

## **Electronic Supplementary Material**

### **Protected area as an indicator of ecological sustainability? A century of development in Europe's boreal forest**

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**Table S1** The main units of the European boreal forests based on the explanatory text to the Map of Natural Vegetation of Europe by Bohn et al. (2004)

|                                                                                                                                                                                                                                                                |                                                                                                                                                           | Main formations: Mesophytic and hygromesophytic coniferous and mixed broadleaved-coniferous forests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| Western boreal forest                                                                                                                                                                                                                                          |                                                                                                                                                           | Eastern boreal forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Spruce forests ( <i>Picea abies</i> , <i>P. obovata</i> , <i>Picea abies</i> x <i>Picea obovata</i> ) with partly <i>Pinus silvestris</i> , locally with birch ( <i>Betula pubescens</i> , <i>B. pendula</i> ), alder ( <i>Alnus incana</i> ) or mixed forests |                                                                                                                                                           | Pine-spruce ( <i>Picea obovata</i> , <i>Pinus sibirica</i> ) and fir-spruce-forests ( <i>Picea obovata</i> , <i>Abies sibirica</i> ), partly with <i>Betula pubescens</i> , and <i>Larix sibirica</i>                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <u>Climate and site conditions</u>                                                                                                                                                                                                                             |                                                                                                                                                           | <u>Stand structure and floristic composition</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Northern boreal forests                                                                                                                                                                                                                                        | Low summer temperature, considerable water supply. Gley podzol and peat soils                                                                             | Reduced growth, reduced canopy closure and low timber yield. The average height of spruce in mature stands is 15-17 m. Dominant tree layer in the west are <i>Picea abies</i> , and <i>Picea obovata</i> in the east. Specific species: <i>Loiseleuria procumbens</i> , <i>Phyllodoce caerulea</i> . Lichens: <i>Nephroma arcticum</i> . Shrubs: <i>Calluna vulgaris</i> is common, on dry sites – <i>Sorbus aucuparia</i> , <i>Juniperus communis</i> and <i>Rosa acicularis</i> , on wet site – <i>Betula nana</i> , <i>Salix lapponum</i> and <i>S. phylicifolia</i> . Birch and aspen are pioneer species after forest fires and clear-cutting. | Low summer temperature, considerable water supply. Loamy-sandy gley podzols and peat-podzol-gley soils. | The tree canopy is low (40-60%) with dominant <i>Picea obovata</i> , regular admixtures of birch ( <i>Betula pubescens</i> ) and to a lesser extent <i>Pinus sibirica</i> (10-20%). Open and species-poor understorey with <i>Sorbus aucuparia</i> , <i>Juniperus communis</i> , <i>Rosa acicularis</i> , <i>Betula nana</i> , <i>Alnus fruticosa</i> .                                                                                                                                                                          |
| Middle boreal forests                                                                                                                                                                                                                                          | Moderately warm and moist summers; cold, snow-rich winters. Flat interfluvial plains with glacial and fluvioglacial sediments. Podzolic and wetted soils. | Well developed, usually single-species tree layer. <i>Picea abies</i> , <i>P. abies</i> x <i>P. obovata</i> and/or <i>P. obovata</i> with a canopy cover of 70-80%. Average height of fully-grown spruces – 18-20 m. The shrub layer is absent or weakly developed with <i>Juniperus communis</i> and <i>Sorbus aucuparia</i> being most frequent. In the western part – <i>Rosa majalis</i> , <i>Rosa acicularis</i> and <i>Lonicera pallasii</i> .                                                                                                                                                                                                | Moderately warm and moist summers; cold, snow-rich winters. Podzols and gley-podzols soils.             | Tree species mainly <i>Picea obovata</i> and <i>Abies sibirica</i> , and on moist sites <i>Pinus sibirica</i> and <i>Larix sibirica</i> . Widespread species: <i>Sorbus aucuparia</i> and Siberian elements – <i>Sorbus aucuparia</i> subsp. <i>sibirica</i> , <i>Rosa acicularis</i> , <i>Lonicera pallasii</i> . The dominant type of spruce forests with <i>Vaccinium myrtillus</i> , <i>Linnaea borealis</i> , <i>Maianthemum bifolium</i> , <i>Vaccinium vitis-idaea</i> , <i>Luzula pilosa</i> , <i>Orthilia secunda</i> . |

