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Gender Specific Determinants of Diet Choice in three communities in Nunavut, Canada: A Comparative Analysis

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Introduction: The traditional diet of many Inuit includes the consumption of country foods (e.g., fish and marine mammals) which are highly nutritious and important to their health and well-being. The gathering and consumption of country foods also has great social, cultural and economic importance to Inuit communities. While country foods may provide a better source of minerals and nutrients than store-bought foods, some country foods have been identified as having elevated levels of environmental contaminants, which has led to increased human exposure. It is therefore important for risk management efforts to balance the benefits and risks associated with the consumption of country and store-bought foods. Understanding the factors that influence dietary choices in the Arctic is necessary for the development of culturally appropriate dietary advice, and to highlight potential avenues for dietary intervention. For these reasons, the objectives of the current study are to: (1) understand the gender specific determinants of dietary choice; and (2) identify culturally acceptable strategies to promote healthy dietary choices.

Methods: Through comparative analysis, this qualitative study has identified the factors that influence dietary choices among Inuit living in Cape Dorset, Iqaluit and Kimmirut in Nunavut, Canada. A "snow-balling" technique was used for the recruitment of study participants. In-depth semi-structured interviews (n=124) were conducted with women and men 18 years of age and older. NVivo software was used to analyze the interview data.

Results: The following factors were identified as influencing diet choice: socio-cultural factors, available resources, time and convenience, environmental conditions, knowledge, nutritional factors, taste and variety. Of these, socio-cultural factors, available resources and environmental conditions were very important due to their impact on participant's ability to access desired foods.

These factors were discussed by both men and women, however specific differences in how the factors were described by the participants was noted. Different socio-cultural roles for men and women influenced the needs of men and women, and which factors were more important to them. For example, for women, having access to a hunter was critical to having access to country food. While for men, having access to hunting equipment and other resources was critical to their ability to hunt for country foods.

Participants also emphasized certain aspects of the factors differently among the three communities. For example, in Kimmirut and Cape Dorset, sharing of country foods was common and sharing networks allowed residents to obtain country foods, especially those who would not normally be able to hunt for country foods themselves. However in Iqaluit, similar sharing networks are harder to maintain due to population growth and large community size.

Participants made several recommendations including: having a community freezer, financial support for local hunters, community land programs, exchange of traditional knowledge with youth, increased awareness of healthy food choices and preparation techniques (i.e., cooking classes), decreased cost of healthy foods, and more community feasts and cultural events.

Discussion and Conclusion: The results of this research complement existing studies and helps to provide more informed, effective dietary advice for Aboriginal peoples living in Arctic Canada.

Can trees move north? Reproductive potential of forest expansion in the circumpolar north

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As climate warms, it is anticipated that some species will expand their ranges northwards (and upwards, in alpine ecosystems) as environmental constraints on establishment lessen. Modelling and experimental evidence have shown a time lag between periods of climatic warming and range shifts in treeline, or forest-tundra ecotone, vegetation. One of the leading explanations for this time lag is seed limitation, caused by a low productivity or poor dispersal of seeds. Adverse environmental conditions at the forest-tundra ecotone may limit seed production and dispersal, seed viability, and/or tree growth and survival, thereby limiting forest expansion. Our objective was to measure seed production and viability of the dominant tree species across the circumpolar forest-tundra transition. We hypothesized that the reproductive ability of individuals would be lower at the margin of tree occurrence than within continuous boreal forest. Study sites were established within the forest-tundra transition in northern Canada, Sweden, Norway, and Russia. Cones or catkins were collected from the dominant tree species (black and white spruce, tamarack, balsam fir, mountain birch, Scots pine, and Siberian spruce) in each study site for one to three years from 2007-2009. Germination tests were carried out to determine seed viability. Although the dominant species at each study site differed, the overall patterns in reproduction remained the same: 1) trees in continuous forest produced more seed than individuals in sparsely-treed tundra during the sampling period; and 2) seed production and viability were variable across sampling years. As a consequence, the overall pattern was a reduction in reproductive potential across the forest-tundra ecotone in circumpolar boreal forests. The factors driving the observed gradient in reproductive potential were primarily the change in forest density, and secondarily, variations in seed viability and productivity per tree. For these reasons, spatial gradients in stand density are likely to be a key factor determining seed availability beyond the forest limit. Stand infilling (i.e., increases in density) within the forest-tundra ecotone may thus be an important precursor to the development of sufficient seed inputs to support treeline advance in response to climate. High annual variability in seed production and viability suggests that individual years of high seed production may contribute disproportionately to tree recruitment at the forest-tundra ecotone, making annual variability in climate conditions a key control of treeline movement. Seed availability is not the only factor influencing treeline movement, however. Safe sites for seed germination and establishment are critical for recruitment. Local processes, such as seed predation, herbivory, and fire, may affect the amount of viable seed for dispersal, the survival of seedlings, or the availability seedbeds. In conclusion, our synthesis of data suggests that, where there is sufficient viable seed and optimal seedbed, treeline responses to climate change will be a) initially driven by stand infilling near the forest limit, and b) strongly influenced by stochastic processes of annual variability in climate and seed production.

A Regional Dendroecological Analysis of the Impact of Herbivory for Fennoscandian Treelines

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Fennoscandian treelines have been shown to be sensitive indicators of global environmental change. However, these ecotones are subject to herbivory by both semi-domesticated reindeer and autumnal moths. Herbivory may be influencing both the form of response of this ecotone to climate change and the speed with which the treeline responds to such changes. In this study we present what we believe is the largest dendroecological study of treeline in Fennoscandia. Data are presented from more than 4700 stems of the dominant treeline species in the region (*Betula pubescens ssp. czerepanovii*). These data were gathered from 65 sites in Norrbotten and Västerbotten counties. Dendroecological techniques are used to determine establishment dates for these trees growing within the treeline ecotone. Similar techniques are also used to develop ring-width chronologies which are used together with chronologies for Scots pine to identify outbreaks of the autumnal moth in the region. These data provide a regional scale picture of the relative importance of herbivory and climate to the establishment of trees within the treeline ecotone. The results indicate that the response of both the pattern and location of the treeline is not constant across a large area and should be interpreted as a complex interaction of multiple drivers and constraints.

Maternal contaminant concentrations in Northern and Southern Canada

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Introduction: Since 1991, the Northern Contaminants Program (NCP) has analyzed a wide range of metals and organochlorines in maternal blood in the Canadian Arctic. The Canadian Health Measures Survey (CHMS) and a study conducted by the Commission for Environmental Cooperation (CEC) have examined a similar group of contaminants in women of child bearing age (WCBA) and first time mothers, respectively, in Southern Canada. This paper will examine differences in these contaminants between a random sample of WCBA and two convenience samples of first birth mothers to determine if factors such as region and ethnicity influence contaminant levels.

