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Forest planning as the most important aspect of sustainable forest management

Key words: sustainable forest management, forest planning, intensive forest management and use, sustainable volumes of forest use, conservation of forest ecological values, remote sensing and GIS, modeling of expected results.

Forest planning is an important condition for sustainable, economically efficient and ecologically responsible forest management and use. In North-West Russia, in particular in the Komi Republic, the increasing role of forest planning is closely connected with the obvious necessity to transfer from extensive way of forest management and use of primary natural forests to sustainable forest management and intensive forestry in the harvested secondary forests. Forest planning in these conditions should provide the demand of economics in timber under condition of keeping the forests' ecological and social importance, taking into account the existing spatial structure of the forest fund.

Forest planning is quite a general and diversified notion. According to the article 85 of the Russian Federation Forest Code, planning dealing with use, protection, conservation and regeneration of forests (forest planning) is aimed at sustainable development of territories [4]. Herein, forest planning is implemented by means of forest plans development by the Russian Federation constituent entities, forest management regulations of forest management units and forest parks; projects of forest use. But these documents make a kind of code of regulations and rules for use, protection, conservation and regeneration of specific territories. While sustainable forest management demands a concrete and complete from different spheres «action programme» made for forest areas of a specific territory (for example, a leased area by a timber logging company). This article outlines forest planning in such a context; it also considers the most acute and typical for many leased forest areas problems: estimation of sustainable volumes of forest use and conservation of their ecological values during forest use activities.

Economical sustainability is the most important aspect of forest management. The economical sustainability principle of economical sustainability of forest management was introduced by M. M. Orlov already in the XIX century and in fact was defined by the annual forest use volume which allows to keep forest use volume during next years and guarantees the most complete use of timber during a rotation period. The definition made by the Federal Forest Agency for sustainable forest management is – forest use in a certain volume and by such means that can guarantee its stable sustainability within a rotation period or for a long-

term period. In order to reach the goal and provide sustainable forest use a certain volume of harvested timber (annual allowable cut) is calculated and approved. It is widely accepted that an annual allowable cut is a scientifically grounded volume of sustainable forest use. However its applicability in Russia shows that it does not always guarantee sustainability of forest use. The existing experience in forest use planning shows that it is difficult to guarantee the timber harvesting volume according to the defined for the certain forest area annual allowable cut volume for a long term period of time in many forest leased areas. Forest survey forecasts calculations for the rotation period were made for these certain forest areas, in case of annual allowable cut there is quite a fast process of forest overuse. All the above mentioned proves the necessity to make adjustments in methods of defining the annual allowable cut, that were developed in 1950-1970 and haven't changed ever since.

The initial data to calculate the annual allowable cut are the data about the forest covered area and timber volume of commercial forest fund according to the tree species, site indexes and age groups. But in order to define the real economically sustainable volume of forest use it is important to take into account other important factors.

First of all, economically not accessible forests should be excluded from the calculations. These are forest stands with low stock volume where timber harvesting is not economically efficient. In modern Russian economical conditions timber harvesting in most cases is cost-efficient when timber volume is 70–90 m³ and more per hectare [1], but this figure is increasing proportional to the distance from the transportation network. Timber volume amount per hectare is closely connected with the forest stand site index. Therefore, one can estimate share of forests with low stock volume by use of data about share of low site indexes forest stands. In the Komi Republic forests of V site index and lower make more than 65% of the forest fund area [5]. Most of these forests, in spite of the fact that they are economically not efficient for timber harvesting are used in annual allowable cut calculation. As a result, an increased annual allowable cut by means of low productive forest stands is completed mostly in high productive forests and leads to a fast overuse. In order to avoid that, calculation of annual allowable cut should include data about forest stands, cost-efficient timber volume per hectare (in age of a mature forest stand). Many timber harvesting companies operating in the middle and southern taiga of the Komi Republic consider a cost-efficient volume of 110-140 m³ per hectare.

Other forest areas that should be also excluded from an annual allowable cut calculation are so-called «deconcentrated» forest fund – small areas of mature forests, located among old

harvested forest areas, huge wetland areas, etc. Timber harvesting in such areas that are located far from the transportation network quite often doesn't cover the costs for strip roads construction. In annual allowable cut calculation it is important to consider relatively small non-exploitation areas (wetlands, forest glades, spare forest areas) and economically non accessible forests (with low stock volume), located within the calculated stand delineations. When making forest inventory small forest areas quite often are not included as separate stand delineations and are often joined to the neighboring bigger stand delineations. Such a stand delineation area is not huge but in case of high fragmentation it can overestimate economically accessible forest areas.

