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0139

Representation of Forest-Tundra Ecotone at Multi-Resolution Satellite Images: from QuickBird to Landsat

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This study is carried in the Laboratory of Aerospace Methods, Faculty of Geography MSU, within the PPS Arctic project, which aims to investigate dynamics of the northern forest boundary in connection with climate change. Images from Landsat satellites available over the last three decades, but their resolution 30 m is not sufficient for clear representation of sparse northern forests. Therefore it is necessary to know what do we have in situ inside the 30x30 m pixel area? We answer this by analysing a very high resolution QuickBird image.

The study area is located in the northern part of Kola Peninsula, Russia. We compare ETM+/Landsat, ASTER/Terra, and QuickBird images. After fieldwork in 2009 we have made a vegetation map from the QuickBird image by visual interpretation, which we used as a quasi ground truth. Comparison of this map with ETM+/Landsat and ASTER/Terra images demonstrated that 8 ecosystem types discernible in the QuickBird image merge into 3 in coarser resolution images. Forests with dwarfshrub understorey merged with dwarfshrub tundra (which can be with groups of trees, with single trees and without trees). Therefore forest line and tree line disappear from the image.

We have analysed ground cover composition inside the areas of 30x30 m. Subsets of this size were extracted from the QuickBird image for 8 ecosystem types. They were classified into surface types (tree crowns, three shadows, dwarfshrub, lichen, stones); their area and % cover proportion were calculated; spectral signature for each type was obtained and then spectral signatures for Landsat TM pixels were modelled by linear mixing. They are in good agreement with the real Landsat TM image. This analysis helped to explain the disappearance of forest boundaries in Landsat TM images and enables to select an optimal method for change detection.

0140

Remote Sensing Methods for Mapping the Above-Ground Phytomass of Plants in the Forest-Tundra Ecotone

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Mapping of above-ground phytomass at the northern limit of forests provides a baseline for monitoring climate-induced changes. This is important for practical applications, such as assessing quality of pasture and defining reindeer migration routes. Use of very high resolution (1 m and better) aerial and satellite images is of particular interest, because then changes at the level of individual trees can be monitored over comparatively large areas.

The goals of this study are to: i) establish relations between phytomass values and structure, and spectral reflectance, derived from ground research; and ii) upscale from ground data to QuickBird satellite imagery to compile maps of above-ground phytomass for key sites.

This research is part of PPS Arctic, the IPY project which investigates current status and past changes in the circum-arctic treeline zone, as well as associated social and natural factors, including climate change. Vegetation changes due to climate would be mostly reflected in the changing structure of phytomass.

The field research focused on two sites in the central and northern parts of the Kola Peninsula, Russia. Over 50 vegetation samples were measured with a Skye Instruments 4-channel radiometer, geobotanically described, separated by species and plant parts, dried at 105^{o}C, and weighed.

These data were compared to derive relationships between reflectance, phytomass values and structure. The ground radiometry data were upscaled to QuickBird imagery of the study sites using spectral unmixing techniques. Finally above-ground phytomass maps of the key sites were compiled from QuickBird imagery.

Mapping the above-ground phytomass in tundra and forest-tundra can be used to predict changes in phytomass structure due to climate change. In future we plan to develop our results to include relations between soil nutritional status and vegetation composition.

This study is financially supported by the Benefits Russo-Norwegian project of the Norwegian Research Council (OST 185023/S50).

0147

Tree-Height Measurements Using Stereo Images and Shape-From-Shadow Technique in Comparison to Field Data

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Height of is one of the criteria for definition of trees in a forest-tundra transition zone. Definition of forest line, tree line and other borders in the transition area is important to study the structure of the forest-tundra ecotone. Estimation of tree height requires very high resolution (VHR) remotely-sensed data (satellite or airborne images), because coarser imagery cannot resolve the necessary detail. We used GeoEye stereo satellite images acquired on 22 August 2009 for a study area in the Tuliok River valley, Khibiny Mountains, Kola Peninsula, Russian Federation. We compare two methods for tree-height extraction from imagery and validate the measurements on the basis of field data acquired one month before the image date. Classical stereo measurements with 1 pixel parallax accuracy were performed on a panchromatic band with 0.5 m resolution for 50 trees near the tree line. Shape-from-shadow technique is a combination of local and focal automatic analysis of a VHR image, developed for detailed interpretation of sparse forests. This technique was applied to an image stereo pair, in which multispectral and panchromatic bands were resolution-merged. Using this technique we can extract the spatial position of trees with an accuracy of 1.2 m and tree heights with an accuracy of 1.0 – 1.5 m. We further plan to compare these results, calculate more precisely the errors of image measurements and analyse the applicability of these methods to ecotone studies.

This research is part of PPS Arctic, the IPY project which investigates current status and past changes in the circum-arctic treeline zone, as well as associated social and natural factors. The study is carried out in the Laboratory of Aerospace Methods of the Faculty of Geography, Moscow State University, financially supported by the Benefits Russo-Norwegian project of the Norwegian Research Council (OST 185023/S50).

0190

Quality of Life Socially-oriented Observations in Apatity and Kirovsk cities of Murmansk Oblast, Russia

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Socially-oriented observations (SOO) of quality of life (QL) have been carried out in Apatity and Kirovsk cities of Murmansk Oblast during the IPY according to the methodology of the Northern Socially-oriented Observation Network construction developed by Institute of Geography, Russian Academy of Sciences in cooperation with Norwegian, Canadian and the UK researches within PPS Arctic IPY project under the leadership of Norway. SOO in the cities of the Russian North are of special significance as urban areas concentrate the majority of population of this region. Economic activity of northern cities is based mainly on natural resources exploitation and tackle mostly the same QL problems with some important local peculiarities. The aim of SOO is to determine the issues and targets for QL improvement which helps to distinguish main indicators for further monitoring.

First results of SOO carried out in Apatity and Kirovsk cities within three time cycles of community-based interviewing in overall covering 150 people of different ages and occupation show that:

General issues marked by residents in descending order are: low wages (100%), unemployment (90%), bad physical as well as mental health (70%), pollution of the environment (60%), climate change (45%). Nevertheless almost 80% of people are satisfied with its present life and social status. This shows a high level of optimism, which is a valuable factor and indicator for QL improvement.

Although main indicators in rapidly changing socio-economic situation are time dependent and have different rate during the observation time cycles, a “flexible” list of most important indicators for further monitoring in Apatity and Kirovsk cities is produced. It is important to continue SOO among different citizens’ groups of these cities comparing them with the further observations planned in other cities and rural communities within the Northern Socially-oriented Observation Network launched within the IPY PPS Arctic.

