Modern vegetation mapping of the boreal forest biome of the Eastern European Russia

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The purpose of our research is revealing a modern diversity of forest vegetation East-European part of taiga Biome and regularities of its distribution for the creation of a series different-scales maps of actual vegetation on this territory.
Cartographical materials and publications are put in a basis of work: map “Vegetation of the USSR”, “Vegetation of the European part of the USSR and Transcaucasia, “Map of the Natural Vegetation of Europe” and series of regional maps: “Vegetation of the Moscow area”, “Vegetation of the Kola Peninsula”, “Vegetation of the Transvolga area”
For work the following positions are accepted

- Boreal forests are considered as a part of Boreal Biome in territory of East European Plain in structure of zone divisions: forest-tundra open forests, north-, middle-, south-taiga forests and a strip of broad-leaved-coniferous forests.

- The ecologic-morphological classification of plant communities for display of a current diversity of boreal forests is used.

- The application of its in cartographical modeling will provide an effective estimation of its state, and use of the information in different geographical regions of the taiga Biome.
For a work the following positions are accepted

- The scheme corresponds to the structure of divisions of a boreal zone accepted for CBVM. It is using a combination of physiognomic, structural, vegetation-typological, climatic, site-related and geographical features to create various hierarchic levels.

- The highest level of classification includes climatically based **zonal** and **edaphic** vegetation formations.

- Geographical variants of boreal forests should be correlated to scheme of phyto-geographical divisions into districts.
Ecoregions of Russia

Ogureeva G.N., 2010
Regional complexes of plant formations in limits of ecoregions are allocated.

9 – Kola-Karelia hypoarctic boreal, 10 – Mezeno-Pechora hypoarctic boreal, 15 – Pre-Baltic-Vetluga boreal, 16 – Pre-Ural boreal, 23 – Smolensk-Volga hemiboreal, 24 – Kama r. hemiboreal
Allocation of ecoregions is confirmed with the statistical analysis of climatic parameters on the territory EEP. The borders are corrected by climatic features.

- MAIBIO1 = Annual Mean Temperature
- BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
- BIO3 = Isothermality (BIO2/BIO7) (* 100)
- BIO4 = Temperature Seasonality (standard deviation *100)
- BIO5 = Max Temperature of Warmest Month
- BIO6 = Min Temperature of Coldest Month
- BIO7 = Temperature Annual Range (BIO5-BIO6)
- BIO8 = Mean Temperature of Wettest Quarter
- BIO9 = Mean Temperature of Driest Quarter
- BIO10 = Mean Temperature of Warmest Quarter
- BIO11 = Mean Temperature of Coldest Quarter
- BIO12 = Annual Precipitation
- BIO13 = Precipitation of Wettest Month
- BIO14 = Precipitation of Driest Month
- BIO15 = Precipitation Seasonality (Coefficient of Variation)
- BIO16 = Precipitation of Wettest Quarter
- BIO17 = Precipitation of Driest Quarter
- BIO18 = Precipitation of Warmest Quarter
- BIO19 = Precipitation of Coldest Quarter
### V.I.1.1. European north boreal types

<table>
<thead>
<tr>
<th>Draft of legend for Eurasian boreal vegetation (CBVM)</th>
<th>Offered variants</th>
</tr>
</thead>
</table>

### V.I.1.2. European middle boreal types

| V.I.1.2.1. North European spruce forests | East Scandinavian (Karelia) |
| V.I.1.2.2. Northeast European hygrophilous spruce forests | East European (Ladoga-Vychegda r.) |
| V.I.1.2.3. Northeast European spruce f. | |

