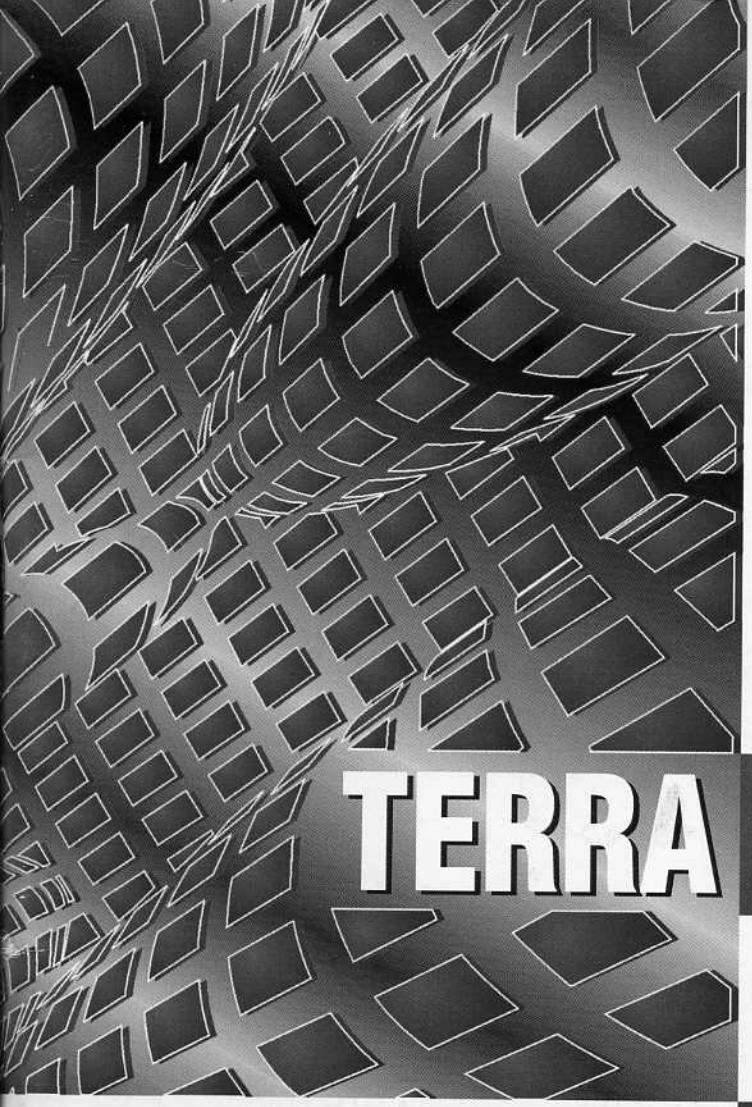

STU

TERRA SPECTRA

Central European Journal of Spatial and Landscape Planning

2 2009

SPECTRA
Centre of Excellence

Alexander Khoroshev
Anna Koshcheeva

LANDSCAPE ECOLOGICAL APPROACH TO HIERARCHICAL SPATIAL PLANNING

Planning human activity in a landscape requires adaptation to natural heterogeneity as well as stakeholders' needs. Severe ecological restrictions and penalties should not be considered the only possible instruments to make the behaviour of stakeholders more environmentally friendly. Hierarchical landscape planning is an effective tool to regulate spatial and temporal organization of land use. Understanding the role of each landscape unit in functioning of the higher-order one is critical to distribute activities within and among landscapes, river basins and patches. Lateral interactions between landscape units are dramatically underestimated. Landscape ecology is expected to work out effective criteria for assessment of this kind of linkages. We should elaborate methods of how to compensate loss of ecological functions in any landscape unit by correct management of neighbouring or even distant unit connected by matter and energy flows. Rational distribution of human activity in time could enable to avoid simple ecological prohibitions. We provide examples from case studies of forest and recreation management in Russia, that illustrate opportunities for hierarchical spatial planning needed for adaptive management using a landscape approach.

Introduction

The landscape planning deals with large heterogeneous territories. Heterogeneity is both the cause and the condition for diversity of land use opportunities. Moreover, uniformity of land use practice is in most cases harmful for landscape, since its units differ in provided ecosystem services, resilience, and sensitivity. Planning human activity in a landscape requires adaptation to natural heterogeneity as well as stakeholders' needs and desires. Multifunctional landscape planning is gaining more and more support (Brandt et al., 2000). Unavoidable conflicts of interests require looking for the best ways for adapting land use to landscape heterogeneity (Haines-Young and Potschin, 2000; Nieschulze, 2003; Bettinger et al., 2005; Musio et al., 2007; Dyakonov et al., 2007). The common challenge in land use planning is contradiction between regional priorities and local land use conditions (Perera et al., 2007). Often the roots of the problem are traced in disagreement of administrative borders with natural boundaries especially with those related to river basins (Saunders, Briggs, 2002; Kazmierski et al., 2004). Land use priorities and decisions are the products of complex interaction of factors acting at different hierarchical levels. Hierarchical approach to landscape planning is dictated by hierarchical organization of nature. Forestry, agriculture, recreation have a number of requirements for nature conditions which involve spatial interaction between landscape units. On the other hand, nature imposes restrictions on opportunities for land use. Evaluation of opportunities depends both on own properties of landscape unit and its functional role in broader landscape, basin and regional context. Hence, hierarchical geographical analysis is needed to make correct assessments (Wickham et al., 2000; Hrnčiarova and Izakovičova, 2000; Neave, Neave, 2005).

Our research focuses on review of several landscape-ecological and geographical concepts that afford to make correct environmentally friendly and economically effective land use decisions. Case studies in forest regions of Russia have provided material for elaborating methods for regulation of spatial and temporal organization of land use. We argue that rational distribution of human activity in time and space could ensure a kind of trade-off between strict ecological prohibitions and stakeholders' interests. Below we analyze opportunities and demands for landscape planning on the levels of region, river basin, landscape and catena.

Regional geographical analysis

Regional scale of landscape planning provides preliminary framework for choosing land use priorities. Assessment of landscape value requires examining wide geographical context. It means that a landscape unit with unique or rare attributes should be preserved for the sake of landscape and biological diversity in the whole region. Landscape rarity can result either from unique combination of geographical factors or from palaeogeographical history or from vast anthropogenic or natural disturbances. The geographical analysis aimed at assessment of degree of landscape rarity relies upon a set of thematic maps, topographic materials, remote sensing data and field investigation. Huge amount of work involves landscape classification. In Russia usually genesis-based principle of landscape classification worked out by N.A.Solnetsev (1948) and V.A.Nikolaev (1979) is applied. It assumes priority of geomorphologic and geologic attributes at higher levels of classification, while plant cover, soil attributes and anthropogenic disturbance are considered at the lower levels.