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| Southern boreal forests | A mild climate, a longer vegetation period. Soils are weakly podzolic. A rough and well structured glacial accumulation relief after being glaciated during the last ice-age. | Stands are dominated by <i>Picea abies</i> in the west and <i>Picea obovata</i> and transition forms with <i>Betula pendula</i> , <i>B. pubescens</i> and/or <i>Populus tremula</i> . The shrub layer is very open with <i>Sorbus aucuparia</i> , <i>Corylus avellana</i> , <i>Lonicera xylosteum</i> and <i>Daphne mezereum</i> . | A mild climate, podzoloc, loamy-sandy and loamy soils. | The tree layer is formed by <i>Picea obovata</i> and <i>Abies sibirica</i> . The shrub layer is well developed and species-rich with nemoral species: <i>Tilia cordata</i> , <i>Lonicera xylosteum</i> , <i>Viburnum opulus</i> , <i>Frangula alnus</i> , <i>Rosa acicularis</i> and <i>R. majalis</i> . The herb layer has a high degree of coverage and species-rich with typical boreal forests as well as nemoral elements. |
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**Table S2** The sources of data on protected areas in Europe's boreal forest

| Published sources                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Internet sources                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| 1. Bakka, A., and S. Bakka. 1997. <i>Особо охраняемые природные территории Нижегородской области</i> [Specially Protected Natural Areas of Nizhegorodskaya Oblast']. Annotated list: Nizhniy Novgorod (in Russian)                                                                                                                                                                                                                                                                                                        | <a href="http://kartkatalog.dirnat.no/map_catalog_dataset.asp?datasetid=0&amp;download=yes&amp;language=EN">http://kartkatalog.dirnat.no/map_catalog_dataset.asp?datasetid=0&amp;download=yes&amp;language=EN</a><br><a href="http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-5">http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-5</a><br><a href="http://oopt.info">http://oopt.info</a> Checked 10.09.2012.                                                                                                                         |
| 2. Bakka, S., and N. Kiseliova. 2009. <i>Особо охраняемые природные территории Нижегородской области</i> [Specially Protected Natural Areas of Nizhegorodskaya Oblast']. Annotated list: Nizhniy Novgorod. (in Russian)                                                                                                                                                                                                                                                                                                   | <a href="http://paslo.ru">http://paslo.ru</a> Checked 10.09.2012<br><a href="http://www.duproos.ru/files/gd2010_g17.doc">www.duproos.ru/files/gd2010_g17.doc</a> Checked 10.09.2012<br><a href="http://www.duproos.ru/files/gd2010_pril3.doc">www.duproos.ru/files/gd2010_pril3.doc</a> Checked 10.09.2012.<br><a href="http://prirodnadzor.mari-el.ru/oopt.html">http://prirodnadzor.mari-el.ru/oopt.html</a> Checked 10.09.2012.<br><a href="http://www.oopt.aari.ru">http://www.oopt.aari.ru</a> Checked 10.09.2012.                                                                                           |
| 3. Van'kovskiy, L. (ed.) 1983. <i>Природные памятники Пермской области</i> . [Natural Monuments of Permskaya Oblast'] Perm'. (in Russian)                                                                                                                                                                                                                                                                                                                                                                                 | <a href="http://www.biodiversity.ru/kola">http://www.biodiversity.ru/kola</a> . Checked 10.09.2012<br><a href="http://zapoved.ru">http://zapoved.ru</a> Checked 10.09.2012.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 4. Degteva, S. (ed). 