# Fire impact on forest formation in the light-coniferous forests of the southern Siberia

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Wildfire is the main disturbance factor in the boreal forests of Siberia. The majority of fires occur in the south of Siberia where the highest anthropogenic pressure is observed. We have examined in situ fire effects at 570 sample plots for the last 15 years. Forest formation process in the light-coniferous forests of the southern Siberia was found to depend significantly on zonal and geographic particularities of the forest lands. Different forest regions are characterized by specific factors of forest formation, which impact on fire behavior and its consequences. Fire tolerance of the tree species and stands depends on the ecological demands of the trees, terrain, and forest conditions. Postfire tree mortality depends greatly on the fire characteristics and periodicity. The biggest stand damage after surface fires in the southern Siberia was found in the forests of Angara region and Altai-Sayan mountain region. Tree mortality in the similar forest conditions after fires of identical type and severity could differ 2-4 times depending on the region. High-severity steady fires in all forest regions of Siberia result in nearly all or total tree mortality. Anthropogenic factors often increase negative fire consequences. Climate warming causes droughts intensification and change of fire regimes thus leading to the steppification and desertification of the forested lands and extension of the rocky areas. These processes mainly happen in the southern latitudinal forest border (forest-steppe zone in the southern Siberia and southern regions of the Zabaikalsky krai), as well as in the lowest and highest altitudes (more often –in the southern slopes). Wildfires accelerate transformation of the forests and shift of the borders zones and subzones. Based on our field data, with a use of satellite images and forest inventory datasets, we were able to develop methodology to forecast postfire forest ecosystem state and estimate natural fire danger dynamics. This research was supported by the Russian Foundation for Basic Research (grant # 15-04-06567) and NASA Land Cover and Land Use Change Program.

Keywords: fire type and severity, tree mortality, zonal and geographic particularities

 

# Soil $CO_2$ efflux rates after wildfires in ecosystems of Central Siberia

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Fire is a main disturbance factor in boreal forest ecosystems, which is very important to the ecology of these sensitive forests and plays a central role in carbon cycling. The rapid influence of fire on carbon cycle occurs through the emission of carbon into the atmosphere during biomass burning. Besides this direct influence fire initiates succession and thus regulates patterns of C accumulation through net primary production and also influences the soil thermal and moisture regime, which, in turn, affect patterns of soil respiration.
Since 2006 the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org) a research platform for large-scale climatic observations is operational in Central Siberia (60°48’N, 89°21’E). The data of high-frequency trace gas measurements at the tall tower are used in atmospheric inversion studies to infer the distribution of C sinks and sources over central part of Northern Eurasia. We present our estimates of carbon release through soil respiration in boreal forest ecosystems of Central Siberia after large-scale fires that occured in 2012 in the tall tower footprint area.
Burned landscapes in the tall tower footprint area were estimated based on Landsat ETM 5,8 satellite images. For selected burned areas a magnitude of ecological change caused by fires (“burn severity”) was measured and mapped with a Normalized Burn Ratio index (*dNBR*) and further calibrated by a complementary field based Composite Burn Index (*CBI*). Additionally, values of combustion efficiency (*CE*) for studied areas were calculated based on the time series of $CO/CO_2$ mixing ratios measured at 300 m a.g.l. in fire plumes while air transport from specific wildfires upwind of the measurement site was traced based on ensembles of 24-hrs backward trajectories from ARL NOAA HYSPLIT model. Active fire spots were detected from Terra/Aqua MODIS satellite data. Field investigations were performed on study plots established after fire in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) where estimations of woody C pools and their mapping were made with a laser-based field instrumentation system. Soil respiration rates were measured within the plots using a dynamic closed chamber method by a portable LI-6400 system.
Within all studied ecosystems soil efflux rates 3 yrs after fire demonstrated 15 - 25% lower values compared to pre-fire conditions. The highest values within ecosystems after fire have been found out in wet and less disturbed dark and mixed forests (up to 3,8). In these ecosystems fires occured mostly in a smoldering phase (*CE* = 0,92 - 0,93) and a field calibrated *dNBR* didn’t exceed 25 –30%. Such fires could cause only a surface mineralization that resulted in soil fertilization after fire and a spread vegetation cover was found within the plots. A linear regression analysis has shown a good correlation ($r^2$=0.91 –0.98) of soil efflux rates and soil temperature (10 cm depth), which confirms the essential input of autotrophic respiration into a total C flux. In turn the lowest values (≈ 2,5) were typical within the dry pine stands with the highest *dNBR* (≈ 45%), where *CE* could reach up to 0,99 demonstrating a prevailing flame phase of fire. Within these plots we found out >80% of dead trees and highly damaged vegetation cover with patches of exposed mineral soil. Decomposition processes in C cycling of such ecosystems are believed to be prevailing. Linear regressions analysis of efflux rates and soil temperature didn’t demonstrate any correlation ($r^2$ =0.02), which also suggests a primarily heterotrophic origin of C flux.
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Keywords: Wildfire, Siberia, Carbon balance, Soil respiration

