# MAPPING TECHNIQUES FOR SPATIO-TEMPORAL SIBERIAN VEGETATION CHANGES

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**ABSTRACT**
The paper shows mapping techniques for spatio-temporal vegetation changes in Siberia. As an example a part of Forest Fund of Russian Federation near Samotlor lake (Khanty-Mansi Autonomus Area, RF) is taken into account. Map-making was based on topographic maps or forestation plans as GIS layers formed in process of forest management. Paper includes the following maps: track map, temporal series map, map showing value difference between two dates. Rate of vegetation changes at the testing site has been determined.

Siberia occupies more than a half of Russian territory. It is subdivided into the West and the East parts. Almost all natural zones (from tundra to mountainous forest-steppe) are presented here. The relief is also inhomogeneous: alongside with lowlands there are many mountain systems. This determines complex structure of vegetation cover as well as species and biocenosis diversity.

When making vegetation maps we set the task to represent the plant community distribution pattern throughout the earth surface. By its content, the map may be floristic, representing distribution of certain species (areals) or geobotanical. Geobotanical maps represent areas occupied by certain types of plant communities (associations, formations, etc.).

At present most of the geobotanists consider vegetation cover as a spatial object, whereas it is a process, and plant diversity regularity cannot be understood out of time. Floristic method of vegetation classification has become a common interest for many of geobotanists, this resulted in formalized approach to the plant communities differentiation to a degree that made this classification unsuitable for both vegetation dynamics study and its mapping (Galanin, Galanina, 2012).

The object of geobotanical mapping is either current vegetation cover or the vegetation, which had existed on the territory before the latter was developed by man. At present, there are three types of maps: revegetation species maps which give an

idea of native vegetation (forest and steppe); maps of current (actual) plant cover taking into account the degree of lands development; dynamic maps, representing mature plant communities replacement due to anthropogenic impacts or environmental effects of current waters, fires, deforestation, etc. To our opinion, we should also differentiate forecasting maps, which show the trends of future vegetation changes.

Geobotanical map is fairly considered as a model for vegetation cover of any size, and the larger is the map scale the more detailed is the model, with all smaller units of taxonomic classification being represented. Thus, the units of topological level are represented in large-scale maps, those of regional level – in medium- and small-scale maps, and global – in general-purpose maps of the world or continents.

Plant cover classification is significant for geobotanical mapping. The most common principles applied in geobotanics are those of ecological-and-morphological classification developed as early as 30-s in works of V. N. Sukachev, A.P. Shennikov, E.M. Lavrenko and A.V. Prozorovsky. They were used for different scales geobotanical maps making. Also important for cartography is a geographic-and-genetic classification, developed by V.B. Sochava. It is based on phytocenological, ecological-and-geographical and genetic principles. The classification presents two series of plant cover subdominants. The first series corresponds to the topological maps, the second one refers to geobotanical zoning problems.

There exist several techniques for electronic mapping of changes: application of temporal series of maps, track-map making (several positions of the object in the same map), or demonstration of the values difference between the two or several dates or instants of time. In other words, three types of time dependencies may be shown in the map:
- Tendencies – changes taking place between two or more dates or instants of time;
- Situation before and after – conditions preceding and following the event;
- Cycle – changes taking place in repetitive time intervals, such as day, month or year.

Three testing sites were chosen in the north, medium and south taiga of West Siberia for mapping spatio-temporal vegetation changes. As a result of mapping, the greatest spatio-temporal vegetation change has been revealed in the vicinity of Lake Samotlor (Khanty-Mansi Autonomous Area, R.F.) in medium taiga. The change is a result of the strong anthropogenic impact of the fuel-energy complex enterprises in the given area. The maps of the other two sites in north and south taiga of West Siberia are not presented, as the rate of vegetation changes over the relatively short period of time is insignificant. The plant cover was mapped completely as a single object without

taking into account taxonomic units, in accordance with the requirements of forest management instruction.

