each subcomponent is calculated. It is calculated by multiplying the score for the respective group of factors ($g$) by the difference between the maximum possible and the actual current state score for the subcomponent in question (this difference is proportional to the one between the maximum possible and actual current conservation effectiveness): $p = g \times (4 - c)$. Thus, for equal factor significance scores, the impact magnitude is higher when the actual conservation effectiveness for the subcomponent in question is lower. In principle, this procedure is unnecessary for a one-time evaluation of an individual subcomponent, but it is required for a comparative analysis, and for the calculation of aggregate indicators for conservation functions and their components, which encompass several subcomponents whose conservation effectiveness may differ. In those broader contexts, it is necessary to use weighted scores for factor groups – impact magnitudes.

At the next step, a relative contribution of each factor group to the incompleteness of the conservation effectiveness is calculated as a ratio of its magnitude to the sum of magnitudes of all factor groups, expressed as a percentage: $i_n = (p \times 100)/p$.

Based on relative contributions of each group to the incompleteness of the current conservation effectiveness of the subcomponent in question, potential current conservation effectiveness, or hypothetical effectiveness with the impact of constraining factors removed, can be estimated. For that purpose, it is proposed to use the following two indicators:

a) ***minimal potential current conservation effectiveness*** ($pF_{min}$), corresponding to the removal of all management deficiencies, i. e. factors controlled by the PA, with all other constraining factors remaining in place. The indicator is calculated using the following formula: $pF_{min} = F + [(100 - F) \times i_{min}]/100$, where $i_{min}$ – is the share of constraining factors associated with PA management deficiencies in the total magnitude of all impacts;

b) ***maximum potential current conservation effectiveness*** ($pF_{max}$), corresponding to the removal of all adverse factors controlled by any entity at any level, i. e. factors of all groups except for (e). The indicator is calculated using the formula: $pF_{max} = 100 - [(100 - F) \times i_n]/100$, where $i_n$ is the share of natural factors of irresistible force and uncorrectable deficiencies of PA planning in the total magnitude of all impacts.

### *5. Calculation of aggregate indicators for components of conservation functions*

**A.** Based on the indicators calculated for individual subcomponents of conservation functions, similar aggregate indicators for components of those functions (see the second column in Table 2) are produced, with the exception of the ecological stabilization function, for which each subcomponent is treated as a separate component. For *representativeness*, *contrast with surroundings*, and *current state*, ***average values*** across subcomponents of the respective component are calculated, whereas for *conservation value* and *conservation significance* values for individual subcomponents are ***summed***. Using the latter two indicators, the *conservation effectiveness* for the entire component is calculated in a way similar to the one used for individual subcomponents.

Since certain components of conservation functions are evaluated based on one or two permanent subcomponents, whereas some others, like «Reference ecosystems», «Rare species» etc. may encompass a long list of subcomponents determined on an individual basis for each PA, a special approach is required to balance relative significance of different components and conservation functions to the overall conservation value and significance of a PA. For that purpose, it is proposed to introduce ***significance coefficients*** for individual components. The purpose of those coefficients is to compensate for possible distortions of actual role of conservation functions as a whole and their individual components, which may result from different numbers of subcomponents of individual components and components of individual conservation functions. ***Empirically, the following optimal values of significance coefficients were determined for different components of conservation functions: 10 – for the component «Disturbed and transformed landscapes», 8 – for the component «Ecosystem services», 5 – for the components «Environmental diversity» and «Non-native elements», 2 – for components of the refuguim and monumental functions, 1 – for all other components, i. e. the component «Reference ecosystems» and all components of the reserve function.*** When using these coefficients, the approximate aggregate conservation value for each function, given the maximum representativeness and contrast scores, as well as a moderate expected number of reference ecosystems and rare environmental features (10 for each category), will be about 200 with approximately equal contribution of each component. Thus, under the given conditions, the conservation value of the PA as a whole will be some 1000 with approximately equal share of each function.

Another possible approach towards balancing aggregated indicators of conservation value for individual components and functions is averaging indicators across the lists of reference ecosystems, rare species and communities, etc. However, this approach is deemed less effective and adequate, since the very number of entities within those categories meeting the inclusion criteria is an indicator of a PA's conservation value.

When numerous and diverse unique and rare natural features of outstanding conservation or scientific and educational value (component 4.1) are found within the PA in question, it may be interesting to produce aggregate indicators for their individual subgroups including *geological-geomorphological, hydrological, and glaciological features* respectively.

**B.** To evaluate *potential current conservation effectiveness* at the component level, the impact magnitudes for each group of constraining factors are summed, and the contribution of each group to the total impact magnitude at the component level (as a percentage) is calculated. Then the formulas described above are used to calculate the *minimum* and *maximum potential current conservation effectiveness* for each component.

#### *6. Calculation of aggregate indicators for conservation functions*

**A.** In a way similar to the one described in the previous section, aggregate indicators for each of the five conservation functions are produced by ***averaging*** *representativeness, contrast with surroundings*, and *current state* scores across all components of the respective function, and by ***summing*** *conservation value* and *conservation significance* indicators for the respective components. Using the latter two indicators, the overall *current conservation effectiveness* for each function is calculated.

**B.** Within each conservation function, impact magnitude indicators for each group of factors underpinning the incompleteness of conservation effectiveness are summed, and the contribution of each group to the total impact magnitude at the function level (i. e. the sum of magnitudes across all factor groups) is calculated. Using formulas similar to those introduced above, the *minimum* and *maximum potential current conservation effectiveness* for each conservation function is calculated.

#### *7. Calculation of aggregate indicators for the PA*

**A.** In a similar way, aggregate indicators for the entire PA are calculated by ***averaging*** *representativeness, contrast with surroundings*, and *current state* indicators across the five conservation function and by ***summing*** *conservation value* and *conservation significance* indicators for the function. Using the conservation value and conservation significance indicators produced in that way, the *current conservation effectiveness* for the entire PA is calculated.

**B.** Impact magnitudes for each group of factors underpinning the incompleteness of conservation effectiveness are summed across all conservation function, and the share of each group in the total impact magnitude is calculated. Using formulas similar to those provided above, the *minimum* and *maximum potential current conservation effectiveness* for the entire PA is calculated.

## Analysis of the evaluation results

Depending on specific needs, analysis of the results of evaluation of conservation value, conservation significance, and current conservation effectiveness of the PA can be carried out at different levels, which represent specific stages of the overall assessment process and are associated with certain stages of the indicator evaluation procedure (see Figure 2).

**1.** For **individual subcomponents** of conservation functions and components including only one subcomponent, the following steps can be of interest:

– comparison of relative contribution of representativeness and contrast with surroundings to the conservation value resulting in a conclusion on what factor determines the PA's conservation value with regard to the given subcomponent to a greater extent – its representativeness within the PA or its state compared to the surroundings, as well as a similar comparison of contributions of conservation value and current conservation effectiveness to conservation significance in order to understand what factors determine the latter;

– analysis of relative contribution of different groups of factors to the incompleteness of conservation effectiveness with subsequent identification of the most significant factors and most promising approaches towards the improvement of the conservation effectiveness. For the most significant subcomponents, characterized by the incompleteness of conservation effectiveness stemming from several groups of factors, it can be helpful to produce *pie charts* demonstrating relative significant of the five groups of incompleteness factors.

**2.** For **components of conservation functions**, which include several components, it is recommended to:

– carry out a comparative analysis of relations between representativeness and contrast scores, as well as conservation value and current state scores for different subcomponents, and identify subcomponent groups (if the number of subcomponents is large enough) characterized by distinct types of those relations; it is recommended to visualize the patterns identified using *XY-charts*;

– evaluate the contribution of different subcomponents (or their arbitrary combinations identified based on specific objectives or circumstances) to the overall conservation value and significance of the given component and identity subcomponents the most and the least valuable and significant in terms of conservation, visualizing the results using *pie charts*;



– identify subcomponents characterized by the highest and the lowest conservation effectiveness;

– carry out a comparative analysis of significance of the main groups of factors underpinning the incompleteness of conservation effectiveness, and identify subcomponent groups characterized by similar patterns of relative significance of those factors; the analysis can be illustrated by *percentage bar charts*;

– compare current conservation effectiveness for different subcomponents, identifying those for which it is possible (or impossible) to achieve a significant increase in the effectiveness, and carry out a comparative analysis of relations between actual and potential conservation effectiveness for individual subcomponents, visualizing those relations using *clustered bar charts*;

– estimate relative contribution of different groups of incompleteness factors to the incompleteness of conservation effectiveness for the entire component, presenting the results in a *pie chart*.

In their entirety, these steps should help answer the following questions:

– which subcomponents of the given component are the most and the least valuable and significant in terms of conservation, and which subcomponents make the largest and the smallest contribution to the overall conservation value and significance of the component?

– with regard to which subcomponents is the PA the most and the least effective?

– for which subcomponents of the given component can the current conservation effectiveness be increased, by what means, and to what extent?

**3.** For **conservation functions**, recommended types of analysis are generally similar to the ones for their individual components:

– comparative analysis of relations between the representativeness and contrast with surroundings scores, relations between conservation value and current state, and relations between conservation value and significance;

– evaluation of relative contribution of different components to overall conservation value and significance of the given function, and identification of components the most and the least valuable and significant in terms of conservation with subsequent visualization of results in the form of *pie charts*;

– identification of components characterized by the highest and the lowest conservation effectiveness;

– comparative analysis of relative significance of the main groups of factors underpinning the incompleteness of conservation effectiveness

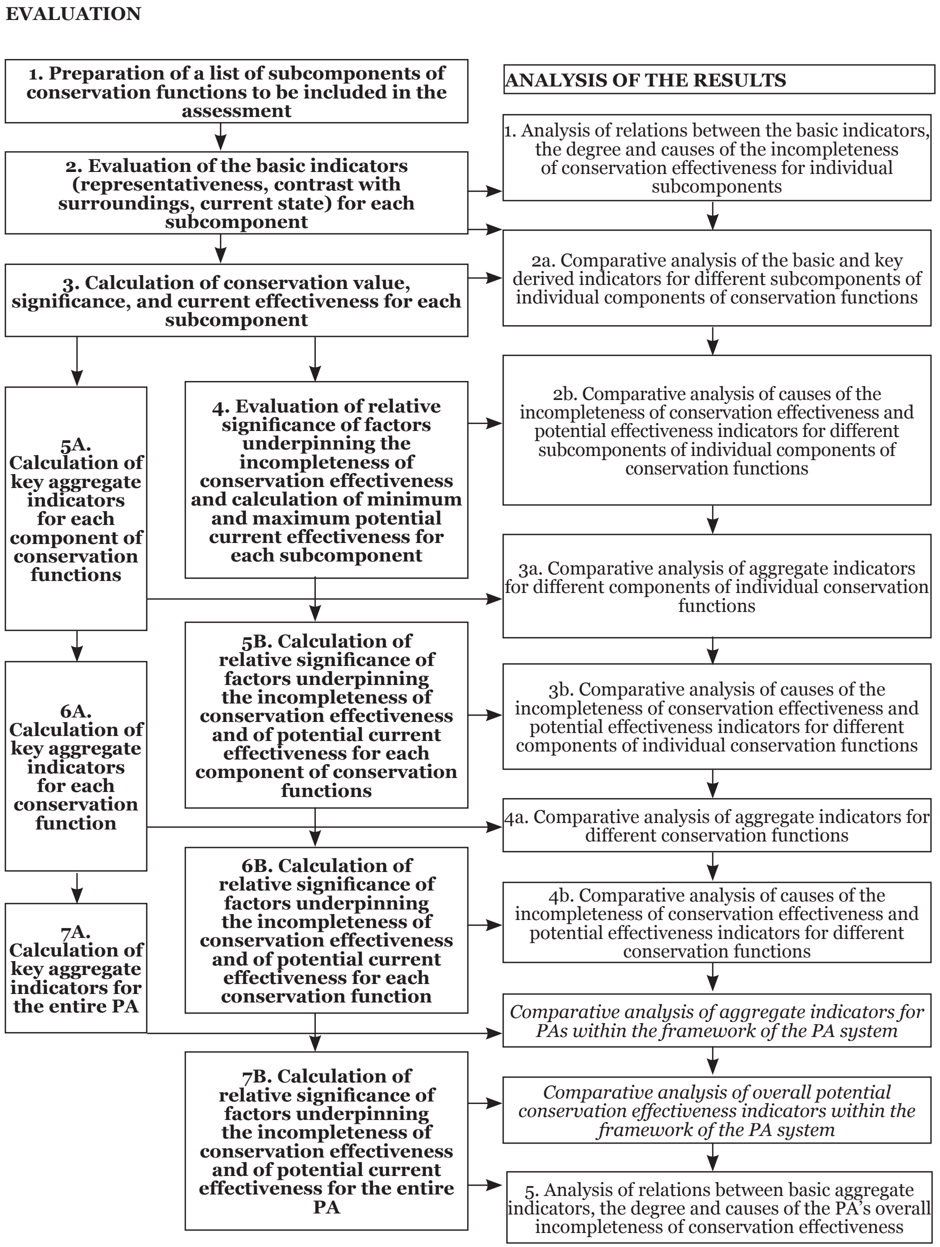


**Figure 2.**

General process of the evaluation of conservation value, significance, and current effectiveness, and analysis of the results (see explanation in the text).



for different components of the given function; the analysis is illustrated by *percentage bar charts*;

– comparison of potential current conservation effectiveness indicators for different components and identification of those for which a significant increase in the effectiveness is possible (and impossible), and a comparative analysis of relations between actual and potential current conservation effectiveness for different components; the results are visualized using *clustered bar charts*;

– evaluation of relative contribution of different groups of incompleteness factors to the overall incompleteness of conservation effectiveness for the given function with subsequent visualization of results in the form of a *pie chart*.