Another important factor that defines economical sustainability of forest use while calculating annual allowable cut is forest resources transport accessibility. While calculating the annual allowable cut all forests located in the needed area are taken into account (forest management unit, leased area). At that, transport accessibility within the area can differ in different parts and this fact should be considered as well. As a result, the annual allowable cut, calculated for a comparatively huge territory is completed in transport accessible forest stands that are limited and this fact leads to their overuse. The problem increases if the territory for which the annual allowable cut calculation was made is huge and a transportation network is uneven and poor. It follows thence, in order to define an economically sustainable forest use volume it is important to take into account transport accessibility of forests in fact and to exclude from calculations remote forest areas where logging is impossible within an inventory period of time.

Forest inventory data make the information background to calculate an annual allowable cut. Therefore the more accurate and real is the data, the better is the calculation. There are some legislative limits about the minimum area of stand delineations that cause the fact that some non exploitation areas are included into the stand delineations that are used in calculations. The total area of that type of non exploitation areas is increasing when a forest inventory is not detailed and there is a spatial heterogeneity of a landscape. In case of a really heterogeneous wetland landscape in the third rate of forest inventory small non exploitation areas (wetland borders, rocks, etc.) sometimes make by 1/5 of a forest area included into the data base for the annual allowable cut calculation [1]. From the experience one can say that data about the stock volume from forest inventory are quite often exaggerated, sometimes more than two times. All the above mentioned factors can lead to an annual allowable cut overvaluation.

Besides use of real data about a forest exploitation fund to define sustainable volume of forest use demands the total evaluation of the forest fund dynamics and an annual allowable cut for a long-term perspective (100-120 years) in case of its complete use. If the calculations show its decrease that means that a forest harvesting area is exaggerated and can not correspond to economically sustainable forest use.

Economically sustainable forest use is an important condition for a long-term perspective. But at that spatial planning of forest use that considers their ecological value and protective role is also an important aspect of sustainable forest management and use.

The existing legislation set out activities that should provide protective, research, cultural, esthetic, and recreational and health protective values of forests. Nature protected areas are created for that, as well as protective forests and strictly protected areas. Lands of nature protected areas are fully or partly out of forest use. For protective forests there are limits in forest use and special regimes for forest management activities, but methods used for their delineation are based on direct methods that are not considering real nature-geographical conditions of the territory. A good example can be an approach in water protective forests delineation.

Water proof areas are allocated in order to prevent pollutions, littering and siltation of a water object and in order to preserve flora and fauna along the water streams and rivers, according to the Water Code of the Russian Federation [6]. The width of the water protective area depends on the river (stream length (up to 10 km – 50 m, from 10 till 50 km – 100 m, from 50 km and more – 200 m). Forests that are located in water protective areas belong to the category of protective forests. A similar formal approach in water protective zones allocation does not consider nature-geographical conditions of the river valleys, whereas valleys' structure, their width, afforestation, valley sides have an important meaning when defining the width of water protective forests. As a result in some areas the width of water protective areas is too big, while in the others too small. Nevertheless, M.V. Rubtsov has suggested in 1983 a method of water protective areas delineation based on nature-geographical conditions of the river valley analysis (morphometric method). Here, the floodplain and erosion banks of the river valley should be included in the regulation category of water protective forests, but that category can be limited by water absorbing forest area that should stop the land runoff and erosion in the areas near the rivers. Water protective forests delineation based on Rubtsov's method might have some challenges that is a difficulty to define the morphometrical elements of the river valley parameters (flood basin width, slopes and their length, etc.) [3]. Most