0193

The Northern Socially-oriented Observation Network Construction: Results from the IPY PPS Arctic Project in the Russian North

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Socially-oriented Observations (SOO) in the Russian North were supported by multidisciplinary IPY PPS Arctic project under the leadership of Norway and funded by the Research Council of Norway, as well as Russian Academy of Sciences. The main objective of SOO is to increase knowledge and observation of changes in living conditions (state of natural environment including climate and biota, safe drinking water and foods, well-being, employment, social relations, access to health care and high quality education, etc.) as well as - to reveal trends in human resources and capacities (health, demography, education, creativity, spiritual-cultural characteristics and diversity, participation in decision making, etc.). SOO have been carried out in industrial cities as well as sparsely populated rural and nature protection areas in observation sites situated in different bioms (from tundra to southern taiga zone) of Murmansk, Arkhangelsk Oblast and Republic of Komi. SOO were conducted according to the protocol included in PPS Arctic Manual. Developed approaches of SOO based both on local people's perceptions and statistics help to identify issues and targets for life quality and human resources improvement and thus to distinguish main leading SOO indicators for further monitoring. The Northern Socially-oriented Observation Network launched by PPS Arctic is building capacity for community-based monitoring in Russia and is intended to contribute to the long-term international Sustained Arctic Observation Network activities. First results of this network show that changes in human capital (depopulation, unemployment, lack of sufficient education, marginalization etc.) are becoming the major driving force effecting land use pattern and overall sustainability. Changes in climate and biota (ice melting, tundra shrubs getting taller and more numerous, etc.) have become an add factor in accelerating or influencing social changes. In relation to the future sustainability in nature and society it is northern communities, their adaptive capacities and creativity that are decisive.

0200

Plant-induced variability in soil nutritional status of forest–tundra ecotones in the Kola Peninsula, Russia

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Climate change may result in altitudinal and latidudinal advance or retreat of trees and shrubs. This influences soil nutritional status and may induce both negative and positive feedbacks. This paper addresses the potential impacts of climate-change-induced vegetation shifts on soil nutritional status in the forest–tundra ecotones. Using Kola Peninsula, Russia, as example region we studied variability in the soil nutritional status induced by Norway spruce (*Picea abies* (L.) Karst.), Scots pine (*Pinus sylvestris L.*), white birch (*Betula pubescens* Ehrh.), shrubs, dwarf shrubs, green mosses and lichens in the forest–tundra ecotones in the Khibiny Mountains (altitudional gradient) and in the surroundings of Lake Kanentiavr (latitudional gradient). Comparison of soil nutritional status of moss- and lichen-dominated vegetation compartments with those dominated by spruce, pine, birch and shrubs shows that trees and shrubs appearing in moss- and lichen-dominated tundra would lead to increased level of bio-available nutrients in the soil. Norway spruce demonstrated the strongest effects. Because nutrients regulate the litter decomposition rate, we argue that higher content of nutrients, such as calcium and manganese, resulting from the increased presence of tree and shrub species, could cause higher rate of organic matter decomposition in tundra previously dominated by lichens and mosses. This would promote further colonization by trees and shrubs, their successful growth and development, and carbon sequestration in the growing biomass.

0259

Comparing Warming and Grazing Effects on Birch Sapling Growth in the Tundra Environment – a 10 Year Experiment

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Background: Tree encroachment of tundra is a generally predicted response to climate warming. However, herbivory play an important role in structuring tundra systems and responsiveness to warming.
Aims: To experimentally test how grazing and increased growing season temperature influence growth and physiognomic stature of birch in the alpine zone.
Methods: Trait responses, of natural regenerated birch saplings, to warming (OTCs), changed grazing regime (exclosures) and unmanipulated conditions were analysed over a 10 year period (1999-2008). Effect of treatment over time and differences between treatments was analysed with repeated measures GLM and simple contrasts in GLM.
Results: Warming alone had no major effect on trait response, however significantly smaller leaves and increased number of short-shoots indicated warming related growth constraints. Grazing showed a strong hampering effect on most traits, conserving a low stature sapling stage characterized by fewer shoots and larger leaves, compared to non-grazed treatments.
Conclusions: The results points to a grazing controlled response to environmental change in the alpine tundra, with climate (warming) as a secondary force. This herbivore-driven concealing of expected climate-driven tree expansion emphasizes the necessity to consider changes in grazing regimes along with climate change, in order to avoid misleading interpretations regarding climate-driven tundra encroachment.

0260

Contrasting Climate- and Landuse-Driven Tree Encroachment Pattern of Sub-Arctic Tundra in Northern Norway and Kola Peninsula

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High latitude regions are experiencing substantial climate change and the forest-tundra transition is assumed to sensitively track these changes through advancing treeline and increased tundra encroachment. However, herbivores may influence these responses. Present study address how mountain birch treelines and sapling cohorts beyond the treeline has responded to last decade's climate warming in six areas across North European sub-arctic regions with different climate and grazing characters. The results show deviating response patterns, representing advancing-, stationary-, and possibly retreating treelines, among regions. Recruitment was abundant over last decades in all areas except one, with predominantly arctic conditions, where both tree- and sapling cohorts were old. Areas with high annual precipitation show advancing birch populations characterized by young individuals and partly overlapping tree- and sapling age distributions. Areas in reindeer summer-herding districts show stationary or retreating birch populations characterized by non-overlapping age distributions, and sapling survival constraints. Recruitment pattern beyond the treeline generally corresponded with non-growing season climate variables, with emphasis on precipitation, indicating importance of a protecting snow cover throughout the winter. The results highlight the important interplay between abiotic and biotic control over tundra encroachment and treeline dynamics, and the importance of multi-site studies when addressing forest-tundra ecotone responses to global warming.

0273

Norwegian Monitoring Program for Palsa Peatlands

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Ongoing and anticipated warming trend at high latitudes has increased the need for monitoring programs designed to track response of fragile ecosystems and edaphic and biotic structures they depend on. Palsa peatlands belong to permafrost landforms that incorporate both fragile edaphic structures and fragile biotic communities. The spatiotemporal distribution of palsas depends on local and regional climatic factors and their change at decadal and century scales. In Norway palsas are common features in peatlands mainly in two regions, one in the south restricted to the Dovre region, and one broader northern in Troms and Finnmark. The development of palsa peatlands during the latter half of the 20th century has been dominated by decline. The documentation has however been slightly biased towards “late successional” palsa features with a somewhat obscured holistic picture. A Norwegian monitoring program designed to capture the constant flux of changes caused by permafrost alternations (including palsa features, thermokarst pond development, pond colonization, vegetation change) was started in 2004 to aid profound conclusions for change rate and management considerations. Six selected palsa areas represent different climatic regions confined by variation in major environmental gradients from northern to southern Norway. Changes are analyzed by air photos and ground-based line analyses of 28 variables (categories: land cover type; bottom-, field- and shrub layers; thaw depth; peat crack frequency; height above mire level). Most monitored peatlands have experienced a reduction in palsa frequency and cover during last decades, but sparse formation of new palsas occurs both in the north and south. The most pronounced decreasing trend in palsa cover, and increase in sedge covered areas, is shown in northern coastal regions and in the wettest parts of individual peatlands. Dryer regions or peatland parts show only minor changes. The main climatic background is a pronounced change in the precipitation regime.