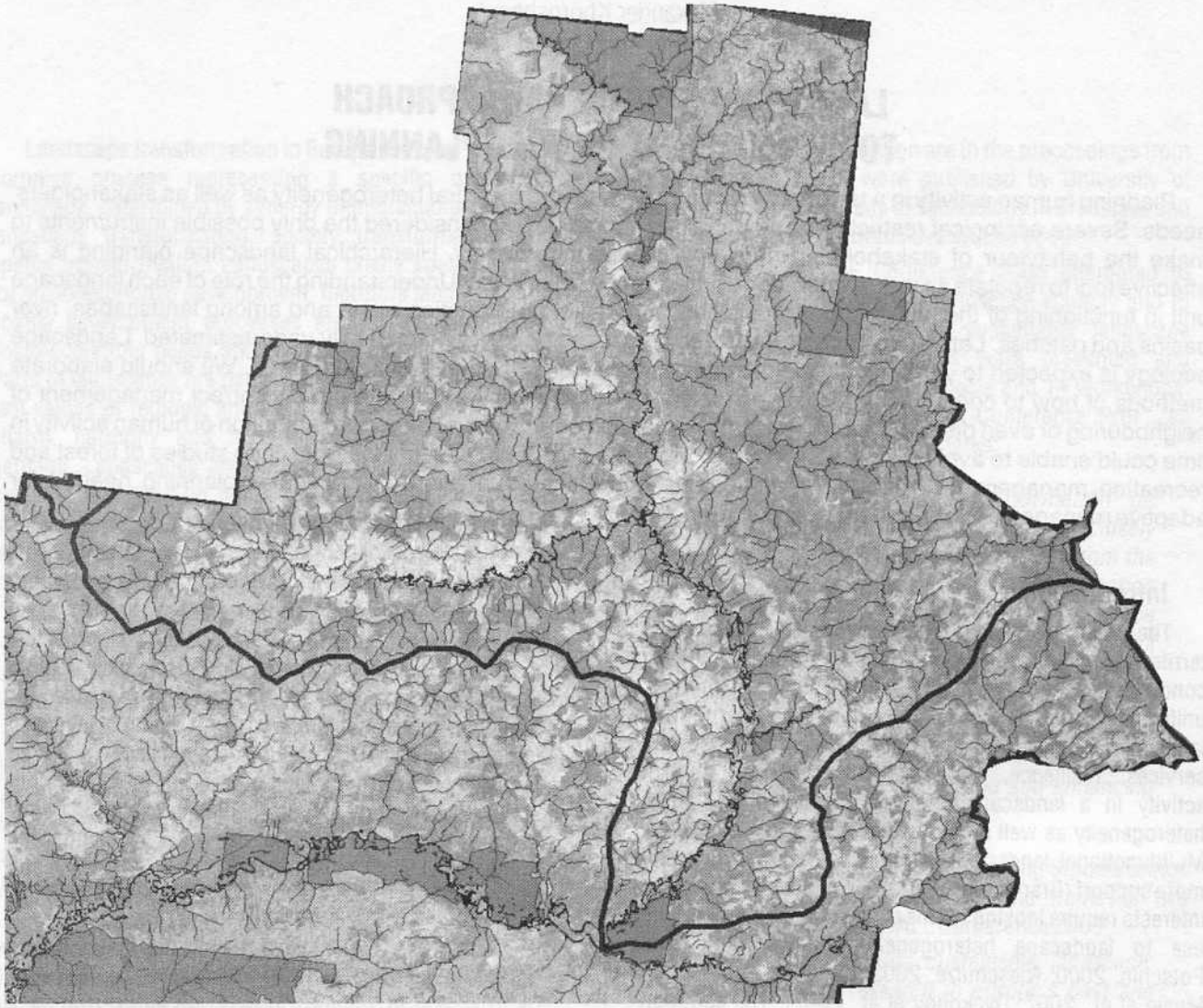

Fig. 1: ***Unique sandy dune landscape of the Curonian Spit*** *(photo by A.Khoroshev)*

The example as follows illustrates anthropogenically induced rarity. In the Kostroma southern taiga region intact spruce and fir-tree stands can be assessed as rare units despite their zonal nature since concentrated harvesting in 1960-1980s resulted in present-day dominance of secondary small-leaved forests. Special restriction measures are now required in forestry planning to protect zonal boreal species having refuges in zonal taiga stands. At the same time pine forests, also typical for the southern taiga in sandy habitats, do not require severe restrictions since recovery succession do not include stages of dominance of different tree species. Hence, pine-oriented plant and animal species are subject to much less threat as compared to spruce forests. It should be noted that restrictions in most cases can be temporal and last for several decades until recovery of zonal communities embraces vast areas.

Natural rarity of landscape units can be related to a number of factors. Below we show the approach to rarity assessment on the example of the Curonian Spit. The Curonian Spit is a narrow sandy strip that stretches north-eastward between the south-eastern Baltic Sea and the Curonian Lagoon. Approximately half of the Spit by length is located within Russia, the other part within Lithuania. The eolian sandy landscape is covered mainly by planted pine forests (Pinus silvestris – 53.6 %, Pinus mugo – 6.4 %) with patches of alder (Alnus glutinosa – 17.5 %), spruce and broad-leaved forests. Since 2000, the Curonian Spit has been on the UNESCO's World Heritage List under cultural criteria as „an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture, or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change".

For Russia sandy landscape of combined marine and eolian genesis on the Curonian Spit is assessed as unique though some similar landscapes occur within the Baltic region as a whole (Fig. 1). At the national level it gained status of Nature Protected Area (NPA) as the National Park. Since preservation of biodiversity is one of the principal

objectives for the National Park, typical and rare landscape units were identified within the landscape of the Spit. Most area is covered by planted pine forests with dominance either of Pinus silvestris or Pinus mugo. However, the occurrence of morainic loams in the small central section of the Park is the sufficient reason for delineating functional zone of strict protection since it is the best habitat for broad-leaved trees (oak, hornbeam, maple, lime, elm, ash-tree) and accompanying herbs and shrubs. The mesophytic meadow and oligotrophic bog require also protection due to their uniqueness within the park despite frequent occurrence at the East Baltic coast in general.

