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CONSERVATION OF RUSSIAN ARCTIC BIODIVERSITY

ABSTRACT. Russian Arctic represents the most typical landscapes of high latitudes: forest-tundra; tundra zone (with subzones of southern, typical and Arctic tundra), and the polar deserts zone. All types and variants of ecosystems, soils, and phytocenoses characteristic for the Arctic region as a whole are represented there. Recently the role of anthropogenic variants of tundra and meadows has also increased noticeably. There is up to 80% of all circumpolar biodiversity within terrestrial and water areas of the Russian sector of Arctic regions. Therefore the ecological projects directed on studying, preservation and sustainable use of biological resources in the Russian Arctic might be considered representative for the whole circumpolar area. The organization of several large reserves with a strict regime of protection is necessary for preservation of unique biodiversity of this region. The development of areas of traditional wildlife management could solve both ethno-cultural and ecological problems, including the conservation of terrestrial Arctic biota.

KEY WORDS: biodiversity, terrestrial ecosystems, conservation, Arctic, tundra, major factors influencing, nature protected areas

INTRODUCTION

Russian Arctic regions area is about 21,2 million km². Herewith the land accounts for nearby 7,2 million km². It is presented by the most typical landscapes of high latitudes: forest-tundra; tundra zone with subzones of Southern, typical and Arctic tundra; and the polar deserts zone. All characteristic for Arctic

region types and variants of ecosystems, soils, and phytocenosis are represented there. In massif masses of these and other natural zones are presented altitudinal zonality variants of tundra and polar deserts: oro-tundra and oro-polar-desert landscapes, and also lithic aggregations on different rocks. Among intrazonal landscapes lowland complexes of Northern rivers, flowing mainly from the South to the North and serving as specific ecological corridors for progression by more Southern boreal flora and fauna to Arctic regions, constitute the main expansion. Here specific landscapes with brushwood and wood fragments (willow-shrubs, dwarf birches, poplar, chosenia), and also grasslands of lowland bogs and aggregations of inflated alluvial sands are present.

The role of Arctic bogs, among which such types as coastal salted and deltaic marches, cotton-grass-sedgy, sedgy-dupontia mineral bogs, sedgy hummocky, sphagnum-hypnum knolly, polygonal, bolsterious, and hillocky bogs are widespread, is rather significant. Last years the role of anthropogenic variants of tundra and meadows has also noticeably increased ("greening tundra" processes).

BIODIVERSITY OF THE TERRESTRIAL ARCTIC

This wide variety of ecosystems serves as habitats of unique Arctic overland flora and fauna. By estimations of Academician Yu.I. Chernov [2004], based upon researches and results of Russian specialists in study of flora and fauna, in Arctic regions there are presented approximately 25 000–26 000 species, i.e. about 1,5% of the described

Table 1. Global biodiversity of the Earth and estimation of a share in it of the basic groups of terrestrial biota in regions of Russian Arctic [Global biodiversity, 2000; Chernov, 1999, 2004; Tishkov, 2006, 2009]

World	Phylum	Number of species known to the science: on the Earth/in Arctic regions	Estimation of a share of the Russian Arctic regions biota in the structure of specific taxonomic units, %
Vertebrates	Mammals	4 630/75	1.6
	Birds	9 946/240	2.8
	Reptiles	7 400/1	0.01
	Amphibians	4 950/2	0.04
	Fishes and Cyclostomes	25 000/430	1,72
Invertebrates	Insects	963 000/3300	0.34
Fungi		72 000/3 000	4.2
Plants	Angiosperms	270 000/2 300	0.8
	Lichens	17 000/1 660	10.1
	Bryophytes	16 100/900	5.6
Totally on all groups of organisms		1 750 000/25 000–26 000	1.3–1.4

species of modern Earth biota, but total representation of actually Arctic biota, apparently, should be within the limits of 0,6–0,7% [Chernov, 2004; Tishkov, 2009].

About half of species richness of Arctic biota falls at the share of animals. From 6 up to 7 thousand of them are land species (however in many groups the division on water and land and also on fresh-water and sea species is rather conditional). Half of land animal species are insects, which share constitutes about 16% of all biota of Arctic regions. The relative species variety of animals in Arctic regions is considerably lower, than on the Earth as a whole. The share of animals in world biota as whole, by different estimations, constitutes about 75%, and the share of insects is not less than 50%. In most cases it is possible to explain distinctions in relative variety rather correctly, proceeding from features of biology of corresponding groups of organisms. Yu.I. Chernov [1978, 2002] has showed that in the Arctic biota the share of the groups borrowing rather low evolutionary-phylogenetic level raises. In flora of Arctic regions there are about

2300 species of vascular plants (0,8% of their world variety), 900 of bryophytes (3,6%) and 2000 of lichens (11,7%). The given series of abundance certainly shows the increase of tolerance of primitive forms to thermal climatic pessimum and correspond to our conceptualizations about advantages of tolerant adaptive strategy in high latitudes and about decrease in a share of the most progressive taxonomic units, making a basis of a biodiversity of the Earth, in the Arctic biota [Chernov, 2004]. Also the comparison of relative species wealth of 3 groups of animals, mastered high latitudes most successfully serves as one more telling argument to it. The fauna of insects of Arctic regions makes only 0,3% of this taxonomic unit on a global scale (Table 1), a variety of the fishes obviously less dependent on the climate is about 2,0%, and the diversity of birds, leaving high latitudes in the winter is 2,8% [Chernov, 1995, 1999, 2004, 2003, 2005; Chernov et al., 2000a, 2000b].