0415

Socially-oriented Observations on Kolguev Island, Nenetsky Autonomus Okrug, Russia

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Socially-oriented Observations (SOO) on Kolguev Island (KI) have been carried out according to the methodology of the Northern Socially-oriented Observation Network construction developed by Institute of Geography, Russian Academy of Sciences in cooperation with Norwegian, Canadian and the UK researches within PPS Arctic IPY project under the leadership of Norway. SOO concentrated mainly on monitoring indicators showing local communities quality of life (QL) changes were also connected with the concept of Integrated Ecosystem Management implemented in KI within the GEF ECORA project. KI is a valuable site for SOO as: 1) many QL issues and indicators set for monitoring are typical for most indigenous peoples' rural communities in remote tundra regions of the Russian North; 2) KI, having the highest goose density in the Barents Sea and unique population of reindeer, is extremely important by its role in providing ecosystem services in the whole Barents region.

According to local people's perception main QL issues listed in descending order are: poor transport accessibility, bad housing conditions, insufficient food supply, low wages, poor quality of drinking water. Also high unemployment and bad physical as well as mental health, degradation of traditional culture are documented as great problems. Overall low QL and further human capital deterioration on the KI leads to negative impacts on nature, increasing uncontrolled harvesting of game birds and their eggs for subsistence needs and poaching. Moreover hydrocarbon development leads to reindeer pastures shrinking accelerated by still unknown human-nature processes resulting in changes in tundra vegetation (biodiversity, number of species and their distribution). SOO conducted by reindeer herders communities including phenological observations may also clarify this situation and reflect human perception of occurring changes. SOO have shown that one of important ways for better QL is the nature protected areas establishment where indigenous peoples will play a major role.

0479

Detection of forest-tundra ecotone properties in very high resolution satellite imagery through enhanced shadow-vegetation method

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The goal of this study is to develop techniques for extraction of detailed information from the very high resolution (VHR) satellite imagery on spatial structure of forest, as well as position of forest line and tree line in forest-tundra ecotone. We have analysed different methods of obtaining detailed information about trees and integrated them into a complex image processing method. This is an enhanced shadow-vegetation method for automated processing of satellite images. It integrates local and focal image processing algorithms, and GIS-analysis of vector data. We applied the method to a Quickbird image acquired on 28 June 2006 for a study area in the Tuliok River valley, Khibiny Mountains, Kola Peninsula, Russia. The method delineates single trees and shrubs in sparse forest in forest-tundra ecotone with an accuracy over 80%, as proved by visual validation for over 2700 trees in different parts of the ecotone. Tree heights have been calculated with 1.0 – 1.5 m accuracy using the shape-from-shadow technique. Tree line and forest line have been delineated through automated zonation on the basis of tree height and distances between trees. Tree canopy cover and stand density of the site has been calculated for various grid sizes. These derived maps will be used for further comparison with coarser-resolution imagery and development of multi-scale mapping approaches.

This research is part of PPS Arctic, the IPY project which investigates current status and past changes in the circum-arctic tree-line zone, as well as associated social and natural factors. The study is carried out in the Laboratory of Aerospace Methods of the Faculty of Geography, Moscow State University, and financially supported by the Benefits Russo-Norwegian project of the Norwegian Research Council (OST 185023/S50).

0496

Are Trees Invading the Arctic? Circumpolar Treeline Research during IPY

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The location of the tundra-taiga interface (TTI) zone corresponds to historic and recent climate and disturbance regimes. The zone is expected to respond rapidly to climate warming by tree and shrub advance, with ecological, socioeconomic and climatic consequences at local to global scales. However, the predicted advance is based on simple models that neglect ecological constraints and time-lags. The circumpolar TTI is diverse and complex, and cannot be expected to respond in a homogeneous manner throughout its vast geographical biome. During IPY a large number of projects have begun to reveal a varied pattern of response to recent environmental changes, challenging the assumption of a common, simplistic, rapid northward forest advance. A detailed circumpolar analysis awaits further results, but at a coarse global scale only half of the study sites show recent advance. Responsiveness is linked to both the structure of the zone and its geoclimatic location. Advance appears to prevail in alpine areas and regions affected by moist air masses, while some latitudinal treeline regions dominated by dry arctic air show stationary or even retreating behaviour. Large arctic herbivores such as reindeer/caribou can dominate TTI dynamics at region- and species specific levels by modifying e.g. recruitment, survival and growth. Herbivore-driven modification of expected climate-driven tree expansion emphasises the need to consider changes in grazing regimes and other perturbations (fire, insects etc.) along with climate change, to avoid misleading interpretations regarding rates of climate-driven encroachment. The vast area and remote location of many study sites calls for remote sensing as a monitoring tool of decadal tree cover changes. Efficient algorithms have been developed for local scales and dense forest, although difficulties remain for sparse forest and global scale mapping.

0640

Possible influence of various climate changes on the spreading of vegetation in forest-tundra ecotones in the Kola Peninsula

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The climate induced changes of treeline ecotones have been reported and predicted for different locations in the Northern hemisphere, such as Fennoscandia, Urals, the Kola Peninsula, Alaska and Yukon (Kullman, 2002; Moiseev and Shiyatov, 2003; Lloyd, 2005; Kammer et al., 2009; Danby, Hik, 2007; Mathisen et al., 2009). The focus of this paper has been to study the modern condition of vegetation and possible changes in the species composition and spreading of plants in the forest-tundra ecotone in the Kola Peninsula, Russia. Our results in some areas of the Khibiny (altitudinal gradients) and in some areas around the lake Kanentjavr (latitudinal gradient) register the modern condition of vegetation and relations between lichen populations with higher plants. In conditions of the assumed climate warming higher plants will have more advantages in increasing their productivity (biomass) and expansion from the treeline towards forest-tundra and tundra ones both in the plain, and in the mountains. Lichens, being poor competitors as weak organisms, will decrease their abundance in ecotone communities at the boundary of forest due to the lack of, first of all, arctalpine species, less resistant to shading (which will be increasing due to the increase of higher plants cover). The growing number of precipitation in the flat conditions will result in the excessive humidification (expansion of water-logged areas), which lichens do not withstand – i.e. a significant degradation of lichen cover will take place. At the same time the consequences of the increasing humidification of climate will not tell much on the condition of the lichen cover on well-drained mountain slopes, as a whole. In case of climate cooling, more favorable conditions (compared to higher plants) will probably be preserved in ecotone communities along the forest-tundra boundary both in the plain and in the mountains for the lichen cover and the latter will increase its abundance provided the higher plant abundance decreases along with the decrease of the upper boundary of forest vegetation in the mountains and its retreat southwards in the flat landscapes.