Methods: As the result of low populations rates in most Northern regions, several NCP studies have collected convenience maternal blood samples over one or more time points. Similarly, the CEC study has collected a convenience sample of first time mothers from five Southern Canadian centres (n=125, 2005-2007). Conversely, the CHMS recently examined over 5000 individuals in a stratified random sample and measured concentrations of contaminants in a nationally representative sample of WCBA (2007-2009). Concentrations of heavy metals and persistent organic pollutants (POPs), including total mercury, lead, several polychlorinated biphenyl (PCB) congeners, and various organochlorine pesticides, are examined.

Several statistical methods are implemented for comparisons of contaminant concentrations in the blood of first birth mothers from the NCP and CEC studies (i.e., lognormal distribution for skewed data, ANOVA hypothesis testing, and survey sampling techniques such as weighting and bootstrap variance estimation). Multiple regression analysis will also be used to compare contaminant concentrations in the presence of possible confounders including ethnicity, region, age, diet, smoking status, and occupation.

Results & Discussion: Convenience samples from Northern (NCP) and Southern (CEC) Canada are similar in their timing, size, and sampling methods and may be directly compared, while the CHMS dataset for WCBA will present a descriptive baseline for maternal data.

Initial analyses indicate that, for several contaminants, Northern data for Inuit and Inuvialuit first birth mothers are higher than mothers sampled in the Southern CEC study. Conversely, some contaminants show similar or higher concentrations in the CEC study compared with Dene/Metis and non-Aboriginal mothers from the Inuvik region. Further, populations in the Western Arctic tend to demonstrate lower concentrations for legacy contaminants than Inuit mothers sampled from the Eastern Arctic.

These observations support the premise that the traditional Northern lifestyle and marine mammal diet, which includes the regular consumption of country foods such as walrus, seal, and whale, is an important source of contaminants for Inuit populations. It is thought that the land-based diet of caribou, moose, and fish of Dene/Metis peoples can lead to lower exposure.

Conclusions: Women of child bearing age, Northern mothers, and first time mothers in the South have a similar suite of contaminants in their blood. While contaminant concentrations in maternal blood are decreasing over time in the Canadian Arctic, some contaminants remain higher for Inuit / Inuvialuit mothers compared with first time mothers from Southern Canada.

Co-producing Adaptive Knowledge From Community-Based Research: An Example of Policy-relevant Synthesis for Action on Regional Climate Change in the Arctic

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Abstract: During International Polar Year, members of the International Polar Year "PPS Arctic – Impacts of a Changing Treeline" team conducted a host of studies throughout the circumpolar region. Here we draw from results reported in the outcome of a particular workshop held under the auspices of PPS Arctic to review photographs collected as part of the "Plants and Photos Through Time". Locally-held, qualitative, temporally-based knowledge of environmental change was articulated in response to shared photographs in community focus groups and workshops. Coupling this experiential local knowledge with direct observations of physical phenomena and processes of environmental change at other Arctic sites results in a conceptual model capable of integrating local, qualitative, shared perceptions of particular changes in the environment, with multidisciplinary regional science. The adaptive consequences of this conceptual modeling include: 1) policy and program opportunities for mitigation of local and regional impacts of a changing Arctic environment with special reference to sea ice; 2) linkages between infrastructure development and technology adoption and long-term change; and 3) greater capacity to situate meaningful mitigative measures at the level at which local communities possess potential for agency. This co-production of knowledge across scale, from local knowledge observations over time, coupled with particular instances of observed phenomena and science at regional scales offers insight into community experience as well as contributory factors that once understood, may be subject to control. By linking local observations and experiences of change with physical mechanisms that are accessible to meaningful local interventions, it becomes possible to offset the magnitude of cross-scale factors contributing to environmental change while enhancing local capacity to intervene adaptively. Using the example of increasing ice fragility and paleoecological research we examine the co-production of knowledge relevant to adaptation and as a strategy for enhancing community resilience. It also leads to avenues for new policy and program recommendations for action to slow regional warming in the Arctic Region.

Transforming Research Through the Power of Partnering: Lessons from Working With Nunavut Communities During International Polar Year and Beyond

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Abstract: During International Polar Year (IPY), the international circumpolar study "PPS Arctic – Impacts of a Changing Treeline" involved an international team led by Hofgaard and a Canadian team led by Harper with several field sites across Canada. The studies we report here focused on Nunavut communities of Cape Dorset, Sanikiluaq, Iqaluit and Qikiqtarjuaq. Our research findings strongly support the views of northerners expressed in many regions: first that they themselves observe significant changes in the environment; and second that these changes are widespread and pervasive, whether considering environmental, social or cultural aspects. This is understandable in part through the integration of ecological-social-cultural systems in northern communities. Our third finding, the focus of this paper, is that the impacts of partnering in the research itself also have consequences in the north, and it is the nature of the research enterprise and its imprints that we examine here as an important element of lessons learned en route from knowledge to action through engaged research under IPY. Our studies addressed two key concerns of Inuit: 1) changing environments and impacts on community food access, and thus health and well-being; and 2) the engagement of elders and youth, as well as leaders, in research impacting our collective understanding of the changing Arctic. We worked to tailor both our research framework and our methodologies to mesh constructively with the preferences of communities as understood through on-going relationships between community members and research team members. Here we present a retrospective examination and analysis of the transformative aspects of the research process, as a contribution to envisioning processes of adaptation to climatic and geopolitical change through research activity.

Photos and Plants Through Time: Knowledge of the Impacts of a Changing Treeline Through Community Based Research

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Abstract: Working in Cape Dorset and Sanikiluaq, Nunavut, the Photos and Plants Through Time project enabled our research team consisting of community members and academic and government specialists to collect, preserve and document primary evidence of a changing Arctic in the form of plants, databases, maps, and images. The team found over 200 species of plants including a number (ten at present) that were new to Nunavut. Verification and additional research has been underway in partnership with Dr. Laurie Consaul of the Canadian Museum of Nature during the past two years. Collections were also made of photographs taken in earlier times by community members and re-taken during International Polar Year. The resulting "photo-pairs" where reviewed by the communities using an innovative process designed to elicit shared understandings of social-cultural-ecological changes. The process shifted the power of interpretation to the community members themselves as they first made "sense" of the comparisons between early and later photographs, in terms of changes and impacts of the "outside world" on personal histories. By sharing narratives or "memories" within the focus group and then with us, during focus group and workshop discussions, the community retraced the processes of changes as experienced by the broader group. This collective recounting enriched the understanding of all by expanding the inevitably partial accounts accessible to individuals alone. In addition to the fundamental contributions to the science of climate change and adaptation of records like that of the green orchid and integration of traditional knowledge to constitute benchmarks (Consaul et al.,2011), the methodological innovations reported here constitute a new contribution to an emerging paradigm of social technologies for linking knowledge holders to co-create shared understanding from memory as a basis for the social cohesion necessary for effective policy and action.