### V.I.1.3. European south boreal types

| V.I.1.3.1. Fennoscandinavian moss-rich spruce forests (*Picea abies*) with dwarf shrubs and herbaceous plants, locally alternating with pine and spruce mires. | East Scandinavian moss-rich spruce forests (*Picea abies*) with dwarf shrubs and herbaceous plants |
| V.I.1.3.2. Scandinavian-east European spruce forests (*Picea abies*, in the east *Picea abies* x *P. obovata*), partly with *Tilia cordata*, and *Corylus avelliana*, with herbs, dwarf shrubs and mosses | East European (Pre-Baltic-Vetluga) taiga of spruce (*Picea abies*) and pine (*Pinus sylvestris*) forests with *Oxalis acerosella* and nemoral herb species (*Galeobdolon luteum*, *Hepatica nobilis*, *Stellaria holostea*, *Pulmonaria obscura*) |
| *Pre-Ural* taiga consists of spruce and fir-spruce (*Picea obovata*, *Abies sibirica*) forests with nemoral herbs (*Pulmonaria obscura*, *Asarum europaeum*, *Aegopodium podagraria*) and Siberian tall forb species (*Aconitum septentrionale*, *Crepis sibirica*, *Cacalia hastata*) |
Researched regions

Modeling territories in limits of ecoregions
The modeling scheme of vegetation cover structure

Data of the field investigations

Base of the cartographical data

Materials of satellite shooting

Classification

Interpolation of typified local characteristics on a regional level

The general software (GIS)

The applied software

Classification

Interpolation of typified regional characteristics on a global level

Base of the cartographical data

Materials of satellite shooting
The main used information sources:

- Forest inventory data
- Remote sensing data
- Topographic maps
- Vegetating maps

• Field Research Materials
Morphometrical characteristics of a relief (Advances in Digital Terrain Analysis, 2008), considered on basis Digital Model of a Relief with a method of the step-by-step discriminate analysis. The list of indicator parameters can be added with indicators climatic, moisture soils, soil building rock, features of economic activities etc.
Different season satellite images of various systems (Landsat, Spot, Aster etc.), recording conditions of a terrestrial surface are used.
Modeling site – Kola Peninsula
(fragment of a vegetation map)

(scale 1:100 000)
Kola Peninsula
Pine and spruce forests
Modeling site – Transvolga area
(fragment of vegetation map)

Scale 1:500 000
<table>
<thead>
<tr>
<th><strong>Legend of the Vegetation Map</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Dark-coniferous, broad-leaved-coniferous forests</strong></td>
</tr>
<tr>
<td>Polytric and sphagnum pine forests</td>
</tr>
<tr>
<td><strong>Spruce moss f. in combination with spruce swampy herb-moss</strong></td>
</tr>
<tr>
<td>Oak and lime pine forests</td>
</tr>
<tr>
<td><strong>Spruce haircap-moss and moss-sphagnum f.</strong></td>
</tr>
<tr>
<td>Aspen and birch secondary forests with spruce and pine</td>
</tr>
<tr>
<td><strong>Oak-spruce, lime-spruce forests</strong></td>
</tr>
<tr>
<td>Aspen and birch secondary forests with lime-trees</td>
</tr>
<tr>
<td><strong>Aspen and birch secondary f. with spruce and fir trees forests</strong></td>
</tr>
<tr>
<td><strong>Broad-leaved forests</strong></td>
</tr>
<tr>
<td><strong>Aspen and birch forests with lime trees</strong></td>
</tr>
<tr>
<td>Oak and lime-oak forests</td>
</tr>
<tr>
<td><strong>Agriculture lands</strong></td>
</tr>
<tr>
<td>Lime forests</td>
</tr>
<tr>
<td><strong>Pine- and broad-leaved-pine f. (Pinus sylvestris)</strong></td>
</tr>
<tr>
<td>Aspen and birch forests with lime and oak trees</td>
</tr>
<tr>
<td><strong>Moss pine-forests in combination with grass marsh forests</strong></td>
</tr>
<tr>
<td>Agriculture lands</td>
</tr>
</tbody>
</table>
**Generalised map of actual vegetation of Nizhegorodskoe Zavolzhie region** (Transvolga area)