As in the previous case, these steps should help answer the following questions:

– which components of the given function are the most and the least valuable and significant in terms of conservation, and which components make the largest contribution to the overall conservation value and significance of the components?

– for which components of the given function is the PA the most and the least effective?

– for which components of the given function can the current conservation effectiveness be increased, by what means, and to what extent?

**4.** For the **PA as a whole**, using scores and indicators for its conservation functions, it is proposed to**:**

– evaluate relative contribution of each function to overall conservation value and significance of the PA and identify the most valuable and significant function, presenting the results in the form of *pie charts*;

– identity conservation functions characterized by the highest and the lowest conservation effectiveness;

– carry out a comparative analysis of relations between conservation value and current conservation effectiveness for different functions, presenting results in the form of an *XY-chart*;

– carry out a comparative analysis of relative significance of factors underpinning the incompleteness of conservation effectiveness for different functions and visualize results using *percentage bar charts*;

– carry out a comparative analysis of actual and potential current conservation effectiveness.

In general, answers to the following key questions are expected from the analysis:

– which functions make the largest and the smallest contribution to the overall conservation value and significance of the PA?

– for which conservation functions in the PA the most and the least effective?

– for which functions can the current conservation effectiveness be increased, by what means, and to what extent?

**5.** For the **PA as a whole**, the following steps based on aggregate indicators are recommended:

– comparison of relative significance of overall representativeness and contrast with surroundings scores in order to identify which factor makes a larger contribution to the overall conservation value of the PA, and a similar comparison of relative significance of overall conservation value and current conservation effectiveness to the overall conservation significance in order to understand which factors primarily determine the latter;

– analysis of relative contribution of different factor groups into the overall incompleteness of conservation effectiveness of the PA in order to identify the most significant factors, opportunities for improving the overall conservation effectiveness and its limits; impacts of different groups of factors are presented in the form of *a pie chart*.

Moreover, aggregated indicators for individual PAs can be used for an assessment and analysis of systems of PA and for comparison of different PAs in terms of those indicators.

# 2. EVALUATION OF POTENTIAL THREATS AND SECURITY

**Potential threats** are defined as probable in the near future (10–15 years) adverse impacts on the PA and its environmental complexes, which may potentially cause damage to its protected features (see Chapter 1). The main characteristic of a potential threat is its **relevance**, viewed as a function of parameters characterizing potential damage to protected complexes and features of the PA, and the probability of the realization of the respective threat within the timeframe considered. A quantity opposite to the relevance of a potential threat is **security** of the PA from that threat (one hundred percent minus the threat relevance expressed as a percentage ratio), which equals 100% when the threat in question is absent, and 0% when the threat has the maximum possible relevance.



In addition, one can evaluate **minimized relevance of threats**, which is defined as the relevance of existing threats mitigated with feasible control or prevention measures. It is assumed that the likelihood of the implementation of such measures depends on the administrative or governance level at which the respective impacts can be controlled and mitigation measures can be taken. The implementation of all measures against threats controlled by the PA itself or at the local (municipal) level is considered the most probable, whereas the mitigation of threats requiring actions at the international level is considered the least probable. For a number of threats (see below), there can be no feasible control or prevention options at all. A quantity opposite to minimized relevance is **potential security** of the PA, which can be achieved by minimizing relevance of the respective threats.

## Potential threats being evaluated

Potential threats being evaluated include several categories of *anthropogenic* and *natural* impacts able to cause a serious damage to protected environmental complexes and features of the PA. Potential threats associated with administrative decisions (withdrawal of the protected status or reduction of the PA size, modification of boundaries etc.), although relevant in some cases, are not taken into account under this methodology.

**Anthropogenic threats** are divided into 7 main categories defined on the basis of somewhat different principles. Five categories encompass impacts of economic activities outside the PA, while the remaining two are associated with impacts of activities within the PA differing in terms of their legal status:

a) ***external pollution*** – any type of industrial, household, and other pollution originating from outside the PA;

b) ***external changes in the hydrologic regime*** – unfavorable changes in the hydrologic regime within the PA resulting from hydraulic engineering, land improvement, and other activities outside the PA;

c) ***anthropogenic fires*** – fires resulting from human actions and originating from outside the PA;

d) ***exploitation of animal populations outside the PA*** – all types of hunting or other exploitation outside the PA, which affect the state of populations within the area, e. g. the hunting of bird species nesting within the PA in their wintering areas or along their migration routes etc.;

e) ***invasions, epizootics, and epiphytotics*** – adverse impacts of biocenotic nature resulting from or triggered by economic activities outside the PA;

f) ***illegal use of natural resources within the PA and other violations of the conservation regime*** – any violations of the PA's existing conservation regime within its boundaries, including all types of illegal nature use, local pollution etc.;

g) ***activities permitted within the PA*** – any activity permitted by the policies regulating the PA's conservation regime, which nevertheless is able to cause adverse impacts on its environmental complexes and factors (limited economic activities, sport fishing, ecological tourism as a source of disturbance etc.).

Such an approach toward classification of anthropogenic threats is intended to not only support quantitative evaluation of their relevance, but also help prioritize possible actions on the improvement of the PA's security, identifying the most important measures. In terms of this categorization, it is clear that when the most significant threats belong to the category (f), the main efforts should be focused on improving the effectiveness of the protection service, whereas with the main threats belonging to the category (g) the priority steps should involve changes to the PA's conservation regime.

If an impact belonging to one of the categories listed above is possible but obviously does not involve any damage to protected environmental complexes and features, such an impact is not viewed as a threat.

**Natural threats** encompass possible impacts, including catastrophic ones, which, despite their natural causes, can cause a serious damage to protected environmental complexes and features within the PA. The question whether natural phenomena should be viewed as threats has been a subject of ongoing discussions and does not have a clear-cut answer. However, in this particular context any impact causing damage to the environmental features whose conservation the PA is intended to ensure should be treated as a threat.

Five types of potential natural threats can be identified:

a) ***geological phenomena and disasters*** – major landfalls and landslides, mudslides, volcanic eruptions etc.;

b) ***climatic changes*** – gradual climatic changes on the global scale and resulting changes in the level of water bodies, geochemical situation, speed of geological and geomorphological processes etc.;

c) ***hydroclimatic phenomena and disasters*** – floods, droughts, winter thaws etc.;



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d) ***natural fires*** – fires caused by thunderstorms and other natural factors;

e) ***biocenotic phenomena*** – rapid increases in the abundance of individual species, epizootics and epiphytotics of natural origin, competition between natural species etc.

When evaluating natural threats, one should take into account that the same factors may have different significance for different PAs. For example, major natural floods or fires in some cases may lead to disastrous consequences, including total loss of valuable natural features, whereas in other cases they may be a more or less regular phenomenon, essential for the normal existence and development of environmental complexes in question. *In the latter case, such phenomena are* ***NOT considered*** *threats.*

## Indicators and evaluation process

The proposed methodology of assessment of potential threats is based on the respective section of the publication *Techniques of Rapid Effectiveness Assessment and Prioritization of Protected Area Management Systems* (Moscow: Tyrlyshkin V. – M., WWF Russia, 2005. – 36 pp.) with some modifications. The entire assessment process includes five stages.

1. Identification of relevant threats

At the first stage, a list of potential threats that can be significant (relevant) to the PA in question with some probability within the next 10–15 years is compiled. At the subsequent stages, only threats included in the list are analyzed.

2. The scoring of basic indicators for individual categories of potential threats

Five basic indicators are scored for each category of potential threats.

**I. Likely extent (*a*)**, which characterizes potential spatial extent of possible impacts or share of environmental features affected in case of the realization of the respective threats. This parameter is scored on a four-point scale (see Table 5).

**Table 5.**

*Scale for the scoring of likely extent of potential threats*

| | | |
|---|---|---|
| 4 | **ubiquitous** | The impacts will affect most of the area (more than 50%) or most of the protected environmental features and complexes |
| 3 | **widespread** | The impacts will affect a significant part of the area (15–50%) and/or a substantial portion of the protected environmental features and complexes |
| 2 | **sporadic** | The impacts will affect a relatively small part of the area (5–15%) and/or a few categories of environmental features |
| 1 | **local** | The impacts will affect individual protected environmental features, manifesting itself over less than 5% of the area |

**II. Likely impact magnitude (*i*)**, which represents the degree of damage to protected environmental complexes and features as a result of impacts in question. This parameter is scored on the following four-point scale (see Table 6).

**Table 6.**

*Scale for the scoring of likely magnitude of potential threats*

| | | |
|---|---|---|
| 4 | **critical** | Irreparable damage to the protected environmental complexes and ecosystems, the integrity of the PA, the level of biodiversity or resources associated with it can be expected |
| 3 | **severe** | Clear and significant but recoverable damage to the protected environmental complexes and features can be expected |
| 2 | **moderate** | Serious but moderate changes in the state of the protected environmental complexes and features can be expected, that would not pose a threat to their existence and would not impair their normal development |
| 1 | **insignificant** | Changes in the state of the protected environmental complexes and features insignificant in terms of their conservation objectives can be expected |

**III. Duration of the recovery period (*r*)** – time necessary either for natural recovery of the potential damage to the area or for the recovery supported by special remediation measures, after the cessation of the factors causing the damage. The following four-point scale is used for the scoring of this parameter (see Table 7).

**Table 7.**

*Scale for the scoring of duration of the recovery period after expected adverse impact*

| | | |
|---|---|---|
| 4 | **very long (permanent)** | Over 500 years would be necessary for the recovery of the area (ecosystem, environmental feature) in a natural way or by means of active remediation measures (e.g. after open-pit mining) |
| 3 | **long** | Natural or facilitated recovery of the area would take 100–500 years (e.g. after the clearing of a mature deciduous forest) |
| 2 | **medium** | The recovery of the area would take 10–100 years (e.g. after the plowing of a steppe area) |
| 1 | **short** | The recovery of the area would take less than 10 years without human intervention (e.g. after stopping the hunting of an abundant population of wild animals with a high reproductive capacity) |



**IV. Probability of the threat realization (*p*)**, viewed as the probability of not only the very fact of the future impact, but the entire forecast including the estimates of impact extent and magnitude, as well as the recovery period. As in the previous cases, this parameter is scored on a four-point scale (see Table 8).

**Table 8.**

*Scale for the scoring of probability of threat realization*

| | | |
|---|---|---|
| 4 | **almost inevitable** | probability 0.9–1 |
| 3 | **high probability** | probability 0.5–0.9 |
| 2 | **low probability** | probability 0.1–0.5 |
| 1 | **almost unlikely** | probability 0–0.1 |

**V. Level of control over the threat (*c*)** characterizes the level (individual PA, local, regional, national, international), at which the threat can be controlled and prevented. Unlike all previous cases, this parameter is expressed as a fraction between 0 and 1. The scoring scale is presented in Table 9.

**Table 9.**

*Scale for the scoring of level of control over the threat*

| | |
|---|---|
| **0** | Controlled and can be prevented by the PA itself and/or at the local (municipal) level |
| **0.25** | Controlled and can be prevented or mitigated at the regional level |
| **0.5** | Controlled and can be prevented or mitigated at the national level |
| **0.75** | Controlled and can be prevented or mitigated only at the international level |
| **1** | Cannot be controlled in principle |

### *3. Calculation of relevance of individual threats and relative security of the PA*

For each category of potential threats, threat relevance is calculated by multiplying the four basic scores described above: A = a × i × r × p.

In principle, this indicator is sufficient for the subsequent analysis. However, in certain cases in can be complemented with intermediate indicators characterizing threats.
These indicators include *potential severity of threats* calculated by multiplying the impact extent and magnitude scores ($\boldsymbol{P} = \boldsymbol{a} \times \boldsymbol{i}$), and *potential scale of impacts* calculated by multiplying potential severity of threats by the recovery period score ($\boldsymbol{I} = \boldsymbol{P} \times \boldsymbol{r}$).

**Relative security** of the PA from each category of threats is defined as a quantity opposite to the ratio of actual threat relevance to its maximum possible value, i. e.: $\boldsymbol{S} = 100 - (\boldsymbol{A} \times 100/\boldsymbol{A}_{max})$, where $\boldsymbol{A}_{max} = 256$.

### *4. Calculation of minimized relevance of and potential security from individual threat categories*

**Minimized relevance** is calculated using the formula $\boldsymbol{mA} = \boldsymbol{A} \times \mathbf{c}$, which means that minimized relevance is equal to actual relevance in the case when the threat cannot be controlled and prevented in principle, and is equal to zero when the threat can be controlled by the PA itself or at the local level, i. e. can be prevented with the highest possible probability. Intermediate values of the indicator represent the cases in which the threat prevention requires actions at the regional, national, or international levels.

