REMOTE SENSING OF FOREST COVER IN BOREAL ZONES OF THE EARTH

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Present-day use of satellite imagery in different countries is far from exhausting its capabilities in solving planetary-scale forest problems. Ecological tension coming from active human activities generates a need for joint efforts of countries in the boreal zone aimed at sustainable forest development in the northern latitudes, including:
– conservation of forests binding carbon and ensuring stability of the atmosphere gas composition;
– preservation of purity and water content of forest areas as conditions ensuring sustainability of historically formed structure of forest landscapes;
– preservation of the whole flora and fauna species composition diversity as a condition for sustainable existence and functioning of forest ecosystems.
Solving these problems is particularly topical in the near future due to a possible climate warming which can increase the forest's negative feedback. In particular, in the forest zone of Siberia, the climate aridization will inevitably result in periodic drying of shallow bogs and upland forests with thick forest litter in dry years. This will bring fires of unseen intensity which will lead to catastrophic pollution of the atmosphere throughout the whole boreal zone with carbon dioxide and smog. In this connection, the above problems can be solved only by the united efforts of boreal-zone countries, through establishing uniform system for remote sensing of forests aimed to obtaining and periodic update of comprehensive information for rational decision-making in prevention of adverse human effect on all northern forests.

A need to join efforts in this field of natural resource management is determined by disparate data on forests stored in artificially created forest accounting economic units, contributing mainly to the solution of economic timber resource problems. No one from ecological tasks outlined above can be solved correctly by a separate country and be markedly useful for all boreal forests if consider them within these territorial entities. They can be solved at a relatively full volume only using uniform technologies of forest remote sensing that are registered within constant boundaries of natural territorial complexes (landscapes) established throughout the whole boreal zone.
Knowledge of forest state within natural territorial entities having specific physiographic conditions allows, with account for current and future anthropogenic load, to define evidence-based forest growth potential at these landscapes, optimally sufficient to ensure development of historically formed ecological properties of the forest. Constantly updated information will permit to regulate human pressure on forests in northern latitudes, without reducing their role in the biosphere processes of carbon accumulation and release in forests, through sustainable management of its dynamics based on agreement between boreal zone countries.

Development of strategies and tactics of remote monitoring within identified landscape requires initial quantitative information about forests and in the whole about biotic components of landscapes and their abiotic environment. These data should be presented by indicators and parameters determined through both ground-based measurements and remote sensing. Thus, a kind of passport should be kept for each landscape containing informational base or a starting point for subsequent updating of remote sensing monitoring of forests and their habitats for the comparative assessment of changes in forest cover.
Implementation of the forest cover remote monitoring across the whole boreal zone of the Earth is possible only on the basis of geographical and genetic typology of forests developed by Kolesnikov (1956) and phyto-geomorphological method of aerospace image interpretation, developed by Howard and Mitchell (1980). Both approaches are based on the use of relationships between topography and vegetation, and were successfully applied by the author (1991, 1995) to a development of methodological approaches to aerospace monitoring of the forest cover of West Siberian plain.
Several natural-territorial complexes are shown here as an example. They were identified in a space image, and the assessment of forest state and dynamics is intended to be performed within their boundaries using satellite imagery in combination with aerial photographs. Each identified landscape unit within the forested area is presented by a complex of six forest formation types - pine, cedar, spruce, fir, birch, and aspen, each characterized by a set of forest survey parameters recorded in passports. Besides forest survey data, each landscape passport includes information about abiotic environment of forest and its dynamics.

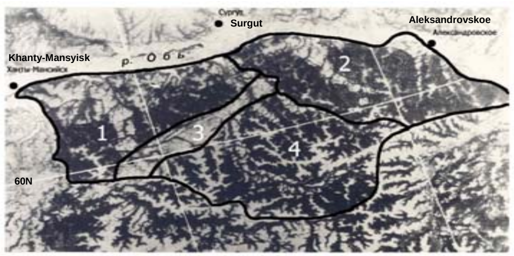

Fig.1. Winter image. Left side of of the Ob river-bank, 1 landscape unit of 1st level, 4 landscape units of 2nd level (Ob-Irtysh watershed area)

1. Ob-Irtysh, dissected, normally drained plain, consisting of topographic steps of various age extending in parallel, composed of lacustrine-alluvial deposits, covered with birch, aspen, deciduous-cedar, larch- spruce, and partially pine forests, and upland, transitory, and lowland bogs.
Elevation 40 to 100 m
Total area 22,500 sq. km
Forested area 14,200 sq. km.
Forest coverage 63.1%
Total standing volume 258,100 thousand cubic meters
Total standing phytomass of forests 166,100 tons

2. Ob-Yugan, deeply dissected, well-drained plain consisting of asymmetrical river valleys and interfluves, composed of variegated lacustrine-alluvial deposits, covered with pine, birch, birch-cedar forests, and upland, transitory, and lowland bogs.
Elevation 40 to 110 m
Total area 26,300 sq. km
Forested area 19.9 thousand sq. km
Forest coverage 75.7%
Total standing volume 420,900 thousand cubic meters
Total standing phytomass of forests 266,100 tons