Russian researches on typology and zone structure of vegetative cover and animal population, climatic gradients

and climatogenic trends of Arctic regions biodiversity have old practice. But it is necessary to recognize significant ambiguity of treatments by many national and foreign authors of the basic landscape-zonal categories (zone, subzone) and their borders in Northern regions of Russia. The Russian experts (biologists first of all and geographers with some deliberation) consider structure and spatial regularities of Arctic regions biota as result of extraneous position in global trends of biodiversity, as the aggravated expression of global tendencies [Chernov, 1999]. The researches of biodiversity trends relation with latitudinal gradients of climatic heat can be applied in forecasting and modeling of climatic changes influence on biota and ecosystems of Arctic regions.

There are up to 80% of all circumpolar biodiversity in territories and water areas of the Russian sector of Arctic regions. *Therefore the ecological projects directed on studying, preservation and sustainable use of the biodiversity and biological resources in the Russian Arctic regions might be considered as representative for all circumpolar area.*

Last years economic activity extended noticeably here that threatens with essential expansion of the area of disturbed lands and with fragmentation of natural ecosystems and habitats. Negative tendencies in maintenance of traditional activities of the native population of Russian Arctic regions remain unchanged. All this imposes on Russia the special responsibility for performance in the Arctic regions of requirements of the Convention on Biological Diversity, of programs of the Arctic Council and European Union (of "Northern Dimension", for example; Tishkov, 2002).

The species wealth of Arctic regions is distributed on the main taxonomic groups as follows: mushrooms – 3000, algae – 2000, lichens – 1 660, vascular plants – 2300, protozoa – 1500, invertebrates – 13 000. Animals constitute almost 60% of Arctic biota; approximately 6000 of them are terrestrials [Chernov, 2004; Tishkov, 2009]. About the

same variety is characteristic also for sea fauna of the Russian sector of Arctic regions.

The number of mammals' species in all Arctic regions is estimated from 50 up to 75 (nearly 15 of them are cetaceans and pinnipeds). Their number reaches 60 in Russian Arctic regions. The number of birds' species in all Arctic regions is approximately, nearly 200 of them nests in territory of Russia. All fishes of Arctic regions in circumpolar volume is estimated by 430 species. Of them 115 species live in fresh waters, but it is impossible to mark sharp border between sea and fresh-water forms. It is impossible for nonce use to determine precisely the number fishes' species in the Russian Arctic regions with a view to lack of data about distribution of sea forms, but in any case it makes not less than 85% of all Arctic fishes [Chernov, 2004].

Before fixing on the analysis of a situation with an estimation of tendencies of change of biodiversity and prospects of its preservation and preservation of natural terrestrial ecosystems and bio-resources of Russian Arctic regions, we shall realize a referential estimation of their modern condition, relying on our materials and the data published at last years [Andreyashev, Chernova, 1999; Tishkov, 1996, 2004, 2006, 2009; The state of biodiversity ..., 2004; Chernov, 1994, 2004, 2005; Chernov, Matveeva, 2002].

PRESENT-DAY STATE OF NATURAL ECOSYSTEMS AND BIODIVERSITY OF RUSSIAN ARCTIC REGIONS

Polar deserts. The given biome has circumpolar allocation. In Russia it is widespread on islands and archipelagoes of Arctic Ocean (Northern Island of Novaya Zemlya, Franz Josef Land, etc.) Also it is presented fragmentary in the North-East Taimyr Peninsula [Matveeva, 1998]. A landscape variety here is impoverished, owing to a youth of surfaces, extremeness of the climate and, accordingly, poverty of biota structure. Landscapes of uneven-aged

morainic and sea deposits and stony substrata are represented widely. Micro- and nanorelief are formed by stony rings, spots, mineral landfills, plugs. It is marked full domination of sporous plants – weeds, lichens, liverworts (*Hepaticae*) and mosses (*Bryophytes*) in the vegetative cover. They form a thin film of a life with fragments of vascular plants (*Saxifraga*, *Puccinellia*, *Poa*). The local flora of vascular plants (the number of species on 100 km²) makes only 20–30. For example, the flora of Franz Josef Land archipelago entirely located in a zone of polar deserts consists of about 60 species. As of vertebrate animals, the species connected with the sea, such as polar bear (*Ursus maritimus*), polar fox (*Alopex lagopus*), walrus (*Odobenus rosmarus*) and seals, are usual here. Landscapes and biota of this biome are preserved in the Big Arctic Reserve and in federal wildlife refuge Franz Josef Land. In the future there exists prospects of their preservation in projected national park the Russian Arctic (on the northernmost tip of Novaya Zemlya) and in Severnaya Zemlya wildlife refuge.

Arctic tundra. The biom has circumpolar allocation. In the European part of Russia arctic tundra are presented on islands of Arctic Ocean (Southern island of Novaya Zemlya, Kolguev, New Siberian Islands and Severnaya Zemlya, etc.). And in the Asian part of Russia it forms rather narrow strip along coasts of Kara, Laptev, Northeast and Chukchi Seas (Yamal and Taimyr peninsulas, coasts of Yakutia and Chukotka). Here ecosystems of seaside plains with polygonal, spotty and spots-and-knolls tundra, polygonal bogs, and salty marches of deltaic territories are usual. In a vegetation cover the share of vascular plants is significant (dominate *Dryas octopetala*, *D. punctata*, *Cassiope tetragona*, *S. polaris*, cereals, sedges, saxifrages). Lichens and mosses form a circle in 5–10 cm, are preventing from deep thawing of frozen ground. The local flora in the biome works out 70–150 species on 100 km². In structure of vertebrates' fauna the reindeer (*Rangifer tarandus*), polar fox, lemmings (*Lemmus*