Relict landscape units are subject to strict protection at any case. Almost everywhere their recovery after disturbance is impossible. Legal opportunities for protection vary from establishment of NPAs to status of High Conservation Value Forests or Special Protected Forest Sites, the latter being statutory formality in the Forest Code of Russian Federation. The Rhododendron caucasicum communities in the alpine belt of the Central Caucasus are the example of relict Neogene flora subject to protection in the Prielbrusie National Park. In the granite low mountains of the Central Kazakhstan pine forests are rather widely spread, but protection status is highly needed for all of them due to impossibility of recovery after disturbance in present-day climatic conditions. The latter are much more arid than in the Pleistocene pluvial epochs few millennia ago, that had favoured penetration of boreal forests into regions now occupied by steppe and even semi-desert zones. Contrast of pine forests in the Kazakhstan highlands with zonal arid conditions dictates high priority for recreation activities and water-protective functions as compared to logging.

Compensation principle in landscape planning

Application of compensation principle is intended to provide balance of matter input and output within vast geographical unit such as landscape district, river basin or single landscape. The principle can be formulated as follows: loss of ecological functions or habitats in certain part of the region should be compensated by preservation of similar unit in the other part linked to the first one by matter and energy fluxes. The most usual kinds of matter transfer are surface runoff, groundwater flows, animals' migration, seed dispersal by winds and birds, geomorphologic processes (e.g. eolian transportation, landslides, mudflows etc.).

At the local scale compensation function is realized via construction or preservation of water protection and soil protection zones, preservation of small biotopes among arable lands etc. These applications of compensation principle are required by legal regulations in most countries. In Russia necessary width of protection zones is regulated by Forest Code, Water Code, and Land Code.

At the landscape and basin scales the need for ecological compensation is often underestimated and not regulated by legal instruments. Anthropogenic loads can result either in direct and rapid destruction of geosystem structure (e.g. forest harvesting, construction building, ploughing) or indirect and gradual changes (e.g. forest recreation, hunting).

Let us consider the example of desired spatial organization of vast territories subject to forest harvesting and agriculture. During the realization of the project of ecological network for the Kostroma region (total area 60.200 km^2) in Russia ("Kostroma-EcoNet") much attention was paid to location of natural protected areas (NPAs) with restrictions for cutting among deforested areas (Khoroshev et al., 2005, 2008). Since the fertility of taiga podzolic soils is not very high, quite a few areas in the Kostroma region can be characterized by concentration of arable lands. Almost all of them are located within erosional plains with rugged terrain where close to surface carbonate Mezozoic rocks and soil-forming loess-like loams provide rich mineral nutrition. One of such areas is located in the lower reaches of the Vokhma river (right tributary of the Vetluga) basin (Fig. 2). High solid matter and fertilizers input to the river from cultivated fields as well as increase of surface runoff can cause critical changes in the river ecosystem. At the same time the upper reaches of the Vokhma basin are used for extensive forest harvesting which contributes to undesirable changes in water regime and solid matter input. To compensate ecological losses in the basin we included into the ecological network project several natural protected areas covering upper reaches of the Vokhma and its tributaries in remote uninhabited areas (Fig. 2). Restrictions for logging, hunting, construction building, mining, agriculture were established. The established NPAs are located close to the national-scale divide between the Volga and the Severnaya Dvina river basins. Hence, NPAs influence vast areas to the north and to the south. The important trend in the district's economy is current shifting of logging to remote areas in the upper Vokhma basin because less distant forest resources are exhausted. In this situation it is critical to avoid total and rapid deforestation in runoff-forming landscapes. Establishment of NPAs forces forest industry to consider the crucial ecological needs in planning spatial distribution of new cutting areas.

In the lower reaches of the Vokhma basin and the adjacent section of the Vetluga valley two important NPAs were included in the ecological network project. These NPAs include forest and meadow floodplains as well as bogs on river terraces and fens on floodplains. Their function is to compensate loss of habitats in surrounding agricultural areas and deforested valleys and to link southward and westward migration routes along river valleys. This group of NPAs serves as the important node in the ecological network. Preservation of selected forests stands within the areas of industrial cutting beyond NPAs can also be needed.

Fig. 2: **Location of nature protected areas (red-outlined patches) within the Vokhma river basin in the Kostroma administrative region of Russia). Landsat 7 space image. Thin black lines – river network. Bold black lines – boundaries of the river basin.**

However, this can be crucial not forever but for a certain period necessary for recovery of disturbed area. Restrictions could last for several decades in case it is the critical for rehabilitation of ecological functions in adjusting areas.

The need to compensate ecological losses requires, at least theoretically, comparability of sizes between NPAs and disturbed areas. In practice, in most cases it can hardly be realized. However, one of the ecological network objectives is to provide ecological control over vast areas by protecting relatively small ones. Hence, we need to identify and protect key landscapes being the sources of matter dispersion, either via runoff or animals migration. The ability to exert influence of remote landscapes depends greatly on location in relief and on hierarchical order of water divide. The Kostroma-EcoNet project proposed to establish larger NPAs on the highest order watersheds. The largest one embraces giant mire on the watershed between the Severnaya Dvina and the Volga river basins. The sources of the largest rivers with densely populated basins are protected by the larger NPAs in comparison with the smaller rivers and less populated basins. At the same time a number of watershed NPAs are aimed at protection of undisturbed taiga forests, important taiga habitats for animals and bogs in unpopulated areas. Most of them are located within outwash sandy plains in the lower Unzha basin.

Now we turn to the example of the Curonian Spit National Park at the westernmost border of Russia to illustrate application of the compensation principle in the areas without direct and rapid disturbance of landscape components. The main challenge for the national park is to combine the necessity to protect the unique World Heritage cultural landscape with recreational needs of people from the Kaliningrad region who use the territory for weekend beach and forest rest. The lack of beach facilities, parking places and foot-paths makes people to disperse along the entire coast. By so doing they penetrate to functional zones with restricted access and inflict detriment to populations of rare plant and animal species. The particularity of the Spit is its narrowness varying from 0.4 to 3.8 m, being 1.5 km at average. Increased threat of habitats fragmentation and loss of habitats can result in decrease of biodiversity. The strategic plans for economic development of the Kaliningrad region require realization of infrastructure projects that could increase fragmentation of forest habitats. That is why the Management Plan for the Curonian Spit composed with one of the authors participation in 2008 assumes redistribution of recreation loads across the territory (Fig. 3).