 

# Assessing pyrogenic impact on Scots pine (*Pinus sylvestris L.*) stands after surface fires in Central Siberia

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In the face of increasing number of wildfires, there is no doubt about large uncertainties existing in their assessing which occur mostly on the stage of ground investigations. Whereas a lot of remote sensing data on fires are developed intensively, accurate *in situ* estimates of fire induced changes in ecosystems are still the most variable and sparse. A laser-based field instrumentation system supplemented by the other measurements (assessment of woody carbon pools, forest evaluation, vegetation and soil descriptions etc.) provides a powerful tool for comprehensive description of spatial development of wildfires within the study area. Such observations demonstrate the spatial heterogeneity of burns and how fire interacts with vegetation and topography. It permits analysis of relationships between spatial parameters and intensity of burning and thus providing estimations of fire damage of trees linked with many other related parameters within the area (such as undergrowth, slash, etc.).

Field investigations were performed on study plots established in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) after large-scale fires that occurred in 2012. Using a linear regressions analysis we have selected two main factors that are vital for Scots pine in survival during high-intensity ground fire: individual characteristics of a tree and spatial location (type of damages, stores of biomass available for combustion around the tree) (R = 0.81) and the diameter of root collars (R = 0.86). Surface location of root system has been found to be a reason of a strong drop in fire-resistance of Scots pine. Within the fast-moving surface fires we found out that dead trees with surface location of root system reached around 42% and after steady surface forest fire mortality could achieve up to 91%. Individual morphometric parameters of trees (big-butt, slope, and curvature of a stem) have been found to be a next influential factor of tree mortality. We found out that visible post-fire damages of stem were deadly significant for Scots pine mature trees if fire scars reached more than 2/3 of circumference (for damage of cambium layer). Such damages could be a reason of 89% mortality of Scots pine trees. In such cases if tree survived after the fire, it could be destroyed by the next fire due to increased pitch flow, which decreases fire-resistance of the tree. These results confirm that for mature pine stands surface forest fires are as dangerous as crown fires.

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Keywords: Central Siberia, Scots pine, surface forest fires, root collar, impact of wildfire, estimations of fire damage

 