sibiricus, *Dicrostonyx torquatus*), geese, ptarmigan (*Lagopus mutus*), numerous species of ducks and graybacks is usual. Last decade there was a tendency of destruction of Arctic tundras assemblages in places of investigation, extraction and transportation of oil and gas – on Kolguev island and Yamal and Gydan peninsulas. Rare and disappearing plants species are numerically insignificant. Walrus, swans (*Cygnus*), white goose (*Chen hyperboreus*), and brants (*Branta*) are most known of rare animals. Biota and ecosystems of arctic tundra are representatively presented in reserves: Big Arctic (on islands and coast of Taimyr Peninsula), Ust Lenski (outflow of Lena River), and Wrangell Island in Chukchi Sea (Table 1).

Subarctic tundra. In structure of landscapes spotty and polygonal tundra, knolly bogs, and shrubs in valleys of tundra rivers prevail. In a vegetation cover bushes (*Betula nana*, *Alnaster fruticosa*, species of *Salix*), dwarfs (*Vaccinium uliginosum*, *V. vitis-idaea*, *Empetrum nigrum*), *Cyperaceae* and *Poaceae* are widely presented. The flora of mosses is exclusively rich (up to 150–200 species in several points). The local flora of vascular plants increases more than in 2 times in comparison with previous biome and makes 250–300 species on 100 km² [Tishkov, 1996]. The fauna of vertebrates increases also in times – up to 70–100 species of birds and about 20–25 species of mammals in several geographical points. Falcons (*Falco rusticolus*, *F. peregrinus*), swans (*Cygnus bewickii*), geese (*Anser erythropus*), and brants (*Rufibrenta ruficollis*), which number in some of regions falls because of conditions of wintering in more southern regions and hunting during the spring period are among rare species of special interest. Biota of subarctic tundra of the European Russia is protected only in Lappish reserve (Kola Peninsula), in the Asian Russia – in Nenets, Taimyr, Putorana (mountain tundra of Taimyr), Ust Lenski reserves, in Bering natural park, and in some federal wildlife refuges (Nenets, Murmansk (tundra), Tuloma, Severozemelski, Pur, Swan, Kunovatski, Nadym, Lower Ob).

MAJOR FACTORS INFLUENCING THE STATE OF TERRESTRIAL BIOTA AND ECOSYSTEMS

Landscapes and biological variety of Arctic regions in comparison with both Western and Central Europe, and Southeast Asia were kept much better. However their active degradation occurs, despite of spot character of anthropogenic infringements, which consequence becomes destruction of soil-vegetation cover, thermo-erosion, fragmentation of habitats of the arctic fauna, replacement of natural vegetation by its derivative forms, decrease in number of rare species, etc. All this occurs on a background of enough deep natural changes, which are consequence of global and regional reorganizations of climate, changes in atmosphere circulation and of World Ocean level, of tectonic movements. All of these also lead to changes in number and distribution of species of Arctic biota, to displaying of its new qualities and regularities of dynamics.

Among the major factors influencing a modern condition of biota and ecosystems of Russian Arctic regions it is possible now to allot:

natural

- global and regional climate change of Arctic regions, expressed in increase of duration of vegetative period (for plants), of nesting period (for birds), of warm season (for invertebrates) and so forth, and leading in some areas to north of forest boundary, to active expansion of several plants', mammals', and birds' species realms, to change of their migration ways, to introduction of alien species and so forth;
- the transformation of climatic conditions for terrestrial biota (growth of climatic anomalies frequency: winter thawing weather; summer freezings; growth of amount of precipitations, including snow; and so forth), caused by changes in circulation of atmosphere and in oceanic

currents, that leads to mass mortality of several populations (for example, of reindeer at formation of an ice crust in the winter or at return of colds at fawning) or, on the contrary, to favorable conditions for opening of Arctic territories by boreal species (for example, of forest tundra and southern tundra by brown bear);

- active neotectonic processes expressed in several cases in modern land raising and formation of its new areas for settling by biota (formation of new, growth and closure of old islands; formation of sea terraces and marsh surfaces; and so forth);

anthropogenic

- global, regional and local environmental pollution – tropospheric transmission, emissions from impact sources, emergency oil pollutions and oil spills, and so forth, capable to transform a vegetative cover and the animal population of several territories, to include polluting substances in food circuits, and to lead to accumulation of pollutants in organisms of the highest order consumers (predatory mammals, birds and fishes, etc.);
- mechanical alterations of a soil-vegetative cover as the result of not restricted transport movement, construction activities, carrying out of geological prospecting, and so forth, leading to ecosystems fragmentation, to formation of semi-natural and artificial habitats and to their settling by undesirable plants;
- destruction of a vegetative cover as the result of domestic deer excessive grazing and infringement of traditional norms and places of grazing;
- poaching and not regulated use of biological resources reducing their stocks, including in borders of ethno-economic areas;
- introduction adventitious species of plants, opening of new habitats by

them, that balks the restoration of initial vegetation; premeditated and undevised introduction of alien species (except for reacclimatization of the musk ox) in Arctic ecosystems, capable to cause regional ecological crisis.

Before the estimation of the role of factors influencing the modern condition of Russian Arctic regions biodiversity, we shall check on some conceptual problems of its stability.

PRINCIPAL PARAMETERS OF ARCTIC BIOTA AND ECOSYSTEMS STABILITY

The problem of biodiversity conservation for Russian Arctic regions with their rather poor biota structure and exclusive “sensitivity” of ecosystems to various anthropogenic influences have the prior value.