Then **potential relative security** is calculated according to the formula similar to the one used for calculating relative security of the PA**:** $\boldsymbol{pS} = 100 - (\boldsymbol{mA} \times 100/\boldsymbol{A}_{max})$**.**

### *5. Calculation of overall threat relevance and PA's security*

After the production of all scores and indicators for individual threat categories, a number of aggregate indicators encompassing all categories are calculated, including **overall threat** *relevance*: $\boldsymbol{A}_{sum} = \Sigma \boldsymbol{A}$ and **overall current security of the PA:** $\boldsymbol{S}_{sum} = (100 - (\Sigma \boldsymbol{A} \times 100/\Sigma \boldsymbol{A}_{max})$, as well as overall minimized threat relevance**:** $\boldsymbol{mA}_{sum} = \Sigma \boldsymbol{mA}$ and **overall potential security of the PA:** $\boldsymbol{pS}_{sum} = (100 - (\Sigma \boldsymbol{mA} \times 100/\Sigma \boldsymbol{A}_{max})$. If the threats relevant to the PA in question include both anthropogenic and natural threats, it is also recommended that the overall indicators described above are calculated for each of the two groups separately.

## Analysis of the evaluation results

**1.** First, one calculates a share of each threat category significant to the evaluated PA in the overall threat relevance, identifying the most significant categories. It may also be helpful to carry out such an analysis separately for anthropogenic and natural threats and compare overall current relevance of these two groups. The results can be visualized in the form of *pie charts* representing relative relevance of all threat categories, individual categories of anthropogenic and natural threats (provided they are diverse enough), as well as relative relevance of anthropogenic and natural threats as two different groups.



**2.** Then relative contribution of threats with different levels of control into the overall threat relevance is calculated and compared; the most significant threat groups in terms of level of control are identified and the results are presented in the form of a *pie chart*.

**3.** Actual and potential security of the PA from each threat category and from all threats taken collectively is compared; the threats which can be prevented to the greatest and the least extent are identified. The result is presented in the form of *comparative bar charts*.

The assessment of potential threats to and security of the PA should lead to the identification of the main threats to the PA, opportunities for increasing its security, and priority areas of activity to achieve that.

# 3. EVALUATION OF RESILIENCE TO LONG-TERM ENVIRONMENTAL CHANGES

Resilience of PAs to long-term global environmental changes, primarily climate change and immediately related phenomena, includes two aspects. The first one is **conservation resilience**, which characterizes the possibility for PA to preserve its environmental complexes and their components in their current state. The second one is **dynamic resilience**, characterizing the possibility of natural geographic changes in the biota and biocenotic cover in response to the abovementioned environmental changes. Both components of resilience can be evaluated based on a number of parameters underpinning them, which are described below. Some aspects of the resilience can, in principle, be optimized (changed in the direction of improved PA's resilience). It is also possible to evaluate potential for such optimization and, in addition to current conservation, dynamic and overall resilience indicators, produce similar **potential** indicators.

For point PAs (such types of protected natural monuments as individual trees, microrelief forms, point hydrological features etc.) such assessment is not carried out. Possible changes in their state due to environmental change are evaluated within the framework of security assessment (see Section 2).

## Evaluated parameters of resilience to environmental changes

Conservation resilience of a PA to global environmental change is determined by its *geographic location, size and landscape diversity of the area*, and *resilience of the lithogenic base of landscapes to climatic changes***.**

**1. Geographic location** of the PA determines its conservation resilience to a significant extent, since possible degree of changes in the state of biota and biocenotic cover under a given magnitude of global environmental changes may differ substantially depending on geographic conditions. Such differences may stem from:

a) location of the PA relative to **the boundaries of physiographic divisions determined by the climate**, primarily to the boundaries of natural zones and subzones, as well as divisions representing different degrees of climate continentality etc. The importance of this aspect stems from the fact that under given conditions leading to the shift of physiographic boundaries, the areas located close to their boundaries will experience more rapid and dramatic changes than those located in the central parts of the respective divisions;

b) location of the PA relative to **sea coasts and major inland water bodies**, where climatic changes are amplified due to the interaction between the land and large water masses, and immediate consequences of such changes (e.g. changes in the water level) occur, leading to a transformation of coastal landscapes and ecosystems;

c) location of the PA relative to **areas with extreme climate**, which is important in this context, since ecosystems of such areas are always much more sensitive to the changes in question and may undergo a complete transformation or loss under the magnitudes of environmental changes insignificant to moderate-climate ecosystems.

**2. Size and landscape diversity** of the PA, like its geographic location, may substantially influence its conservation resilience:

a) **the PA's size** determines the probability that landscape and ecosystem transformations resulting from climatic changes (the shifting of physiographic boundaries determined by the climate) will not affect the entire area even in the case of full landscape homogeneity;

b) **landscape diversity**, first, determines possibilities for the conservation of a grater or a lesser part of landscape units in an unchanged or slightly changed state in the cases when the PA encompasses a series of landscape units determined by a climate gradient; second, it determines opportunities for the conservation of populations and communities experiencing adverse effects of climatic change in various refugiums (extrazonal habitats etc.).

In many cases, both of those aspects – the PA's size and its landscape diversity – can be optimized by expanding the PA or changing its boundaries; therefore it is possible to evaluate these opportunities for improvement and calculate potential resilience indicators corresponding to the implementation of the respective measures.



**3. Resilience of the lithogenic base of landscapes to climatic changes** is determined by the sensitivity of the key landscape-forming processes and their components to climatic changes and can differ substantially for different landscape types. Among the most sensitive to climatic changes are the landscapes whose essential features are associated with permafrost, glacier's ablation zones, ice cover (in case of water bodies), water level etc. In such landscapes, significant climatic changes may lead to rather rapid and large changes not only in their biotic component, but also in their lithogenic base, leading to a significant transformation or destruction (as in the case of yedoma plains) of the landscape. The landscapes, whose essential features are determined by components and processes less sensitive to climatic changes, will be less affected by that kind of phenomena, and therefore will be more **stable** under climate-related environmental changes**.**

<u>Dynamic resilience</u> of a PA, or its ability to support potential natural changes in the biota and biocenotic cover in response to environmental change, is determined by somewhat different factors, the key ones being:

**1. Diversity of extrazonal and relic elements** of the biota and biocenotic cover, i.e. the elements whose climatic optima are located in other natural zones (extrazonal elements) or existed in the area in question in the past (relic elements), and which, in case of major climatic changes, can provide a basis for the formation of new biotic complexes better suited to new climatic conditions. In this particular context, diversity is viewed as not only and not so much diversity of taxa and communities as diversity of climatic preferences. In some cases it is possible to optimize (improve) this parameter by expanding the PA to include some adjacent areas characterized by the presence or a high diversity of elements in questions; this also should be reflected by the respective indicators;

**2. Connectivity of the PA with other undisturbed or less-disturbed areas** (both protected and unprotected ones) allowing for more or less natural and free migration of floristic and faunistic complexes along the gradients of climatic changes and determined by the state of the PA's surroundings and/or the presence of sufficiently effective ecological corridors. In addition to the current situation, the evaluation should take into account the possibility of its degradation (as a result of further economic development of the PA's surroundings) or improvement (as a result of cessation of economic activities in the PA's surroundings, land remediation etc.) in the future, as well as opportunities for preventing expected connectivity decline by establishing legally defined ecological networks.

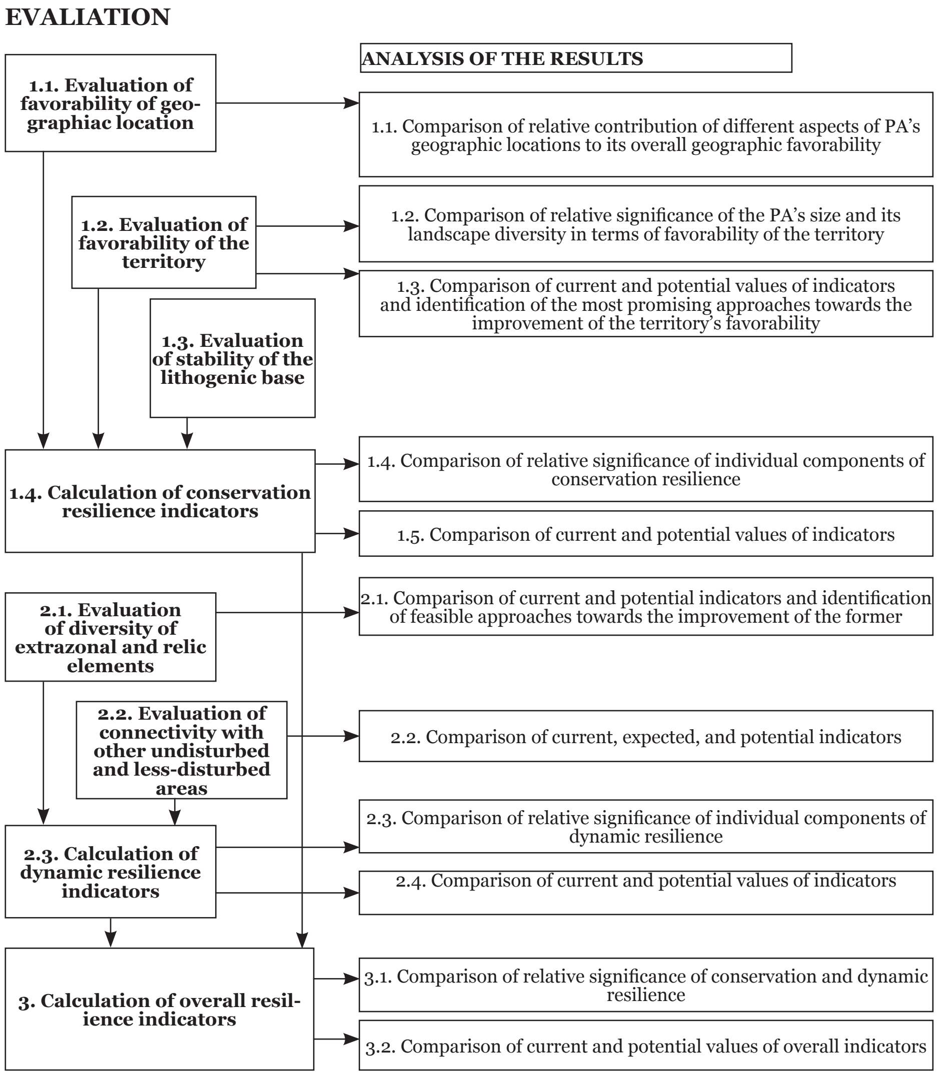


**Figure 3.** General process and main stages of evaluation of the PA's resilience to long-term



## Indicators and evaluation process

The process of evaluation of PA resilience to global long-term environmental changes comprises two basic stages corresponding to the two components of the overall resilience: conservation and dynamic one. Each stage, in its turn, comprises several steps. At the third, final stage, indicators characterizing overall resilience are calculated (see Figure 3). ***All final resilience indicators are relative values expressed as a percentage of their maximum possible values.***

## *1. Evaluation of conservation resilience*

This stage includes four steps, at which three aspects of conservation resilience are evaluated and then overall conservation resilience indicators are produced.

### 1.1. Evaluation of favorability of geographic location

At first, one scores three basic indicators determining favorability of the PA's geographic location in terms of its resilience to environmental changes:

a) *location relative to the boundaries of physiographic divisions determined by the climate* (***b***);

b) *location relative to the boundaries of sea coasts and major inland water bodies* (***c***);

c) *location relative to areas with extreme climate* (***e***).

All three indicators are scored on similar scales with three levels – 0, 2, and 4 points (see Table 10). If the protected area comprises several clusters, first the scores are determined for each individual cluster; then values for each indicator are averaged across all clusters to produce indicators for the entire PA.

**Table 10.**

*Scales for the scoring of favorability of the PA's geographic location for its resilience to environmental changes*

| ***Location relative to the boundaries of physiographic divisions determined by the climate, b*** | |
|---|---|
| **4** | The PA is located in the central part of a large physiographic division determined by the climate, far from the division's boundaries |
| **2** | The PA is located in the central part of a smaller physiographic division determined by the climate or in the periphery of a large division |
| **0** | The PA is located on the physiographic boundary determined by the climate, or in the immediate vicinity of such a boundary, or is crossed by more than one such a boundary |

| | |
|---|---|
| | ***Location relative to sea shores and major inland water bodies*, c** |
| **4** | The PA is located far from sea coasts and major water bodies and is not immediately influenced by them |
| **2** | The PA is located far from sea coasts and major water bodies, but is immediately influenced by them |
| **0** | The PA is located on the coast of a sea or a major inland water body and/or is an offshore PA |
| | ***Location relative to areas with extreme climate*, e** |
| **4** | The entire PA or most of it is located in an area with moderate climate |
| **2** | The entire PA or most of it is located in an area with subextreme (subarctic, semiarid, subalpine) climate or includes the entire range of climatic conditions from moderate to extreme |
| **0** | The entire PA or most of it is located in an area with extreme (Arctic, arid, alpine) climate |

The resulting indicator of **favorability of geographic location (*L*)** is calculated as a ratio of the sum of the three basic scores to their maximum possible sum equal to 12, and is expressed as a percentage:

$\boldsymbol{L} = [(\boldsymbol{b} + \boldsymbol{c} + \boldsymbol{e}) \times 100]/(\boldsymbol{b}_{max} + \boldsymbol{c}_{max} + \boldsymbol{e}_{max}) = [(\boldsymbol{b} + \boldsymbol{c} + \boldsymbol{e}) \times 100]/12$

When it is necessary or of particular interest, one may calculate favorability indicators for each of the three aspects, expressing their scores as a percentage of the maximum possible score.