0641

Analogous Tree Growth Pattern in Contrary Climate Regions Along the Arctic Margin

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The northern distribution limit of Scots pine, *Pinus sylvestris,* is predominantly controlled by climate and as temperature increase, a northward shift and more vigorous growth is expected. Implications of changed forest cover include changed carbon sequestration, changed land-atmosphere energy balance and ecosystem changes. Understanding of climate related height- and diameter-growth patterns across geographical regions is therefore essential. The main focus in this study is climate-growth relationship for pine during last decades, along longitudinal and coast-inland gradients in Northern Norway and Kola Peninsula; by analysing i) how height and diameter growth at the northern distribution margin have responded to climate variability; ii) if growth responses differ between climatic regions; and iii) if short-term height and diameter growth-climate relations are useful predictors for forest cover change. Six pine woodland sites along the forest-tundra zone were analysed for annual height growth (saplings, i.e. <2m) and diameter growth (adult trees) and compared with local climate data. Pearson's correlation analyses and bootstrapped confidence intervals were used in the analyses. Height growth correlated strongly among all sites while diameter growth showed limited correlation among sites. However, an inter-annual pattern with common growth peaks among sites is evident for both height and diameter growth. Although summer temperature is the most important factor(s) to both height growth ($July_{t-1}$) and diameter growth ($July_{t-1}$, $June_t$, $July_t$), winter (November-February) and late non-growing season (April-May) temperature and precipitation showed significant importance to both height and diameter growth. The results highlight the importance of generally overseen precipitation and non-growing season factors to growth at northern distribution limits. Detailed data on climate-growth relations is essential to feed models for forest cover change. However, short-term generated data may be of sub-ordinate long-term value due to high inter-annual climate variability at the Arctic margin and occurrence of infrequent severe climate events.

0642

Remote Sensing Study of 50-year Permafrost Lakes Dynamics in the Yana river Lower Course Region

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This study is topical due to the interest of the world scientific community to the global climate change. Permafrost lakes and ponds are believed to indicate permafrost thawing and, hence, climate change. The study site is situated in the north-east of Russia, on Yana-Kolyma lowland (ca. 100 km eastwards of the Yana River delta) in the area of continuous permafrost. The research is based on remotely sensed images from 3 periods: black-and-white aerial photographs of 1951, Landsat MSS satellite images of 1972 and Landsat ETM+ satellite images of 2001. The map of permafrost lake changes (1972-2001) for the whole study site was created by supervised classification of the satellite images. Visual interpretation of high-resolution (ca. 1 m) aerial photographs for a smaller territory within the study site was used to create the map of permafrost changes for the longer period (1951-2001). Examination of this map displayed a 10% decrease in total area of permafrost lakes and ponds. A closer examination revealed that the majority of lakes were drained by rivers.

Remote sensing analysis revealed the absence of climate-induced changes of lake areas. Such a conclusion is in accordance with weather station records. Weather data, obtained from the Chokurdakh weather station, situated 300 km east of the study site, showed insignificant increase of the mean annual temperatures ($0.3^{o}C$) and annual precipitation sums (6-8 mm) during the 50-year period (1951-2001). This means that climate should not have led to significant changes in lake areas.

This research is being carried out at the Laboratory of Aerospace Methods, Department of Cartography and Geoinformatics at the Faculty of Geography, Lomonosov Moscow State University.

0661

Small-Scale Remote Sensing Mapping of Geosystems in Taymyr–Putoran Region

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The aim of this research which is part of the international IPY PPS Arctic project is to study the modern state of vegetation, as well as geosystems in general, in a large part of north-central Siberia, including the Taymyr Peninsula and southward territories (66°00'- 77°43'N, 85°00'- 115°00'E) by way of compiling a small-scale (1:2,500,000) map of geosystems. The map will include such components of geosystems as vegetation, relief, and geocryological features. The resulting map should become the basis for large-scale field investigations of treeline ecotone in the region. Monthly MODIS composite images (spatial resolution 250 m) of 2005, processed and refined by the Space Research Institute (Russian Academy of Sciences) serve as the main source of up-to-date environmental information. Several thematic maps, including the Circumpolar Arctic Vegetation Map (2003, 1:7,500,000), the Vegetation Map of USSR (1990, 1:4,000,000), the Geocryological Map of USSR (1996, 1:2,500,000) are being used used to recognize different types of geosystems in satellite images. Map compilation is based on visual interpretation of MODIS images and DEMs (VMAP0, GTOPO30) to match borders of geosystems with natural orographic boundaries. Field validation of the map is planned for summer 2010.

This research is being carried out at the Laboratory of Aerospace Methods, Department of Cartography and Geoinformatics at the Faculty of Geography, Lomonosov Moscow State University, and financially supported by the Benefits Russo-Norwegian project of the Norwegian Research Council (OST 185023/S50).

0771

Changes in growing season length in northernmost Fennoscandia for the 1873 - 2008 period as measured from historical and recent phenology data

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Northern Fennoscandia is a climatic heterogeneous region and monitoring of the phenological development over time is complicated since the observation network is limited. To map the trends in onset, end and length of the growing season for birch (*Betula pubescens*) in the northernmost Fennoscandia, historical and recent phenological data from 18 observation stations and phenological metrics extracted from satellite data were used. The data cover, the period 1873 to 2008 and include four International Polar Years. The average date (day of the year: DOY) for the onset of leafing/budburst in Naimakka, Edefors and Vidsel (low land, Sweden) was 24, 11 and 9 days earlier in the period 1982-2008 compared with the period 1873-1924. For Tromsø (coastal, Norway) and Abisko (alpine, Sweden), the onset of leafing/budburst was 6 days earlier in 1982-2008 than in 1925-1939. For the International Polar Years, the maximal change in onset of leafing/budburst was observed in Naimakka and was 23 days earlier in 2007-8 compared with 1882-3. The end of the growing season (shedding of leaves), seem to start earlier (DOY: 254) in Abisko in the recent period (1982-2008) than in the earlier periods (DOY: 270-271) back to 1920. In Tromsø, the average shedding is 4 days earlier (DOY: 278) in the period 1982-2008 compared with the period 1940-1981 (DOY: 282). Altogether, a slight shift in the growing season length (GSL) seems to be the common trend for the most stations. The effects of an extended growing season may not only have consequences for plant and animal ecosystems, but persistent increases in GSL may lead to long-term increases in carbon storage and changes in vegetation cover with potential feedbacks to the climate system.