<table>
<thead>
<tr>
<th></th>
<th>moss with herb</th>
<th>peatmoss</th>
<th>nemoral (with lime)</th>
<th>derivate aspen and birch forests</th>
<th>derivate agricultural territories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spruce</strong></td>
<td>![Pink Square]</td>
<td>![Pink Square]</td>
<td>![Green Square]</td>
<td>![Green Square]</td>
<td>![Green Square]</td>
</tr>
<tr>
<td><strong>Fir-spruce</strong></td>
<td>![Teal Square]</td>
<td>![Teal Square]</td>
<td>![Green Square]</td>
<td>![Green Square]</td>
<td>![Blue Square]</td>
</tr>
<tr>
<td><strong>Pine</strong></td>
<td>![Yellow Square]</td>
<td>![Gold Square]</td>
<td>![Orange Square]</td>
<td>![Green Square]</td>
<td>![Yellow Square]</td>
</tr>
<tr>
<td><strong>Oak</strong></td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td></td>
</tr>
<tr>
<td><strong>Lime</strong></td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td>![Brown Square]</td>
<td></td>
</tr>
<tr>
<td><strong>Sphagnum bogs</strong></td>
<td>![Gray Square]</td>
<td>![Gray Square]</td>
<td>![Gray Square]</td>
<td>![Gray Square]</td>
<td></td>
</tr>
</tbody>
</table>
Transvolga area
Fir-spruce forests

Oxalis acetosella
The fragment of the Map “Natural vegetation of Europe” (Pre-Baltic-Vetluga ecoregion)
Fragment of the actual vegetation map of East-European area (Pre-Baltic-Vetluga ecoregion) by satellite image, climate data and DEM

The legend for the fragment

- **Forests**
  - Boreal dark-coniferous forests
    - Northern boreal spruce forest types (*Picea excelsa, P. obovata*)
    - Middle boreal spruce forest types (*Picea excelsa, P. obovata*)
    - Southern boreal spruce forest types (*Picea excelsa*)
  - Middle boreal lowland-colline pine-spruce forest types (*Picea obovata, Pinus silvestris*)
  - Southern Pre-Ural fir-spruce forest types (*Picea obovata, Abies sibirica*)
  - Boreal light-coniferous forests
    - Northern boreal pine forest types (*Pinus silvestris*)
  - East-European hemiboreal forests
    - (Smolensk-Pre-Volga ecoregion)
  - Hemiboreal dark-coniferous forests
  - Lowland-colline pine-spruce forest types (*Pinus silvestris, Picea excelsa*)
  - Hemiboreal light-coniferous forests
    - Southern boreal to hemiboreal lowland-colline pine forest types (*Pinus silvestris*)
  - Hemiboreal and nemoral lowland (to submontane) pine forest types (*Pinus silvestris*)
  - East-European nemoral broad-leaved forests
    - (Dnepr-Pre-Volga ecoregion)
  - Subcontinental Transvolga-Kazachstan steppes
    - Lowland-colline meadow steppe and steppe-like grass types
    - Lowland-colline herb-grass steppe types (*Stipa ucrainica, S. zalesskii*)
  - Azonal boreal types
  - Mires
    - Boreal aapa mire complexes
    - Sphagnum fuscum-raised bog complexes in the boreal zone
    - Sphagnum magellanicum-raised bog complexes in the hemiboreal and nemoral zones
    - Transitional mires (nutrient-poor fens)
    - Small-sedge-brown-moss fens
  - Alluvial forests
    - Northern to middle boreal coniferous and mixed broad-leaved forest types
    - Southern boreal coniferous and mixed broad-leaved forest types
Conclusion

- The results of research enable to carry out the comparative analysis of ecosystem diversity of boreal forests at a regional level in different natural regions, to reveal the general regularities of spatial structure of East-European boreal forests and to create cartographical model of regional part of Circumboreal taiga biome.
Thanks for attention!