1.2. Evaluation of current and potential favorability of the PA's territory

One evaluates *size of the PA* (***a***) and its *landscape diversity* (***d***) in terms of their conduciveness to the PA's resilience to global environmental changes. The indicators are scored on scales similar to the ones used to evaluate geographic location (see Table 11).

**Table 11.**

Scale for the scoring of favorability of the PA's size and landscape diversity for its resilience to environmental change

| | |
|---|---|
| | ***Size*, a** |
| **4** | Very large, so that in case of the shifting of physiographic boundaries determined by the climate a substantial part of the area will likely remain in the same climatic range |
| **2** | Large enough, so there is some probability that in case of the shifting of physiographic boundaries determined by the climate a certain part of the area will remain in the same climatic range |
| **0** | Very small, so that the effects of climate, if they occur at all, will affect the entire area |
| | ***Landscape diversity*, d** |
| **4** | The PA encompasses more than one landscape division and/or in includes numerous and diverse extrazonal landscape units similar to those characteristic to neighboring and more remote zones and subzones |
| **2** | The PA is homogenous in terms of natural zone, but it includes extrazonal landscape units similar to those characteristic to neighboring subzones, as well as diverse intrazonal elements |
| **0** | The PA is homogenous in terms of natural zone and landscape; extrazonal landscape elements are absent or very rare; the diversity of intrazonal habitats is low |



Then potential for the optimization of both components is evaluated. The potential is scored «0» when there are no opportunities for improvement; «2» if the component's current score can be improved by two points (from 0 to 2 or from 2 to 4); and «4» if the current score 0 can potentially be improved to 4. For each component, the sum of the current score and improvement potential, which cannot exceed 4, is calculated to produce scores for **potential size** (${}_p\boldsymbol{a}$) and **potential landscape diversity** (${}_p\boldsymbol{d}$) of the PA's territory.

The indicators of **current** and **potential favorability** of the PA's territory for conservation resilience are calculated as follows:

$\boldsymbol{T} = [(\boldsymbol{a} + \boldsymbol{d}) \times 100]/(\boldsymbol{a}_{max} + \boldsymbol{d}_{max}) = [(\boldsymbol{a} + \boldsymbol{d}) \times 100]/8$ and

$\boldsymbol{pT} = [({}_p\boldsymbol{a} + {}_p\boldsymbol{d}) \times 100]/({}_p\boldsymbol{a}_{max} + {}_p\boldsymbol{d}_{max}) = [(\boldsymbol{a} + \boldsymbol{d}) \times 100]/8$, respectively**.**

As in the previous case, it is also possible to calculate current and potential favorability indicators for individual components (size and landscape diversity) by expressing their scores as a percentage of the maximum possible value.

### 1.3. Evaluation of relative stability of the landscape lithogenic base

This step is intended to evaluate the ***resilience of the lithogenic base to climatic changes*** (***p***), which is determined by the sensitivity of the key landscape-forming components and processes to such changes. The resilience is scored using the scale presented in Table 12.

**Table 12.**

*Scale for the scoring of resilience of the landscape lithogenic base of to climatic changes*

| | |
|---|---|
| **4** | The key landscape-forming components and processes are virtually insensitive to climatic changes, therefore the latter lead only to insignificant changes in the lithogenic base of landscapes |
| **2** | The key landscape-forming components and processes are sensitive to climatic changes to a significant extent, therefore those changes may lead to significant changes in the lithogenic base of landscapes |
| **0** | The key landscape-forming components and processes are highly sensitive to climatic changes, therefore the latter lead to a complete transformation of the lithogenic base of landscapes resulting in the destruction (transformation) of the landscapes themselves |

The indicator of **stability of the lithogenic base** is the current stability score expressed as a percentage of its maximum possible value: $\boldsymbol{P} = (\boldsymbol{p} \times 100)/\boldsymbol{s}_{max}$.

### 1.4. Calculation of overall conservation resilience indicators

Using the produced indicators for individual components of conservation resilience, one calculates **current overall conservation resilience** as the average of indicators for the three individual components: $\boldsymbol{CR} = (\boldsymbol{L} + \boldsymbol{T} + \boldsymbol{S})/3$. **Potential overall conservation resilience** is calculated in a similar way, with potential territory favorability indicator used instead of the current one: $\boldsymbol{pCR} = (\boldsymbol{L} + \boldsymbol{pT} + \boldsymbol{P})/3$.

## *2. Evaluation of dynamic resilience*

Evaluation of the PA's dynamic resilience includes three steps, two of them dealing with evaluation of its individual aspects – *diversity of extrazonal and relic elements* and the *PA's connectivity with other undisturbed and less-disturbed areas*. At the third step, overall dynamic resilience indicators are produced.

### 2.1. Evaluation of diversity of extrazonal and relic elements

**Current diversity of extrazonal and relic elements** within the PA is scored using the scale presented in Table 13.

**Table 13.**

*Scale for the scoring of diversity of extrazonal and relic species*

| | |
|---|---|
| **4** | The PA has diverse extrazonal communities similar to the ones characteristic to neighboring zones and/or relic communities |
| **2** | In addition to various extrazonal and relic species diverse enough, individual extrazonal and relic communities or their fragments are found within the PA |
| **0** | There are no extrazonal and relic elements within the PA, or they are represented by a small number of species |

One also evaluates opportunities for increasing the diversity of the elements in questions by expanding or reconfiguring the PA. The potential for increasing diversity is scored «0» when there are no such opportunities; «2» – when the diversity score can be increased by two points (from 0 to 2 or from 2 to 4); and «4» – when the diversity can be increased from 0 to 4. The sum of the current score and the improvement potential score (which, by definition, cannot exceed 4) is considered the score of **potential diversity of extrazonal and relic elements** (${}_{p}\boldsymbol{x}$).

The indicators of **current** and **potential diversity of extrazonal and relic elements** are calculated on the basic of the respective scores using the following formulas:

$\boldsymbol{X} = (\boldsymbol{x} \times 100)/\boldsymbol{x}_{max}$ and

$\boldsymbol{pX} = ({}_{p}\boldsymbol{x} \times 100)/{}_{p}\boldsymbol{x}_{max}$, respectively.



#### *2.2. Evaluation of the PA's connectivity with other undisturbed or less-disturbed areas*

To evaluate **the PA's current connectivity with other undisturbed and less-disturbed areas** (***n***), the scale presented in Table 14 is used.

In addition, likely changes in the PA's connectivity in the near future (20–25 years) are evaluated. They are scored «0» when no serious changes in the connectivity are expected; «–2» or «–4» when the connectivity is expected to decrease by two or four points respectively as a result of economic development of the areas surrounding the PA; and «2» and «4» when the connectivity is expected to increase by two or four points respectively. The sum of the scores of current connectivity and expected changes is the score of **expected connectivity** (${}_{c}\boldsymbol{n}$), whose possible values are the same as ones used for the current connectivity score (***n***), i. e. 0, 2 or 4.

When the expected connectivity is lower than the current one, i. e. the degree of the PA's isolation is expected to increase, one can evaluate potential for preventing that process by means of creating a legally defined ecological network. Again, such potential is scored «0» when there are no opportunities for such measures; «2» in cases when it is possible to fully offset a two-point connectivity decline of partially offset a four-point decline; and «4» when it is possible to offset an expected four-point decline fully or for the most part. Using these values, one can produce a **potential connectivity** score (${}_{p}\boldsymbol{n}$), defined as the sum of the scores of expected connectivity and optimization potential (potential for offsetting the expected decline).

**Table 14.**

*Scale for the scoring of the PA's connectivity with other undisturbed or less-disturbed areas*

| | |
|---|---|
| **4** | The PA is generally surrounded by undisturbed and/or recovering landscapes connecting it to all or most PAs located close to it, or is an element of an ecological network, which includes all necessary elements and is connected to other PAs and other less-disturbed areas by full-fledged ecological corridors |
| **2** | The PA is connected to other less-disturbed areas (protected and unprotected) by a few ecological corridors |
| **0** | The PA is completely or almost completely isolated from other protected and undisturbed areas by anthropogenic landscapes |

Thus, three relative indicators of connectivity are calculated for the PA: **current connectivity** – $\boldsymbol{N} = (\boldsymbol{n} \times 100)/\boldsymbol{n}_{max}$, **expected connectivity** – $\boldsymbol{cN} = ({}_{c}\boldsymbol{n} \times 100)/{}_{c}\boldsymbol{n}_{max}$, and **potential connectivity** – $\boldsymbol{pN} = ({}_{p}\boldsymbol{n} \times 100)/{}_{p}\boldsymbol{n}_{max}$. When the connectivity is expected to remain unchanged or improve, the latter two indicators are equal.

#### *2.3. Calculation of overall dynamic resilience indicators*

Using the indicators for individual aspects of dynamic resilience produced in the way described above, one can calculate three overall relative indicators characterizing **current dynamic resilience**: $\boldsymbol{DR} = (\boldsymbol{X} + \boldsymbol{N})/\mathbf{2}$, **expected dynamic resilience**: $\boldsymbol{cDR} = (\boldsymbol{X} + \boldsymbol{cN})/2$, and **potential dynamic resilience**: $\boldsymbol{pDR} = (\boldsymbol{pX} + \boldsymbol{pN})/2$. The second indicator corresponds to the situation when dynamic resilience of the PA changes under the impact of economic activities without any dedicated actions to improve it, whereas the third indicator, like all similar «potential» indicators, characterizes future resilience in a hypothetical situation when all possible measures to improve it are taken. When no decline in connectivity is expected, the latter two indicators are equal.

## *3. Calculation of overall resilience of the PA to environmental changes*

Indicators representing the PA's overall resilience to global long-term environmental changes are calculated as averages of the respective indicators for the two components of resilience: conservation and dynamic ones. Thus, three indicators are calculated at this stage of the assessment:

**Current resilience** – $\boldsymbol{R} = (\boldsymbol{CR} + \boldsymbol{DR})/2$;

**Expected resilience** – $\boldsymbol{cR} = (\boldsymbol{CR} + \boldsymbol{cDR})/2$;

**Potential resilience** – $\boldsymbol{pR} = (\boldsymbol{pCR} - \boldsymbol{pDR})/2$.

## <u>Analysis of the results</u>

The overall process and the main stages of the analysis of resilience of a PA to environmental changes are presented in Figure 3.

**1.** Based on the results of the evaluation of <u>conservation resilience,</u> the following steps are taken:

1.1. Comparative analysis of relative significance of individual aspects of the geographic location of the PA to the overall favorability of its geographic location in terms of resilience; the comparative data are presented in the form of a *bar chart*.

1.2. Comparative analysis of relative significance of the PA's size and landscape diversity to the overall favorability of the territory in terms of resilience; the comparative data are presented in the form of a *bar chart*.

1.3. Comparison of current and potential favorability of the PA's size, landscape diversity, and the territory as a whole with subsequent conclusions regarding the possibility of optimizing the PA's territory in order to improve its resilience to environmental changes and significance of such optimization; the comparative data are visualized in the form of a *bar chart* presenting both current and potential indicators.

1.4. Comparative analysis of relative contribution of the three aspects of conservation resilience to its overall current level; the comparative data are presented in the form of a *bar chart*.

1.5. Comparison of actual and potential levels of the three aspects of conservation resilience with subsequent conclusions regarding the possibility of improving the PA's conservation resilience and significance of such improvement; the comparative data are visualized in the form of a *bar chart* presenting both current and potential indicators.

**2.** Based on the results of the evaluation of <u>dynamic resilience,</u> the following steps are taken:

2.1. Comparison of current and potential indicators of diversity of extrazonal and relic elements of the biota and biocenotic cover with subsequent conclusions regarding the possibility and desirability of improving the diversity; the comparative data are presented in the form of a *bar chart*.

2.2. Comparison of current, expected, and potential indicators of the PA's connectivity with other undisturbed and less-disturbed areas, which leads to conclusions regarding the possibility and desirability of improving the connectivity by means of establishing or expanding legally defined ecological networks; the comparative data are visualized in the form of a *bar chart* presenting both current and potential indicators.

2.3. Comparative analysis of relative contribution of the two aspects of dynamic resilience to its current level; the comparative data are presented in the form of a *bar chart*.

2.4. Comparison of current, expected and potential levels of the total dynamic resilience and its two components with subsequent conclusions regarding the possibility and desirability of improving the dynamic resilience; the comparative data are visualized in the form of a *bar chart*, presenting both current and potential indicators.

**3.** Based on the results of the calculation of the <u>overall resilience of the PA</u> to environmental changes, the following steps are made:

3.1. Comparison of conservation and dynamic resilience; the comparative data are presented in the form of a *bar chart*.

3.2. Comparison of overall current, expected, and potential resilience indicators with subsequent conclusions regarding the possibility of optimizing the overall resilience and significance of such optimization; the comparative data are visualized in the form of a *bar chart*, presenting both current and potential indicators.