First, unlike for ecosystems of more southern regions, the limited set of dominants and large-populated species of plants and animals for Arctic regions, their deeper differentiation on functions in an ecosystem, and weakening due to it of competitive attitudes between species for resources is characteristic. *Destruction of a specie or reduction of its populations' number entails significant reorganization of all food circuits and of ecosystem as a whole.*

Secondly, restoration after natural and anthropogenic violations of soils, permafrost conditions, vegetation, and animal population comes rather long. Here deficiency of local flora and fauna species, capable to participate in ecosystems restoration is observed. Namely for this reason new weed plants insinuate so fast and borrow anthropogenic habitats, and the fauna complex of northern cities and settlements becomes for short term completely synanthropic.

Thirdly, the period of active functioning of Arctic ecosystems in an annual cycle is very small, from 2 to 3 months. Animals-migrants (basically – birds among which there many rare species) spend the most part of an annual cycle outside of Arctic regions. Planning

of actions on preservation and restoration of their number demands association of inter-regional and international efforts – as a matter of fact, the centralized and joint actions with other northern countries.

According to it, among most acute problems of the estimation of stability of terrestrial biodiversity and natural ecosystems during ecosystem exploitation of Russian Arctic regions it is possible to detach:

1. Rather weak level of exploration maturity of Russian Arctic regions biodiversity. Inventory, mapping, and estimations of a modern condition of Arctic plants and animals' populations are carried out far from completely. Unfortunately, our understanding about the vegetative cover, natural ecosystems and landscapes of the majority of regions of Russian Arctic is limited to areas with the fully formed infrastructure of industrial development and directly depends on their transport availability. The flora of the Russian Arctic regions has appeared most investigated – the issuing of 10-volume “Arctic flora of the USSR” is completed in 1987, where floristic reports on Bolshezemelskaya tundra and Yamal, Taimyr peninsulas, Wrangell island, Franz Josef Land, Putorana mountains, etc. are published. The fauna of several Arctic regions is studied with relative inferiority, especially concerning invertebrates. As a result, development of many regions of Arctic regions begins earlier, than we can receive full data on their biodiversity.

2. Spot and strip-spot economic development of Arctic regions through active transformation of the vegetative cover passes to a phase of continuous-frontal development at which fragmentation, and in some cases, full ecosystem destruction takes place. New anthropogenic habitats appear suitable for less than half of species of native flora and for isolated individual representatives of fauna. Biota and ecosystems of Kola Peninsula, Murmansk Coast and Kandalaksha Bay, low reach of Pechora, Bolshezemelskaya tundra, Gulf of Ob, Yamal and Gydan peninsulas,

Ob-Taz and Pyasina-Yenisei watershed areas, Norilsk surroundings, areas of diamond mining development in northern Yakutia, Chukchi tundra have turned out to be under the threat of transformation and even disappearance. Last decades here the centers of economic development have become essentially larger, their merging is observed in some places, initially due to communications and their arrangement, and then due to expansion of industrial zones and settlements themselves.

3. The transitive national economy, transfer of leadership in nature protection activity in the North from the state to managing subjects, some separatism of northern territories, and also growth of unemployment and poverty of the population of the separate regions which have been not borrowed in extracting branches, have led to that the state control over a biota condition and biological resources using become loose in Russian Arctic regions. Such kinds of infringements, as pollution of atmosphere, reservoirs and soils; transport irregularities; uncontrolled above-level expansion of the areas of land allotments for the construction of settlements, industrial targets and linear constructions; poaching have got extensive development.

4. Regulatory and legal framework and government administration of protection of flora and fauna and of use of biological resources of Russian Arctic regions *do not meet the requirements of market economy* as the main expenditures connected with decrease in "the negative rent of position" in natural, financial (including rental) and human capitals in Arctic regions still the state bears (these are features of northern policy of exploitation of natural resources). Subjects of management have appeared in different (often contrast) conditions concerning reproduction of resources, operational expenses (including nature protection), social charges, and so forth. Forces of smoothing of this factitious differentiation practically are absent for the state. Many-subjectness of resource using in Russian Arctic regions has

not led to expected increase of efficiency of managing. That affects the ecosystem condition.

5. Arctic biota is especially sensitive to chemical pollution that is determined by prevalence of sporous plants on biomass and species diversity. The algae, lichens, liverworts and mosses have no developed conducting system, so they accumulate non-selectively polluting substances. In this feature, the polar deserts, tundra and forest-tundra have similarity to sphagnum bogs. The share of sporous plants in production of phytomass in these ecosystems may reach 70–90%. Mosses and lichens drop out specifically first from ecosystems in zones of industrial emissions influence and along the routs of caterpillar transport unregulated movement. This causes marked practically with nobody pauperization of floristic variety and disappearance of unique ecosystems with domination of lichens. Food circuits of Arctic regions are predisposed to intensive accumulation of polluting substances at tops of a trophic pyramid – at predatory birds, mammals and fishes. In conditions when it is evidenced in Arctic regions not only local pollution, but also global fall-out of polluting substances, such feature of the biota strengthens negative consequences for ecosystems themselves and for their food circuits, regularly ending with human beings.