0798

Dendroclimatic relationships at treeline in northern Sweden indicate continued dominance of mountain birch

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Changing climate in the Arctic is expected to have significant effects on the pattern and distribution of terrestrial vegetation. Species characteristic of specific zones in the mountains of northern Sweden have been shown to migrate up and downslope with changes in climate over the Holocene. This study evaluates the potential for Scots pine (*Pinus sylvestris*) to become a treeline dominant at Fennoscandian treelines replacing mountain birch (*Betula pubescens* ssp. *czeropanovii*). Data from paired mountain birch and Scots pine tree-ring chronologies for 8 locations in northern Sweden are used to develop climate tree-ring width index (RWI) relationships. Modeled climate RWI relationships are then used to predict the relative RWI values of the two species under a suite of climate change scenarios using an ensemble of three global climate models. Results indicate that birch and pine RWI are both correlated with summer temperatures, but pine is more likely than birch to be influenced by moisture conditions. Predictions of RWI under future climate conditions indicate that mountain birch is unlikely to be replaced by Scots pine within the next century.

0822

Changes of forest-tundra vegetation distribution in Kola Peninsula (Kanentiavr key site)

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This investigation was made in the Laboratory of Aerospace Methods, Faculty of Geography MSU, in the framework of PPS Arctic/Benefits projects. The goal of investigation was to answer the question: are there any changes in boundaries and character of forest-tundra transition zone in Kola Peninsula in the last 50 years in context of climatic changes?

The study of vegetation dynamic was made for the Kanentiavr key site. It is situated on Kola Peninsula, 55 km to the east of Murmansk and 45 km south of the Barents Sea shore. Three natural zones are present there: forest, forest-tundra and tundra. Analyses of vegetation cover changes were made for 2 periods: 1960-1985 and 1985-2004.

For the first period changes in vegetation cover were investigated with topographic maps of 1:100 000 scale (made from air photos of 1961) and of 1:50 000 (air photos of 1984). Maps were overlaid and compared. Despite the different scale of the maps, the generalization was taken into account. Plots smaller than 4 mm^2 were excluded from results. Later we acquired copies of air photos, originally used for map compilation. Validation of map analysis results for 5 control sites has shown, that there were no changes in vegetation cover on this territory, and plots that allegedly had vegetation changes were mistakes of cartographers.

For the second period 1985-2004 changes in vegetation cover were investigated with ASTER image (2004) and air photos (1984). We noted increasing forest and shrub cover instead of tundra vegetation. We observe a northward shift of the forest tundra transition zone. But the resolution of these images is very different (15 m for ASTER image and 1 m for air photos). This is why results of this comparison still need further validation with field data and very high resolution satellite imagery.

0858

Change of the treeline ecotone in Khibiny Mountains, Kola Peninsula, Russia, over the last 50 years

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Changes of the treeline ecotone were analysed for the Khibiny Mountains, Kola Peninsula by the means of aerial photos from 1958 and 1990, high-resolution satellite imagery from 2006/2008, and age structure data of birch (Tuliok River valley) and pine (Yumechorr mountain). Recorded changes were compared with regional temperature and precipitation data (Murmansk meteorological station) since 1936. The temperature data show no trend during the last 70 years, while precipitation shows a clear increasing trend. The upper-most trees were identified in the multitemporal imagery: air photos acquired on 14/08/1958 (2 m spatial resolution) for both sites; QuickBird satellite image acquired on 28/06/2006 (0.6-2.4 m spatial resolution) for Tuliok; and WorldView satellite image acquired on 29/07/2008 (0.5 m spatial resolution) for Yumechorr. Locations of these trees were used as reference points and indicators of treeline change over the study period. Age structure of trees and saplings were analysed for temporal and species-specific recruitment patterns. Treeline at both sites show consistent but slow upward movement of <30 m over the studied 50-year period. Most of the birch colonization occurred after the 1960s, with establishment peaks from mid-1980s, and the pine colonization was initiated somewhat earlier; after 1950s with peaks in the 1970s and 1990s.
There were generally low or no correlation between establishment pattern and monthly, seasonal or annual temperature and precipitation variables. However, for pine number of individuals established in the respective years significantly correlated with January and February precipitation and total winter precipitation (Dec-Feb). Although restricted to a local area it can be concluded that the general expectation for an ongoing swift treeline advance needs to be adjusted by empirically based response rates; and incorporation of non-growing season variables is essential when constructing tundra encroachment scenarios.

0871

A comparative analysis of the gender specific determinants of diet choice in three communities in Nunavut, Canada

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Dietary choice for Arctic residents is part of a complex system of daily factors that influence health. Understanding the factors that influence dietary choices in the Arctic is necessary for the development of culturally appropriate dietary advice. To support health promotion efforts, this International Polar Year funded study (4 year) contributes to an expanding body of dietary research through a comparative analysis of the factors that influence dietary choices among Inuit living in Cape Dorset, Iqaluit and Kimmirut in Nunavut, Canada. The objectives of the research are to: (1) understand the gender specific determinants of dietary choice; and (2) identify culturally acceptable strategies to promote healthy dietary choices. Particular attention is given to understanding how cultural, economic and environmental factors influence dietary choice. In-depth semi-structured interviews (n=128) were conducted with women and men 18 years of age and older in Cape Dorset, Iqaluit and Kimmirut, Nunavut. The results of this research complement existing studies (e.g., Furgal et al., 2003; Kuhnlein et al., 2003; Donaldson et al., 2006) and can be used to inform effective dietary advice about country food for Aboriginal peoples living in Arctic Canada.

0988

The Importance of a Community-Based Approach to Health Research in the Arctic: A case study

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The objective of this paper is to outline a community-based approach that was applied to a 4 year International Polar Year (IPY) dietary choice project in Nunavut, Canada. A variety of mediums were employed to engage participants, community members, organizations and local governments. During 2007-2009, in-depth semi-structured interviews (n=128) were conducted with men and women in Cape Dorset, Iqaluit, and Kimmirut, Nunavut, Canada. In total, 128 interviews were analyzed using NVivo 8; a qualitative data analysis software package. Grounded Theory methods (Strauss and Corbin, 1990) were employed to analyze the transcripts in NVivo 8 for: (1) emergent themes and relationships; (2) exploring gender differences; (3) building analytic categories through further interviews; (4) making gender comparisons and comparisons between each set of interviews; (5) making cross-community comparisons between each set of interviews by community. The results demonstrate the importance of community research partnerships, the involvement of community members in all phases of research, the process that was employed to collect, analyze and interpret the findings, and the mediums used to communicate the research results. This paper provides a new foundation that could be used to build future community-based health research projects in the circumpolar region.