The most crucial challenge is one-day attendance for beach and forest rest. We proposed to stimulate concentration of one-day visitors in the southern part of the Curonian Spit where the risk of eolian processes activation and proportion of rare species are the lowest. Given that high-quality leisure facilities would be provided, most one-day local visitors from the Kaliningrad region are expected not to penetrate to the remote and more valuable sections of the park. At the same time one-day visitors from mainland Russia and other countries, who are interested mainly in unique sandy dunes, would pass the southern part without stop and visit attraction sites (giant dunes, fragments of intact coniferous and broad-leaved forests, bogs, lakes) in organized excursion groups without opportunity to disperse within the protected zones. This redistribution of tourist categories is believed to reduce attendance of key animal habitats. The facilities for prolonged attendance should be concentrated within the smaller part of the most widely spread landscape unit - pine forests with dominance of Deschampsia flexuosa in herb layer that has the lowest level of biodiversity. It should be noted that the main part of this landscape unit would be left inaccessible to preserve undisturbed wildlife habitats. The patches of alder-oak forests in the southernmost section of the National Park adjacent to Zelenogradsk city are found to be unsuitable for cottage construction due to several reasons. The first one is high concentration of rare species including those introduced by German foresters in the 19-20th centuries. Second, construction building could result in subsidence of underlying peat deposits. Third, these low-lying patches are subject to threat of floods during storm events on the Baltic Sea. Fourth, unavoidable tree cutting increase threat of windfall at forest margins which is very typical for the Curonian Spit.

Thus, the proposed measures to redistribute recreation loads take into consideration requirements of different categories of visitors. Realization of management plan for the Curonian Spit national park will provide both preservation of valuable landscapes and opportunities for environmentally friendly tourism.

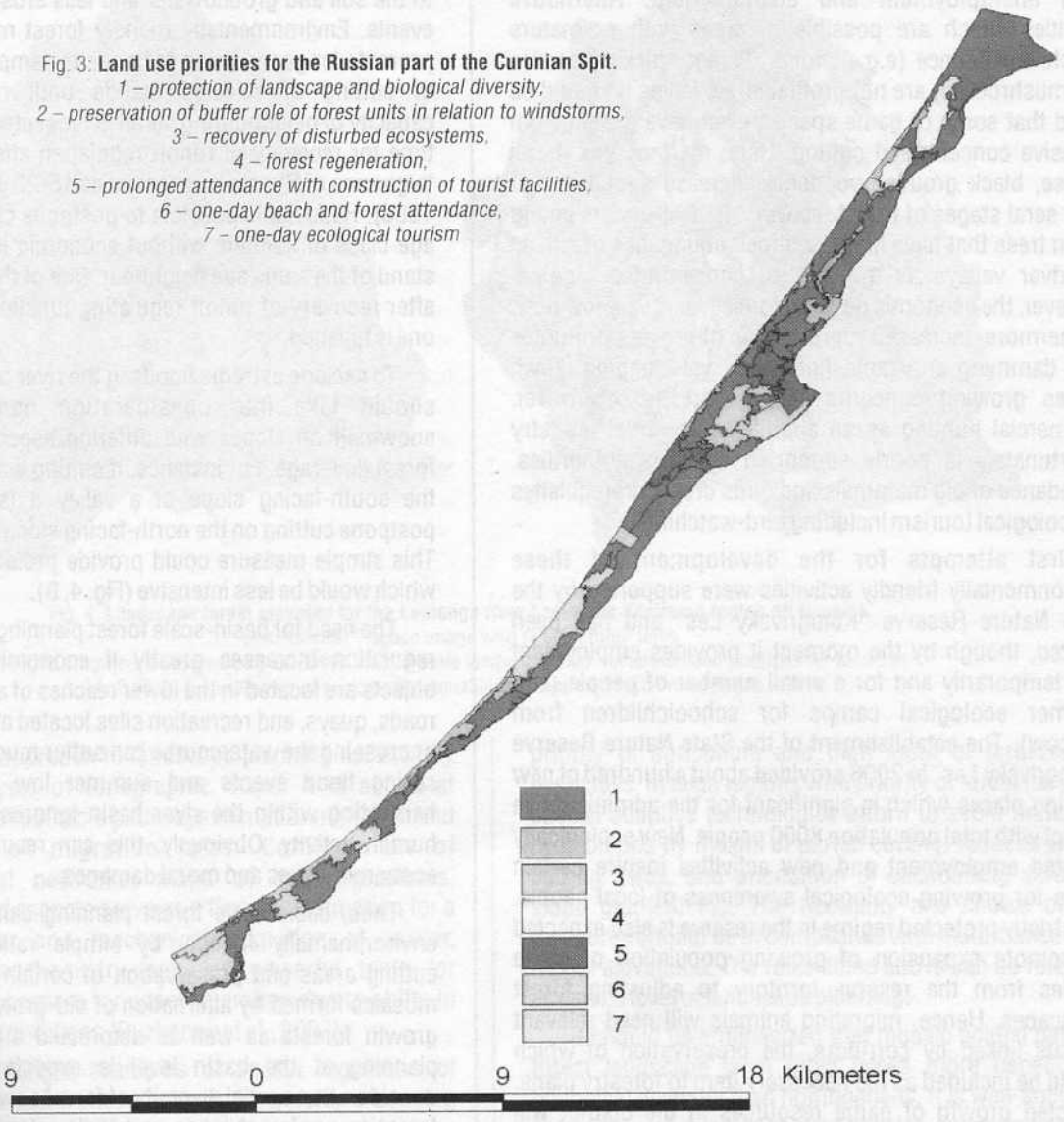

Fig. 3: **Land use priorities for the Russian part of the Curonian Spit.**
1 – protection of landscape and biological diversity,
2 – preservation of buffer role of forest units in relation to windstorms,
3 – recovery of disturbed ecosystems,
4 – forest regeneration,
5 – prolonged attendance with construction of tourist facilities,
6 – one-day beach and forest attendance,
7 – one-day ecological tourism

River basin level of planning

River basin is a clearly delineated geosystem which has holistic character due to dominance of one-way direction of matter and energy fluxes. Spreading of disturbances by means of runoff can be relatively easily forecasted within the basin. Proportion and location of different kinds of landscape units within a basin can affect hydrological component of landscape greatly as well as transfer of solid and dissolved matter. We illustrate decision-making process on the basin level on the example of forest planning in the southern taiga subzone of European Russia which is rather typical for forest zone as a whole. We believe that spatial parameters and location of preserved forests within the regions of industrial timber harvesting is the important topic that should be considered in close connection to river basins characteristics.