## 4. Evaluation OF PROSPECTIVE CONSERVATION EFFECTIVENESS

Prospective conservation effectiveness of the PA is defined as a function of its *current conservation effectiveness, security,* and *resilience to environmental changes*. Therefore indicators reflecting the PA's prospective conservation effectiveness are produced on the basis of overall indicators characterizing those three areas. It is advisable to calculate the indicators for two possible scenarios – namely relatively stable environmental conditions and significant global environmental changes, particularly climate-related. Both current and potential indicators are calculated for each scenario. Thus, a total of four overall indicators of prospective conservation effectiveness are produced:

**1. Current prospective effectiveness of the PA under relatively stable environmental conditions:**

$\boldsymbol{E_s} = \boldsymbol{F} \times (\boldsymbol{S}/100)$,

where ***F*** is relative conservation effectiveness of the PA, ***S*** – its relative security.

**2. Potential prospective effectiveness of the PA under relatively stable environmental conditions:**

$\boldsymbol{pE_s} = \boldsymbol{pF} \times (\boldsymbol{pS}/100)$,

where ***pF*** is potential relative conservation effectiveness of the, ***pS*** – its potential relative security.

**3. Current prospective effectiveness of the PA under significant environmental changes:**

$\boldsymbol{E_{ch}} = \boldsymbol{F} \times (S/100) \times (\boldsymbol{R}/100)$,

*where* ***R*** is relative resilience of the PA to environmental changes.

**4. Potential prospective effectiveness of the PA under significant environmental changes:**

$\boldsymbol{pE_{ch}} = \boldsymbol{pF} \times (\boldsymbol{pS}/100) \times (\boldsymbol{pR}/100)$,

where ***pR*** is potential relative resilience of the PA to environmental changes.

In the process of the subsequent **analysis** of the PA's prospective conservation effectiveness, it is recommended **to**:

1) compare the significance of the PA's current conservation effectiveness and security as two factors determining the observed level of the PA's prospective effectiveness;



2) compare prospective effectiveness under stable conditions and environmental changes, identifying the significance of the latter and the resilience to them to the PA's prospective effectiveness;

3) compare current and potential indicators, identifying opportunities for improving the PA's prospective effectiveness and factors that can be leveraged to improve it.

All comparative data are presented in the form of *bar charts*.

# II. ASSESSMENT OF CONSERVATION EFFECTIVENESS OF REGIONAL PROTECTED AREA SYSTEMS

***Current*** and ***prospective*** **conservation effectiveness** can also be evaluated at the level of regional PA systems. It is assumed that the current, i. e. observed at the present moment, conservation effectiveness of a PA system depends on: a) *conservation effectiveness of individual PAs comprising the system*; b) *completeness of the system in terms of environmental diversity of the respective region*; c) *integrity of the system*, i. e. its ability to support natural processes connecting individual PAs of the systems. The factors determining a system's prospective conservation effectiveness include, in addition to its *current effectiveness*: a) *security*, determined by security of individual PAs; b) *resilience to environmental changes,* also determined by resilience of individual PAs; c) *prospective integrity of the system*, being a function of its current integrity and stability of that integrity.

In the context of comparative analysis of different regional PA systems, also of interest are their overall **conservation value and significance**, which are determined by: a) *a sum of conservation value and significance indicators across all PAs of the system*; b) *completeness of the PA system*; c) *integrity of the systems*.

Thus, two groups of indicators are used to calculate conservation effectiveness, value, and significance for a regional PA system.

1. ***Indicators defined at the level of individual PAs and aggregated (summed or averaged) across all PAs of the system.*** Those indicators, discussed in Part I in the context of individual PAs, include:

a) **average conservation effectiveness (*FS*)**;

b) **security, a sum across individual PAs (*SS*)**;

c) **average resilience (*RS*)**;

d) **conservation value, a sum across individual PAs (*sumV*)**;

e) **conservation significance, a sum across individual PAs (*sumI*)**.

2. ***Indicators that can be defined only at the system level***, i. e. are applicable only to a regional PA system as a whole:

a) **completeness (*CS*)**, which characterizes representativeness of a PA system in terms of environmental diversity of the respective region and its sufficiency for supporting the ecological stability;



b) **integrity (*GS*)**, characterizing the system's ability to support natural processes that are not limited by the boundaries of individual PAs;

c) **prospective integrity (PGS)**, characterizing the prospects of preserving the current integrity in the future and based on the **stability of the integrity (SGS)**.

A general approach to the evaluation and analysis of conservation value, significance, and effectiveness of a PA system is presented in Figure 4.

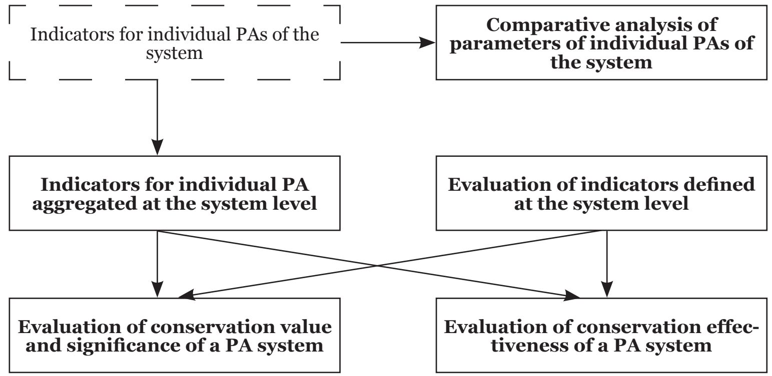


**Figure 4.** General approach to the evaluation and analysis of conservation value, significance, and effectiveness of a PA system.

## 1. AGGREGATE INDICATORS FOR AND COMPARATIVE ANALYSIS OF PROTECTED AREAS COMPRISING A REGIONAL SYSTEM

Indicators of conservation value, significance, and resilience, as well as security and resilience to environmental changes, produced for individual PAs, are used to calculate aggregate indicators for the entire system. It is also recommended to analyze the variation of those indicators within the system and their distribution, and identify the PAs characterized by minimum and maximum values of the indicators.

### 1.1. Calculation of aggregate indicators and comparative analysis of conservation value, significance, and effectiveness of protected areas comprising a regional system

Comparative analysis of conservation value and significance of PAs within the given system is carried out using the respective indicators for individual protected areas (see Part I). In addition, those indicators are used for producing aggregate indicators for the entire system.

It is worth mentioning that overall indicators aggregated across a PA system are useful mainly for comparative analysis of different regional systems. The indicators, more important in the context of analysis of a single regional system, include indicators for individual conservation functions, aggregated across the entire PA, which provide a better and a more detailed picture of conservation significance of the given system. Indicators aggregated across PAs of a specific type and administrative level, instead of all PAs of the system, can also be useful, since they help analyze relative contribution of those divisions to the system's overall conservation significance.

## Indicators and evaluation process

To produce indicators for the system as a whole in addition to the indicators of conservation value, significance and effectiveness for individual PAs, the following steps are taken (see Figure 5):

### *1. Calculation of aggregate indicators of conservation value, significance, and effectiveness for a PA system*

By summing conservation value and significance indicators across all PAs of the system (or its given subsystem), **overall conservation value** and **overall conservation significance** of the system are calculated. Then they are used to produce **average current conservation effectiveness** (***FS***) of the system's or subsystem's PAs. This procedure is carried out, and aggregate indicators are produced for:

a) *the entire PA system of the region*;

b) *each conservation function of all PAs of the region*;

c) *all PAs of a given type within the region (strict nature reserves, national and nature parks, nature sanctuaries, natural monuments)*;

d) *groups of PAs administered at a given level (federal, regional, municipal)*;

e) *each conservation function of PAs of individual types*;

f) *each conservation function of PAs of individual administrative levels*.

Furthermore, by dividing aggregate conservation value and significance for different PA types and administrative levels by the number of PAs in the respective category one calculates ***specific conservation value*** and ***specific conservation significance*** for each PA type and administrative level.



### *2. Calculation of potential average current conservation effectiveness*

For each group of factors underpinning the incompleteness of conservation effectiveness, impact magnitudes are calculated by summing respective magnitudes across all PAs of the given system (subsystem). Then contribution of each group to the total magnitude (the sum of magnitudes for all groups) is determined. Using equations similar to those introduced in Part I, ***minimum*** and ***maximum potential average current conservation effectiveness*** indicators are calculated**.** Such calculations are carried out for:

a) *the entire PA system of the region*;

b) *all PAs of a given type within the region (strict nature reserves, national and nature parks, nature sanctuaries, natural monuments)*;

c) *groups of PAs administered at a given level (federal, regional, municipal)*.

## Analysis of the results

Analysis of data produced at this stage can be divided in two parts. One of them deals with indicators for individual PAs, produced earlier, whereas the other one used aggregate indicators for the entire system or its subsystems. The analysis process is presented in Figure 5.

### *On the basis of conservation value and conservation significance indicators for individual PAs, produced earlier:*

1) Relation between conservation value and conservation effectiveness of individual PAs is analyzed; the PAs are divided into four main groups defined by different combination of high and low values of the two indicators. The results are presented in the form of an *XY-chart*.

2) Relation between current and potential conservation effectiveness of individual PAs is analyzed; the PA are divided into groups defined by different combinations of values of the two indicators. The results are presented in the form of an *XY-chart*. PAs with the highest and the lowest potential for the improvement of their conservation effectiveness are identified.

### *On the basis of calculated aggregate indicators:*

**1.** One compares contribution of different conservation functions to aggregate conservation value and significance for:

a) *the entire PA system of the region*;

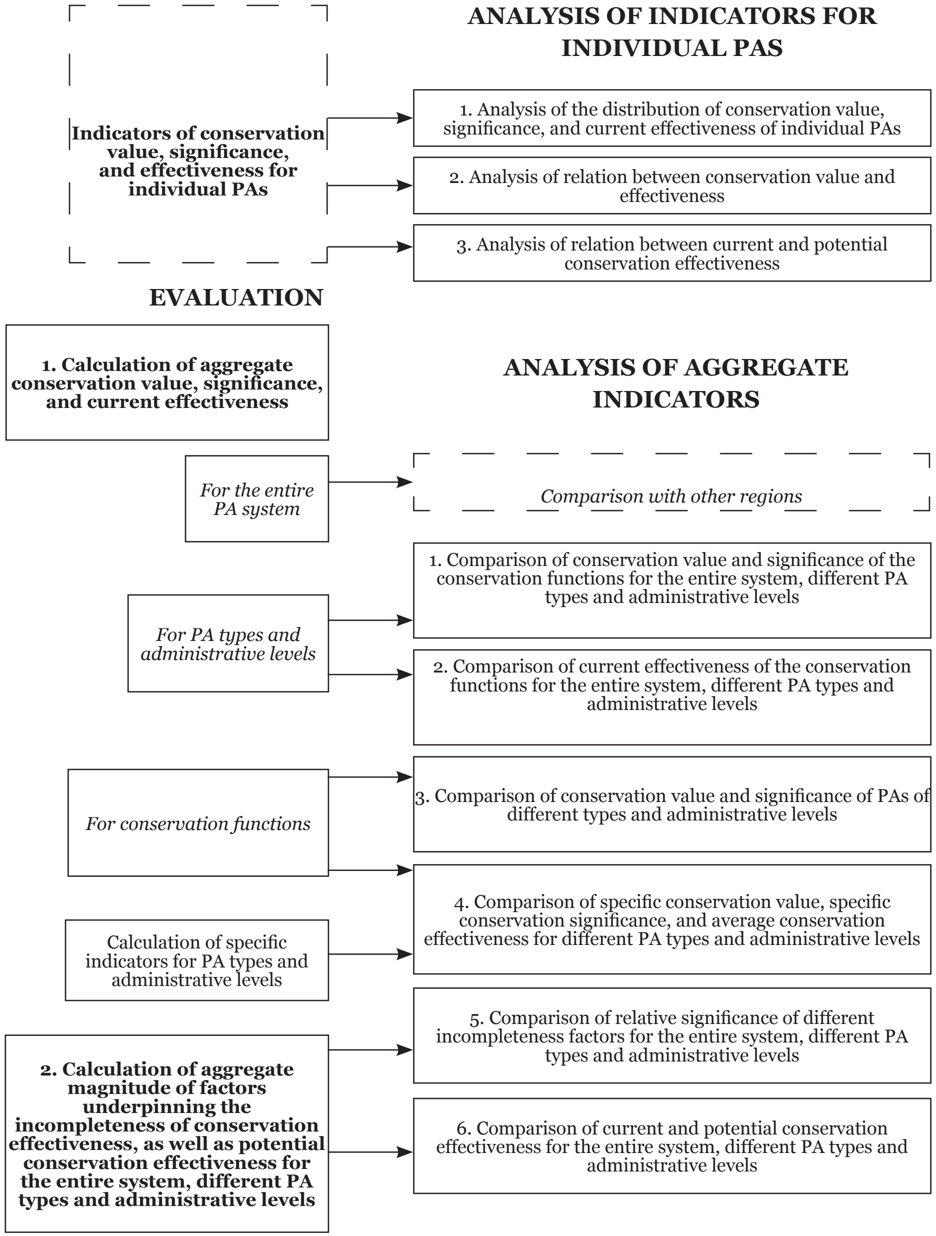


**Figure 5.** General process and the main stages of evaluation and analysis of conservation value, significance, and current conservation effectiveness of a PA system (see the text)



b) *all PAs of a given type within the region (strict nature reserves, national and nature parks, nature sanctuaries, natural monuments)*;

c) *groups of PAs administered at a given level (federal, regional, municipal)*.