# Climatic fluctuations of the terrestrial atmosphere in Central Siberia: long-term monitoring at ZOTTO observatory

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In this study we present the analysis of climatic data for the prevailing ecosystem types in the footprint area of the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org), a research platform for large-scale climatic observations that is operational in Central Siberia (60°48’N, 89°21’E) since 2006. The data of the high-frequency trace gas measurements at the tall tower are used in atmospheric inversion studies to infer the distribution of carbon sinks and sources over central part of Northern Eurasia. Thus knowledge of climatic fluctuations of the terrestrial atmosphere linked with time series of trace gases and aerosols measured at the tall tower are vital for our understanding how they are affect each other.
Systems to measure environmental variables were installed at the tall tower and local ecosystems (pine forest, peat bog). Climatic data for the period 2009 - 2015 yrs used in this study were collected during continuous high-frequency WMO sertified measurements of the main meteorological parameters: air temperature and air humidity (Combined temperature and humidity probe KPK1-6-ME-H38, MELA Sensortechnik GmbH, Germany), precipitation (Precipitation transmitter 5.4032.35.009, Adolf Thies GmbH, Germany), air pressure (Air pressure sensor 61202V/61302V, R.M.Young, USA), wind speed and direction (Ultrasonic-anemometer 3D 1210-R3 / R3-50, Gill Instruments Ltd. UK; 3D heated METEK USA-1, METEK GmbH, Germany), solar radiation (Combined net radiometer CNR1, Kipp & Zonen B.V., Netherlands), soil temperature (Soil temperature sensor 902830-Jumo, Jumo GmbH, Germany) and soil moisture (Soil moisture probe ML-2x, Delta-T Devices, UK). In this study method of climatic and microclimatic observations was used.
Results reflect atmospheric conditions and processes, and demonstrate direct and inverse feedbacks between mesoclimatic conditions in study area and the processes in global earth’s climate system. We found out that western wind drift is a prevailing for study area and continental polar air could be a reason of a strong radiation cooling effect in wintertime. Climatic parameters reflect the typical continental conditions of the region. Wind rose demonstrated mainly southeast wind directions that can be attributed to impact of the Asian anticyclone. However during the period of measurements the cyclonic activity in the region was unstable and could contribute to the climate conditions both on regional and continental levels. Due to the relatively high homogeneity of the landscape in study area the derrived results are representative for the tall tower footprint area (1000 $km^2$) and can catch even larger territory of Central Siberia.
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Keywords: Climate, Siberia, Greenhouse gases, ZOTTO

 