The most dramatic mistake of forest harvesting within the taiga zone of Russia in 1960-1980s was simultaneous cutting on vast areas embracing the whole small river basins. More than 50-70 ha could be cut at once, and the adjusting forest stands could be cut in 2 or 3 years. This resulted, on the one hand, in imbalance of water regime, loss of fish resources and damage to wetland habitats. Many big rivers lost their navigability either just after flood period or totally (the Vetluga, the Unzha, the Sukhona rivers etc.). Impossibility to provide water transport links with remote villages resulted in decrease of life quality and depopulation. On the other hand, in economic sense, such kind of concentrated cutting caused the necessity to exclude harvesting activity in vast areas for at least 50-60 years (in case timber industry requires birch) or 80-100 years (in case spruce or pine is required). The case study in the Kostroma region showed that as a result big settlements specialized in forest harvesting now suffer

from unemployment and abandonment. Alternative activities which are possible in areas with premature forests dominance (e.g. hunting, fishing, picking berries and mushrooms) are not profitable. However, it should be noted that some of game species even have gained from intensive concentrated cutting. Hare, marten, lynx, hazel grouse, black grouse, woodcock increase abundance at early seral stages of forest recovery. Beaver prefers young aspen trees that have increased their abundance greatly in the river valleys as a result of concentrated logging. However, the economic demand for beaver is very low now. Furthermore, increased reproduction of beavers promotes river damming and rapid floodplain waterlogging which causes growing concerns among foresters. However, commercial hunting as an alternative to forest industry unfortunately is poorly supported by state authorities. Abundance of big mammals and birds create prerequisites for ecological tourism including bird-watching.

First attempts for the development of these environmentally friendly activities were supported by the State Nature Reserve "Kologrivsky Les" and has been realized, though by the moment it provides employment only temporarily and for a small number of people (e.g. summer ecological camps for schoolchildren from Moscow). The establishment of the State Nature Reserve "Kologrivsky Les" in 2006 provided about a hundred of new working places which is significant for the administrative district with total population 8000 people. New ecologically oriented employment and new activities inspire certain hopes for growing ecological awareness of local people. The strictly protected regime in the reserve is also expected to promote expansion of growing population of game species from the reserve territory to adjusting forest landscapes. Hence, migrating animals will need relevant habitats linked by corridors, the preservation of which should be included as the necessary item to forestry plans. Expected growth of game resources in the district will compensate loss of game areas that were included in the reserve. This example shows that long-term multifunctional landscape planning should have prior interest in both present-day and future possible spatial interactions between different landscapes.

The common problem of the "ecology-economy" conflicts is in the contradiction of ecological ambitions to preserve as much as possible and economic ambitions to cut as much and as soon as possible. We believe that at least some of the conflicts could be solved by means of temporal regulation of economic activity. Our research in the Kostroma region showed evidence that runoff regulation can be provided by redistributing sequence of cutting activity within the river basins. Ratio of spring and summer runoff depends greatly on duration of snowmelt. Simultaneous and rapid snowmelt across the deforested basin results in low water level in summer. Longer and less intensive snowmelt is provided by preservation of forest stands evenly distributed among cutting areas. Mosaics of coniferous and deciduous forests affects water regime positively as well. This ensures better penetration of water to the soil and groundwater and less erosion during flood events. Environmentally friendly forest management can promote longer duration of floods by temporal postponing of cutting of selected stands until runoff-regulating capacity of neighbouring stand is recovered (Fig. 4, A). The time for recovery of runoff regulation after cutting in the taiga zone of Russia is assessed as 15-20 years (Voronkov, 1988). Hence, it is possible to postpone cutting within the age class of conifers without economic loss in case two stand of the same age neighbour. One of them could be cut after recovery of runoff regulating function in the second one is finished.

To exclude extreme floods in the river basin the planner should take into consideration non-simultaneous snowmelt on slopes with differing aspect, gradient and forest coverage. For instance, if cutting was performed on the south-facing slope of a valley it is reasonable to postpone cutting on the north-facing slope for 10-15 years. This simple measure could provide prolongation of flood which would be less intensive (Fig. 4, B).

The need for basin-scale forest planning aimed at runoff regulation increases greatly if economically important objects are located in the lower reaches of a basin. Bridges, roads, quays, and recreation sites located at the floodplains or crossing the watercourse can suffer much from extreme spring flood events and summer low water if forest harvesting within the river basin ignores other kinds of human activity. Obviously, this can result in significant economic losses and moral damages.

Thus, basin-scale forest planning can become more environmentally friendly by simple rational choice of cutting areas and preservation of certain level of spatial mosaics formed by alternation of old-growth and second-growth forests as well as deforested areas. Long-term planning at the basin level is expected to take into consideration spatial diversity of forest cover, proportion of forest to nonforest lands and their neighborhood at any period aimed at preservation of natural seasonal runoff regime.

Landscape context

Landscape context is extremely important for planning if anthropogenic activity provokes increase of lateral matter flows. The latter can manifest themselves in various ways: e.g. increased runoff after deforestation in rugged terrains, snow avalanches caused by mountain skiing or deforestation on slopes, eolian processes caused by construction works, migration of animals as a result of habitat loss etc. Though most human activities are impossible without nature disturbance, it is within the human's competence to foresee undesirable processes and to minimize harmful effects. It is a privilege of landscape planning to consider mutual location of flows input and output, matter migration routs, possible barriers and filters as well as to propose regulation measures.

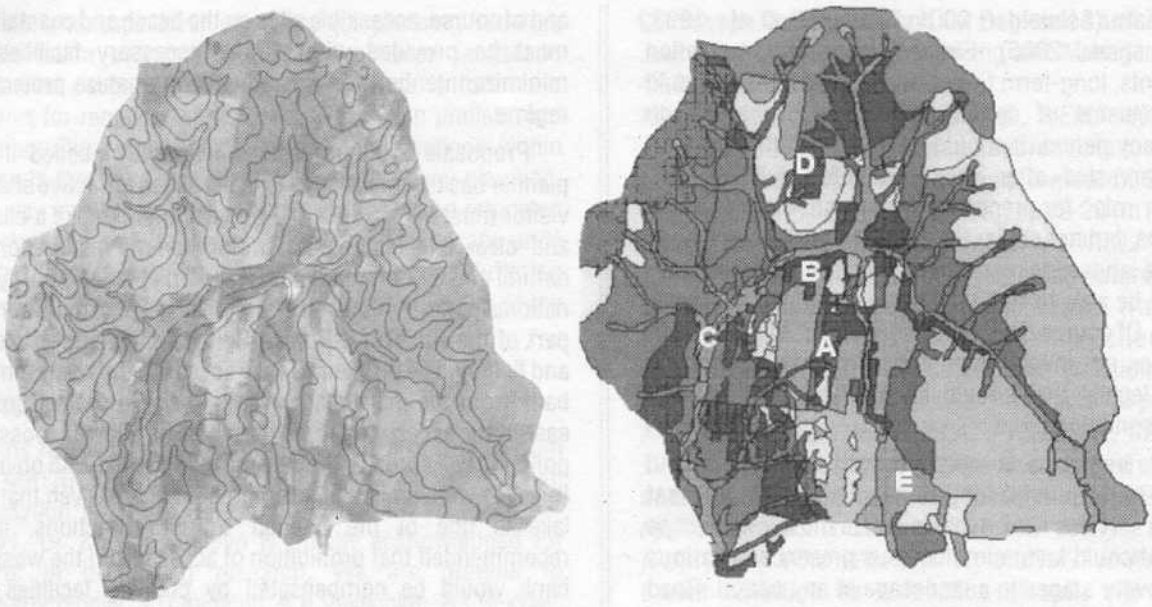

Fig. 4: **Landscape forest planning for the Lomenga river basin (the Kostroma region off Russia).**
Left: Landsat 7 space image with relief contour lines
Right: Fragment of landscape plan based on fine-scale landscape map: recommended priorities for land use.
A, B, C, D, E – examples of ecologically valuable landscape units (comments see in text)