The results are visualized in the form of *pie charts*. Then one identifies the most and the least valuable and significant functions for the entire systems, as well as for PAs of different types and administrative levels.

**2.** One compares average current conservation effectiveness in terms of different conservation functions for:

a) *the entire PA system of the region*;

b) *all PAs of a given type within the region (strict nature reserves, national and nature parks, nature sanctuaries, natural monuments)*;

c) *groups of PAs administered at a given level (federal, regional, municipal)*.

The results are visualized in the form of *bar charts*. Then one identifies the most and the least effective functions for the entire systems, as well as for PAs of different types and administrative levels.

**3.** Contribution of different PA types and administrative levels to the overall conservation value and significance of the PA system is identified. The results are visualized in the form of *pie charts*. Then one identifies the PA types and administrative levels providing the greatest or the least contribution to the overall value and significance of the PA system.

**4.** Specific conservation value and significance, as well as average conservation effectiveness for different PA types and administrative levels are compared. The results are presented in the form of *bar charts*. The PA types and administrative levels characterized by the highest and lowest values of specific conservation value, specific conservation significance, and average conservation effectiveness are identified.

**5.** Relative contribution of different groups of incompleteness factors to the overall incompleteness of conservation effectiveness is determined for:

a) *the entire PA system of the region*;

b) *all PAs of a given type within the region (strict nature reserves, national and nature parks, nature sanctuaries, natural monuments)*;

c) *groups of PAs administered at a given level (federal, regional, municipal)*.

The results are visualized in the form of *pie charts*. Then one identifies the most and the least significant incompleteness factors for the entire system, as well as for individual PA types and administrative levels.

**6.** One compares average current and potential conservation effectiveness for the entire system, as well as for individual PA types and administrative levels. The results are presented in the form of *bar charts*. PA types and administrative levels with the highest and the lowest potential for the improvement of conservation effectiveness are identified.

### 1.2. Evaluation of the security of a PA system and comparative analysis of its constituent areas

The security of a regional PA system is evaluated in terms of cumulative relevance of potential threats (i. e. the sum of relevance indicators across all constituent PAs). Like in the case of aggregate conservation value and significance, cumulative indicators for different PA types and administrative levels may also be of interest in addition to cumulative relevance for the entire regional system. On the other hand, one can estimate not only cumulative relevance for the entire range of threats, but also cumulative values for different threat categories and group of threats controlled at a given level.

## Indicators and evaluation process

The evaluation process includes two stages. At the first stage, cumulative relevance of threats for different threat categories and PA groupings is calculated, whereas at the second stage security indicators for the entire PA system and its various subsystems are calculated.

#### *1. Calculation of cumulative relevance of threats*

Indicators of current and minimized relevance of threats for individual PA, produced at an earlier stage of analysis, are summed for:

a) *all types of threats and all PAs of the system*;

b) *all types of threats for individual PA types*;

c) *all types of threats for individual levels of PA administration*;

d) *each threat type for all PAs of the system*;

e) *all natural threats and all anthropogenic threats for all PAs of the system*;

f) *threat groups characterized by a different level of control for all PAs of the system.*

#### *2. Evaluation of current and potential security*

Using techniques described in Part I, current and potential security indicators are calculated for:



a) *the entire PA system*;

b) *different types of PA*;

c) *different levels of PA administration*.

## Analysis of the evaluation results

**1.** PA groups characterized by different types of relation between relevance of natural and anthropogenic threats are identified. The results are visualized in the form of an *XY-chart*.

**2.** Current and potential security of individual PAs comprising the system is compared. The results are presented in the form of an *XY-chart*. One identifies PAs with the highest and the lowest values of current and potential security, PA groups characterized by different types of relation between those two indicators, and PAs combining the greatest need for the improvement of their security with the maximum potential for such improvement.

**3.** Relative contribution of different categories of natural and anthropogenic threats to overall cumulative relevance of threats for the entire PA system is compared. The results are presented in the form of *pie charts*. Threat categories the most and the least relevant to the PA system are identified.

**4.)** Shares of threats characterized by different control levels in the overall cumulative relevance of threats for the entire PA system are compared. The results are presented in the form of a *pie chart*. Levels of control associated with the potential threats most significant to the PA system are identified.

**5.** Current and potential security indicators for different PA types and administrative levels are identified. The most and the least secure PAs, as well as those combining the greatest need for the improvement of their security with the maximum potential for such improvement, are identified. The results are presented in the form of *bar charts*.

### 1.3. Evaluation of the resilience of a PA system to environmental changes and comparative analysis of the resilience of constituent pas

Like security evaluation, evaluation of a PA system's resilience to long-term environmental changes is based on the respective indicators for individual PAs. Aggregate indicators of *current and potential conservation, dynamic, and overall resilience* for the entire PA system and its subsystems are produced by averaging the respective indicators for individual PAs produced at an earlier stage.

## Indicators and evaluation process

The evaluation process includes the calculation of **average current and potential conservation, dynamic, and overall (total) resilience indicators for**:

a) *all PAs comprising the system* (except for point natural monuments);

b) *different types of PA*;

c) *different levels of PA administration*.

Analysis of the evaluation results

**1.** Current conservation and dynamic resilience indicators for individual PAs are compared. The results are presented on an *XY chart* with one axis corresponding to the former indicator, and the other axis – to the latter one. PAs with the highest and the lowest conservation resilience, as well as PA groups with different relations between the two indicators are identified.

**2.** Current and potential overall resilience for individual PAs is compared. The results are visualized using an *XY chart*. PAs combining the greatest need for the improvement of their resilience with the maximum potential for such improvement are identified.

**3.** Average current conservation, dynamic, and overall resilience for different PA types and administrative levels is compared; the maximum and the minimum values of the indicators are identified. The results are presented in the form of *bar charts*.

**4.** Current and potential resilience for the entire PA systems, as well as different PA types and administrative levels is compared, and opportunities for its improvement are identified. The results are presented in the form of *bar charts*.

# 2. EVALUATION OF THE COMPLETENESS OF A REGIONAL PA SYSTEM

**Completeness of a PA system** is defined as its representativeness in terms of environmental (both biological and landscape) diversity of the respective region and the system's sufficiency for the conservation of the environmental features that determine ecological stability of the region and play a key role in supporting natural process at the landscape and regional levels.

General analysis of the completeness of a regional PA system encompasses the following eight aspects:

**1) landscape representativeness** – the system's representativeness in terms of landscape diversity of the region;



**2) ecosystem and biocenose representativeness** – the system's representativeness in terms of diversity of ecosystems and biocenoses of the region with particular emphasis on rare and endangered ecosystems and biocenoses, as well as those specific to the region;

**3) floristic and faunistic representativeness –** the system's representativeness with regard to the fauna and flora of the region, evaluated in terms of the representation of vascular plants and vertebrate animals, as well as all regionally endemic taxa within the system's PAs;

**4) completeness with regard to rare taxa –** the degree of representation of areas of critical significance to the conservation of rare and endangered (both at the national and the regional level) taxa within the PA system;

**5) completeness with regard to areas of special conservation values –** the degree of representation of areas having a special conservation status (Ramsar wetlands, important bird areas, frontier forests, areas supporting significant populations of wild relatives of cultivated plants, areas characterized by a high level of biodiversity etc.) within the PA system;

**6) completeness with regard to notable natural features –** the degree of representation of natural features of outstanding conservation or scientific and educational value, and landscapes of high scientific and educational or aesthetic value within the PA system;

**7) reproduction completeness –** the degree of representation of areas supporting the reproduction of biological resources (e. g. hunting and commercial species etc.) within the PA system;

**8) ecological stabilization completeness –** the degree of representation of areas essential to the regional stability and supporting natural processes at the local and regional level within the PA system.

## Indicators and evaluation process

Two main indicators based on individual scores for each of the eight aspects listed above are used to characterize overall completeness of a PA system – **current completeness** (***CS***) and **potential** (***pCS***) completeness. Correspondingly, the evaluation process includes two main stages.

### *1. Evaluation of current completeness of a PA system*

Each of the eight aspects of completeness listed above is scored on a five-point scale (from 0 to 4). The scoring criteria (different for each indicator) are presented in Table 15.

Then the scores for all aspects are summed, and **current completeness of the system** (***CS***) is calculated as a percentage ratio of the sum to its maximum possible value (32).

**Table 15.**

*Scales for the scoring of aspects of completeness of a regional PA system*

| | | |
|---|---|---|
| *Landscape representativeness* | **4** | The PA system includes all landscape types typical and specific to the region, with a complete range of morphological components and ecogenetic series characteristic to them |
| | **3** | The PA system includes most landscape types found within the region, including all the most typical and widespread ones |
| | **2** | The PA system is far from encompassing all landscape types characteristic to the region; some of the most typical and widespread ones are missing |
| | **1** | The PA system includes only few types of regional landscapes, which are not among the most typical or widespread |
| | **0** | Only fragments of certain landscapes of the region are represented within the system's PAs |
| *Ecosystem and biocenose representativeness* | **4** | The PA system includes all the key varieties of reference, rare and endangered communities and ecosystems |
| | **3** | The PA system includes most varieties of reference, rare, and endangered communities and ecosystems, including all varieties most typical or specific to the region |
| | **2** | The PA system includes most varieties of communities and ecosystems found within the region, with some typical and specific and/or rare and endangered varieties being missing |
| | **1** | The PA system encompasses only a small fraction of the regional diversity of communities and ecosystems with a significant number of typical and specific and/or rare and endangered varieties being missing |
| | **0** | The PA system encompasses only a few communities and ecosystems |
| *Floristic and faunistic representativeness* | **4** | All or almost all species of vascular plants and vertebrate animals of the region, as well as all endemic taxa are represented within PAs of the system |
| | **3** | Most species of vascular plants and vertebrate animals of the region, as well as all regionally endemic taxa are represented within the PAs of the system |
| | **2** | A significant portion of the regional species richness of vascular plants and vertebrate animals (though not most of them), as well as most regionally endemic taxa are represented within the PAs of the system |
| | **1** | A significant portion of the regional species richness of vascular plants and vertebrate animals (though not most of them) is represented within the PAs of the system, with a significant number of regionally endemic taxa being missing |
| | **0** | Only a small portion of the regional species richness of vascular plants and vertebrate animals is represented within the PAs of the system |
| *Completeness with regard to rare taxa* | **4** | The PA system encompasses all areas of critical significance to the conservation of populations of all species included in Red Books at both the federal and the regional level |
| | **3** | The PA system encompasses all areas of critical significance to the conservation of populations of most species included n Red Books, including all species listed in the Red Book of the Russian Federation |
| | **2** | The PA system encompasses areas of critical significance to the conservation of most rare and endangered taxa of the region; however, some areas essential for the conservation of populations of the taxa included in the Red Book of the Russian Federation are missing |
| | **1** | The PA system includes areas of critical significance for the conservation of a small fraction of rare species of the region |
| | **0** | The PA system does not include areas of critical significance for the conservation of rare and endangered (included in Red Books) species found in the region |
| *Completeness with regard to areas of special conservation value* | **4** | The PA system encompasses all or almost all areas of special conservation value in the region |
| | **3** | The PA system encompasses most areas of special conservation value in the region |
| | **2** | The PA system encompasses a significant portion of areas of special conservation value in the region, though not most of them |
| | **1** | The PA system includes few areas of special conservation value found in the region |
| | **0** | The PA system does not include any areas of special conservation value found in the region |
| *Completeness with regard to notable natural features* | **4** | The PA system encompasses all or almost all natural features of outstanding scientific and educational or aesthetic significance in the region |
| | **3** | The PA system encompasses most natural features of outstanding scientific and educational or aesthetic significance in the region |
| | **2** | The PA system encompasses a significant portion of natural features of outstanding scientific and educational or aesthetic significance in the region, though not most of them |
| | **1** | The PA system includes few natural features of outstanding scientific and educational or aesthetic significance found in the region |
| | **0** | The PA system does not include any natural features of outstanding scientific and educational or aesthetic significance found in the region |
| *Reproduction completeness* | **4** | The PA system encompasses all areas essential for the reproduction of biological resources |
| | **3** | The PA system encompasses most areas essential for the reproduction of biological resources |
| | **2** | The PA system encompasses a significant fraction of areas essential for the reproduction of biological resources |
| | **1** | The PA system includes only a very small fraction areas essential for the reproduction of biological resources |
| | **0** | The PA system does not include any areas essential for the reproduction of biological resources |
| *Ecological stabilization completeness* | **4** | The PA system encompasses all areas essential to the regional ecological stability and supporting natural processes at the landscape level |
| | **3** | The PA system encompasses most areas essential to the regional ecological stability and supporting natural processes at the landscape level |
| | **2** | The PA system encompasses a significant fraction of areas essential to the regional ecological stability and supporting natural processes at the landscape level |
| | **1** | The PA system includes an insignificant fraction of areas essential to the regional ecological stability and supporting natural processes at the landscape level |
| | **0** | The PA system does not include areas essential to the regional ecological stability and supporting natural processes at the landscape level |



### *2. Evaluation of potential completeness of a PA system*

For the aspects of completeness whose current score is below the maximum possible level (4), opportunities for the enhancement of completeness by means of creating new PAs, expanding the existing ones, or optimizing their boundaries are considered. To quantify those opportunities, one evaluates the difference between the completeness score for the best possible situation achievable by the means listed above, and the current completeness score. Thus, the enhancement potential score can take five possible values:

**0** – there are no opportunities for the enhancement of the completeness;

**1** – very limited opportunities;

**2** – limited opportunities;

**3** – somewhat broad opportunities;

**4** – broad opportunities.

The difference score «4» can be assigned only if the current completeness score equals 0; the score «3» – when the current completeness score equals 0 or 1; the score «2» – when the current completeness scored 0, 1 or 2; the scores «1» and «0» – at any values of the current completeness score, except for 4.