Natural science research of the forest-tundra ecotone structure and changes in Russia

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We present results of collaborative research carried under nationally funded project BENEFITS as part of the IPY core project PPS Arctic. We apply the PPS Arctic concepts in the Russian territory by characterising structure, position and dynamics of the forest-tundra ecotone and comparing these in mountains and plains, in continental and oceanic climatic conditions. We analyse specific roles of soils and terrain, and of anthropogenic factors, including aerial pollution and land use. We build upon integrating i) field ecological research, characterising vegetation, soils and terrain of key sites; and ii) traditional and novel ways of extracting information on position and structure of the ecotone areas from remotely sensed imagery, with particular focus on very high resolution (0.5-4 м, for key sites) and moderately-high resolution (15-30 m, for larger areas) satellite images. Project activities have been carried out in two contrasting regions: north-west Russia (2008-2010, centre and north of Kola Peninsula) and north-central Siberia (2010, Ary-Mas in south Taimyr and south-central shore of Lake Lama in western Putorana Plateau). Key tree species include birch, pine and spruce in NW Russia and larch in Siberian sites. Within sites controlled by mostly natural factors, advance or stagnation of treeline is recorded; recession of treeline is noted only in sites severely damaged by industrial activity, e.g. near Monchegorsk nickel smelters.This research has been financially supported by the Russian-Norwegian collaboration program of the Norwegian Research Council (OST 185023/S50).

Vegetation dynamics at the southern limit of the Arctic:
A Canadian perspective

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Abstract: The Arctic is delimited in the south by the forest-tundra transition (often called treeline). With climate change, trees are expected to encroach upon tundra at its southern limit thereby shrinking the extent of the non-treed Arctic landscape. I present a synthesis of the results of PPS Arctic Canada, an interdisciplinary International Polar Year (IPY) Canada research program that investigated the causes and consequences of change of the forest-tundra transition. Our studies formed the Canadian component of the IPY core project PPS Arctic that studied these topics at a circumpolar level. Our objectives included analyzing recent change in vegetation and microclimate, determining the mechanisms of this change, mapping the spatial pattern of the forest-tundra transition, assessing the role of disturbance and developing models of the relationship between environmental change, resource availability and human health and well-being. Together with our international team we developed common protocols and collected data during the summers of 2007-09 to examine change in the forest-tundra transition at over a dozen locations in the Yukon, Northwest Territories, Nunavut, northern Manitoba, northern Quebec and Labrador. Data were collected on trees of all ages, recruitment dynamics, seed availability, vegetation, soils, climate, microclimate, snow and ice, spatial pattern, soil and socioeconomic indicators regarding the impacts of changes in climatic conditions on the forest-tundra transition and their consequences on ecosystems and communities. Evidence of change in and movement of the forest-tundra transition was evident in some sites but not in others despite increasing temperatures. Recruitment may be hindering the movement of the forest-tundra transition at some sites where there appears to be a bottleneck to tree expansion due to limitations of seed production, seed viability and seedling mortality. Disturbance or lack thereof has been shown to affect the amount and species of regenerating trees. Shrubs appear to be a conduit of change by actively preceding tree expansion into tundra at some sites. Our key finding was the large amount of variability in tree growth, regeneration and spatial pattern among tree species, regions across Canada and even sites within the same region. This variation in response of the forest-tundra transition may be extremely challenging to outline general strategies for climate change adaptation in Arctic environments for northern communities and ecosystems.

Fine-scale patterns of vegetation across the forest-tundra transition in northern Manitoba and northern Quebec, Canada

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Abstract: The forest-tundra transition may be shifting due to climate change, affecting both regional biodiversity and northern communities. In this study we explored the fine-scale spatial pattern of vegetation to gain insight into the spatial relationships between different plants and the possible effects of climate change. We investigated the spatial pattern of trees, shrubs and ground vegetation cover along 100-150 m long transects across the forest-tundra transition in northern Manitoba and northern Quebec, Canada. Spatial pattern analysis was used on data collected in 1x1 m contiguous quadrats to determine locations of patches and locations of abrupt changes in vegetation. Our main objective was to determine if changes in pattern along the transect coincided for different groups of plants. Preliminary results indicate that moss and lichen cover often had opposite spatial patterns with greater moss cover towards the forest and greater lichen cover towards the tundra. Patches of lichen were often found where there were fewer short shrubs. Tall and short shrubs also had opposite patterns in cover along most transects. Wavelet analysis revealed that different plant groups sometimes had significant changes in abundance at the same positions along the forest-tundra transition, but not consistently. The irregular correspondence of these fine-scale patterns of different plant groups suggests that the response of vegetation in the forest-tundra transition to climate change would be complex.

At the leading edge of forest expansion into tundra:
The structure and dynamics of tree islands within the Canadian forest-tundra transition

