NATURAL AND SOCIAL SCIENCE RESEARCH COOPERATION IN NORTHERN RUSSIA AND NORWAY FOR MUTUAL BENEFITS ACROSS NATIONAL AND SCIENTIFIC BORDERS

Applying institutions and principal contacts:
Norwegian Institute for Nature Research (NINA): Annika Hofgaard
Moscow State University (MSU): Faculty of Geography Olga Tutubalina
Russian Academy of Science (RAS):
Institute of the Industrial Ecology of the North, Kola Science Centre, Ludmila Isaeva
Oleg Shumilov
Centre for Problems of Forest Ecology and Productivity, Natalia Lukina
Institute of Geography, Tatiana Vlasova

The here proposed cooperation project will be linked to the newly started International Polar Year (IPY) research project *PPS Arctic Norway* (RCN 176065/S30, 2007-2010, Attachment 1) which is the Norwegian contribution to the core project *PPS Arctic* (*P*resent day processes, *P*ast changes, and *S*patiotemporal variability of biotic, abiotic and socio-environmental conditions and resource components along and across the *Arctic* delimitation zone; see www.polararet.no, www.ipy.org project #151) coordinated by Dr. A. Hofgaard, NINA, and Dr. G. Rees, Scott Polar Research Institute, Univ. of Cambridge, UK. *PPS Arctic* is a multidisciplinary research cluster focusing on circumpolar northern regions and sub-arctic environments, and the transition zone to the Arctic. These regions and the zone are internationally recognised due to its exceptional importance in terms of climate feedbacks, global vegetation, and settlements by indigenous people. Large scale changes in the structure and location of this zone (as predicted) will affect the total northern environment with its people, landscapes and sustainability of resource use. *PPS Arctic Norway* includes Russian field sites but funds from the Research Council of Norway do not cover fieldwork or salary expenses for Russian colleagues. Accordingly, funding requests for the here proposed bilateral research cooperation, within its international frame, emphasise needs for Russian partners. Brief background to activities making up the scientific foundation in the proposed research cooperation is given below along with rational for network funding. The short name of the here proposed project, BENEFITS, is henceforward used.

RELEVANCE TO CALL

This project entails two prioritized thematic areas of the call: "*Cooperation projects that will strengthen cooperation and contact between Russia and Norway*" and "*Subject areas from the humanities, social sciences and other fields aimed at increased knowledge of socio-economic, political and living conditions specific for the High North, including public health. The gender perspective and strengthening of the civil society are important dimensions*". The project includes the following eligible activities: *Research cooperation; Exchange of scientists; Establishment of networks within higher education and research;* and *Seminars, workshops, and conferences with Norwegian and Russian partners.*

OVERALL AIM

Develop long-lasting scientific and educational collaboration network between Norwegian and Russian institutions with focus on development in northern regions through combined natural- and social science approaches.

PROJECT THEMES

The overall aim will be reached through emphasis on three focal research themes, based on ongoing nationally funded research projects. These scientific components making up BENEFITS jointly seeks to generate comprehensive information on, and tools for characterizing and monitoring of ***i)*** environmental status and spatiotemporal changes of northern forest-tundra ecosystem; ***ii)*** distribution

and change of human land use and underlying environmental and social drivers; and ***iii)*** subsequent consequences to human societies and the environment.

,

Theme I	Characterisation of and monitoring tool development for the transition from forest covered regions to tundra
Theme II	Vegetation dynamics and growth responses to environmental changes and stressors
Theme III	Construction of a Northern Socially oriented Observation System Network

PROJECT STRUCTURE

BENEFITS is organized into four work packages (WPs) integrating the three thematic areas (Figure 1):

WP I	Exchange of visiting scientists and graduate students
WP II	Joint workshops held in Russia and Norway
WP III	Joint fieldwork activities in Russia
WP IV	Communication and dissemination of progress and results

This organization will ensure scientifically and nationally mutual and integrated research cooperation to be formed, based on sound ecological, remote sensing and socio-economical experience.