When comparing forest sub-compartment boundaries (within the boundaries of forest resources) by the materials of forest management (inventory) and vegetation cover (table 1), correlations to be used for map-making were obtained. These maps represent current and restored vegetation superposition. To designate objects in the map hatching and colouring were applied separately or in combination.

As a result of mapping four maps were made to demonstrate techniques for spatio-temporal vegetation changes were made.

Temporal series of maps (maps 1 and 2): green areas show vegetation cover, yellow areas are non-vegetation areas, white areas show other lands not belonging to Forest Fund (as a rule these are industry lands). Map 1 shows the situation in 2000, map 2 shows the situation in 2008.

Track map (map 3). Green areas show the vegetation cover conditions in 2000 (top) and in 2008 (bottom).

Map showing value difference between 2000 and 2008 (map 4). Yellow are vegetation cover area with no changes (39,6 square kilometers, 69,7% of total area), Green areas show decreasing of vegetation cover area (14,9 square kilometers, 26,2% of total area), red areas show increasing of vegetation cover area (2,3 square kilometers, 4,1% of total area).

Map-making was based on topographic maps or forestation plans as GIS layers formed in process of forest management. Vegetation maps contours either reproduce the forest sub-compartment boundaries or unite some of them. In 2000 forest management materials (inventories) were based on the aerial survey data. In 2008 forest management materials were formed by interpreting multispectral satellite images produced by artificial Earth satellites with spatial resolution of 1 – 2.5 m. In both cases images were rectified and projected for geographic coordinate system.

Mapping is a final stage of natural objects geographical study. For quantitative estimation of the plant cover, various characteristics may be used including average contour area, maximum contour area, contours density, contours boundaries density, and average entropy of contours (M. Yu. Gafarov). In addition to the above mentioned, nonnormalized rate of vegetation cover changes was determined at the characteristic testing site near Lake Samotlor (Khanty-Mansi Autonomous Area, R.F.). This rate amounted to 0.33 km$^2$/year with negative sign (Table 2).

Table 1. Forest sub-compartment boundaries and vegetation cover characteristics correlation

| Forest sub-compartment boundaries characteristics group | | | | № | Vegetation cover |
|---|---|---|---|---|---|
| Forest lands/ha | with forest vegetation cover | | Total | 1 | W |
| | | | including sylvula | 2 | W |
| | without forest vegetation cover | open forest plantations | | 3 | W |
| | | forest nurseries and plantations | | 4 | W |
| | | Natural forest thinnings | | 5 | W |
| | | reafforestation resource | burned-out forests | 6 | W |
| | | | perished forest plants | 7 | W |
| | | | clearings | 8 | W |
| | | | glades, barrens | 9 | W |
| | | | total | 10 | W |
| | forest lands, total, | | | 11 | W |
| Non-forest lands/ha | arable lands | | | 12 | W |
| | hayfields | | | 13 | W |
| | pastures | | | 14 | W |
| | water | | | 15 | O |
| | gardens, mulberry groves, berry fields | | | 16 | W |
| | roads, glades | | | 17 | O |
| | farmsteads and other | | | 18 | O |
| | swamps | | | 19 | W |
| | sand | | | 20 | O |
| | glaciers | | | 21 | O |
| | other lands | | | 22 | O |
| | non-forest lands, total | | | 23 | O |