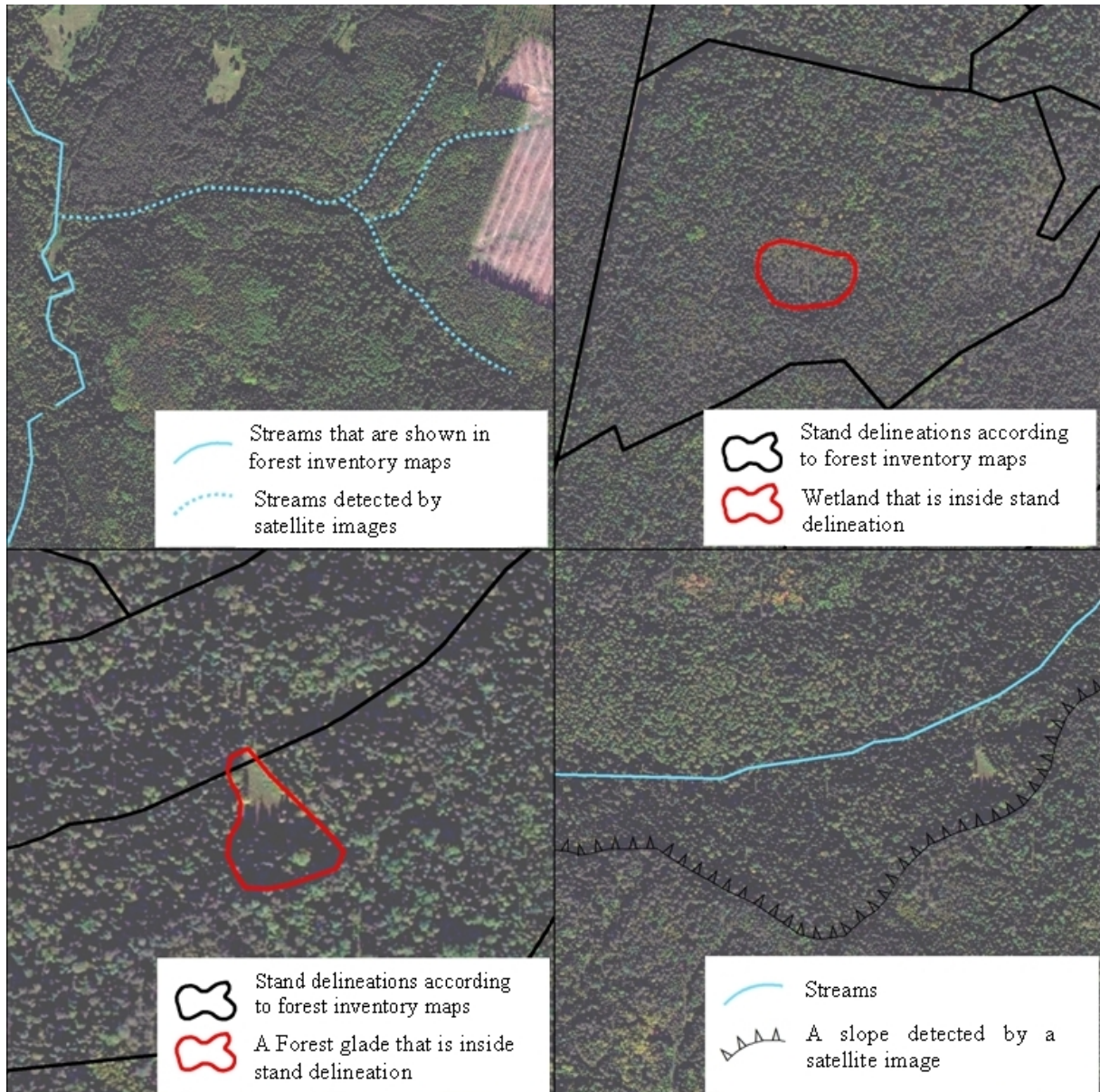
probably due to this reason his method was not widely used in practice. However now when GIS technologies and remote sensing are developed there are no barriers for this method implementation. Method introduced by Rubtsov, implemented with the use of GIS technologies is successfully tested in R&D works in Syktyvkar forest Institute.

Ecological sustainability of forest use is achieved not only by means of valuable forest massifs and separate nature protected forest areas conservation, delineation of protective forests and strictly protected areas. It is important to take into account landscape and ecological peculiarities of forest areas while forest use planning in commercial forests. Traditionally forest planning is based on the forest inventory data. In fact, use of such materials to make forest planning has the following challenges:

- Old data (forest inventory data in some forest management units is more than 10-15 years old);
- Poor accuracy of maps (real borders can differ from the map borders by ten or sometimes hundred meters);
- Lack of detailed data (borders of delineation and other objects might be general and relatively small compartments can be joined to the bigger ones);
- Not all important ecological objects are presented on maps (small streams and wetlands, temporary water flows, etc);
- Lack of relief information on maps;
- Low level of real mensurational forest description (real mensurational description data can differ from those in the document, for instance age and tree species composition, forest stand volume).