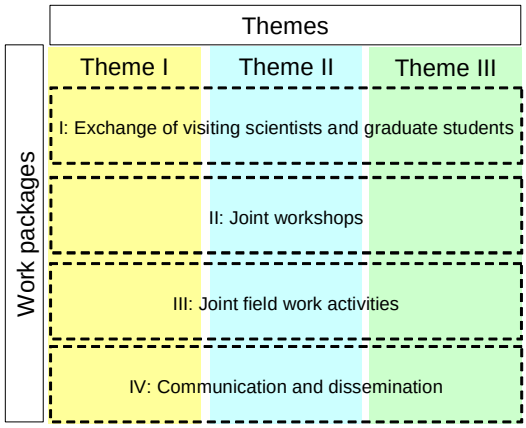

Figure 1. Project structure

SCIENTIFIC AND GENERAL RATIONALE FOR THEMES INTEGRATED IN *BENEFITS*

Background

The interface between the boreal forest and the arctic tundra, with its location and changes, is a major determinant 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

[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.

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 short distances and that can have major effects on global climate. Northern Norway and North-western Russia 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 biomes. The transition zone between 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 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 location of various components of the boundary (e.g. location 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 present location, relation to historic locations 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.

Methods and activities within the three Themes

Theme I and II: Details for Theme I and II are given in Attachment 1 as these are identical to the basis in the RCN funded project *PPS Arctic Norway* (cf. above).

Theme III: Theme III "Construction of a Northern Socially oriented Observation System Network" aims at increased knowledge and observation of changes in living conditions, socio-economic, health and political situation specific for the Northern regions of Russia. The project is collaborating with the IPY core project CAVIAR through Dr. Natalia Fedorova (cf. www.ipy.org #157). Two interrelated activities of the Theme III network are: 1) establishment of representative sites in Kola Peninsula (Murmansk District); and 2) development of protocols harmonised with CAVIAR and PPS Arctic. The studies and results will be validated through analogous studies in Arkhangelsk, Komy Republic, and Yamalo-Nenetsk AO. Selected sites represent different sub-arctic regions of Western Russia with diverse socio-ecological situations and specific problems of sustainable development.

Network site measurements will be constructed to serve as instruments for socio-economic and environmental monitoring, integrating local/traditional knowledge, science and policy and allowing to integrate not only circumpolar scientists from different disciplines, decision-makers but local/indigenous peoples interested to share their experience and compare best results in achieving sustainability in communities and local settlements. The main objectives are human capacity development for better quality of life. To achieve this, a comprehensive educational program is envisioned being necessary to provide active participation of all groups of northern residents including indigenous communities, women and young scientists in socially oriented monitoring.

A principle component for facilitating high quality data collection and implementing the project is organization of workshops (WP II), involving broad participation of Arctic residents (local administrations, business, indigenous people's communities, women organizations, school teachers and pupils, etc). During workshops main limits to better quality of life will be identified, along with key indicators to monitor. Data gathering includes social surveys, structured and unstructured interviewing, official statistics, and results from analysis of water, soils, and air quality. This will be done during joint field activities (WP III). Further, phenological surveys will be organized at representative sites in the Kola Peninsula; i.e. phenological list of questions will be discussed with local people and disseminated through school teachers, pupils and other residents interested in carrying out phenological observations. These social and natural science methods, combined with local/traditional knowledge, will enable identification of important human dimension indicators, necessary to the success of a social observation and monitoring network.

WORK PACKAGES

WP I Exchange of visiting scientists and graduate students

Exchange of knowledge is fundamental to scientific development and validation. Promotion and encouragement for exchange of scientist, postdocs and graduate students is therefore essential at individual-, institute-, national- and thematic levels.

Objectives: To accomplish exchange of scientific personnel between Russian and Norwegian institutions within BENEFITS.