1157

Treeline changes in the Kola Peninsula, Russia: natural and anthropogenic factors

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In this study, we analyse dominant factors of treeline change for three key areas within a limited region (150 x 80 km) in the Kola Peninsula, Russia. Two areas are situated in mountainous and comparatively continental setting: of these the first area in Khibiny Mountains is relatively unaffected by industrial pollution, while treeline changes in the second area in the Monchetundra Range are strongly controlled by sulphur dioxide and heavy metal emissions from the Severonikel smelter. In Khibiny, with fairly productive soils, the treeline has moved upslope by 20-30 m since 1950s, while in Monchetundra the treeline ascended by hundreds of meters due to forest disappearance as result of the industrial emissions. The third and northernmost area represents latitudinal, rather than altitudinal treeline, and is situated in rolling hills and plains near Lake Kanentiavr in northern Kola Peninsula, in a comparatively coastal setting (40 km south of the Barents Sea coast) with less productive soils. Treeline changes in the last 50 years are small, and both stagnation of the birch treeline ecotone and possible advance confined to topo-climatic favorable landscape segments are observed. This combination of case studies within a limited region demonstrates the significance of industrial emissions, as well as local climate and soil factors, that can significantly alter the expected picture of widespread climate-driven treeline advance at high latitudes.

1244

Advancement of the northern forest lines in northern Norway in the period 1914 – 2007

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The interface between the boreal forest and the arctic tundra is the Earth's largest vegetation transition zone and climate change as well as change in land use can alter the position of this zone. In order to detect changes in the northern latitudinal forest lines of birch and pine in Finnmark county (Norway), we used old and new forest maps, topographic maps as well as remote sensing based imagery and maps. For the latter data we used both traditional spectral classification as well as "spectral unmixing" on imageries from sensors like Landsat and Quickbird for detection of the forest lines. Comparison of the birch forest lines from 1914 and 2007 revealed a north-ward advancement of up to 11 km in the western part of the study area (Western Finnmark County), an advancement of 22 km in the middle parts of Finnmark to 12 km in the eastern part of Finnmark. The advancement for the period 1980 to 2007 was less than 1 km in northern direction for most of the area. The analysis revealed only minor changes in the position of the pine forests for most of the study area and the period 1914-2007. On the contrary, the advancement of the pine forest in eastern part of Finnmark has been up to 4-5 km. The changes in the position of the northernmost birch forest line are considered to be a combined effect of reduced grazing (reindeer, goats and sheep) and climate change. The recorded slower forest cover change rate seen for pine is, hypothetically, both related to differences in species-specific response patterns and due to extensive exploitation of the pine forests during World War II and the following decades.

1338

Methods for assessment of the degree of the anthropogenic factor expression in the dynamics of boundaries of the forest-tundra ecotone, Kola Peninsula

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Rate of dynamics of the forest-tundra ecotone is defined by the relative expression of natural (mostly climatic) and anthropogenic factors. Within the PPS Arctic/Benefits project, we have analysed spatial distribution patterns of heavy metals (Cu, Ni, Pb, Zn) in leaf litter and soils of the region as an indicator of anthropogenic pressures for assessment of their role in the ecotone vegetation dynamics. Forest-tundra ecotone ecosystems were studied along profiles at slopes of varying altitude, slope angle, aspect and distances from the polluter. At each reference plot complete geobotanical descriptions and sampling of litter and soil were performed. Heavy metal content was measured with the Spectroscan XRF-analyzer. Gross metal concentrations were expressed in Clarks. Copper and nickel concentrations were significantly correlated with smelter pollution. Lead and zinc pollution correlated with car-related pollution along highways. The distribution of toxicants in litter and soil influenced the altitudinal zonality structure and ecotone dynamics. Since the 1930s the forest line moved up by several tens of meters due to natural factors, whereas the anthropogenic factors lowered the forest line by tens to hundreds of meters and significantly changed species composition, alpha and beta-diversity.

We argue that three types of areas can be defined by the degree of the anthropogenic factor expression:

i) natural, where the anthropogenic factor is expressed only through global fallout and the content of toxicants in the litter and soil does not exceed 1-3 Clarks.

ii) transitional, where the degree of the anthropogenic factor expression is comparable to the natural and heavy metal content does not exceed 10 Clarks.

iii) anthropogenic, where the anthropogenic factor strongly prevails over the natural and content of heavy metals exceeds 100 Clarks.

These areas can in general be identified through vegetation condition and often through remote sensing methods.

1565

A (Complicated) Story of Treeline Dynamics in the Mealy Mountains, Canada

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We adopted a multidisiciplinary approach to study treeline dynamics in the Canadian sub-arctic. Using IPY-PPSA protocols, transects were established in Forest, Transition, and Tundra zones. Point-centre-quarter methods showed that trees and shrubs were generally more dense, but less variable in the Forest compared to the Transition zone. For dendroclimatology, multi-species results suggest that coastal conditions reinforce the thermal sensitivity of trees with precipitation being more important for radial tree growth. Downscaled climate predictions suggest density and composition of the alpine treeline ecotone will change with increases in summer temperature and precipitation; however, insect infestations may moderate these changes. From animated climate stations and downscaled long-term and gridded data, a warming trend has been documented in the Mealy Mountains that will support shrub and forest expansion, synchronous with regional and global patterns. Temperature increases of 2ºC would allow for an upward movement of 250 m from current treeline (ca 600 m a.s.l.). Soil conditions, are variable along an elevational transect but have similar levels of nutrients, N and P, suggesting available nutrients are not limiting for tree species in any zone. Biotic influences set the template for future forests, and include positive facilitative effects (e.g. shrubs/moss seedbeds on conifer seedlings) and negative effects (e.g. herbivory), which limit seedling growth and recruitment. Planted seedlings can grow above present treeline but a major bottleneck to treeline movement is reproductive limitation and lack of available viable seed. Fire does not appear to play a role in tree recruitment and low levels of episodic insect herbivory results in a disturbance regime driven by gap replacement. In Forest, exposed mineral soil associated with windthrows is the most significant disturbance factor involved with seedling establishment. Analysis of spatial-temporal vegetation patterns using multi-date satellite imagery shows a progression of vegetation (particularly shrubs) up slope through low-lying, sheltered valleys.