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Abstract: Tree islands located at the northern limit of the forest-tundra transition in Canada would be at the leading edge of forest expansion into tundra due to climate change. Tree islands are small patches of trees surrounded by treeless tundra and may or may not include krummholz (stunted trees). The goals of our study were: 1) to assess the structure of tree islands and to look for evidence of expansion, 2) to evaluate reproductive effort and success through an investigation of seed production, viability and recruitment within tree islands and 3) to explore possible effects of expansion on the surrounding vegetation. We sampled trees during the International Polar Year within tree islands in Churchill, Manitoba, in the Mealy Mountains, Labrador, and in the Mackenzie Delta region, Northwest Territories, which enabled us to make comparisons across sites. We also sampled other plant species at tree islands and the surrounding tundra at all sites. In the Mackenzie Delta region, tree islands were 4-40 m wide with 3-744 upright stems that had growth forms ranging from low lying mats to trees >2 m tall. We found some evidence of expansion of 8-15 m wide, 3-7 m tall tree islands with 4-30 stems in Manitoba including the presence of <15 cm tall saplings at the edges. Sampled tree islands in the Mealy Mountains were 4-9 m wide krummholz patches <70 cm tall (except one) with no signs of expansion and few distinct upright stems. Tree island shape at Churchill was variable and not affected by predominant wind direction as expected.The form of trees (height:diamter ratio) appears to be related to the size of tree islands in Churchill. We found no true seedlings in the Mackenzie Delta region or in the Mealy Mountains. In the Mackenzie Delta region, trees in tree islands were shorter and not as healthy as in nearby forest stands. At Churchill, moss, *Vaccinium uliginosum* and *V. vitis-idaea* were more abundant and lichen, *Dryas integrifolia* and *Rhododendron lapponicum* were less abundant within tree islands compared to tundra. In the Mealy Mountains, lichen and *V. vitis-idaea* were more abundant and moss, total herb cover and *Arctostaphylos alpina* were less abundant in tree islands compared to tundra. Vegetation composition was similar between forest stands and tree islands in the Mackenzie Delta region. Possible vegetative expansion of tree islands is expected to result in site-specific changes in plant species composition at the edges of tree islands. However, tree islands, at least in the Mackenzie Delta region, are not likely to be important sources of viable seed for infilling of the forest-tundra transition.

Is the east really different? Treeline change in eastern Canadian Mountain habitats

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Due to a perceived lack of climate warming in eastern, compared with western Canada, research into mountain and tundra vegetation change has been limited in the east mountain ecosystems. However temperature in coastal northeastern Canada has increased ~1-2^{o}C. Our group investigated the role of disturbance, facilitation and reproductive bottlenecks on a multispecies (black and white spruce, larch and balsam fir) treeline in high subarctic and tundra in Labrador, and modelled long-term climate induced change. Unlike western Canada small-scale, low-level insect herbivory is the dominant disturbance mechanism at eastern treeline, rather than fire. Using dendrochronological techniques it appears that centuries-old persistent individuals are dynamic in their response to recent climate change, forming the leading edge of treeline advance. Few naturally occurring seedlings are found in the transition zone of the Mealy Mountains, but facilitation of future seedlings may be via feathermosses rather than shrubs. Experimental plantings above treeline indicate seedling can survive for more than 5 years; however herbivory by slugs and rodents may set the template of future tree distribution by modifying recruitment. Lack of seedlings is also a function of insufficient seed production, causing a bottleneck to treeline expansion. Cone production is highly variable across the treeline and seed viability is limited by a combination of insufficient growing degree days and damage caused by insects. In this multi-species treeline, black spruce is dominant and along with larch, had the highest percentage of germinable seeds. Together with higher stem density, black spruce would most likely to lead seed-mediated treeline advance as conditions improve. As in the west, shrubs are expanding and increasing in density in both treeline and tundra systems, leading to a similar prediction for ecosystem change in the east.

PPS Arctic - Circumpolar Treeline Research during IPY
From model predictions to site-based knowledge

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The IPY core project *PPS Arctic* is a circumpolar research program focusing on the southern border of the Arctic with its transition zone into shrub and tree dominated regions (i.e. the circumpolar tundra-taiga interface; TTI). The project is composed of individual national and bilateral projects jointly focusing on causes and consequences of TTI changes.

The circumpolar boreal forest is expected to move northward. As a result, a larger proportion of the earth's surface area may become darker and thus absorb more heat. Through feedback mechanisms, change of this nature could have a major impact on global climate. The PPS Arctic project examined the dynamics of this zone. The predominant assumption is that a warmer climate will cause the forest to advance steadily northward. Preliminary results from our project, however, do not confirm such an assumption outright.

The TTI location corresponds to a combination of 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 zone is diverse and complex, and cannot be expected to respond in a homogeneous manner throughout geographical regions. During the past years and decades 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 and elevational forest advance. A detailed circumpolar analysis awaits further results, but at a coarse global scale far from all study sites show recent advance. Responsiveness is linked to both the structure of the zone and its geoclimatic location. Advance appears to prevail in some alpine areas and regions affected by moist air masses but not all, while some latitudinal treeline regions dominated by dry arctic air show stationary or retreating behavior. Large herbivores such as reindeer can dominate the dynamics of the zone at region- and species-specific levels by modifying recruitment, survival and growth of trees. Herbivore-driven or other disturbance-driven modification of expected climate-driven tree expansion emphasizes the need to consider changes in grazing regimes and other perturbations (e.g. tundra- and forest fires, wind, insects, permafrost alternation) along with climate change, to avoid misleading interpretations regarding rates of climate-driven encroachment.

Comprehensive project results representing the circumpolar perspective are not yet available as these will be based on publications and theses by over 60 graduate students. However, some preliminary patterns are evident:

- The influence of climate is seen at most sites even if this is complicated by differences in regional land use pattern.
- Responses differ greatly between different climate regions; between coastal and continental regions of the circumpolar north; and according to the dominant tree species.
- Examples of advancing, retreating and stationary forest-tundra zones are seen across study sites. Advancing zones seem to be dominating, but the rate of change does not confirm modeled predictions.

Forest cover change and treeline advance-rates along the Arctic margin at latitude 68-70N in Norway and western Russia: causes, consequences and predictions

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Latitudinal and altitudinal relocation of treelines 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 a combination of site-based age structures and tree growth patterns, and region-wide mapping of current and historical forest cover and distribution limits.

The presentation reviews results from the bilateral Norwegian-Russian part of the IPY core project PPS Arctic (http://ppsarctic.nina.no). The research group has used multiple sites and study approaches.

- 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. This importance of non-growing season factors for tree growth at high latitudes, together with the role of short-term climate variation are often overlooked. Future climate scenarios predict moister and milder winters for large areas of high latitude regions. Thus, detailed analyses of region-specific climate-growth relations that focus on growing season vs. non-growing season effects are essential in the evaluation of future forest cover response to climate change.
- In regions with historical and current high grazing pressure an herbivore-driven concealing of expected climate-driven tree expansion is evident, with climate as a secondary force. This emphasizes the necessity to consider changes in grazing regimes along with climate change, in order to avoid misleading interpretations regarding climate-driven tundra encroachment.
- Greatly deviating treeline response patterns, representing advancing-, stationary-, and retreating treelines, are shown among climate regions (Arctic vs. Atlantic; coast vs. inland). Advance appears to prevail in regions affected by moist air masses and characterized by high annual precipitation, while regions dominated by dry arctic air show stationary or retreating treelines. Recessions of treelines are also observed in areas influenced by industrial activities and local air pollution.
- The combination of remote sensing and tree community data proved useful for detailed monitoring of the subtle changes characterizing the treeline ecotone at high latitudes. Remote sensing data offer precise information on the total rate of changes while the establishment data give detailed information on the dynamics of changes and indications of underlying causes. This is necessary information for fine-tuning tundra encroachment scenarios into empirical based predictions. Accurate mapping of the treeline ecotone and local/ regional casual backgrounds is important when coarser resolution remote sensing data are to be used to analyse and monitor the circumpolar extension of the ecotone.