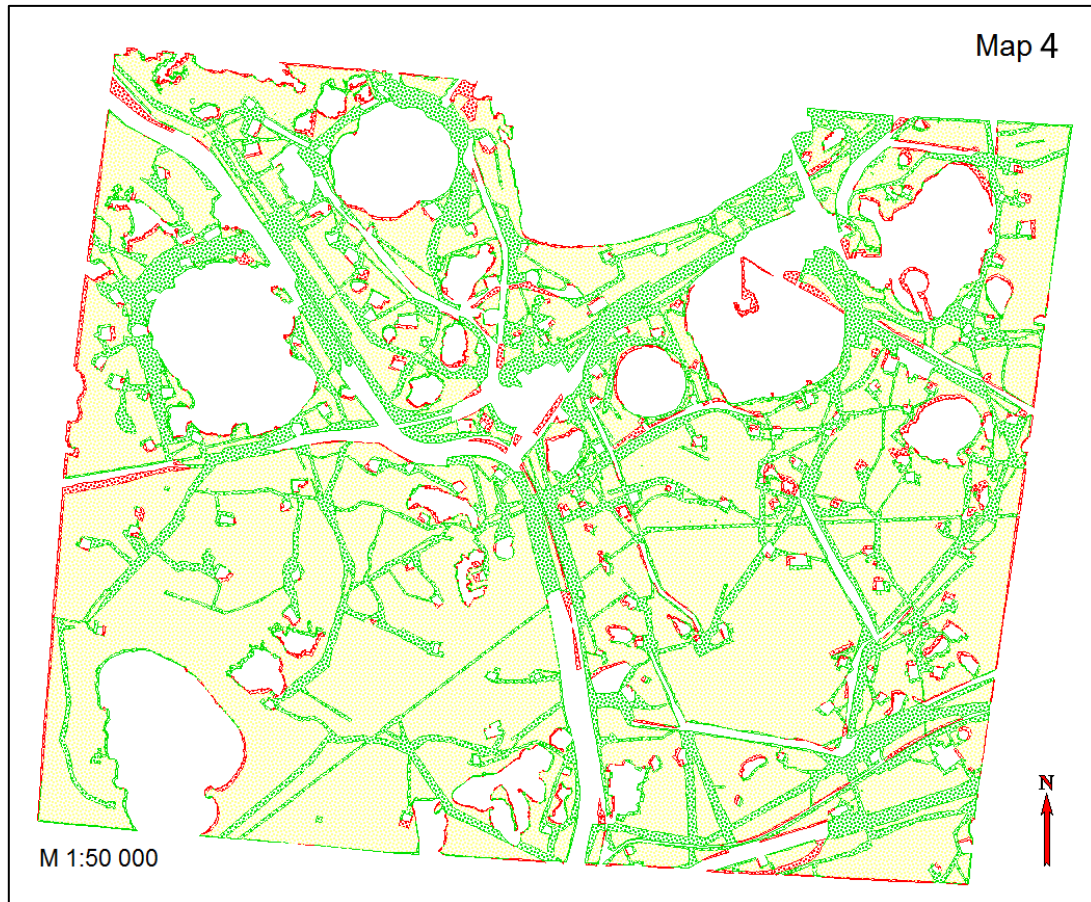| W | - with vegetation cover |
|---|---|
| O | - without (or with scarce) vegetation cover |

Table 2. Determination of nonnormalized rate of vegetation cover changes in the testing site near Lake Samotlor (Khanty-Mansi Autonomous Area, R.F.)

| Forest management/years | Area, $m^2$ | Rate, $km^2$/a year |
|---|---|---|
| 2000 | 44,5284 | - |
| 2008 | 41,9249 | - |
| 8 | 2,6035 | - 0,33 |