1801

Analysis of timberline white spruce growth in Yukon Beringia

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Nine white spruce (*Picea glauca* var. *albertiana*) trees growing below, at and above timberline on a gentle south slope in the non-glaciated Mt. Nansen region of the Yukon Territory were examined. The objective of this research was to determine how stem growth occurred at the nominal timberline in white spruce, the dominant conifer species in the Yukon plateau region. Radial growth was investigated by stem analysis at successive meter intervals along each trunk, measuring ring widths across four cardinal directions. On some disks growth pattern corresponded during the same calendar-year period. However, annual ring maxima did not predictably occur in the same calendar-year periods at successive tree heights, and the cardinal position of overall radial growth within each tree varied with height. Tree age was not proportional to tree height. Trees above timberline were relatively young and less tall. Trees from below timberline with relatively larger size were not always the more vigorous in cambial growth. Each of the nine trees had its own unique signature of growth, and periods of increased radial growth corresponded poorly in chronology among trees. These observations enabled the identification of periods in the past when there were both tree specific and general effects of the environment on promotion/retardation of growth. They also showed that radial growth of white spruce within the same area can vary markedly.

1852

The spatial configuration of trees at treeline: How is the structure of the Canadian forest-tundra ecotone changing with global warming?

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The forest-tundra ecotone may be shifting due to climate change, affecting both regional biodiversity and northern communities. We were interested in how this shift is occurring by focusing on the pattern of infilling of trees within the ecotone. We investigated the spatial configuration of trees in the forest-tundra ecotone across Canada in Yukon, Manitoba and Labrador. Our objectives were to describe trends in the spatial pattern across the forest-tundra ecotone, to evaluate hypotheses about factors affecting tree recruitment and growth, and to investigate geographical variation. Tree abundance was measured in contiguous quadrats along transects up to 100 m long and within 30 x 30 m plots at different locations along the forest-tundra gradient. Spatial pattern analysis was used to estimate patch size, as well as the scale, intensity and amount of aggregation. Patches of trees tended to be smaller, farther apart and less dense away from the forest. Shorter trees may be clumped at some sites due to shelter from the wind. Competition does not seem to be a contributing factor to tree recruitment since there were few sites with regular spacing of trees. With climate change, forests will likely develop above the current treeline develop as patches of trees enlarge and new patches establish. While temperature may be a limiting factor for treeline advance, wind may be a structuring factor in determining the spatial configuration of treeline. However, site-specific results indicate that local factors appear to be strongly affecting processes within the forest-tundra ecotone.

1888

Trends in snow cover and NDVI for southwest Yukon, Canada, derived from MODIS, 2000-2008

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Analyses of trends in NDVI across the Arctic suggest a recent 'greening' of tundra ecosystems. However, results for mountainous areas of the Arctic and Subarctic are difficult to interpret because there is significant landscape heterogeneity within the (minimum) 1x1 km grid cells typically used in these analyses. Furthermore, while the greening trends are associated with increasing temperatures, changes in the timing of snow melt and length of the snow-free season may be a more direct mechanism of change. We examined trends in NDVI and snow cover across the mountainous southwest Yukon Territory, Canada, since year 2000 at 250m and 500m resolution, respectively, using data collected by the moderate resolution imaging spectroradiometer (MODIS). Length of snow-free period, dates of seasonal snow accumulation and melt, maximum NDVI, and date of maximum NDVI were calculated for each year. Linear regression was used to determine significant trends in the data, cluster analysis was used to identify spatial grouping of these trends, and a multivariate analysis using regression trees was used to identify a hierarchy of physical variables that influence interregional differences. Results indicated some spatial clustering of significant trends in most variables, but there has not been a ubiquitous 'greening' of this region, nor have trends in snow cover been directionally widespread. There was some spatial clustering of trends, but these have not been unidirectional, and many other areas have experienced no significant trends. Instead, the most apparent trend was the substantial interannual variability in both snow and vegetation related indices. Variability in NDVI is partly related to interannual variability in timing of snow melt, illustrating the importance of considering snow-related variables in future ecological monitoring and in models of ecosystem change.

1958

Change of the forest line ecotone in Torneträsk-Karesuando area, Northern Sweden over the last 100 years

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Latitudinal and altitudinal relocation and change of forest lines and forest covered areas, have implications for terrestrial carbon sequestration, land-atmosphere energy balance, and regional biodiversity. Hence information on potential rates and causes of change are essential in scenarios for climate change responses. However, such data are scarce but can be obtained from comparisons of current and historical vegetation, using old geo-botanical descriptions and maps. In this study, extensive descriptions of vegetation conditions for Northern Sweden for the period 1905-1912, are compared with late 20th century map and satellite data to quantify change in the birch forest line ecotone. The ancient vegetation map included 10 vegetation types tailored to the needs of reindeer husbandry, at a scale of 1:200,000. Used recent data encompassed a vegetation map from 1982-3, aerial photographs and SPOT-images from 2008-2009.The results show an altitudinal birch forest advance of up to 100 meters since 1909 across northern Sweden. For the last three decades (1982-2009) an elevational advance of at the most 20-30 meters is indicated. The changes in the position of the northernmost birch forest line are considered to be a combined effect of a warming trend of ca 1.5 degrees over the analysed period, and changed reindeer herding system in the early 20th century leading to both reduced grazing pressure and reduced fire wood harvest at the forest line. The recorded altitudinal advance by approximately 1 meter per year over the last century has caused a large scale forest cover change, but its combined landuse and climate background needs consideration when applied in scenarios for future responses.

1985

Photos and Plants through Time and Food Choice Research: Collaborative Community Research

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Purpose: During the International Polar Year (IPY), the Government of Canada supported "Photos and Plants Through Time" (PPTT, within PPS Arctic Canada), a community-based project using local plant collections and local photographs, and “Food Choice” (FC, also within PPS Arctic Canada) to bring academic researchers and members of communities into partnership to develop our understanding of environmental change in the Arctic and its impacts on dietary choices in everyday life and the health and well-being of people living there. The PPTT project took place primarily in Cape Dorset and Sanikiluaq, and the FC project was located in Cape Dorset, Iqaluit and Kimmirut, Nunavut.

Methods: The PPTT team investigated the human face of arctic environmental change, using photographic techniques and collaborative methods, linking data from community observations, interviews, and focus groups. The FC team used grounded theory and in-depth semi-structured interviews (n=128). Through the partnerships approach a wide range of knowledge sources, perspectives and experiences from western science and local knowledge are drawn on in this paper.

Results: By using community-based methods to document environmental, social and cultural change, dietary change and by developing and examining photograph and plant datasets in cooperation with communities, we built a shared understanding of landscape, land use and vegetation changes through time, connecting community health and well-being with climate change impacts.

Discussion: These results provide insight into adaptive strategies, social-cultural-ecological change and important connection to health and well-being in selected communities in Nunavut. The long-term outcomes include infrastructure frameworks and baselines for citizen science focused on environmental change and climate at the local level.

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Using a maximum entropy approach for delineation of the northern forest line on Lovozersky tundra mountains

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In the case of increased attention to global climate change it is worth noting the high significance of studies of the transition taiga – the tundra zone – as the zone most sensitive to climate changes. Vegetation is the face of the landscape and thus reflects changes in its components. Fixation of the present state of the northern boundary of the forest will continue to reveal the nature of the change, and consequently the extent of climate change. The basis of such studies should be remote sensing data as the most relevant and precise source of information.