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. A stronger focus on factors limiting forest-tundra ecotone response to climate change is needed. This would take us closer to explaining the mismatch between model predictions and site based empirical results.

Spatially explicit modelling of treeline change in the Mealy Mountains (Labrador)

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Observed treeline changes are often slower and patchier than predicted by existing treeline change models. Traditional approaches based on statistical relationships can predict a trend of change, but they are often inadequate when used to explain processes such as nonlinear responses, feedbacks, influences of fine scale factors and the associated uncertainties, which are behind the spatial and temporal variations of change. Climate change impact studies have been ongoing in the Mealy Mountains (Labrador) for 10 years investigating the influence of abiotic and biotic factors such as climate, soil processes, ground vegetation, shrub- and tree-line dynamics, including mechanisms such as disturbance, facilitation and herbivory. Results suggest that the four dominant conifer species (*Picea glauca, P. mariana, Abies balsamea, Larix laricina*) at the treeline will show uneven responses to climatic change. With a complex network of causal factors identified, our group will simulate how future climatic change will influence the composition and location of the treeline in a complex landscape. The fragmented spatial landscape due to patchy distribution and clonal growth habits of tree species at the research site, together with the difference in individual species' response to the influence of biotic and abiotic factors, the existence of both positive and negative feedbacks and the uncertainties in future climate change warrant the use of an individual-based model. Such models are intrinsically bottom-up, and are appropriate for incorporating fine scale ecological data and simulating nonlinear relationships and feedback processes such as in seedling recruitment. Calibrated using field data and satellite images, the model can be used to produce visually intuitive predictions and to illustrate the spatial, temporal and compositional dynamics of change that may happen under different climate change scenarios. This study will provide new insight into the spatial and temporal processes and patterns of treeline change in the Mealy Mountains and help understanding the mechanisms underlying these treeline dynamics in the boreal-tundra ecotone. The spatially explicit model will also serve as a template of how individual-based modelling techniques can be suitable for simulating treeline changes at transition sites which are compositional complex, highly fragmented and facing strong uncertainties in future climate change.

Conversations about Plants: Engaging Northerners in Thinking about Vegetation Dynamics

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Vegetation communities and plant species are often overlooked when the public discusses concerns about environmental change in the North. Many northerners group together the plants in their local environment under general categories such as “buckbrush,” “muskeg,” or “bush,” potentially reflecting a relatively simplistic view of vegetation dynamics in their surroundings. Nevertheless, the response of arctic systems to environmental change will be strongly influenced by changes in terrestrial plant communities, and thus vegetation dynamics are a key research target for northern science. For vegetation scientists, stimulating local interest in plant ecology and biodiversity can be extremely challenging. Here we discuss qualitative outcomes from several approaches to engaging northern residents in “conversations about plants” – discussions and experiences that help engage both residents and outside scientists in developing common interests in vegetation science. We will compare and contrast our experiences with using a) formal courses in northern plants, b) scientific outreach through presentations, c) working with individual northern residents to conduct vegetation research, d) developing community monitoring programs for berry plants, and e) facilitating cooperative workshops with communities about local plants, as approaches to stimulating increased and sustained public interest in vegetation dynamics. Observations of these activities and their outcomes are based on our collective experience from several decades of plant-focused research and outreach in Yukon Territory and Newfoundland and Labrador, Canada. We will discuss the required investment of resources and compare this with our perceptions of observed outcomes for each activity. This information will help characterize a toolbox of approaches to public outreach that may be specifically targeted to different situations and goals for outreach and dialogue in vegetation science. We will also address the “nuts-and-bolts” aspect of undertaking these outreach activities, so that scientists can be better prepared for both the benefits and costs of developing real and meaningful “conversations about plants.” In doing so, we hope to improve our understanding of the many approaches that can be used to stimulate public interest and appreciation of vegetation dynamics as an essential element of northern socio-ecological systems.

Temperature and Snowpack Characteristics Across Treeline

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Studies have suggested that the most important controls on treeline dynamics are at the population level and near-surface temperature is paramount. PPS Arctic Canada protocols included deployment of rooting zone temperature sensors (10 cm depth) and, when possible, snowpack characteristics. Data were collected for at least the growing seasons 2008-9 and at some sites data extend from 2000 to the present. The treeline ecotone was studied at the Mealy Mountains (Labrador), the Hudson Bay Lowlands (Manitoba) and the Kluane Ranges (Yukon). Microclimate installations varied from full-scale weather stations to mini-data loggers and these continuous monitoring stations were supplemented by manually collected data on snowpack characteristics. MAAT ranged from -1.9˚C in the Mealy Mtns. to -5.6˚C in the Hudson Bay Lowlands. For the Mealy Mountains the growing season as defined by the threshold temperature of 3.2˚C soil temperature was 143 days long with a mean temperature of 10.8˚C while over the same period the mean air temperature was 9.1˚C. In the Hudson Bay Lowlands the snowpack depth on the tundra was ~10% that of the forest while the forest-tundra had more similar values to the forest. The ability to conduct heat through the snowpack was 10x greater in tundra than the forest. As a consequence of these conditions the tundra was much colder in winter than the forest with the forest-tundra closer to the forest in its characteristics. Despite low stem density the forest significantly modified microclimate conditions to provide a more moderated condition for trees. Feedbacks between microclimate and tree height and density play a paramount role in treeline characteristics.

Spatiotemporal patterns and processes within a latitudinal ecotone: How has the forest-tundra transition responded to climate change in northern Manitoba, Canada?

