Northern Eurasian Arctic: Impact of Climate Change on Ecosystems

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The coldest land mass of continental scale including all bioclimatic zones of the Northern Hemisphere

Fragile ecosystem which evolutionarily developed under cold climate

The biggest bog-forest ecosystems globally

About two-thirds of the area is represented by permafrost which contains from 500-900 Pg C in permafrost and bogs (methane, hydrates)

The most dramatic climate change over the globe is expected here

Boreal forests of Northern Eurasia is considered as a likely tipping element by end of this century

The region of unregulated and devastating anthropogenic impacts
North of Siberia, July 2013, Terra MODIS

Land surface temperature anomalies for 20-27 July measured 32°C daily July average 16°C

Source: http://earthobservatory.nasa.gov/IOTD/
Acceleration of natural and human-induced disturbances

▲ the average area of wild fires in Russia in 1998 - 2010 exceeded 9 million ha including 5 million ha of forests
▲ fires in 2011 – 20 million ha, 2012 – 25 million ha
▲ these fires produced direct carbon emissions at ~130 million ton C per year
▲ an outbreak of Siberian moth in Russia in 2001 covered ~10 million ha
▲ the total direct C emissions due to disturbances are from 250-300 million t per year
Risks for terrestrial ecosystems

- Negative consequences of permafrost destruction
- Loss of soil fertility, impoverishment of soil biota, decline of productivity of land
- Lack of water resources in arid regions
- Damage of land in river valleys due to increase of denudation
- Anomalous outbreaks and spatial distribution of traditional and new insects
- Alteration of forest fire regimes
- Loss of biodiversity
- “Green” desertification
- Air pollution, soil and water contamination
Full carbon account for Russia in 2009 – flux-based approach

All ecosystems of Russia in 2000-2010 served as a net carbon sink at 0.5-0.7 Pg per year.
Of this sink ~95% was provided by forests.
Source: Shvidenko et al. 2011

Source: Ciais et al. 2010
Practically all environmental/ climate change research deal with fuzzy systems (full complexity or wicked problems)

An Example - Terrestrial Biota Verified Full Carbon Account is a dynamic complicated open stochastic fuzzy system
The direct verification of results of FCA is not possible
Structural uncertainty cannot be reliably recognized within any individually used method

Landscape-ecosystem approach
Process-based models
Flux measurements
Multi-sensor remote sensing concept
Inverse modelling
The world should be planning to adapt to 4°C of warming

Global average surface temperature scenarios for peak emissions at three different dates with 3%-per-year reductions in greenhouse gas emissions.

Source: Parry et al. Nature 458, 30 April 2009
Northern Eurasia under +4°C globally

The impact of a global temperature rise of 4°C (7 °F)

http://www.actoncopenhagen.decc.gov.uk
Distribution of bioclimatic zone in Northern Asia under current (a) and 2090 climate (Tchebakova et al. 2009)

Water (0), tundra (1), forest tundra (2), dark coniferous (3), light coniferous (4), forest steppe (5), steppe (6), desert (7), polar desert (8).
Adaptive forest management: climate change vs management (LDSM Landis – II)

Northern Forest Enterprise of Irkutsk oblast
Source Gustafson, Shvidenko et al. 2008
Need of an integrated approach: the first step - unified information background
Hybrid Land Cover – an information basis of Integrated Land Information System
Hybrid land cover 2009 – a background of the Integrated Land Information System (1 km resolution)
Correction of many year empirical averages for actual climate of individual seasons: An example of temperature impact on forest NPP

Examination of different regression models

\[ \Delta \text{NPP} = F(\Delta \text{DD}>5^\circ\text{C}, \Delta \text{P}>5^\circ\text{C}, \Delta [\text{CO}_2]) \]

\[ \Delta \text{HR} = \phi(\text{N}>0^\circ\text{C}, \text{P}>0^\circ\text{C}, \Delta \text{T}>0^\circ\text{C}, \text{W}) \]

\[ \Delta \text{HR} = \phi \text{ (11 seasonal climatic indicators)} \]

Inter-seasonal variability of NPP and HR can reach 15-30%, dependently of size of area