The potential completeness scores for individual aspects, defined as a sum of the current completeness score and enhancement potential score for the respective aspect, are summed. Then, like in the previous case, **potential completeness of the PA system** (***pCS***) is calculated as a percentage ratio of the sum to its maximum possible value (32).

### Analysis of the evaluation results

Analysis of the results of a PA system's completeness evaluation includes:

a) comparison of current completeness score for individual aspects, and identification of aspects with the highest and lowest completeness for the given system; the results are presented in the form of *bar charts*;

b) comparison of current and potential completeness, and identification of opportunities and limits for their enhancement for each aspect; the results are presented in the form of *bar charts*.

## 3. EVALUATION OF THE INTEGRITY OF A REGIONAL PA SYSTEM

**Current integrity of a PA system** characterizes the system's capacity to suport:

1) natural lifecycles of species undertaking longtime nomadic or other migrations;



2) populations of large animals, whose continued existence within a PA requires regular exchange of individuals with other areas;

3) natural course of regional physiographic processes supporting connectivity between the region's PAs;

4) restoration of disturbed or destroyed environmental complexes within a PA through in-migration of species and communities from other areas;

5) natural changes in the biota and ecosystems in response to cyclic or directional changes of the physiographic environment manifested as shifts of boundaries of zonal divisions.

The worst case in terms of all the five aspects would be a regional system comprised of isolated PAs fully surrounded by anthropogenic landscapes, although even in such situation some migration and exchange between populations are possible. The best case in terms of all those aspects is represented by a system, in which all or most of the region's PAs (except probably for certain natural monuments occupying a small area) are connected to each other and PA systems of neighbor regions by full-fledged ecological corridors, this forming a single ecological network. A particular case of the latter situation is a PA system in a region mostly untransformed by human activities, where most of the region's area remains in its natural state.

All the five aspects of a PA's system integrity are closely interconnected and often supported by the same mechanisms and structures. Nevertheless, a good condition in terms of one aspect does not necessarily imply a similar condition in terms of another one. Therefore it is deemed preferable to produce individual scores for each aspect with subsequent summation of the results.

The current integrity of an existing PA system cannot be seriously improved without the creation of new PAs or restoration of natural landscapes in place of anthropogenic ones. The former means a serious change of the entire system, involving the improvement of its completeness, whereas the latter is possible only in the long-term and difficult to predict. Therefore it does not make sense to speak of potential integrity of a PA system in a sense similar to its potential completeness and other potential indicators.

On the other hand, a concept deemed important enough in **potential integrity** of the PA system, determined by the system's current state, the presence and the development level of a legally defined ecological network, and prospects for further socio-economic development of the region and anthropogenic transformation of its area.

## Indicators and evaluation process

In addition to the evaluation of the **current integrity of a PA system** (***GS***), the proposed procedure includes determination of **potential integrity of the system** (***pGS***) based on its current integrity, **stability of the current integrity of the system** (***SGS***), and **potential for its improvement** (***p***). The evaluation process with regard to those indicators comprises the following stages:

### *1. Evaluation of current integrity of a PA system*

This stage begins with the scoring of the five aspects of the system's integrity, listed above. All the aspects are scored on a single five-point scale (from 0 to 4) presented in Table 16.

**Table 16.**

*Scale for the scoring of aspects of current integrity of a PA system*

| | |
|---|---|
| **4** | The aspect in question is fully or almost fully supported across the entire region |
| **3** | The aspect in question is generally supported across most of the region |
| **2** | The aspect in question is supported partially and/or across a half of the region's area or less |
| **1** | The aspect in question is supported in a few cases and across a small fraction of the region's area |
| **0** | There are no opportunities for supporting the aspect in question |

The scores for individual aspects are summed; then **current integrity of the PA system** (***GS***) is calculated as a percentage ratio of the sum to its maximum possible value (20).

### *2. Evaluation of stability of the current integrity of a PA system*

Stability in terms of each of the five aspects of the system's current integrity is scored on a five-point (from 0 to 4) scale presented in Table 17. **Stability of the current integrity of a PA system (*SGS*)** is a relative indicator defined as a percentage ratio of the sum of stability scores to its maximum possible value (20).

**Table 17.**

*Scale for the scoring of stability of the current integrity of a PA system*

| | |
|---|---|
| **4** | No decrease in the PA system's integrity is expected due to the existence of a legally defined full-fledged ecological network and/or the absence of regional socio-economic development plans, whose implementation could adversely affect the system's integrity |
| **3** | An insignificant decrease in the PA system's integrity is possible as a result of insignificant gaps in the legally defined ecological network and the existence of development plans for areas outside the network |
| **2** | A significant decrease in the PA system's integrity is possible as a result of major gaps in the legally defined ecological network and the existence of active development plans for areas outside the network |
| **1** | A serious decrease in the PA system's integrity is expected due to the legally defined ecological network being represented by individual fragments only and the existence of extensive development plans for areas outside the network |
| **0** | A critical decrease in the PA system's integrity is possible as a result of the absence of a legally defined ecological network and the existence of extensive plans for further development of the region |

### *3. Evaluation of potential stability of the current integrity of a PA system*

In addition to the previous indicator, one evaluated opportunities for the optimization of the region's ecological network aimed at improving stability of the current integrity of the PA system. As in the previous cases, the potential for the improvement of individual aspects of integrity is quantified as the difference between the potential stability score, which can be achieved as a result of stability improvement, and the current stability. Therefore, the improvement potential score can take five values:

**0** – there are no opportunities for the enhancement of the completeness;

**1** – very limited opportunities;

**2** – limited opportunities;

**3** – somewhat broad opportunities;

**4** – broad opportunities.

The difference score «4» can be assigned only if the current stability score equals 0; the score «3» – when the current stability score equals 0 or 1; the score «2» – when the current stability scored 0, 1 or 2; the scores «1» and «0» – at any values of the current stability score, except for 4.

Based on the potential stability score for individual aspects, **potential stability of the system's current integrity** (***pSGS***) is calculated as a percentage ratio of the sum of scores for individual aspects to its maximum possible value (20).

### *4. Evaluation of potential integrity of a PA system*

For each aspect of the system's integrity, individual potential integrity scores are calculated as an average of the current integrity and potential stability scores for the respective aspect. Based on the individual scores, **potential integrity of the entire PA system** (***pGs***), is calculated as a percentage ratio of the sum of individual scores and its maximum possible value, equal to 20.

<u>Analysis of the evaluation results</u>

Analysis of the results of a PA system's integrity evaluation includes:

a) comparison of individual scores for the five aspects underpinning the system's integrity with the results being presented in the form of a *bar chart*;

b) comparison of the system's current and potential integrity with the identification of opportunities for improving it**.**

# 4. EVALUATION OF CONSERVATION VALUE, SIGNIFICANCE, AND EFFECTIVENESS OF A REGIONAL PA SYSTEM

**Conservation value and significance of a regional PA system** are determined, first of all, by the sums of conservation value and significance indicators, respectively, of its constituent PAs. However, it is obvious enough that of two PA systems with those sums being equal, the one with a higher system-level completeness and integrity will have a higher conservation value and conservation significance. Therefore it is necessary to modify equations for a system's conservation value and significance in order to take those factors into account. It is proposed to use the following equations for the calculation of conservation value and significance at the system level:

$$\boldsymbol{VS} = \Sigma \boldsymbol{V} \times [(\boldsymbol{CS} + \boldsymbol{GS})/100] \text{ and } \boldsymbol{IS} = \Sigma \boldsymbol{I} \times [(\boldsymbol{CS} + \boldsymbol{GS})/100],$$

where ***VS*** and ***IS*** are *conservation value and conservation significance of the system, respectively*; Σ***V*** and Σ***I*** – *sums of conservation value and significance indicators across individual constituent PAs*, respectively; ***CS*** – *relative completeness of the PA system*, ***GS*** – *relative integrity of the PA system*.

With the system's completeness and integrity being at the maximum possible levels, its conservation value and significance will be twice as high as the sums of the respective indicators across individual constituent PAs.

When **analyzing results of the evaluation of a system's conservation value and significance**, it is recommended to:

1) compare the respective sums across constituent PAs and indicators calculated for the entire system in order to identify ***relative contribution of properties of individual PAs and system-level properties*** to the system's overall conservation value and significance;



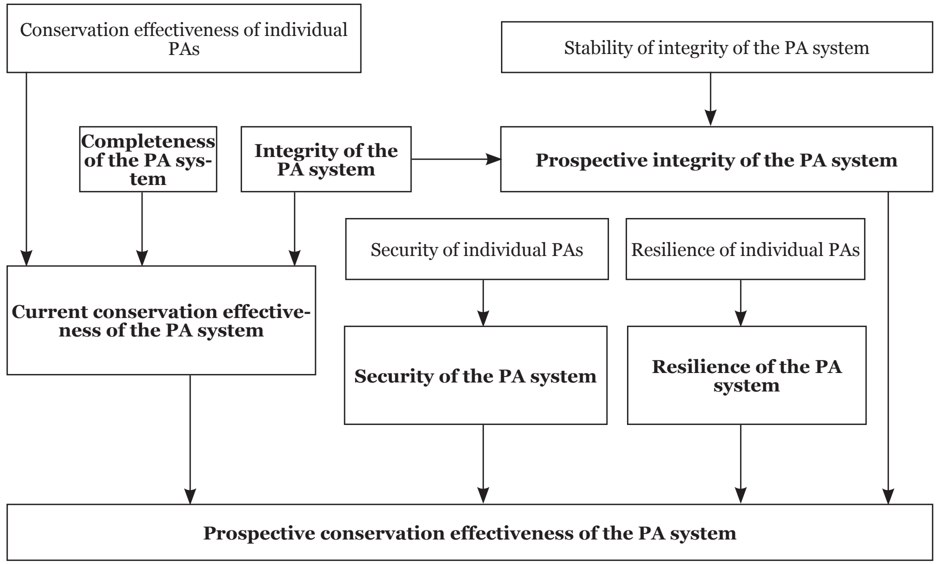


**Figure 6.** System of key indicators related to conservation effectiveness of a PA system

2) compare relative completeness and integrity of the system in order to identify their relative contribution to the system's overall value and significance.

The results of the analysis can be visualized in the form of *bar charts*.

The indicators described in the previous sections are also used for the evaluation of current and prospective conservation effectiveness of the PA system in question. The system of key indicators related to conservation effectiveness of a PA system is presented in Figure 6.

For both current and prospective conservation effectiveness, in addition to their actual values, one calculates minimum and maximum potential values, which can be achieved through optimizing the PA system, improving the effectiveness of its management, and/or optimizing the regional ecological network. Prospective conservation effectiveness is calculated for two different scenarios corresponding to relatively stable environmental conditions and their significant changes. Therefore, one calculates a total of 9 nine conservation effectiveness indicators, which are presented in Table 18.

When **analyzing results of evaluation of a system's conservation effectiveness**, in is recommended to:

1) compare ***relative contribution of the average conservation effectiveness of constituent PAs, the system's completeness***

***and its integrity*** to the system's overall current conservation effectiveness, identifying the most and the least significant factors;

2) compare ***relative contribution of the current effectiveness, security resilience, and stability of integrity*** to the system's overall prospective conservation effectiveness, identifying the most and the least significant factors;

3) compare actual, minimum potential, and maximum potential indicators and identify opportunities for the improvement of actual indicators.

All comparative data are presented in the form of *bar charts*. As an overall result of the assessment, one should identify the «weakest» components limiting the system's current and prospective effectiveness, and explore opportunities for their optimization.