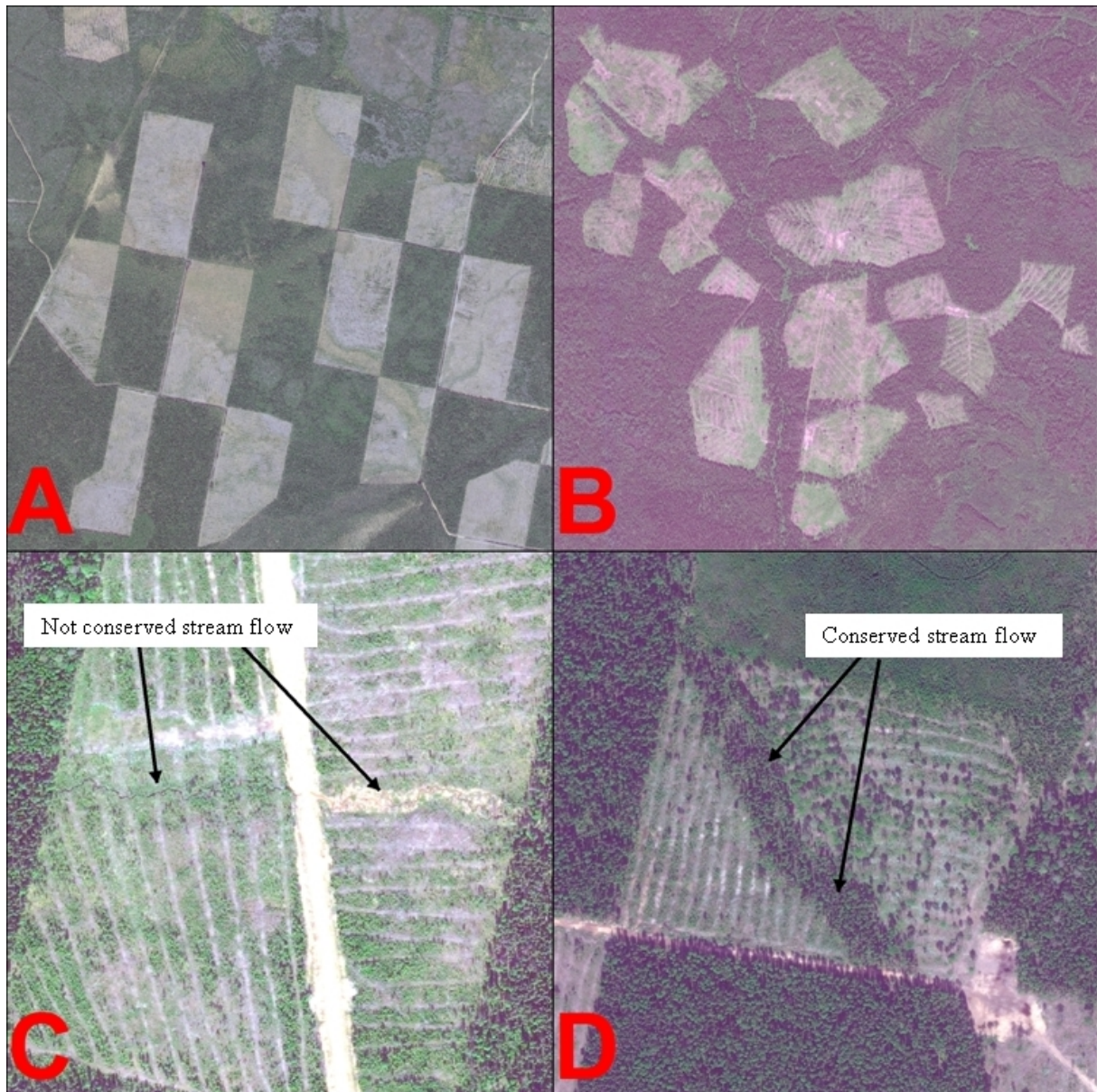
Taking into account all the above mentioned weak points in forest inventory data, it is obvious to use additional information sources in forest planning that can provide additional acute information about ecological and landscape peculiarities of the territory. One of those sources can be remote sensing (satellite images). Satellite images are especially valuable for the key biotope delineation. The Decree № 237 “Methodological recommendations about biodiversity conservation in timber harvesting in the Komi Republic” is approved by the Forestry Committee of the Komi Republic on April 16th 2009. According to this document a key biotope is a forest area that has a special value for biodiversity conservation. The list of the key biotopes includes:

- uncovered forest areas (for example, wetlands, forest glades, open sand areas, dry meadows);
- incomplete stands and open forests (relative density is less than 0,4) and a low productive stand (stock volume is less than 50 m³ /ha);
- coasts of lakes and bogs;
- areas near streams and brooks;
- places of the ground water outcome;
- wetlands and water-logged areas;
- temporary streams and temporary lakes;
- flood plains in the overflow lands of streams, temporary water streams;
- slopes with steepness more than 20 degrees;
- outcome of rocks and stones;
- areas with carbonate soil;
- karst sink holes;
- areas with linden trees in the stand composition;
- areas with cedar tree in the stand composition;
- windows of falling ground;
- forest areas that differ a lot from the rest of forest stands in tree species composition and in age (for example, fire refugium or young stands that are located among middle-aged forest stands);
- areas with many key elements of the stand [2].