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Abstract: Numerous sites along the circumboreal forest-tundra ecotone (FTE) are changing in response to current climate warming. These changes include fluctuations in treeline location, stand infilling, change in tree growth form, and alterations in spatial patterns, among others. As part of an International Polar Year project to investigate spatial and temporal pattern and process across the FTE, numerous sites near Churchill, Manitoba, were sampled in order to evaluate dynamics of vegetation spatial patterns and tree demographics across the FTE of the region. Vegetation surveys and dendroecological analyses were conducted at localized treelines near the southern extent of forest-tundra, as well as at several tree islands near the Hudson Bay coastline. Forest stands were dominated by white spruce (*Picea glauca*), although tamarack (*Larix laricina*) has become increasingly prevalent further inland in recent decades. Localized treelines appear to have advanced during warm periods, and most tree islands have some evidence of expansion. Seedling establishment was the primary mode of reproduction, with little layering observed across the region except in the tree islands. Patchiness of tree cover decreased from forest to tundra, and patches of tall trees were further apart in the ecotone, suggesting facilitation is more important than competition for tree recruitment. Indeed, wind plays a crucial role in the spatial structure of trees populations, as indicated by different patterns among localized treelines with different amounts of wind exposure. At a coarse scale, temperature appears to be the main driver of FTE dynamics around Churchill, although as scale decreases from landscape to community to site, factors such as wind, autecology, facilitation, and edaphic characteristics become increasingly important forcings of FTE dynamics. It is clear the FTE around Churchill is changing with important impacts for ecosystems, and will likely continue to change in the face of predicted warming.

Does temperature explain enhanced shrub growth in the circumpolar Arctic?

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Recent evidence indicates widespread expansion of canopy-forming shrubs in tundra ecosystems. Remote sensing shows a 'greening' of Arctic tundra which has been partially attributed to increasing shrub cover. This increase in woody shrubs is concurrent with increasing temperatures but the mechanisms, magnitude of change in cover and feedbacks promoting expansion over time have yet to be quantified at the biome scale. Shrub expansion in the Arctic has been documented using repeat aerial photography satellite imagery and ground based observations. The observed increases in woody shrubs into and within tundra ecosystems will alter ecosystem functioning by changing albedo, the soil thermal regime, nutrient turnover times, carbon cycling and biodiversity and may create positive feedbacks to further shrub expansion and Arctic warming.

We compared observations of change in shrub cover and canopy height and analyzed shrub annual growth rings from sites around the circumpolar Arctic to test the hypothesis that regional summer warming is causing current shrub expansion. We compiled annual growth ring data collected from sections of individual shrubs sampled at each of the field sites located around the circumpolar Arctic and in alpine locations and compared these data to both local and regional climate data.

This is an ongoing analysis and results are currently preliminary. Early growing season temperatures were a key factor explaining variation in interannual growth for most species at most sites. We observed variability in the growth sensitivity to early growing season temperatures between sites and species. Variation in temperature sensitivity could be explained by variation in growing season temperatures between sites at different latitudes or elevations and the different temperature thresholds for growth response between shrub species. The relative influence of snow cover, winter temperatures, and growing season length might also differ between sites. Some sites have experience greater warming than others in recent decades, and it is the sites that show the most temperature sensitive growth and are experiencing the greatest growing season warming that are predicted to show the greatest change in future shrub abundance.

We have used the growth record of individual plants from multiple shrub species in sites around the circumpolar Arctic to extrapolate vegetation change. Better quantifications of the relationship between the growth of shrub species and climate will inform model estimates of future shrub expansion. Improved projections of vegetation change will contribute to better quantifications of both the resulting ecological impacts of shrub expansion to tundra ecosystems, and the strength of climate-ecosystem feedbacks to future climate change. This data synthesis is an activity of the Shrub Hub Research Network (http://shrubhub.biology.ualberta.ca/).

Potential impact of climate – induced forest advance on soil fertility in forest-tundra ecotones of the Kola Peninsula, Russia

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Climate-induced shifts of treeline ecotones, including shrub expansion, have been reported and forecasted for various locations in the Northern Hemisphere, such as Fennoscandia, the Urals, Kola Peninsula, Alaska and Yukon plant communities. Our work addresses the potential impacts of climate-induced forest advance on soil fertility in the forest–tundra ecotones of the Kola Peninsula. Four study sites have been selected in forest–tundra ecotones in the Khibiny Mountains (altitudinal gradient) and in the surroundings of Lake Kanentiavr (latitudinal gradient). Soil samples were taken from all soil horizons in the predominant compartments identified by detailed mapping of vegetation cover (1:20, 1:100). Soil macrofauna was collected by hand-sorting of soil samples (25x25 cm).

We have found clear differences in the effects of tree and shrub species (Norway spruce, white birch, juniper, willows, dwarf birch, dwarf shrubs, mosses, lichens, herbs on soil fertility in forest-tundra ecotones. Soils below the crowns of spruce and birch were richer with nutrients. Content of total N, C and bio-available Ca, Mn in the organic horizons below the tree crowns was as much as three times higher compared to lichen compartments, and as much as 1.5 times higher compared to moss and dwarf-shrub tundra compartments. Spruce demonstrated the strongest effects. Higher levels of bio-available P and Zn have been found in the organic horizons of white birch compartments. Illuvial horizons were also characterized by higher concentrations of nutrients below tree crowns compared to between the crowns where lichen, moss and dwarf-shrub compartments dominate. We attribute these differences to the effects of plant residue quality, tree and shrub age, size of tree crowns (density, length), and stem and crown water.

Soil macrofauna, in particular earthworms, is an important group for soil formation. Advance of forest, higher thickness of snow cover and higher soil temperature could promote the expansion of earthworms in forest–tundra ecotones. The activity of the frost and soil acidity resistant *Dendrobaena octaedra* may promote further advance of forest vegetation and others species of earthworms to tundra by creating favorable conditions in the soil. In forest and forest-tundra sites *D. octaedra* is often suppressed by the wide-spread epigeic *Lumbricus rubellis*. Immigration of *L. rubellis* will increase the rate of litter decomposition. On the next stages of succession the expansion of *Aporrectodea caliginosa* could be expected.

In summary, advance of trees, shrubs and soil macrofauna will result in increase of bio-available nutrients in soil of lichen- and moss-dominated tundra and forest-tundra. This would promote further colonization by trees and shrubs and carbon sequestration in the growing biomass and carbon accumulation in the soil.

