GENERAL RATIONALE FOR *PPS ARCTIC*

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The position and dynamics of the arctic-boreal boundary are major determinants for land atmosphere interactions at the circumpolar scale and for ecological and socioeconomic conditions at the local to regional scale (Beach 1997, Callaghan et al. 2002, Vlassova 2002, Hofgaard 2004, ACIA 2005). This zone, the 'tundra-taiga ecotone' varies dramatically in width (up to hundreds of kilometres) throughout the circum-arctic North and has thus a recognized exceptional importance, in terms of global vegetation, climate, biodiversity and human settlement. Further, the particular vulnerability of the zone to changes in climate and land use is recognized, along with concern for subsequent alterations and shifts of its position with consequences for the entire arctic region and the global climate through feedback mechanisms. Despite this recognition, comprehensive and large scale multidisciplinary scientific focus incorporating cause, effect, and importance of its past and present transformation to the biota and human societies, has been lacking.

The contrast in surface characteristics, including albedo (reflectance), across and along the arctic-boreal transition zone is probably the greatest found on land anywhere (Harding et al. 2002). This variation causes massive changes in energy fluxes and temperature conditions. The dynamics, including feedback mechanisms and sensitivity to environmental change of this boundary, is of crucial importance to the scientific and political community. Even small changes can be expected to cause profound alteration of the land-atmosphere interactions with radical consequences for large-scale climatic systems (Harding et al. 2002) and consequently to broad-scale conditions in the Arctic as a whole (ACIA 2005). Increased forest volume and density is normally considered to reduce the radiative forcing because of the sequestration of atmospheric CO_2. However, changes in forest cover will also change the reflective properties of the surface (albedo), especially in areas which are snow covered part of the year[1]. This may offset the benefits of negative radiative forcing from carbon sequestration (Betts, 2000). Nevertheless, a comprehensive framework for climate assessment of land-cover transitions is not included in the Kyoto Protocol and in policy strategies due to limited data and lack of accounting frameworks. Furthermore, the understanding of the location, dynamics and environmental drivers (natural and human factors) at regional and circumpolar level is poor. To be able to predict the effect of future climate changes and feedbacks from the system profound knowledge on how the position is changing in response to a range of abiotic and biotic forces (e.g. climate, edaphic conditions, herbivory), together with refined techniques for detection of spatial displacement of the boundary over large spatial scales is needed. A rewarding way to gain this knowledge is to analyse and use past and present changes of the boundary in regions with contrasting major environmental drivers that occur within fairly short distances and that can have major effects on global climate. Northern Norway, Northwest Russia, and Northeast and Northwest Canada are ideal areas in this respect.

High latitudinal ecosystems are adapted to cold conditions, and face many natural stresses. However, they may be particular vulnerable to changes in the environment due to slow ecosystem processes in cold environments, including highly variable (in space and time) regeneration and recruitment capacity, and long recovery times following imposed disturbances (Chapin & Körner 1995, Hofgaard 2004). Further, future changes of climate-related factors are predicted to outrange until present experienced changes in both intensity and variability (IPCC 2001). This could result in unprecedented changes of established systems at scales from species to biomes (Scheffer et al. 2001). These changes will be most apparent and significant in ecotonal areas, i.e. transition zones between for example different

[1] Any dominance shift between present tree species and/or a range shift would strongly influence land cover albedo, energy exchange between the biosphere and the atmosphere, and fluxes of emissions to the atmosphere.

biomes. The transition zone between the two major biomes the treeless tundra and boreal forest is such a boundary, which has been predicted to be particularly sensitive to changes in the climate and human activities (Houghton et al 1996, ACIA 2005). This ecotone is especially abrupt due to the relatively distinct and apparent change in life-form from dominating upright growth to procumbent growth (Sveinbjörnsson et al. 2002). This abrupt transition creates dramatic contrasts in surface characteristics and can thus at the large scale be analysed and monitored by the use of satellite images. However, up to present these studies have generally produced fairly coarse pictures that do not capture the actual boundary position or its structure, partly due to lack of reliable transfer functions based on detailed ground data (Rees et al. 2002). Additionally, model predictions of changes in the location of the boundary contrast recently observed changes (Callaghan et al 2002). Because the position of various components of the boundary (e.g. position of forest line, treeline, species line) are used as measures of effects of environmental change (e.g. climate, pollution, land use) there is a need for both detailed ground data and refined models (e.g. for analyses of satellite images) in order to monitor structural changes of the ecotone over larger areas (regional to circumpolar), and to predict the effect of changed land cover on radiative forcing and feedbacks to the climate system. Conclusively, as much of the forest-tundra boundary is remote with low accessibility, remote sensing from space-borne platforms will have a significant role in determination and monitoring of future changes. Therefore a comprehensive and large scale study of its present position, its relation to historic positions using older remote sensing data, regeneration and growth conditions, in regions dominated by continental and oceanic climates, respectively, is needed. In this way can reliable scenarios for future development of the transition zone and consequences for land-atmosphere interactions and its effect on global climate be constructed, information that with confidence can be used by policy makers/stakeholders at national and international level.

Herewith we propose a comprehensive cross-disciplinary based study using ecological process studies and remote sensing, to approximate effects of environmental pressures on the transition zone, and conclude on feedbacks to the global climate. The main study regions are northern Norway and north-western Russia, and north-eastern and north-western Canada. The Canadian study regions are not part of this proposal but are used as reference regions and will be studied in detail by collaborators in the here presented project, using the same protocol, within the frames of *PPS Arctic Canada* which is the Canadian contribution to the *PPS Arctic* core project.