The preservation of Arctic biota and ecosystems is of especially great significance for the following reasons. *First*, Arctic ecosystems are greatly fragile and extremely vulnerable towards anthropogenic influence. *Secondly*, ecosystems of Arctic zone have no "withdrawal routes" in case of sharp intra-centennial warming, as the zone gradient is broken by Ocean, and refugia character is not characteristic for tundra distribution, so they may lose irreversibly a part of biota. *Thirdly*, changes in terrestrial Arctic ecosystems themselves may make, in turn, profound effect on global processes, such as atmospheric and oceanic circulation, global warming, the ozone layer condition,

and others. *Fourthly*, seaside character of Arctic ecosystems organization directs them towards transit functioning and dependence on carrying of substance and energy between land and ocean, and high-altitude position defines presence of sharp and disproportionate seasonality of functioning (the greater period of year they function without summery biota). *Fifthly*, for Arctic regions as a whole it is peculiar exclusive synergism of influences of natural and anthropogenic changes of the environment, capable to cause “cascade” effect and strengthening of consequences on area, on variety of transformed components, and on the depth of changes. *Sixthly*, in more southern regions some of anthropogenic factors operating in Arctic regions have natural analogues (fires, windfall, water erosion, intensive ranging and so forth) and, accordingly, mechanisms of stability to them of zonal ecosystems, while Arctic ecosystems are practically deprived of it.

It is possible to consider as the major integrated causes defining stability and instability of Arctic ecosystems the following:

1. The low level of biodiversity, restrictions in “changeability” of plants and animals species, their weak resistibility to “new” forms of influences (anthropogenic).
2. Exclusive vulnerability and susceptibility of ecosystems to the chemical pollution, caused by prevalence in the biota structure of sporous plants (algae, lichens, mosses) non-selectively adsorbing polluting substances, and also the low temperatures hindering the fast autopurification.
3. Sharp seasonality of functioning, brevity of the vegetative period, prevalence of migrating species (seals, walrus, whales, polar bear, polar fox, reindeer; sea, water and predatory birds) in structure of the animal population, suffering negative influence on all way of migration and wintering.
4. Low rates of biota and soils self-restoration after infringements (a patch of

tundra is restored several hundreds years after mechanical destruction), connected with deficiency of plants species of pioneer stages, the slowed processes of soil formation, low availability of biogenic substances (nitrogen, phosphorus, potassium, etc.) to plants in cold conditions.

5. Presence of permafrost, their “mobility” at transformation, growth of thermo-erosion, solifluction and other cryogenic processes involving new areas of ground after a local infringement of soil-vegetative cover integrity.
6. Openness of broken ecosystems and new anthropogenic habitats for colonization of alien species. Native species possess low competitiveness on these habitats, therefore across all Arctic regions anthropogenic tundra-meadow ecosystems with prevalence of strangers are formed, which restoration up to the natural condition in foreseeable prospect is of low probability.

All the listed integrated parameters of stability/instability of Arctic ecosystems have quantitative expressions, may become involved into models of modern climatic and anthropogenic dynamics of Arctic ecosystems, and, as the main thing, should be considered during development of strategy and system of actions on environment protection and sustainable development of the region.

BIODIVERSITY CONSERVATION OF THE RUSSIAN ARCTIC REGIONS: POSITIVE EXPERIENCE AND ACTUAL PROBLEMS

Protection of rare ecosystems and rare species of Arctic regions. Human activity in Arctic regions, if not regulated, is capable to transform in a short term the high living circumpolar belt into a monotonous “gray-brown technogenic desert” as it is observed around of Norilsk, Monchegorsk, etc. But whilst in the majority of regions this

process has not accepted wide scales and there is an opportunity for stabilization of conditions. At the same time, the problem of preservation *rare and unique ecosystems of Arctic regions* is faced to us rather sharply. These ecosystems form the basis of cenofund and serve as habitats for a greater part of biota. Occupying on the area no more than 5–10%, these ecosystems bear the major load on preservation of biodiversity high level in regions, remaining some kind of refuges for the bulk of plants and animals. Let us list the basic types of rare and unique Arctic ecosystems, requiring in special territorial protection:

1. Meadows inside polar deserts and Arctic tundra on islands and along the coast of Northern Ocean. They are formed in conditions of a favorable exposition on naturally rich zoogenic earths. Ecosystems of Silent Bay on Franz Josef Land (coastal sites of the south of Severnaya Zemlya may serve here as examples). On Novaya Zemlya, Kolguev island, the western coast of Yamal, along northern coast of Gulf of Ob, in vicinities of polar stations and in other regions these ecosystems have appeared broken.

2. Ornithogenic meadows on decline under the bird colonies of High Arctic regions. In conditions of sufficiency of a nitric and phosphoric feed in tundras and in stony habitats rich in herbs grass aggregations are formed, which serve as a refuge for many more southern plants and animals species. At the same time after the termination of existence of the rookeries these meadows disappear within several years. Therefore the basic problem of their preservation is protection of sea birds colonies. Literally in last 40–50 years there was an essential pauperization of structure and disappearance of many birds' colonies on islands of Murman, on Novaya Zemlya, on other islands and on Northern Ocean coast. Transformation of high latitudes eutrophic meadow vegetation and loss of some kinds from regional flora became a consequence of it.

3. Marches and seaside saline meadows. These rather small on the occupied area ecosystems have great value in formation of a coastal strip landscapes. Marches represent pioneer stages of Arctic ecosystems halophytic succession, stop erosive processes at sea coast and, as the main thing, serve as places of a congestion of migrating birds: geese, eiders, brants, ducks, and graybacks. Full degradation of these экосистем in areas of economic development and near polar settlements stimulates processes of coast destruction.