The main problem of automated interpretation of the northern boundary of the forest is the heterogeneity of the transition taiga-tundra zone. It is expressed in the species diversity of the dominant species composition and depth of the transition zone itself, which in mountainous areas can differ by several tens of meters, and on the plains by up to several tens of kilometres. Standard algorithms of interpretation are not very suitable to produce a clear correlation of each pixel and its corresponding class of images and smooth gradients do not provide adequate results.

In this study, we used multi-seasonal imagery from Landsat 5/7, SPOT-4 and IRS-P6 satellites. The Lovozersky tundra mountains in the Kola Peninsula, Russia, were selected for the study. All the images were classified into classes of forest and non-forest by the maximum entropy method, and the results were compared with different techniques of remote sensing. To validate the results, we have used field data and very high-resolution imagery.

These results provide a more precise selection of borders of the forest zone obtained by using methods of maximum entropy. It is worth noting that by using the probabilistic model of neighbouring pixels belonging to classes of forest, the boundary conditions of non-forest can be more accurately found on the basis of a comparison with field studies. The maximum entropy method is more sensitive when dealing with gradient plots of transition forest-tundra zone and allows a more accurate determination of the boundaries, rather than using classical algorithms for interpretation.

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The influence of climate on needle health of conifers at the Arctic treeline

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Intense solar radiation combined with low temperatures can cause photoinhibition and reactive stress in the photosynthetic material of treeline conifers. Wind-blown snow can thin or remove the waxy cuticle covering needles resulting in excessive water loss and needle mortality, which can negatively affect the plant's photosynthetic capablility during the following growing season. Abrasion combined with insufficient maturation of the cuticle during the preceding summer can lead to excessive winter moisture loss. Consequently, cold and windy conditions impair vital functions and can set the distributional limits of plant species, though conflicting results from some studies confirms the need for further site-specific research. Within the forest-tundra around Churchill, Canada, current-year branch tips (branchlets) of *Picea glauca* (Moench) Voss. (white spruce) and *Picea mariana* (Mill.) BSP. (black spruce) were collected in February 2008 and 2009. Branchlets were sampled at three orientations: northwest (the predominant wind direction); south (aspect of greatest sun exposure) and; east (a control). This sampling was repeated at three heights: above the wind-blown snow abrasion zone (>1.5m above snowpack), within the abrasion zone (between 0 and 1.5m above snowpack) and within the snowpack (up to a depth of 0.1m). A total of 72 branchlets per site were sampled at each of four sites in 2008 as well as three additional sites in 2009. Four sites will be resampled during February 2010, following the coldest Churchill summer on record (3.7°C below the 1971-2000 mean). The most recent sampling presents a unique opportunity to determine to what extent insufficient maturation of the cuticle promotes winter desiccation. Several variables were assessed to determine the health status of branchlets, including: moisture content, transpiration rates, needle viability, and cuticular resistance. Spatial and temporal variations in needle health across the forest-tundra transition as well as implications for treeline migration will be discussed.

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Seedling growth at the Arctic treeline

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Migration of the Arctic treeline is largely dependent on a sequence of steps being accomplished: sexual reproduction, viable seed production, seed germination, and seedling survival. This research project, in the vicinity of Churchill, Canada, was designed to investigate the characteristics of seedlings that naturally colonized or were planted in ecosystems around treeline. The dominant treeline-forming species in this region is *Picea glauca* (Moench) Voss. with *Larix laricina* (DuRoi) Koch and/or *Picea mariana* (Mill.) B.S.P. in some ecosystems. Naturally occurring seedlings were measured in the vicinity of several small tree islands over a number of growing seasons. Additional assessments were conducted in each of the 10 most common ecosystems in Forest, Forest-Tundra and Tundra zones in the region. In addition, seedlings propagated from local-provenance seeds were planted in the tundra and a similar set of measurements were completed. Individual seedlings were monitored over the survey period to assess age, vigour, growth and tissue mortality.

Naturally occurring seedlings <10 cm high had little evidence of stress while those >25 cm commonly exhibited multiple leaders, dead leaders and branches. Seedlings were predominantly found down wind of tree islands and in winter were protected beneath deep snow drifts. Seedlings in existing forested sites had few signs of stress. Planted seedlings on the tundra had been severely stress, as evidenced by poor vigour, leader death and browned-off needles. The growing season after a cone mast year there were numerous one-year-old seedlings. Seedlings occur naturally in protected areas on the tundra and in existing forests near treeline. Indicators of stress appear to increase with exposure on open tundra landscapes.

Clearly, the current treeline position appears not to be restricted by successful seedling establishment where microsites are amenable to survival. However, beyond the treeline, the open tundra remains an hostile environment limiting seedling survival.

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Large-Scale Mapping of Plant Cover in Forest-Tundra Ecotone in Kola Peninsula, Russia

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Plant cover in the forest-tundra ecotone has a mosaic structure. This study is aimed at characterising spatial structure and diversity of forest-tundra ecotone ecosystems, for relatively small areas through field mapping of vegetation micro-mosaic structures and for larger areas using very high resolution satellite imagery. Our approach is to identify and map the elementary soil- vegetation cover units which we call compartments, delineated by distribution of predominant plant species. Large scale (1:20 and 1:100) mapping was carried out in three key areas: Yumechorr (N67.70163, E 33.23808) and Tuliok (N67.70139, E33.78825) in Khibiny mountains and Kanentiavr to the east and west of Lake Kanentiavr (N 68.88811, E 34.26546) in northern Kola Peninsula (Russia). 18 stripes of 10 x 50 m were mapped in the three areas, and 2 stripes of about 800 x 10 m were mapped in Tuliok and Kanentiavr, in tundra, forest and forest-tundra ecotones. The 10x50 m stripes were mapped at 1:20 scale and 800 x 100 m stripes at 1:100 scale. Other field data included species lists, vegetation and soil samples, radiometric measurements in 4 spectral bands, along specific transects and for particular species. Very high resolution QuickBird satellite images of 28.06.2006 (Tuliok) and 05.07.2005 (Kanentiavr) have been interpreted to identify tree stand density and some of the dominant ground cover types. 97 vegetation compartments were determined in total. Only about 20% of these were common for tundra, forest-tundra and forests. By extrapolation of ground data through image classification we hope to characterise structural diversity, contribution of different compartments to landscape structure in forest-tundra ecotone, and to make conclusions about dynamics of vegetation cover, soil nutritional status, and carbon and nitrogen sinks and sources. This research is part of PPS Arctic project, financially supported by the Benefits Russo-Norwegian programme of the Norwegian Research Council (OST 185023/S50).