Picture 1. Detection of landscape and ecological peculiarities of some forest territories by means of satellite images.

Picture 1 shows the samples of forest inventory maps that are compared with the satellite images with high spatial resolution. These fragments also show important landscape and ecological peculiarities of forest territories, that were defined by satellite images but were not defined by the forest inventory documents (streams, wetland, forest glades, a slope of the stream coast). Such objects should be considered in logging areas and the transportation network projecting. This data about their location and shape can influence the spatial configuration of some harvesting areas and the logging scheme of the area in general.



Picture 2. Examples of different approaches to spatial planning of forest use and biodiversity conservation.

Picture 2 shows satellite images of forest areas, demonstrating opposite examples of different approaches in spatial planning of forest use and biodiversity conservation.

The territory shown in picture 2A was clear cut. A straight position of logging areas proves that landscape peculiarities of the territory were not considered in forest management planning. By the end of the cutting cycle the remained forest will be also cut. After that the territory will look similar to the territories after clear cuts. There might be a threat of a wetland formation and erosion, tree species composition change and a different water regime

in the territory. A huge damage is made for biodiversity, especially if there are no key biotopes left within a logging area.

An example of an opposite approach in spatial planning forest use is given in picture 2B. A non-linear shape of logging areas and their non-systematic location testifies to the fact that the territory was pretested and the logging areas projecting was made in accordance to landscape peculiarities of the territory and ecological objects located on the territory. Such an approach allows to prevent many negative consequences of clear cuts and allows to preserve the mosaic structure of the forest landscape, is more rational from the ecological valuable objects preservation and biodiversity points of view.

Picture 2C shows the logging area that was clear cut without the key biotopes preservation. However one can see that the logging area is crossed by the stream. Timber located along the banks is cut. In the left part of the logging area there are strip roads across the stream and in the middle of the logging area the stream is crossed by the road. As a result, the water regime of the water flow and biodiversity in this particular area is destroyed. The opposite example is shown in picture 2D where one can see a preserved key biotope (a water flow with the trees along) located diagonally of the logging area. This approach allows to reduce the negative impact of clear cuts on the water protective functions and forest biodiversity. A preserved biotope will be an additional source for seeds production.

Satellite images provide the process of planning with acute and real information about a forest area, help to detect the key landscape specific features of the planning object, detect important objects and areas from the ecological point of view. But in order to get the most complete picture of a forest area a field study is needed. A general scheme of the ecologically friendly spatial planning of forest use can look like that. At the first stage a commercial forest area is selected with the use of forest inventory data, that is a list and a map of forest delineations is made and mensurational characteristics are in accordance to the types of cuts and legislation regulations. This is mostly made by means of a forest logging project plan – an obligatory document that is required for any forest area leaseholder. Then the maps are updated by means of new satellite images: the cutting areas, roads and other changes made since the last forest inventory are updating on the map of the logging area. The older is the forest inventory data, the more important is to update the map. The next stage is when the landscape peculiarities of the territory and ecologically important objects that were not marked on the inventory maps previously (small wetlands, forest glades, water flows, etc) are mapped by means of methods of automatical and expert satellite images interpretation. Then a field study

of the territory is made when previously detected characteristics are approved, new defined objects are mapped, mensurational descriptions of the forest stands are checked. Based on the results of the field study a final map of the commercial fund is made that contains data about the existing roads, landscape peculiarities of the territory and ecologically important objects that should be preserved in logging of a specific forest areas. This map is a good ground for the ecologically responsible and technically correct forest logging areas and a transportation network planning.

Whereas the above described scheme of planning is dealing with the necessity of collection, processing and joint analysis of different spatial and semantic information, it's good to use GIS technologies.

The current forest and environmental legislation is aimed at sustainable forest use and ecological values conservation. But noted above facts and situations point out some lack of regulations and requirements that are stated by the Law. Really sustainable and ecologically responsible forest use demands additional factors and limitations in estimation of forest use volume and spatial planning. To solve this challenging issue, it is important to use updated, close to reality and really detailed cartographic and semantic information about a forest territory. A wide use of GIS technologies and satellite images helps to make correct decisions in spatial planning of forest use.

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