4. Vegetative communities of original bold shores of northern rivers ("Yars"). They are various according to structure, but they are united by position in a relief, easing of freeze-and-thaw processes influence, presence of light grounds, and favorable mode of snow accumulation. Shrubberies, brushwoods, tundra meadows, fragments of tundra vegetation on sites where the snow is practically blown off in the winter make here a cover basis. For many of Arctic regions there is the highest level of biodiversity in these habitats. Active animal migrations and the facts of "southern species" penetration to northern latitudes during their areal expansion are marked here. Long years the rivers served as practically unique transport arteries for the development of Arctic regions, but the rivers bold shores kept their positions. With technological expansion, river transport enlargement and intensive use of winter roads along the rivers it became obvious, that these unique ecosystems are vulnerable to transport infringements, wave-beating and to any mechanical damages of the vegetative cover. Now there are in especially dangerous condition some coastal ecosystems of Pechora, Usa and their inflows, the rivers of Lower Ob and Southern Yamal, Ob-Taz interfluve, western Taimyr (Pyasina, first of all), Yana, Indigirka, Kolyma, etc. The sharpest forms of influence on these ecosystems has become: transportation of large barges during the spring high water, forcing of water barriers by caterpillar transport, a lining of winter roads along-shore ignoring erosion-hazard, river

crossing by gas and oil pipelines, extraction of gravel in tundra rivers. Scales of these infringements and their consequences for the biodiversity are so great, that demand special discussion.

5. Inundated scrubs. They are the important element of tundras landscape. Historically, they were intensively exploited by local population: cut down on fuel and for other purposes. In a number of regions inundated scrubs have disappeared (Taimyr peninsula, Northern Yakutia, Chukotka), and in some others they were kept only as relicts of the forest-tundra landscape.

6. Inundated woods and brushwoods of tundra zone. Inundated willow-shrubs (poplar stands and chosenia woods in the East) come highly into Arctic along Pechora, rivers of lower reaches of Ob and Yenisei, Pyasina, Yana, Kolyma, Indigirka, Anadyr and Amguema. They played the important role in the local population life as suppliers of fuel and building materials, as shelter places during seasonal migrations for indigenous population. Practically all survived areas of inundated woods and brushwoods demand preservation and special regulations on use.

7. Northern bound forests. Among these also relict woodland ecosystems in the zone of relative treelessness survived after destruction by humans are. Practically along the entire tundra zone belt from Kola Peninsula up to Chukotka the strip of near-the-tundra woods and properly forest-tundra are allocated. On Northeast they are presented by open forests of cold mountains of Cherskyi Range, Verkhoyskiy range, etc. But everywhere a role of northern exclave of woodlands in landscape, in formation of microclimatic conditions, in stabilization of freeze-and-thaw actions, and, certainly, in a life of northern people was and remains rather important. They have lost about half of area in the course of economic development of the North during last centuries. Now they occupy nearby 450 thousand km² (earlier, by our estimations, nearby 1 million km²)

and are fallen to the forests of the first group according to the Forestry Code of 2001. However the legally provided measures are obviously not enough for preservation of this unique circumpolar strip of ecosystems. On Kola Peninsula survived islets of birch crook forest in a valley of Ponoy River and spruce forests on Turiy Cape draw special attention. On the European North there are many unique wood sites on northern bound on the rivers of Cheshskaya Bay, on Timan, in lower reaches of Pechora. Southern Yamal, Taz and south of Gydan peninsulas constitute, for all intents and purposes, a strip of island near-tundra woods, which preservation and restoration is the exclusive mean of stabilization of environmental situation in the region. Creation on Taimyr of sole in the country conservancy areas in forest-tundra (branches of Tajmyrsky Reserve: Ary-Mas and Lukun) does not solve the problem of woods conservation on their northern bound. On the north of Yakutia (unique Tit-Ary wood-island in lower reaches of Lena and a grove on Uhunku river) and on Chukotka grazing, fires and cutting have played a great role in transformations of larch forests and other woods. Now here islets of larch, poplar, chosenia, Cajander birch are presented, and there are no territories, where current conditions of protection would allow these woods to be kept and restored with confidence. The lack of developed system of protected natural territories along the strip of near-tundra woods is the main cause of their proceeding destruction in areas of new development in Timan-Pechora region, on Southern Yamal, in Ob-Taz interfluve, etc.

8. Relic steppes and steppificated extents within Yakutiya and Chukotka sectors of Arctic. This specific phenomenon of Russian Arctic Regions significantly enriches its biodiversity due to a lot of steppe forms of plants (*Stipa*, *Festuca*, *Artemisia* and so forth). These ecosystems are essentially transformed in connection with their involving to agricultural use, grazing of reindeers and frequent fires. Examples of their active territorial protection are not present.

9. Unique Arctic ecosystems, formed on outputs of limestone and stony substrata.

Usually here biodiversity increases because here is presented a lot stenotopic plants species. Each of such sites demands attention and preservation. As well as for typical relic communities, opportunities of restoration for calciphilous and petrophilous biomes of Arctic regions practically not present. Therefore, it is recommended duly inventory of these ecosystems and their inclusion into the system of protected natural territories.

10. Inundated and deltaic complexes of the Arctic rivers generated in conditions of thaw zones (absence of a frozen ground), with well warmed-up shallow reservoirs, fragments of rich in herbs grass meadow vegetation

and scrublands. These habitats are optimal for nesting of waterfowls, including rare and disappearing, spawning of salmon and whitefishes.