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Mapping of Above-Ground Phytomass of Lichen Tundra Using Remote Sensing Methods

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Estimation of supply and structure of Above-Ground phytomass is one of the challenges in addressing to monitoring climate-induced changes. Nowadays the Remote Sensing Data allows to define the spatial structure of vegetation, natural and anthropogenic factors that affect to the supply of phytomass and allows to reduce the field work. The goal of this research work is to determine the possibility of using very high resolution (1 m and better) satellite images for mapping the supply of Above- Ground phytomass of plants in Forest-Tundra Ecotone of Kola Peninsula. The future goal is to use this method for a larger areas. The research work focused on three sites in the central* and northern parts** of the Kola Peninsula (*Tuliok river region, *Cirque Idealnii, **Kanentiavr lake region). Optical properties of tundra landscapes in Kola Peninsula are mostly indicated by the reflectance characteristic of mosses, lichens, shrubs, bushes and trees. Two year field works included collection over 50 (in 2009) and 22 (in 2010) vegetation samples, that were measured with a Skye Instruments 4-channel radiometer and geobotanically described. All vegetation samples were separated into three variants of fractions and types: green parts of plants, not green parts of plants and lichens. After this determining the samples were dried at 105°C, and weighed. The goal of this part of research work was to determine the correlation between above ground phytomass value and the two correlation parameters: NDVI and Average spectral reflectance value in the visible spectrum. The results show, that we can define the values of above ground phytomass only for lichens by using the values of spectral reflectance, all other fractions do not have any correlation with two selected parameters. Based on results by using Erdas Imagine and ArcGIS programs the maps of above-ground phytomass on the key sites were compiled from QuickBird image. The next step of research project is to indicate the possible reasons why the other vegetation samples did not have any correlation with our chosen parameters. Therefore discover the new parameters, which will allow to mapping the supply of Above-Ground phytomass for the whole vegetation types in Forest-Tundra Ecotone. This research work is a part of PPS Arctic- the IPY project which investigates current status and last changes in the circus-arctic tree line zone. This study is financially supported by the Benefits Russo-Norwegian project of the Norwegian Research Council (OST 185023/S50).

Creating and sustaining culturally-relevant science education initiatives in Old Crow, Yukon, Canada: Perspectives from northern researchers, residents and educators

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Fostered and funded by the 2007-2008 IPY, education and outreach continues to be important to northern researchers and communities, but often for very different reasons. Our research explores key stakeholders perspectives on the benefits and challenges of conducting scientific educational outreach, as well as their motivations for helping in the coordination of such initiatives. Two Canadian IPY projects focused on community outreach in Old Crow, in the north Yukon: 'PPS Arctic Canada' studied the impacts of a changing climate on the treeline, and 'Environmental Change and Traditional Use in the Old Crow Flats' studied environmental change in the Vuntut Gwitchin First Nation's traditional territory.

Sixty qualitative interviews were conducted with IPY researchers, northern residents, and educators in order to explore lessons learnt through their educational outreach partnerships. We identified several values and program features that these stakeholders reported as supportive to developing and maintaining a culturally-relevant and academically-rigorous educational outreach initiative, including the fostering of a people-focused, capacity-developing program that is led by a community-level vision with the goal of meeting community-level needs, and which develops culturally educational material that integrate traditional and scientific knowledge, skills and attitudes.

Trees unlike no other? Age structure and tree form across the circumpolar forest-tundra ecotone

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The transition from boreal forest to tundra, or the 'forest-tundra ecotone', is often cited as being extremely sensitive to climate change. Despite this apparent role as an early responding region, ecologists still know very little about how trees at this ecotone are reacting to current changes in climate. Single location studies fail to address the underlying mechanisms and thresholds driving the variability that is observed across broad spatial scales. Results of age structure and individual trait-based data for six species (*Abies balsamea*, *Betula pubescens* ssp. *tortuosa*, *Larix laricina*, *Picea glauca*, *Picea mariana*, *Pinus sylvestris*) across eleven forest-tundra ecotone sites in the United States, Canada, Norway, Sweden and Russia, provide compelling evidence of an asynchronous response to recent climate warming. Using a combination of mixed models and descriptive statistics, we compared this variability within and between the eleven sites to investigate factors contributing to and detracting from a synchronous response of trees in the forest-tundra ecotone to climate warming. The oldest trees sampled were located in Alaska (572 yrs), Churchill, Manitoba (430 yrs) and Labrador (360 yrs) with often The oldest individuals were found in the forest or the lower forest-tundra ecotone, not the upper forest-tundra ecotone. Traditional allometric relationships like height:diameter and age:diameter are not appropriate metrics for use at the forest-tundra ecotone, perhaps because as trees approach their species range limit, growth becomes increasingly more subject to local climate and less dependent on conventional age driven relationships. Moving across the gradient from the forest to tundra, growth form of trees is more influenced by local climatic (e.g., temperature, wind, snow) with the response potential being strongly influences by reproductive life history traits. Climate and age alone are not enough to explain the variability across the forest-tundra ecotone at broad spatial scales. Instead, more attention needs to be given to the interaction between age and climate, and to specific life history traits.

Mount Nansen, Yukon – A Window into Eastern Beringia and Past, Present and Future Biotic Changes Across Subarctic North America

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The Mount Nansen – Klaza River headwater region (62o 06' 22.3" N, 137o 18' 10.1" W) of the Western Yukon Plateau is near the southeastern tip of Eastern Beringia on landscape that was affected by a single glacial advance, approximately 2.7 Ma (Neogene). To the northwest are never-glaciated taiga and tundra ecosystems, and to the southeast are narrow and readily distinguished Reid and McConnell zones of glaciated landscape produced during Late Quaternary. IPY 2007-2008 research findings, based on dendrochronological, pedological, taxonomical, temperature and population DNA investigations, although preliminary nevertheless begin to shed light on the roles Beringia refugia could have had in post-glacial revegetation/reforestation, also on the region's reactions to contemporary climate change. Some examples: Establishment of tundra ground vegetation on barren fragments of weathered rock clearly is a preliminary to upward movement of subalpine timberline. Uneven-aged climax subalpine populations of white spruce (*Picea glauca* (Moench) Voss), ranging from seedlings to specimens > 200 years old, occur on west, south and east aspects. White spruce seedlings have recently established abundantly at altitudes above the white spruce timberline (~1300 m a.s.l.); however, annual ring counts on trees > 2 m height indicated that timberline has been increasing in altitude over at least the last 400 years. Isolated white spruce of tree form and exceeding 100 years of age occurs at altitudes > 1500 m a.s.l.; spreading ground mat phenotypes occur to 1675 m a.s.l. Radial growth rates in white spruce increased only slightly in recent decades compared to those of the last four centuries, and annual ring radial widths produced during cold dry growing seasons were, unexpectedly, found to be equal or greater than those of warmer higher precipitation years. Thus, dendroclimatological inferences are suspect for this region. Black sp ruce (*Picea mariana* Mill. BSP) clones co-occur with white spruce populations in the vicinity of Mount Nansen, clones of larger areal extent being nearer timberline. Black spruce populations in glaciated regions to the east were found to be non-clonal. Chloroplast DNA analysis indicated that black spruce of never-glaciated Beringia is more closely related to populations in northern Alberta than to nearby Reid and McConnell populations, perhaps explainable in terms of refugia in the southern Mackenzie Mountains. Shrubs of *Betula* and *Salix* spp. occur at altitudes well above the spruce timberline. Poplars (*Populus tremuloides* Michx. and *P. balsamifera* L.) invaded the Mount Nansen region only in the last decade, but treesized specimens now occur in tundra above timberline. *Alnus* spp. are absent. Shallow mineral exploration trenches made into tundra permafrost to bedrock > 60 years ago presently display patchy soil formation and surfaces less than 50% re-vegetated despite a plethora of surrounding tundra plant species. Surface permafrost was ubiquitous in the region throughout the 1900's, but today permafrost is > 30 cm below ground level and, in places, is non-existent. This research was undertaken in conjunction with PPS Arctic Canada supported by IPY Canada.