3. Salym-Yugan, weakly dissected, poorly drained plain composed of lacustrine-aeolian deposits, covered mostly with pine forests and upland transitory bogs.
Elevation 60 to 70 m
Total area 5,200 sq. km
Forested area 1700 sq. km
Forest coverage 32.7%
Total standing volume 28,200 thousand cubic meters
Total standing phytomass of forests 18,000 tons

4. Yugan, well dissected, normally drained plain, consisting of symmetrical valleys and flat interfluves, covered with birch, aspen, deciduous-cedar, cedar, and pine bog forests, upland bogs, and lakes.
Elevation 50 to 100 m
Total area 30,100 sq. km
Forested area 19,500 sq. km
Forest coverage 64.7%
Total standing volume 399,900 thousand cubic meters
Total standing phytomass of forests 255,300 tons

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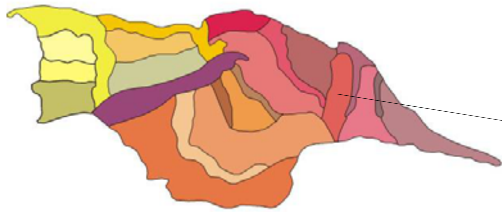
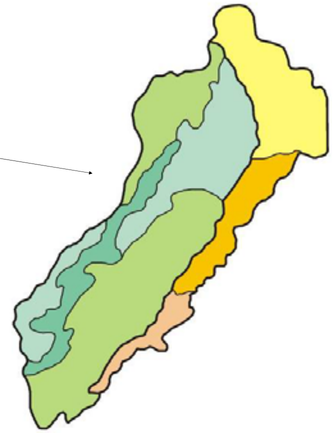
Howard, J.A. and Mitchell, C.W., 1980. Phyto-geomorphic classification of the landscape. Geoforum, 11(2):85-106.
Sedykh, V.N., 1991. [Aerospace Monitoring of Forest Cover]. Novosibirsk: Nauka, 238p. In Russian.
Sedykh V.N., 1995. Using aerial photography and satellite imagery to monitor forest cover in Western Siberia. Water, Air, & Soil Pollution, 82(1-2):499–507.

Figure 3. Third level landscape units of the left-bank latitudinal extent of the Ob river valley subject to identification on satellite images at scale 1:1000000.



Plains
- Ob-Salym streamside plain
- Ob-Balyk streanside plain
- Middle Salym plain
- Middle Balyk plain
- Upper Salym plain
- Upper Balyk plain
- Irtysh-Salym plain
- Ob-Pokur plain
- Yugan-Kuljegan plain
- Kuljegan streamside plain
- Kuljegan-Sosninskaja plain
- Sosninsko-Larjegan plain
- Larjegan streamside plain
- Larjegan-Iljak plain
- Iljak streamside plain
- Iljak-Ob plain
- Maly Yugan streamside plain
- Negusjakh streamside plain
- Negusjakh-Yugan plain
- Yugan plain
- Salym-Yugan plain
- Bolshoy Yugan streamside plain
- Upper Yugan plain

Figure 4. Fourth level landscape units subject to identification on satellite image at scale 1:500000 – 1:200000.



Sosninsko-Larjegan plain:
- Deeply roughed macroslopes of interfluvial areas, covered mainly by pine forests
- Moderately roughed macroslopes of interfluvial areas, covered mainly by cedar and derived (производными) deciduous forests
- Central watershed surfaces covered by cedar and derived deciduois forests

Larjegan streamside plain:
- Low part of streamside plain covered by cedar and derived deciduous forests
- Middle part of streamside plain covered by cedar, pine, and derived deciduous forests
- Upper part of streamside plain covered mainly by pine forests.

Figure 6. Sixth level landscape units subject to identification on satellite images at scale 1:100000 – 1:50000.

Valley slopes:
- -Cedar forests with short-grass and moss cover (80%) associated with cedar forests with berry bush and moss cover (20%)
- -Cedar forests with short-grass and moss cover
- -Cedar forests with berry bush and moss cover (70%) associated with cedar forests with moss cover

Watersheas:
- -Cedar forests with short-grass and moss cover (60%) associated with cedar forests with berry bush and moss cover (40%)
- -Cedar forests with moss cover
- -Cedar forests with moss cover (60%) associated with cedar forests with berry bush and moss cover (40%)
- -Cedar forests with swamp cover

Valley bottoms:
- -Bogs
- -Cedar forests with grass and swamp cover (50%) associated with pine forests with swamp cover 950%)
- - Pine forests with grass and swamp cover

Figure 5. Fifth level landscape units subject to identification on satellite images at scale 1:200000 – 1:100000.

- Deeply roughed macroslopes of Sosninsko-Larjegan plain watersheds:
- Steep slopes covered by automorphic pine forests
- Watersheds covered by semihydromorphic pine and cedar forests
- Valley bottoms covered by hydromorphic pine forests

-Moderately roughed macroslopes of watersheds of Sosninsko-Larjegan plain
- Slopes covered automorphic cedar and derived deciduous forests
- Watersheds covered by automorphic and semihydromorphic cedar and pine for.
- Valley bottoms covered by bogs and hydromorphic cedar and pine forests

-Low part of Larjegan streamside plain:
- Sites inside bog lands covered by automorphic cedar and deciduous forests
- Streamside sites covered by automorphic cedar forests
- Bog lands