11. Ecosystems of mountain and highlands on tundra plains, which differ in tessellation of habitats, in presence of relic and endemic flora and fauna, in fragments of extrazonal vegetation on southern and northern slopes, and in elements of altitudinal zonality. Often here unique conditions are created for snow accumulation and, accordingly, for encroachment of vegetation of more southern natural zones. Territorial protection of such sites in Malozemelskaya and Bolshzemelskaya tundra, on Kolguev Island, on Yamal, Gydan and Taimyr peninsulas,

Table 2. The parameters of biodiversity of polar deserts, tundra and forest-tundra on nature protected areas of Russian Arctic [Tishkov, 2006], number of species*

NN	Reserves and national parks*	Thousandha	Year of creation	Number of species			
				Vascular plants	Birds total	Birds nesting	Mammals
1	Bolshoi arctichesky	4 169,2	1993	189	124	55	16
2	Gydansky	878,1	1996	180	63	57	15
3	Kandalakshsky	70,5	1932	667	240	134	26
4	Koryaksky	327,2	1995	226	153	97	28
5	Kronozky biosphere	1 142,1	1934	810	216	121	32
6	Laplandsky biosphere	278,4	1930	607	180	118	31
7	Magadansky	883,8	1982	727	210	170	41
8	Nenetsky	313,4	1997	130			
9	Vrangel island	2 225,7	1976	376	148	51	8
10	Pasvik	14,7	1992	350	122	75	23
11	Putoransky	1 887,3	1988	398	140	92	34
12	Taimyrsky biosphere	1 781,9	1979	429	110	74	21
13	Ust'-Lensky	1 433,0	1985	402	109	60	27
14	Franz-Joseph Land (wildlife refuge)	4 200,0	1994	60	38	17	2
15	Russian Arctic*	1 426,0	2009	120–150	About 40	About 20	5

* For some reserves the preliminary data of inventory are presented. All information for reserves corrected on ["Modern state of biodiversity ...", 2003].

in tundra of the Siberian sector, and on Chukotka allows keeping the regional centers of higher variety of species and communities.

It is possible to consider as one of biodiversity protection effectiveness index the presence in regions of rare species of plants and animals. In comparison with other natural zones polar deserts, tundras, forest-tundra and northern taiga do not differ in great wealth of rare and endemic species. At the same time, Red books of northern regions include rather big number of species (Table 2).

The Program for the Conservation of Arctic Flora and Fauna of Arctic Council (CAFF) has published the “*Atlas of rare endemic vascular plants of the Arctic*” [Talbot a.o., 1999], in which the annotated list 96 rare and endemic plants of circumpolar Arctic and the description of places of their growth is included. It makes conspicuous, that the significant amount of these species is presented in the Russian Arctic regions, mainly in 4 large regions: Polar Urals mountains; Taimyr peninsula; delta of Lena and its vicinity; Chukotka peninsula and Wrangell Island. The last is in the lead on number of included in the list endemic species, 24. The delta of Lena and its adjacencies are presented in the specified Atlas only by 5 species, but have prospects to expand this list after more detailed researches. That fact puts us on guard that almost half of species mentioned in the Atlas, 47%, practically are not protected, their populations are not presented on Special Protected Natural Areas (SPNA) of any level. 23% more of these kinds are protected partially that is are presented on SPNA of regional and local level. And only 30% the circumpolar list of rare and endemic plants are presented by their populations on SPNA of federal level and are protectively conserved. It is the international aspect of rare species of the Arctic plants protection. It was being developed for long years by Professor B.A. Yurtsev, including within the framework of international “Panarctic flora” project.

The other aspect of problems of conservation of flora in Arctic regions is the conservation of rare and requiring protection plants of Arctic species at national level [see: Gorbatovsky, 2003]. There are about 20 have filled up this list in the new Red Book of plants [2005]. On the diversity the east sector forges ahead: in Magadan Oblast and Chukotka there are 12 of red book species, 5 on Commander Islands, 2 in Yakutia, 3 on Kola peninsula, and 3 species with a wide area. Majority of them are endemics and relicts. One specie (*Cousinia Kuzenovii*), apparently, has disappeared. In reserves only 6 kinds are kept (3 – in Kandalakshsky reserve, 2 – on Wrangell Island, 1 – in Kronotsky reserve).

The list of circumpolar territories rare species, prepared within the framework of the international program of Conservation of Arctic Flora and Fauna is published [*Conservation Arctic Flora and Fauna, 2002*].

Generally, for the decision of problems of Russian Arctic regions flora patronizing protection it is possible to formulate priority directions on the prospect:

- completion of inventory of flora of all Russian Arctic and its separate regions, especially for sporous plants;
- carrying out of an estimation of degradation degree of the flora of regions of economic development and revelation of tendencies of its structure change;
- expansion of rare and disappearing plants representation on available protected natural areas of various status;
- creation of new protected natural areas in places of mass growth rare, endemic and relic species;
- issuing of scientific and popular reports on flora of Arctic and its separate regions and on problems of its preservation;
- carrying out of large-scale actions on ecological restoration of broken

ecosystems with use of local planting material;

- creation of “nurseries of wild flora” system (or *Wild flowers farms*) for regional banks of rare species and manufacturing of transplant for ecological restoration of broken tundra ecosystems.

THE PRACTICE OF TERRITORIAL CONSERVATION OF TERRESTRIAL BIOTA AND ECOSYSTEMS IN RUSSIAN ARCTIC

The detailed information about terrestrial biodiversity conservation in nature protected areas of Russian Arctic is presented in Table 2.