Geographical approach to landscape planning necessarily involves analysis of topographic maps. It is aimed at identification of possible pathways of matter migration and assessment of migration rates. Configuration of hydrographical networks, maps of slope gradients, curvatures and aspects serve as a first approximation for a map of water and mechanical migration of matter. Landscape geochemistry provides powerful tools for delineation of barriers for water migration due to shifts in pH and redox conditions (Dyakonov et al., 2007).

The most bright examples of spatial regulation of matter flows come from forestry and agriculture Logging and ploughing commonly cause severe increase of surface runoff and corresponding decrease of subsurface flows. In boreal forest zone it is encouraged by rapid snowmelt in open areas and low permeability of frozen soils in early spring.

To reduce amount of solid substance reaching watercourses from deforested watersheds it is necessary to leave forest strips on slopes. Their number and width depends on slope length and deforested area. Usually it is highly recommended to preserve (or create) forest strips at the toeslopes, at the lines of slope curvature changes and at the borders of valley slopes and watersheds. In other words, a planner should promote maximum possible protection in sites where migration rates change abruptly. Paulyukyavichyus (1989) elaborated clear procedure to adapt location of forest strips to relief aimed at maximization of water-protecting and soil-protecting functions of forests. Forests strips act as buffer elements of local-scale ecological networks which prevent excessive input of matter to low-lying landscape units (Fig. 4, C). This function acquires paramount importance in regions with priority of agriculture and high input of fertilizers and pesticides. In taiga regions with priority of forest harvesting special adaptive technologies afford to avoid undesirable prohibitions by means of partial cutting, reduced width of cutting areas, and orientation of clearcutting across the slope gradient etc. The necessity and choice of these measures should be in compliance with disturbance area at higher elevations. The rules listed above can be referred to as catena level of landscape planning.

It should be emphasized that mosaic spatial pattern of forest landscape is in most cases more beneficial for biological diversity than homogeneity. It is well-known that abundance of most taiga bird species depends greatly on combination and close neighbourhood of forest and open areas. In the Kostroma taiga elk and marten prefer highly mosaic forest areas since they need various habitats at different periods. At the same time vast premature and mature birch and aspen stands are not favourable for elk, bear, hare which are the important game species for local hunters. Small forest coniferous stand among cutting areas serve as important refuges for game birds, elk, marten, squirrel. To ensure forest regeneration refuges of zonal forest communities are extremely needed in the regions of extensive industrial harvesting.

The attitude to the so-called overmature forests among those involved in timber industry is still negative in Russia. They are considered to exert harmful effects for forest pathology and loss of productivity. The role of old-growth forests in supporting biodiversity and forest regeneration is usually underestimated. Environmentally friendly forest planning requires leaving certain number of old-growth forests that could encourage seeds supply for adjusting cuttings as well as recolonization of disturbed areas by

taiga animals (Schneider, 2001; Mladenoff et al., 1993; Etheridge et al., 2006). Similarly to runoff regulation requirements, long-term forest landscape planning should ensure presence of certain proportion of old-growth forests at any period. It should be noted that these stands can be harvested after they completely fulfilled their ecological role for recovery of neighbouring forest ecosystems, but not earlier than another analogous stands in the same landscape reach the stage close to zonal climax and would be able to fulfill the same ecological functions (Fig. 4, D). Of course, this "shifting mosaic" of old-growth forests does not involve high conservation value forests protected legally that should be preserved without any additional conditions.

Mosaic landscape is effective both ecologically and economically. To provide long-term consumption of forest ecosystem services it is crucial to create mosaic landscape pattern that could favor simultaneous presence of various forest recovery stages in a landscape at any period. Road network should provide accessibility to mature stands at any decade taking into consideration shifting mosaics of recovery stages. At the same time road network should exclude access to landscape units with natural rarity independent of landscape context. For example forests surrounding rare watershed bog expanses are recommended to be inaccessible for logging at any time since they provide runoff-regulating and water-protecting functions (Fig. 4, E).

On the Curonian Spit a number of ideas considering landscape context were included into management plan. Location of cottage construction sites proposed before was rejected due to landscape context reasons. Landscape planning should consider not only anthropogenic threats to landscapes but natural threats to human also. Proposed building sites adjusting directly to the sea coast are subject to severe windstorms which cause sand transportation from the sea beach to inner parts of the spit. Since tree cutting would be unavoidable increased windfall at forest margins would be obvious resulting in threat to lives and buildings. By the way, clear examples can be seen now in the other parts of the spit used for tourist camps. Concentration of visitors in the extremely sensible landscape of the coast would result in destruction of rarified herb layer in pine stands and activation of eolian transportation of sand. Again, similar sites on the spit are completely uncomfortable during frequent windstorms. At the same time sites that are more distant from the coastline (500 m and further) are better protected from the wind threat, given that coastal forest strip is preserved. The latter reduce the wind force and serves as a buffer that prevents harmful windfall in tourist sites (Fig. 3). We propose that tourist settlements should be located at hundreds meters from the Baltic coast linked with the latter by foot-paths and cycling roads. The access to the coastal forests should be under strict control in order to exclude disturbance of herb layer and suppression of undergrowth. Reasons for limitations of access must be clearly explained to visitors, and of course, accessible sites on the beach and coastal line must be provided with all the necessary facilities to minimize intention for violations of the nature protection regime.

Proposals of alternatives are urgently needed if the planner has the intention to limit access to attractive sites. A visitor must be provided the opportunity to make a choice and clear explanations of prohibitions. Preservation of natural and semi-natural landscape units is the priority for national parks. For example, the Chayka Lake in the central part of the Russian Curonian Spit is attractive for leisure and fishery. The problem is easy access to the westernmost bank from the main road while the lake is drained to the east. If the access to the western bank is allowed, possible pollution will spread over the entire water area with obvious threat to wetland habitats for birds and fish. Given that the lake is one of the popular tourist attractions, it is recommended that prohibition of access from the western bank would be compensated by creating facilities for leisure on the north-eastern bank neighbouring to the Rybachye settlement. In this case clear indication of the way to the recommended leisure sites is needed in places of traditional but ecologically undesirable rest.