2010 <i>Особо охраняемые природные территории Республики Коми: результаты GAP-анализа и перспективы развития</i> [Specially Protected Natural Areas of Komi Republic: outputs of the GAP-analysis and development perspectives] Syktyvkar. (in Russian)                                                                                                                                                                                                                                              | <a href="http://kp.ivanovoobl.ru/deyatelnost_komiteta/osobo_okhranyaemye_prirodnye_territorii.php">http://kp.ivanovoobl.ru/deyatelnost_komiteta/osobo_okhranyaemye_prirodnye_territorii.php</a><br><a href="http://kp.ivanovoobl.ru/upload/iblock/df3/OOPT">http://kp.ivanovoobl.ru/upload/iblock/df3/OOPT</a> <a href="http://kp.ivanovoobl.ru/upload/iblock/df3/OOPT">http://kp.ivanovoobl.ru/upload/iblock/df3/OOPT</a> 10.09.2012                                                                                                                                                                             |
| 5. Kobyakov, K. (ed). 2011. <i>Картирование территорий высокой природоохранной ценности на Северо-западе России: Гар-анализ сети охраняемых территорий Мурманского, Ленинградского, Архангельского, Вологодского и Карельского регионов и города Санкт-Петербурга</i> [Mapping of High Conservation Value Areas in Northwestern Russia: Gap-Analysis of the Protected Areas Network in the Murmansk, Leningrad, Arkhangelsk, Vologda, and Karelia regions, and the city of Saint-Petersburg] St. Petersburg. (in Russian) | <a href="http://priroda.pskov.ru/oopt-pskovskoi-oblasti">http://priroda.pskov.ru/oopt-pskovskoi-oblasti</a><br><a href="http://www.dvinaland.ru/power/departments/comeco/terrs/">http://www.dvinaland.ru/power/departments/comeco/terrs/</a> Checked 10.09.2012.<br><a href="http://www.kirovreg.ru/econom/prres/zakaznik/">http://www.kirovreg.ru/econom/prres/zakaznik/</a> Checked 10.09.2012.<br><a href="http://oopt.kosmosnimki.ru">http://oopt.kosmosnimki.ru</a> Checked 10.09.2012.<br><a href="http://forest-karelia.ru/uploads/ff.png">http://forest-karelia.ru/uploads/ff.png</a> Checked 10.09.2012. |
| 6. Litvinova, E. 2011. Состояние сети охраняемые территорий в Новгородском регионе: история формирования и влияние социальных условий [State of the network of protected areas in the Novgorod region: formation history and the impact of social conditions]. In <i>Geographic basis for the development of the ecological networks in Russia and Eastern Europe</i> , 78– 83. Proceedings of the Valdai conference (4-9 April 2011). Moscow: RAS Institute of Geography. (in Russian)                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 7. <i>Красная книга природы Санкт-Петербурга. Охраняемые территории</i> [Red Data Book of Nature of Saint-Petersburg. Protected Areas]ю Professional ANO NGO: Saint-Petersburg. (in Russian)                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 8. Oviosnov, S. (ed). 2009. <i>Особо охраняемые природные территории Пермской области. Инвентаризация</i> [Specially Protected Natural Areas of Permskaya Oblast'. An inventory] Knizny mir: Perm' (in Russian)                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

9. Soloviova, N. (ed). 2002. *Особоохраняемые природные территории Республики Удмуртия*. [Natural Areas of Udmurtia Republic]. Izhevsk. (in Russian)
10. Stepanitskiy, V., Stishov, M., Troitskaya, N., and A. Troitskiy. 2009. Анализ форм управления и категорий федеральных особоохраняемых природных территорий [Analysis of management forms and categories of Federal Specially Protected Natural Areas] In: *Особоохраняемые природные территории России: современное состояние и перспективы развития* [Specially Protected Natural Areas of Russia: current state and development perspectives], 22–50. Ed. Krever, V., Stishov, M., and I. Onufrenia. WWF Russia: Moscow (in Russian)
11. Tishkov, A. 2002b. Nature protection and conservation. In *The physical geography of Northern Eurasia*, ed. M. Shahgedanova, 227–245. Oxford: Oxford University Press.
12. Tyusov, A. 2008. *Оценка охранного статуса территории через пространственный анализ распространения редких видов: на примере Тверской области* [Assessing conservation status of a territory through spatial analysis of rare species distribution: an example of Tverskaya Oblast'. PhD thesis] Perm'. (in Russian)