***Table 18.***
*Indicators of conservation effectiveness of a PA system*

| ***Conservation effectiveness*** | **Actual** | **Minimum potential** | **Maximum potential** |
|---|---|---|---|
| **Current** | $\boldsymbol{ES = FS} \times [(\boldsymbol{CS} + \boldsymbol{CS})/200]$ | $\boldsymbol{pES_{min} = pFS_{min}} \times [(\boldsymbol{pCS} + \boldsymbol{GS})/200]$ | $\boldsymbol{pES_{max} = pFS_{max}} \times [(\boldsymbol{pCS} + \boldsymbol{GS})/200]$ |
| **Prospective under stable conditions** | $\boldsymbol{PESs = ES} \times [(\boldsymbol{SS} + \boldsymbol{pGS})/200]$ | $\boldsymbol{pPESs_{min} = pES_{min}} \times [(\boldsymbol{pSS} + \boldsymbol{pGS})/200]$ | $\boldsymbol{pPESs_{max} = pES_{max}} \times [(\boldsymbol{pSS} + \boldsymbol{pGS})/200]$ |
| **Prospective under significant environmental changes** | $\boldsymbol{PESch = ES} \times [(\boldsymbol{SS} + \boldsymbol{RS} + \boldsymbol{pGS})/300]$ | $\boldsymbol{pPESch_{min} = pES_{min}} \times [(\boldsymbol{pSS} + \boldsymbol{pRS} + \boldsymbol{pPGS})/300]$ | $\boldsymbol{pPESch_{max} = pES_{max}} \times [(\boldsymbol{pSS} + \boldsymbol{pRS} + \boldsymbol{pPGS})/300]$ |

where ***FS*** – average conservation effectiveness of the system's constituent PAs; $\boldsymbol{pFS_{min}}$ and $\boldsymbol{pFS_{max}}$ – average minimum and average maximum potential conservation effectiveness of the system's constituent PAs; ***CS*** – relative completeness of the system; ***pCS*** – potential relative completeness of the system; ***GS*** – relative integrity of the system; ***pGS*** – prospective potential integrity of the system; ***SS*** – summed security of individual PAs of the system; ***pSS*** – potential summed security of individual PAs of the system; ***RS*** – average resilience of the system's PAs to environmental changes; ***pRS*** – average potential resilience of the system's PA to environmental changes.



# III. ASSESSMENT OF COSERVATION VALUE AND PROJECTED EFFECTIVENESS OF PLANNED PROTECTED AREAS

When the region in question has a prospective scheme of the development of the regional PA system, which includes a list of planned PAs with their types, administrative levels, approximate locations, boundaries, sizes, and key protected environmental features, it is possible to carry out a tentative evaluation of the system's **projected conservation effectiveness**. Like with the existing PA system, one can distinguish between *current* and *prospective* effectiveness of the planned system. The formed one is defined as the expected conservation of the planned PA system under the assumption that it has been fully established by the moment of the assessment, whereas the latter one is defined as the system's prospective effectiveness under the same assumption. It is important to keep in mind that if the implementation of the PA development scheme is postponed to a more or less-distant future, both indicators can undergo substantial changes. It is also important to remember that prospective effectiveness of the future system evaluated under the assumption of its immediate creation is not equivalent to the system's current effectiveness at the moment of its creation in the future, since the effects of adverse factors influencing those indicators may differ significantly in cases of the system having been created and its absence.

The projected conservation effectiveness of a planned PA system can be evaluated in two different ways.

1. If there are sufficient reasons to believe that prospective (planned) PAs will have average conservation effectiveness, security, and resilience more or less similar to the respective averages across the existing PAs of the system, the process can be limited to the evaluation of system-level parameters of the planned system, i. e. its completeness and integrity. Then various aspects of the conservation effectiveness of the planned system are calculated using average values for the existing system. Essentially, this approach is equivalent to evaluating changes in the system's effectiveness associated with changes in its completeness and integrity. It does not allow to evaluate conservation value and significance of the planned system, since those indicators are produced by summing the respective indicators across individual PAs.

2. In the cases when one can expect serious differences between average indicators for the existing and planned PAs, or when it is necessary to evaluate conservation value and significance of the planned system, an analysis of all planned PAs on an individual basis is required in order to produce necessary indicators for the aggregation. In

this case, conservation effectiveness of the planned system is evaluated on the basis of indicators averaged across both existing and planned PAs.

## 1. EVALUATION OF CONSERVATION VALUE, SIGNIFICANCE, AND PROJECTED CONSERVATION EFFECTIVENESS OF PLANNED PROTECTED AREAS

The evaluation of individual planned PAs follows the same methodology and uses the same scoring scales as the process for existing PAs, the only difference being that potential values of all indicators are not determined for planned PAs. Consequently, the following steps are carried out for each planned PA:

production of the *representativeness, contrast with surroundings, and current state* scores for all components and subcomponents of expected conservation functions of the planned PA, which provides a basis for the calculation of **conservation value, conservation significance, and expected (projected) current effectiveness** for each function and the planned PA as a whole;

evaluation of possible *relevance* of different threat categories to the planned PA, which provides a basis for the calculation of **overall (cumulative) threat relevance** and **overall security** for the PA in question;

evaluation of *favorability of the PA's geographic location, favorability of its size and landscape diversity, stability of the lithogenic base, diversity of extrazonal and relic elements,* and *connectivity with less-disturbed areas*, which provides a basis for the calculation of **conservation, dynamic, and overall resilience** of the planned PA to long-term environmental changes;

using projected *current effectiveness, overall security,* and *overall resilience*, one calculates **projected prospective effectiveness** of the planned PA under relatively stable conditions and under significant environmental changes.

For the planned PAs taken collectively, one calculates:

aggregate (summed across all planned PAs) **conservation value** and **significance** for each conservation function and for the entire PAs;

**specific conservation value** and **significance**;

average **security** and **resilience to environmental change**s;

average **projected current** and **prospective effectiveness**.



The indicators aggregated across all planned PAs are used mainly for the subsequent calculation of conservation value, significance, and projected conservation effectiveness of the planned PA system. However, it may also be interesting to compare those indicators with similar aggregate indicators for the existing PA. It is important to keep in mind that in this case one compares not the existing and the planned PA systems, but the existing and planned PAs as two different groups.

It is recommended to compare:

1) overall and specific conservation value and significance;

2) aggregate conservation value and significance for each conservation function;

3) average security and resilience of PAs to long-term environmental changes;

4) average current and prospective effectiveness.

All comparative data can be presented in the form of *bar charts*. The comparative analysis should lead to conclusions regarding potential contribution of the planned PAs to the overall value and significance of the planned system and to value and significance in terms of each conservation function, as well as the soundness of PA planning from the standpoint of security and resilience – the factors determining prospective effectiveness of the PA system.

## 2. EVALUATION OF THE COMPLETENESS AND INTEGRITY OF A PLANNED PA SYSTEM

The completeness and integrity of the planned PA are calculated like similar indicators for the existing system, using the same scoring scales for the same aspects. As in the case of evaluating individual planned PAs, potential indicators are **NOT produced** for the planned system.

It is recommended to compare the final indicators, both overall ones and those for individual aspects of completeness and integrity, with similar current and potential indicators for the existing PA system, presenting the data in the form of *bar charts*. This will provide insight into to what extent the planned development of the system will enhance its completeness and integrity and will help realize its potential with regard to those aspects.

## 3. EVALUATION OF CONSERVATION VALUE, SIGNIFICANCE, AND PROJECTED CONSERVATION EFFECTIVENESS OF A PLANNED REGIONAL PA SYSTEM

Conservation value, conservation significance, and projected conservation effectiveness for a planned PA system are calculated using the same equations as similar indicators for an existing system. Depending on the general approach chosen, one uses either average current effectiveness, security, and resilience indicators for the existing PA system or new indicators calculated for the planned system (within includes both planned PAs and the existing ones). Indicators for the entire planned system can be produced by the weighted averaging of the respective indicators produced for two different groups – the existing PAs and the planned ones.

The **final** indicators include:

1) **conservation value** of the planned PA system;

2) **conservation significance** of the planned PA system;

3) **projected current effectiveness** of the planned PA system;

4) **projected prospective effectiveness** of the planned PA system under relatively stable environmental conditions;

5) **projected prospective effectiveness** of the planned PA system under significant climate changes.

It is recommended to compare all final indicators with the respective current and potential indicators for the existing system, presenting the comparative data in the form of *bar charts*. The analysis will help make conclusions regarding possible improvement of conservation value and effectiveness of the regional PA system as a result of the implementation of the proposed development scheme, and the degree of the realization of the existing potential with regard to those parameters.



# IV. PROCEDURE OF THE ASSESSMENT OF CONSERVATION EFFECTIVENESS OF PAS AND THEIR REGIONAL SYSTEMS

To carry out an assessment of the effectiveness of a regional PA system, a **working group** is created and a **coordinator** is appointed**.**

Assessment of the **existing PA system** includes three stages:

**I. Evaluation of conservation value and effectiveness of individual PAs** can be organized in two different ways.

1. Assessment of PAs can be carried out on an individual basis by the staff of each PA being a separate institution, and by authorities responsible for the management of other PAs. It is also desirable to involve external experts having a good knowledge of the PA in question and the region where it is located. Ideally, assessment of an individual PA is conducted by a group comprised of its staff (or the staff of the respective PA management authority) and external experts collectively possessing the entire range of expertise and knowledge necessary for a comprehensive evaluation. A certain exception is natural monuments, whose assessment is relatively straightforward and can be conducted in a centralized manned for the entire region by a single expert or a group of experts. All institutions and experts involved in the assessment are sent guidance materials (description of the assessment methodology with examples of summary tables and data visualization) and evaluation forms in advance. The filled forms are sent or handed over to the assessment coordinator. In addition to the forms, assessment reports for individual PAs can be compiled, containing summary tables, visual materials, and key conclusions made at each stage of the assessment.

2. It is also possible to carry out an assessment of the entire range of the system's PAs within the framework of a special **working meeting** called to assess the effectiveness of the regional PA system. If this approach is chosen, the PAs to be assessed should be allocated among individual participants or small groups. The advantage of this approach is that is allows to use the same experts for the assessment of several PAs. On the other hand, such an approach would be unfeasible for a region with a very large number of PAs. When the assessment is organized in the form of a working meeting, it is recommended to start the meeting with a presentation of the assessment methodology. Like in the previous case, the results are entered into forms of the same format and handed over to the coordinator for subsequent processing. If necessary, assessment reports for each PA or for those being of special interest can be prepared after the meeting.

**II. Calculation of indicators aggregated across the PA system** (by summing or averaging) is carried out or organized by the assessment coordinator. The data for individual PAs are entered into standard evaluation forms (Microsoft Excel spreadsheets), which support calculation of additive and average indicators for a PA group and production of charts illustrating the results.

**III. Evaluation of system-level indicators for the PA system and its overall conservation value and effectiveness** is carried out in the form of a working meeting (although in some cases such evaluation can be carried out by individual experts). The meeting opens with a presentation of the methodology of assessment of regional PA systems and a presentation of the results of assessment of individual PAs (if the assessment of individual PAs is carried out within the framework of the same working meeting, the schedule should provide sufficient time for intermediate data processing). Then the participants collectively evaluate the completeness and integrity of the system in question. The results are entered into the respective evaluation form, which supports the calculation of final indicators and production of charts for the entire system. Then the assessment results are discussed and key conclusions regarding the system's current and potential effectiveness are formulated. After the meeting, the report containing summary tables, charts, and conclusions for all stages of the assessment is prepared.

If the process objectives also include the assessment of a **planned PA system**, one more stage is added.

**IV. Evaluation of projected conservation effectiveness of the planned PA system**. It is also carried out in the form of a two-stage working meeting. At the first stage, evaluation of projected parameters of individual planned PAs is carried out (by all participants collectively or in several parallel groups), whereas the second stage involves evaluation of projected effectiveness of the planned system. The results are also put into special forms, and an assessment report is prepared. The report contains conclusions about to what extent the implementation of the proposed PA development scheme can improve the system's overall effectiveness. It is strongly recommended that authors of the proposed PA development scheme are engaged in the assessment.

Basic indicators (scores) produced at each stage of the assessment are entered into special **standard forms in the Microsoft Excel spreadsheet format**, which support automatic calculation of derived indicators and production of charts illustrating assessment results.

Results of the assessment of individual ***PAs*** are put into the following forms/spreadsheets:



**«1.1-Existing PA-Current Effectiveness»**, into which the data characterizing conservation value, significance, and effectiveness in terms of individual conservation functions is entered, and which supports the calculation of the respective indicators for the PA as a whole.

**«1.2-Existing PA-Prospective Effectiveness»**, into which scores underpinning security and resilience of PAs are entered, and which supports the calculation of the PA's prospective effectiveness.

In the assessment of ***an existing PA system,*** the following forms/spreadsheets are used:

**«2.1-Existing PA System-Aggregate Indicators»**, into which effectiveness, security, and resilience indicators of constituent PAs are entered, and which supports the calculation of the respective aggregate indicators.

**«2.2-Existing PA System-Effectiveness»**, intended for the results of the evaluation of indicators defined at the system level – its completeness and integrity – and for the calculation of the system's current and prospective effectiveness.

The results of the assessment of ***individual planned PAs*** are entered into the form **«3.1-Planned PA-Projected Effectiveness»**, which is a simplified version (without sections related to the incompleteness of conservation effectiveness and it factors) of the forms 1.1 and 1.2 combined into a single spreadsheet.

For the results of the assessment of a planned PA system, the form **«3.2-Planned PA System-Effectiveness»** is used. It is similar to the form 2.2, but also supports comparison of the core indicators for an existing and a planned system.

To ensure flexibility of the process, individual spreadsheets are not linked to each other; therefore some data has to be copied between spreadsheets manually. Empty forms are distributed with the world «Blank» in the name of the respective file before the form code. When the form is filled, the word is replaced with the name of the respective PA or region, and the year of the assessment is added at the end of the filename. E. g.: *«Altaisky Nature Reserve –1.1-Existing PA-Current Effectiveness-2011»* or *«Altai Republic-2.2-Existing PA System-Effectiveness-2011»*.

When it is impossible to use electronic spreadsheets, one can print out tables provided in Annex 1. However, in that case one will have to calculate manually all derived indicators, whose production is supported by the Excel spreadsheets.