Conclusion

Hierarchical landscape planning is an effective tool to regulate spatial and temporal organization of land use. The regional level requires analysis of broad scale geographical information and is based on landscape classification. This level is necessary for assessment of degree of landscapes rarity. The strategy of land use depends on ecological losses from landscape disturbance. In general, rare, unique and relict landscapes are assigned priority of conservation while typical ones can be chosen for intensive use if necessary.

The river basin level of landscape planning is critical for rational distribution of anthropogenic loads in space in time aimed at supporting natural regimes of matter and energy transfer. Water divides and sources of runoff are assessed as key areas that exert powerful control over distant landscapes. The degree of ecological restrictions depends greatly on rank order of water divide. Intact landscapes close to high-order divides deserve the highest priority of protection. Both river basin and landscape levels of planning are important for application of compensation principle. Loss of ecological functions or habitats in certain part of the basin or the landscape should be compensated by preservation of similar unit in the other part linked to the first one by matter and energy fluxes. Spatial distribution of anthropogenic loads should be in accordance with the necessity to support hydrological regime, migration routs of living nature and other kinds of matter transfer. Nature protected areas are the most effective instrument for compensation of ecological losses within the region, river basin or landscape.

The landscape level of landscape planning requires consideration of lateral interaction between landscape units. The purpose of management efforts is to ensure support for recovery of disturbed units from undisturbed neighbouring ones. Consideration of interactions within catena is the particular case of landscape level planning. One-way matter transfer along catena should be regulated in disturbed areas by means of protective landscape units located in sites of migration velocity changes. Buffering undesirable impacts is the most principal objective of the catena level of planning.

Acknowledgements

The research was supported by series of grants from BBI-MATRA Foundation and grants from Russian Foundation for Basic Research 05-05-64335 and 08-05-00441. Dr. Maxim Sinitsyn is greatly acknowledged for efforts in organizing research. We are grateful to A.V.Nemchinova, V.O.Avdanin, A.A.Vasechkin, R.I.Bekkiev, N.V.Moraleva, and N.I.Troitskaya for invaluable cooperation during field research and fruitful discussions.

References

BETTINGER P., LENNETTE M., JOHNSON K.N., SPIES T.A., 2005: **A hierarchical spatial framework for forest landscape planning.** In: Ecological Modelling. Vol. 182. pp. 25–48.

BRANDT J., TRESS B., TRESS G. (Eds.), 2000: **Multifunctional Landscapes: Interdisciplinary Approaches to Landscape Research and Management. – Conference material for the conference on "multifunctional landscapes",** Centre for Landscape Research, Roskilde. 264 p.

DYAKONOV K.N., KASIMOV N.S., KHOROSHEV A.V., KUSHLIN A.V. (Eds.)., 2007. **Landscape Analysis for Sustainable Development. Theory and Applications of Landscape Science in Russia.** Alex Publishers, Moscow. 318 p.

ETHERIDGE D.A., MACLEAN D. A., WAGNER R.G., WILSON J.S., 2006: **Effects of intensive forest management on stand and landscape characteristics in northern New Brunswick, Canada** (1945–2027). In: Landscape Ecology. Vol. 21. pp. 509–524.

HAINES-YOUNG R.H., POTSCHIN M.B., 2000: **Multifunctionality and value.** In: Brandt J., Tress B., Tress G. (Eds.) Multifunctional Landscapes: Interdisciplinary Approaches to Landscape Research and Management. - Conference material for the conference on "multifunctional landscapes", Centre for Landscape Research, Roskilde. pp. 111-118.

HRNČIAROVA T., IZAKOVIČOVA Z., 2000: **Environmental Approaches to Sustainable Development.** Združenie KRAJINA21, Bratislava. 252 p.

KAZMIERSKI J., KRAM M., MILLS E., PHEMISTER D., REO N., RIGGS C., TEFERTILLER R., ERICKSON D., 2004: **Conservation Planning at the Landscape Scale: A Landscape Ecology Method for Regional Land Trusts.** In: Journal of Environmental Planning and Management. Vol. 47, No. 5. pp. 709–736.

KHOROSHEV A.V., SINITSYN M.G., NEMCHINOVA A.V., AVDANIN V.O., 2008: **Landscape approach to formation of ecological network in the Kostroma region.** In: Ecological Planning and Management. No 4(5). pp 19-29 (In Russian)

KHOROSHEV A.V., SINITSYN M.G., PEDROLI B., 2005: **Towards a coherent network of protected nature areas on landscape basis for the Kostroma region** (Russia). In: International Conference on Multifunctionality of Landscapes. Analysis, Evaluation, and Decision Support. Justus-Liebig-University, Giessen. Abstracts. 54 p.

MLADENOFF D.J., WHITE M.A., PASTOR J., CROW T.R., 1993: **Comparing spatial pattern in unaltered old-growth and disturbed forest landscapes.** In: Ecological Applications. Vol. 3. No. 2. pp. 294-306

MUSIO M., VON WILPERT K., AUGUSTIN N.H., 2007: **Crown condition as a function of soil, site and tree characteristics.** In: Eur. J. Forest Res. Vol. 126. pp. 91–100.

NIESCHULZE J., 2003: **Regionalization of Variables of Sample Based Forest Inventories at the District Level.** Dissertation. Gottingen. 131 pp. Neave D., Neave E., 2005: A web of conservation lands across Canada's forests. In: Conservation lands. Integrating conservation and sustainable management in Canada's forests. Eds. B.McAfee, C.Malouin. Ottawa. pp. 15-42.

NIKOLAEV V.A., 1979: **Problems of Regional Landscape Science. Moscow University Press,** Moscow. 160 p. (in Russian)

PAULYUKYAVICHYUS G.B., 1989: **The Role of Forest in Ecological Stabilization of Landscape.** Nauka, Moscow. 215 p. (in Russian)

PERERA A.H., BUSE L.J., CROW T.R., 2007: **Knowledge transfer in forest landscape ecology: a primer.** In: Perera A.H., Buse L.J., Crow T.R. (Eds.) Forest Landscape Ecology. Transferring Knowledge to Practice. Springer. pp. 1-18.

SAUNDERS D.A., BRIGGS S.V., 2002: **Nature grows in straight lines – or does she?** What are thr consequences of the mismatch between human-imposed linear boundaries and ecosystem boundaries? An Australian example. In: Landscape and Urban Planning. Vol. 61. Schneider R., 2001: Establishing a protected area network in Canada's boreal forest: An assessment of research needs. Alberta Centre for Boreal Studies

SOLNETSEV N.A., 1948: **The natural geographic landscape and some of its general rules.** In: Wiens J.A., Moss M.R., Turner M.G., Mladenoff D.J. (Eds.), 2006: Foundation Papers in Landscape Ecology. Columbia University Press, New York. pp. 19-27.