# Northern Eurasia Future Initiative: Facing the Challenges of Global Change in the 21st century

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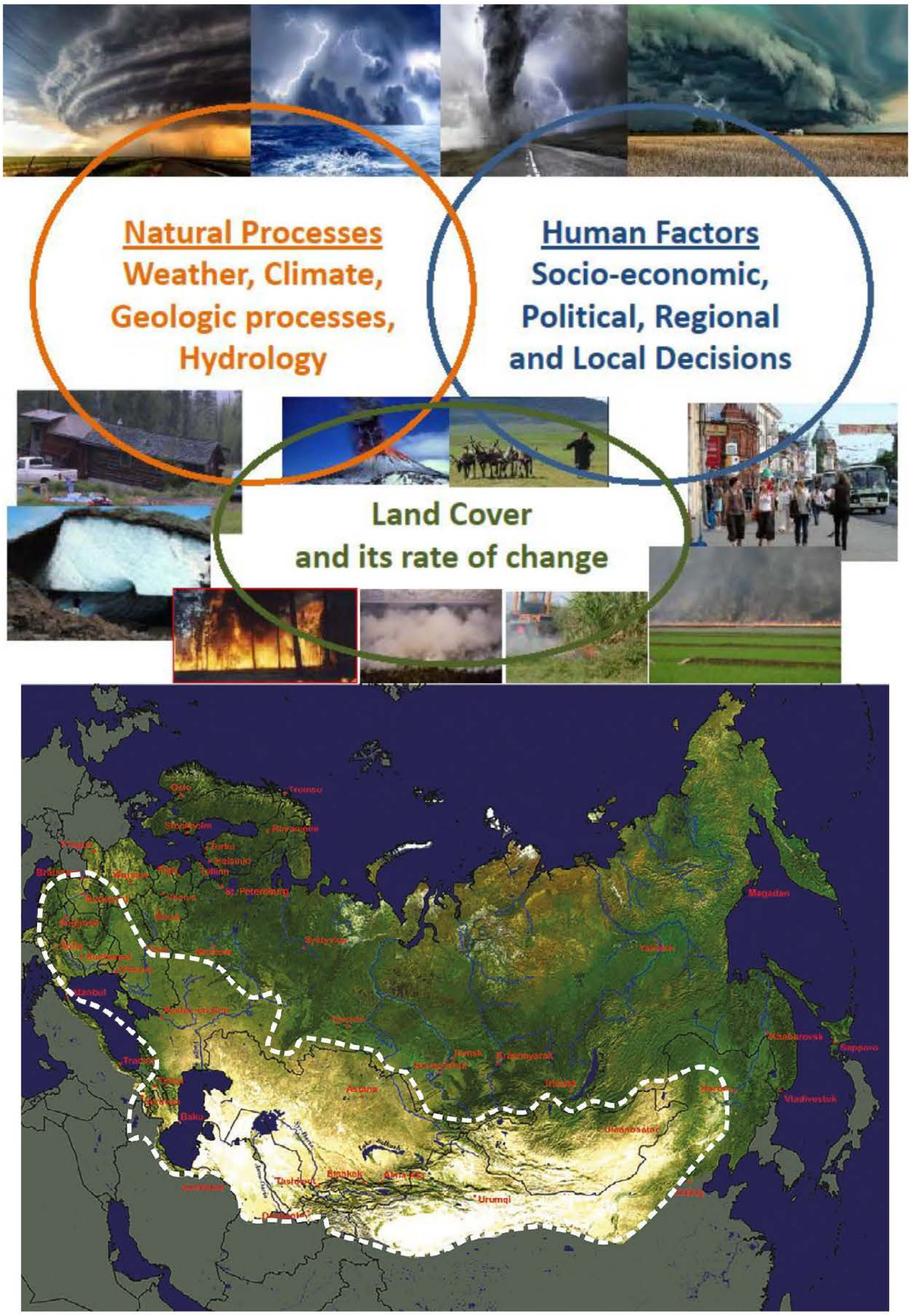
During the past 12 years, the Northern Eurasia Earth Science Partnership Initiative (NEESPI) –an interdisciplinary
program of internationally-supported Earth systems and science research –has addressed large-scale and long-term manifestations of climate and environmental changes over Northern Eurasia and their impact on the Global Earth system. With more than 1500 peer-reviewed journal publications and 40 books to its credit, NEESPI’s activities resulted in significant scientific outreach. This created a new research realm through self-organization of NEESPI scientists in a broad research network, accumulation of knowledge while developing new tools (observations, models, and collaborative networks) and producing new, exciting results that can be applied to directly support decision-making for societal needs. This realm was summed up at the Synthesis NEESPI Workshop in Prague, Czech Republic (April 9-12, 2015) where it was decided to shift gradually the foci of regional studies in Northern Eurasia towards applications with the following major Science Question: “What dynamic and interactive change(s) will affect societal well-being, activities, and health, and what might be the mitigation and adaptation strategies that could support sustainable development and decision-making activities in Northern Eurasia?”. To answer this question requires a stronger socio-economic component in the ongoing and future regional studies focused on sustainable societal development under changing climatic and environmental conditions, especially, under conditions when societal decision-making impacts and feeds back on the environment. This made the NEESPI studies closer to the ICSU research initiative “Future Earth”. Accordingly, the NEESPI Research Team decided to reorganize in the nearest future NEESPI into “Northern Eurasia Future Initiative” (NEFI) and began development of its Programmatic White Paper (in preparation at the time of this abstract submission). The NEFI research foci emerged in discussions within the NEESPI community during the past 20 months. Presentation will provide justification of these foci and approach examples addressing them. The societal challenges, particularly the socio-economic challenges are the top priority in most of them.
Throughout the NEESP Initiative duration, support for it studies has been provided by different national and international Agencies of the United States (in particular, the NASA Land Cover and Land Use Change Program), the Russian Federation (in particular, the Ministry of Education and Science, e.g., mega-grant 14.B25.31.0026), European Union, Japan, and China. After the NEFI White Paper release, we anticipate a similar kind of support for this new Initiative.