Presented above information generalizes data about actions on preservation of terrestrial biodiversity and ecosystems of Russian Arctic regions (creation of federal and regional forms of SPNA, development of patronizing protection of rare species) and shows also some organization faults of its territorial forms – very low representation of biological and landscape diversity on SPNA, shortaging scope of rare species on SPNA, relativele low size of arctic SPNA for effectivelly conservation of migratory animals a.o.

Organization of reserves and other kinds of protected areas is the one only form of biodiversity conservation, which was rather intensively developed during last decades in the territory of Russian Arctic regions (Table 2).

Now formally there is a network of 15 reserves and national parks and federal wildlife refuge “Franz Josef Land” in Russian Arctic regions. They are fallen to special protected natural areas of the 1st category on the classification of the International Union for Conservation of Nature and Nature Resources (IUCN). Their total area makes more than 15 million in hectares. A total area of Arctic and sub-Arctic SPNA is nearby 30 million in hectares. It is approximately 5% of all Russian Arctic regions territory in borders of the Arctic Council programs.

The network of organized and planned SPNA covers all of core key landscapes of the North, including ecotone, typical zonal, island, continental, mountain, and deltaic ones. However the density of SPNA in different regions is rather various. So, on Kola Peninsula there are 6 of them. In East-European, West- and Central-Siberian sectors there exists 12 created and being organized conservation areas. However in all huge Arctic territory of Eastern Siberia there are only 4 operating and few planned SPNA.

Despite of rather big number of special protected areas, it is not enough of all of them from the point of view of modern problems of biodiversity conservation. Now in the Arctic regions of Russia the share special protected areas makes from 2 up to 8%. Even on Kola Peninsula where there are some reserves, they occupy only 3% of territory, 5% on Taimyr, 8% in Putorana, and only 1,5% on Kolyma Range. Meanwhile in Arctic regions where the summer population of birds and mammals is defined by success of the seasonal migrations, protected territories should borrow not less than 20–40% of the area, be representative concerning all taxonomic and landscape variety of the given physiographic province at all levels of its differentiation.

So, on the American continent SPNA of Alaska make about 55% of the area. Greenland is the one, world's largest national park. The archipelago Svalbard (Spitsbergen) more than on 50% is presented by national parks and other forms of SPNA.

CONCLUSION

The situation in tundra areas of Northeast Siberia, including on Chukotka, shows in relief, that reserve management and studies in our Arctic regions as a matter of fact is in embryo, and its prospects are not clear [Tishkov, 2006]. The region is unique concerning biogeographical attitude, not only due to relic features of biota, but also owing to “condensation” of modern localities borders for many species of Eurasian and

American distribution. Unique botanical objects: sites of enhanced species wealth; habitats of straight endemic plant forms; relic vegetative communities, tundra steppes in particular, are widely presented here. Meanwhile there is only one functioning large reserve, "Wrangell Island", and somewhat regional SPNA in this region, comparable with all European part of Russia on the area. The organization of several large reserves is necessary for preservation of unique variety of flora of this region with a strict regime of protection.

It is necessary to recognize also not less actual the expansion of actions on ecological restoration of broken vegetative cover, development of system of native flora nurseries for sowing and planting materials for rehabilitation of Arctic broken earths. Rather perspective for Arctic regions can become the introduction of the concept of the territories reservation for development of the SPNA system.

Concerning omissions in practice of territorial protection of Arctic biota and ecosystems let us note the following:

1. It is necessary to conduct large-scale reservation of the areas in the Arctic regions for creation of different SPNA forms as a preventive and compensatory measure during the new territories development. Their share should make, apparently, not less than 20–30% from the area of the Arctic subjects of the Russian Federation. It is desirable to establish on them the special managing regime to exclude ecologically dangerous forms of economic activities. At the announcement on a legislative basis of all Russian Arctic regions as "the zone of a special by ecological criteria managing regime" the necessity in so large-scale reserving of Arctic ecosystems disappears.
2. The analysis of operating in Russian Arctic regions SPNA system has shown the presence of many lacks and low

efficiency concerning territorial protection of biodiversity and ecosystems and omissions concerning representativity of operating Arctic SPNA system of Russia. It is on short notice necessary the creation of reserves in following regions: on Belomorsk coast of Kola Peninsula, on Kanin Peninsula in places of waterfowl congestion, on Kolguev Island, on Novaya Zemlya (Gulfs of Bezmyannaya, Arkhangelsk and Gribovaya, Goose Earth Peninsula), in Polar Urals Mountains, on Middle and South Yamal, at the Arctic coast between delta of Lena and delta of Kolyma, on Novosibirsk Islands, and on Chukchi Peninsula.

The present conditions in development Arctic SPNA (low representation, weak efficiency in preservation of biota, absence of eco-tourism prospects), unfortunately, cannot be solved by pure mechanical increment of quantity and area of SPNA included in plans of perspective development of federal network of SPNA. Creation in all Russian Arctic regions large national parks – "Russian Arctic" (2009) and "Beringia" (in near future) is obviously not enough for becoming in this region of mass high-latitude extreme, ecologic-cognitive and cruise tourism as it is developed in North American Arctic regions and on Spitsbergen. Absence in many large regions of reserves as base points for ecological monitoring of biota status in Arctic does not still allow to judge about natural and anthropogenic trends in the dynamics of terrestrial biota. Wide development of poaching and real decrease in stocks of resources of terrestrial fauna in a number of large areas of Arctic is connected in many respects with absence of a rational network of wildlife refuges, keeping populations of commercial fauna. As a matter of fact, has not been downright created any territory of traditional wildlife management which could solve not only ethno-cultural, but also ecological problems, including on preservation terrestrial Arctic biota under the conditions of traditional managing of Northern native minorities. ■

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