VORONKOV N.A., 1988: **The Role of Forests in Water Protection. Hyrometeoizdat, Leningrad.** 285 p. (In Russian)

WICKHAM J.D. , WADE T.G., RIITTERS K.H., O'NEILL R.V., SMITH J.H., Smith E.R., Jones K.B., Neale A.C., 2003: **Upstream-to-downstream changes in nutrient export risk.** In: Landscape Ecology. Vol. 18. pp. 195-208.

The landscape level of landscape planning requires consideration of lateral interaction between landscape units. The purpose of management efforts is to ensure support for recovery of disturbed units from undisturbed neighbouring ones. Consideration of interactions within catena is the particular case of landscape level planning. One-way matter transfer along catena should be regulated in disturbed areas by means of protective landscape units located in sites of migration velocity changes. Buffering undesirable impacts is the most principal objective of the catena level of planning.

Acknowledgements

The research was supported by series of grants from BBI-MATRA Foundation and grants from Russian Foundation for Basic Research 05-05-64335 and 08-05-00441. Dr. Maxim Sinitsyn is greatly acknowledged for efforts in organizing research. We are grateful to A.V.Nemchinova, V.O.Avdanin, A.A.Vasechkin, R.I.Bekkiev, N.V.Moraleva, and N.I.Troitskaya for invaluable cooperation during field research and fruitful discussions.

References

BETTINGER P., LENNETTE M., JOHNSON K.N., SPIES T.A., 2005: **A hierarchical spatial framework for forest landscape planning.** In: Ecological Modelling. Vol. 182. pp. 25–48.

BRANDT J., TRESS B., TRESS G. (Eds.), 2000: **Multifunctional Landscapes: Interdisciplinary Approaches to Landscape Research and Management. – Conference material for the conference on "multifunctional landscapes",** Centre for Landscape Research, Roskilde. 264 p.

DYAKONOV K.N., KASIMOV N.S., KHOROSHEV A.V., KUSHLIN A.V. (Eds.)., 2007. **Landscape Analysis for Sustainable Development. Theory and Applications of Landscape Science in Russia.** Alex Publishers, Moscow. 318 p.

ETHERIDGE D.A., MACLEAN D. A., WAGNER R.G., WILSON J.S., 2006: **Effects of intensive forest management on stand and landscape characteristics in northern New Brunswick, Canada** (1945–2027). In: Landscape Ecology. Vol. 21. pp. 509–524.

HAINES-YOUNG R.H., POTSCHIN M.B., 2000: **Multifunctionality and value.** In: Brandt J., Tress B., Tress G. (Eds.) Multifunctional Landscapes: Interdisciplinary Approaches to Landscape Research and Management. - Conference material for the conference on "multifunctional landscapes", Centre for Landscape Research, Roskilde. pp. 111-118.

HRNČIAROVA T., IZAKOVIČOVA Z., 2000: **Environmental Approaches to Sustainable Development.** Združenie KRAJINA21, Bratislava. 252 p.

KAZMIERSKI J., KRAM M., MILLS E., PHEMISTER D., REO N., RIGGS C., TEFERTILLER R., ERICKSON D., 2004: **Conservation Planning at the Landscape Scale: A Landscape Ecology Method for Regional Land Trusts.** In: Journal of Environmental Planning and Management. Vol. 47, No. 5. pp. 709–736.

KHOROSHEV A.V., SINITSYN M.G., NEMCHINOVA A.V., AVDANIN V.O., 2008: **Landscape approach to formation of ecological network in the Kostroma region.** In: Ecological Planning and Management. No 4(5). pp 19-29 (In Russian)

KHOROSHEV A.V., SINITSYN M.G., PEDROLI B., 2005: **Towards a coherent network of protected nature areas on landscape basis for the Kostroma region** (Russia). In: International Conference on Multifunctionality of Landscapes. Analysis, Evaluation, and Decision Support. Justus-Liebig-University, Giessen. Abstracts. 54 p.

MLADENOFF D.J., WHITE M.A., PASTOR J., CROW T.R., 1993: **Comparing spatial pattern in unaltered old-growth and disturbed forest landscapes.** In: Ecological Applications. Vol. 3. No. 2. pp. 294-306

MUSIO M., VON WILPERT K., AUGUSTIN N.H., 2007: **Crown condition as a function of soil, site and tree characteristics.** In: Eur. J. Forest Res. Vol. 126. pp. 91–100.

NIESCHULZE J., 2003: **Regionalization of Variables of Sample Based Forest Inventories at the District Level.** Dissertation. Gottingen. 131 pp. Neave D., Neave E., 2005: A web of conservation lands across Canada's forests. In: Conservation lands. Integrating conservation and sustainable management in Canada's forests. Eds. B.McAfee, C.Malouin. Ottawa. pp. 15-42.

NIKOLAEV V.A., 1979: **Problems of Regional Landscape Science. Moscow University Press,** Moscow. 160 p. (in Russian)

PAULYUKYAVICHYUS G.B., 1989: **The Role of Forest in Ecological Stabilization of Landscape.** Nauka, Moscow. 215 p. (in Russian)

PERERA A.H., BUSE L.J., CROW T.R., 2007: **Knowledge transfer in forest landscape ecology: a primer.** In: Perera A.H., Buse L.J., Crow T.R. (Eds.) Forest Landscape Ecology. Transferring Knowledge to Practice. Springer. pp. 1-18.

SAUNDERS D.A., BRIGGS S.V., 2002: **Nature grows in straight lines – or does she?** What are thr consequences of the mismatch between human-imposed linear boundaries and ecosystem boundaries? An Australian example. In: Landscape and Urban Planning. Vol. 61. Schneider R., 2001: Establishing a protected area network in Canada's boreal forest: An assessment of research needs. Alberta Centre for Boreal Studies

SOLNETSEV N.A., 1948: **The natural geographic landscape and some of its general rules.** In: Wiens J.A., Moss M.R., Turner M.G., Mladenoff D.J. (Eds.), 2006: Foundation Papers in Landscape Ecology. Columbia University Press, New York. pp. 19-27.

VORONKOV N.A., 1988: **The Role of Forests in Water Protection. Hyrometeoizdat, Leningrad.** 285 p. (In Russian)

WICKHAM J.D. , WADE T.G., RIITTERS K.H., O'NEILL R.V., SMITH J.H., Smith E.R., Jones K.B., Neale A.C., 2003: **Upstream-to-downstream changes in nutrient export risk.** In: Landscape Ecology. Vol. 18. pp. 195-208.