Methodology of Socially-oriented observations engaging community perceptions as an instrument for decision-making: case of the northern European Russia

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The methodology of Socially-oriented Observations (SOO) enables to translate results of observations and research of environmental changes into solutions of quality of life (QL) issues and human capital (HC) development. SOO methodology emerged from the experience gained during Arctic Climate Impact Assessment followed by circumpolar discussions devoted to integrated Sustained Arctic Observation Network elaboration. Due to this experience and SOO methodology developed and tested within IPY PPS ARCTIC cluster project in key observation sites of the Russian Arctic, it is revealed that climate change and other environmental issues are better recognized and perceived by both local people and policy makers when they are addressed by the researches in the context of people's quality of life (QL) challenges that arctic residents and governments recognize. According to strategic approach of SOO in order to achieve the main target - the QL improvement and HC development, it is necessary to adapt and implement the development strategies for sound solution of appearing issues of QL and set strategic goals for QL enhancement in interrelated spheres – social, economic, nature-environmental, legal-management as well as the spiritual-cultural. With the help of the strategic approach introduced to SOO observation protocol, based on people's perceptions and statistics, specially recognized main issues and solutions as well as key indicators to observe trends have been identified. First results of SOO, carried out in key sites of observation network including sites situated in diverse biomes (from tundra to southern taiga zone) and various administrative region of the northern European Russia are demonstrated. In many cases they show that environmental changes evident for scientists, such as forested area or treeline changes due to climate change or human impact are not ranked high as limits or opportunities for people QL improvement. This is partly a result of insufficient environmental education and awareness among the local people and their greater concern with the low level of material well-being and unemployment. SOO based on strategic approach, including multidisciplinary scientific research, interviewing and local stakeholders observations, as well as statistics, will help to raise people's awareness of many coupled human-nature issues and opportunities of QL improvement and in such a way will enable to use scientific information and traditional knowledge in decision-making, education and overall HC development.

Growth, reproduction, and establishment of *Picea glauca* across the forest-tundra in the Mackenzie Delta region, Canada

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Climate is considered one of the most important factors controlling treeline ecotone dynamics. As climate change continues the northern location of forest and trees is expected to shift northwards. Central to this prediction is an increase in the growth, establishment, and reproductive capacity of trees throughout the forest-tundra zone. The main objective of this research was to characterize and determine how climate influences the ecological patterns and processes of *Picea glauca* (Moench.) Voss. (white spruce) in the Mackenzie Delta region of the Northwest Territories, Canada. White spruce tree growth, establishment, and reproduction were assessed using the latitudinal gradient as a proxy for an approximate 3ºC increase in temperature and remeasured sites that were studied in the early 1990s.

A total of four forest stand sites and eight tree island sites (clonal populations beyond present treeline), examined in the early 1990s, were located and re-examined in the summer of 2009. Cone production has increased since the early 1990s and cone production decreases northward across the forest-tundra. Germination rates significantly decrease with increasing latitude but have not significantly changed since they were last examined 15 years ago.

In June 1994 seedlings were transplanted at three tree island sites, survivorship of these seedlings ranged from 3 to 20%. No true seedlings were found at the tree island sites in any year. Basal cores were obtained from numerous individuals within each of the sites and an age structure was developed. Establishment of individuals coincided with decades classified as cool and wet.

The yearly diameter growth of trees representing the forest and tree island environment was determined via ring width measurements and two chronologies were built, one for forest stands and one for tree islands. The chronologies were correlated to climate data of temperature and precipitation from the Inuvik airport. The climate-growth responses indicate that temperature is the primary factor controlling growth throughout the forest-tundra ecotone.

We believe that our findings are relevant to the understanding of vegetation change throughout the forest tundra zone in response to climate change. Under warmer and drier conditions, the growth and reproductive capacity of individuals will likely increase, promoting an increase in establishment from seed. However, tree islands are not likely to be important in supplying viable seed for the infilling of trees in the forest tundra, rather infilling will more likely occur from increased seed production in trees at or just south of treeline.

ANALYSIS OF SUBALPINE *PICEA GLAUCA* DIAMETER GROWTH IN YUKON

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Our objective was to compare radial growth rates in subalpine *Picea glauca* (Moench) Voss trees of the Western Yukon Plateau in relation to their varied altitudes, ranging from 1311-1470 m a.s.l., in order to develop a dendroclimatological approach for deducing past climate change. The nine investigated trees grew in proximity to one another on the same southwest-facing gentle slope near Mount Nansen, Yukon, and ranged in position from below to above timberline. Assuming that temperature and precipitation were not variables for the site, we investigated the null hypothesis that within- and between-tree comparisons of radial series of annual ring widths should generate Pearson product-moment correlation coefficients (PMCC) near 1 for similar timberline position. Using WinDendro, calendar year ring widths were sequentially measured across the four cardinal direction radii of disks taken from each trunk at 1 m intervals. PMCCs of those radial series were calculated at the 95% probability level based on within-disk, within-tree, and between-tree radial series correlations. Tree age and height both declined with increasing altitude. Within-disk and within-tree PMCC values spanned a broad range, and within-tree values showed a general tendency to decline towards the tree top. Between-tree PMCCs for the same position within the forest – tundra ecotone were low, in some cases near zero. Between-tree PMCCs for different ecotone positions varied from -0.35 to 0.69. PMCCs for short chronologically matched time spans containing periods of increased radial growth were lower than PMCCs for entire radial series. The results invalidate the null hypothesis and indicate the existence of major uncertainty in climate reconstruction should only cores be extracted from trunks and analyzed. For this subalpine site, dendroclimatology would either oversimplify or otherwise misinterpret true physiological competence in relation to the numerous P = G x E interactions underlying growth and development of trees.