Map 3

2000 year

2008 year

M 1:50 000

N
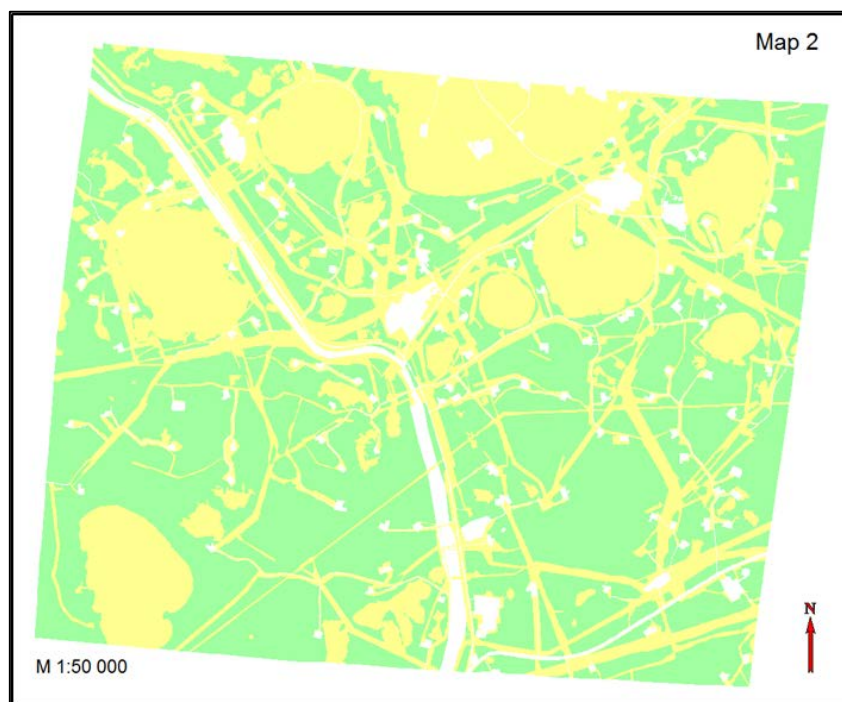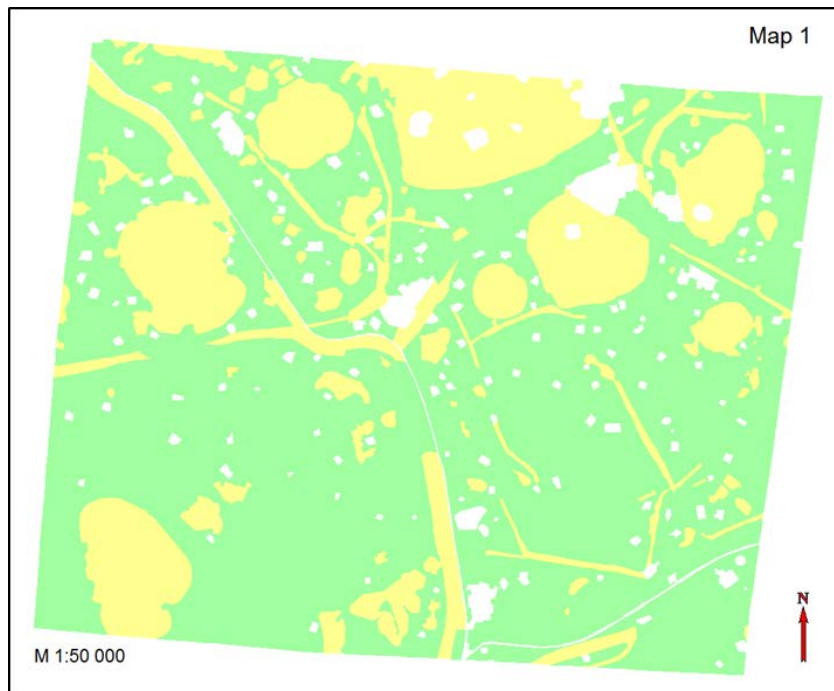
**CONCLUSIONS**

The main purpose of the map is to show spatial location of the objects. On the whole, the maps of vegetation spatio-temporal changes based on GIS layers of forest management materials (inventories) show spatial location of the vegetation and temporal tendencies of vegetation changes. The disadvantages of this kind of mapping include, for one thing, a considerable error (inaccuracy) of forest sub-compartment boundaries determination (at the stage of lands remote monitoring data interpretation by different operators (afforestation inspectors) in different years); for another, the necessity of taking into account not only actual state of vegetation, but also limitations of the conferred right of use of forest estate plots. Taking into account relatively short period of comparison (8 years) we can guess that vegetation cover area is in fact increased by the mentioned inaccuracy (4,1% of total area).

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