Keywords: Northern Eurasia, Environmental change, NEESPI




**Top.** **Major natural and direct anthropogenic processes that affect Northern Eurasia (Soja et al. 2015).**
**Bottom.** **The NEESPI study domain. The Dry Latitudinal Belt of Northern Eurasia is sketched on the map by dashed white line.**

# Snow Cover Monitoring in Northern Eurasia

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Snow covers through its unique physical properties (high reflectivity and low thermal conductivity) and water storage, plays critical roles in energy and water exchanges, hydrology and the ground thermal regime. The main objective of this research is to monitoring snow cover change in Northern Eurasia. The annual surface air temperature in Northern Eurasia is increasing by 2.1 C/ 10 years during the period of 1936 to 2015. Close to the north in the Arctic Ocean, the late summer sea ice extent is decreasing providing a near-infinite source of water vapor for the dry Arctic atmosphere in the early cold season months. There is also evidence of more frequent thaw days over western Eurasia. All these factors affect the state of snow cover.
Changes of snow cover duration, snow depth and snow water equivalent are described.
Snow cover duration (SCD) decrease over several regions of European Russia, Western Siberia and the Atlantic and Siberia Arctic, while positive values of SCD trends are infrequent and randomly scattered. The maximum winter snow depth increases in the Atlantic Arctic, southern part of the forest zone of Western Siberia, central part of Eastern Siberia and Russian Far East. At the same time, the maximum winter snow depth decreases in southern European Russia, Altai and Sayany Mountains and Piedmont and Trans-Baikal regions. The largest change was documented for Trans-Baikal region, the decrease is 13 percent per decade. The increase of maximum winter snow water equivalent in the field is observed in Western Siberia, Sakhalin and eastern European Russia. In the south of the forest zone of Western Siberia, the water equivalent increase is 5 % in ten years. According to course observations in the forest, the decrease in maximum snow water equivalent for the winter is recorded over most of European Russia.
The work was supported by the Ministry of Education and Science of the Russian Federation (grant 14.B25.31.0026).

Keywords: Snow cover, snow cover duration, snow water equivalen, climate monitoring

 

# ELIMINATION OF ACCUMULATED ENVIROMENTAL DAMAGE IN THE RUSSION FEDERATION ARCTIC ZONE

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Protection of the environment is an essential condition for the stable development of the humankind. Elimination of accumulated environmental damage is a significant part of this global problem.
Research was conducted in accordance with the order of the Prime Minister of the Russian Federation dated June 10, 2010 "On approval of the package of measures to reduce and prevent negative impacts on the environment of the Arctic zone of the Russian Federation". Research was carried out at the Alexandra Land island, Graham-Bell island, Hooker island, Rudolfa island, Heysa island and Hoffmann island of Franz Josef Land archipelago.
Scientific research result an elaboration of a practical activity plan. The main stages of technological works on the elimination of accumulated environmental damage that were developed are:
Step1. Comprehensive ecological survey of the Franz Joseph Land wasted territories
Step 2. Logistic operation for delivery of the workers,supplies and equipment;
Step 3. The base camp organization for work on clean-up;
Step 4. Putting into operation of production equipment, getting the first results;
Step 5. Carrying out main works on the Islands;
Step 6. Removal of the collected waste to the “Big Land”;
Step 7. Summarizing the results of the executed works. The definition of plans for the next season.
For example, only for two years, only on the Franz Josef Land archipelago:
47411 drums were collected, cleaned and compacted with total weight of 1892 tons;
1744 tons of oil and fuel were collected and stored in the 50 cubic meter tanks;
2800 tons of other scrap metal were collected;
4797 tons of other waste products including wood, stones etc. were collected and stored;
34 hectares of oil-wasted land were remediated;
Alexandra Land Island is fully cleaned.
Fig1.The characteristic of pollution of the Franz Josef Land archipelago.

Keywords: environmental damage, Arctic zone