Task 1: to organize stay at partner institutions within the network

Task 2: to facilitate participation in fieldwork activities run by other partners (cf. WP III)

Task 3: to carry out exchange between scientific themes

Organization of the work: The work will be coordinated and directed by **Tutubalina** in close cooperation with all PIs within BENEFITS.

WP II Joint workshops held in Russia and Norway

Workshops are main meeting points for scientists across institutional, national or thematic boundaries and are, consequently, a powerful tool for collaboration network development and to introduce young scientists, graduate students and students into a collaborative scientific environment. All of high value for development of a contemporary scientific environment facilitating societal benefits.

Objectives: To mediate scientifically based general and region-specific knowledge; to develop joint understanding of methods, analyses, and data interpretation; and to develop a common platform for collaboration into the future.

Task 1: Two topic specific workshops will be organized (Apatiti spring 2008 & Tromsø winter 2008-2009) where group members representing all three themes are working in both theme specific sessions and in joint sessions. The first workshop has focus on the upcoming field season and implementation of common measurement protocols. One session, connected to Theme III, will include participation by representatives for arctic residents and stakeholders (e.g. local administration, non-government, indigenous peoples, women organizations) from Kola Peninsula sites. The second workshop focuses on results from joint field activities and need for improvements/adjustments.

Task 2: A cross disciplinary workshop will be held in Apatiti in autumn 2009 with emphasis on *i)* results and young scientist/graduate student products and development; and *ii)* improvement

and encouragement for young scientist recruitment within BENEFITS and the geographic region.

Task 3: A final project conference will be held in 2010 in cooperation with the international *PPS Arctic* network (possibly in Murmansk). External scientists, community leaders and other stakeholders will be welcome.

Organization of the work: The work will be guided and coordinated by **Hofgaard** but with organizing responsibilities provided by **Isaeva** and **Vlasova** (Task 1, Apatiti), **Tømmervik** (Task 1 Tromsø), **Lukina** (Task 2) and **Tutubalina** (Task 3).

WP III Joint fieldwork activities in Russia

Field work is the basis for all activities within the scientific fields of the project, but activities have rarely been coordinated between the three fields or between countries.

Objectives:

To run joint field activities at Kola Peninsula site during the summer 2008 and 2009 with the aim to bring natural and social scientists together for mutual benefits, mediated through work based on common protocols agreed on during the preceding workshop (cf. WP II Task 1)

Task 1: The primary task is to through the use of common sites exchange experiences regarding prerequisites for fieldwork: e.g. authorization, accessibility, allowance, student involvement, and costs.

Task 2: Examine the usefulness of using common field sites across scientific themes

Task 3: To use the different scientific traditions within BENEFITS during the common field work junctures to develop a broader basis for a common understanding of field work related problems.

Task 4: To use experiences from task 1, 2 and 3 in the planning of future research efforts and educational programs.

Organization of the work: The work will be guided and coordinated by **Lukina, Isaeva** and **Vlasova**

WP IV Communication and dissemination of progress and results

BENEFITS, with its scientific results, has both scientific and human-environmental importance, and is hence expected to generate political and public interest at a local, national, and international level. The results will be of significant interest to i) the international scientific community within ecology of northern regions, remote sensing and socio-economy, ii) the general public awareness of effects of climate change and consequences to nature and quality of life; and iii) public agencies dealing with reporting on international climate conventions and monitoring of consequences of climate change on ecosystems, human societies and feedback to climate systems

Objectives: To communicate the results of the research within BENEFITS to the international scientific community, the general public and authorities.

Task 1: A web site will be developed, with up-dated project information on scientific background, organisation, study regions, status for ongoing activities, results, data availability, contacts, and personnel. The web-site will be linked to, and part of, the *PPS Arctic* web site hosted by NINA (under development).

Task 2: Data management will follow the IPY Data Policy (cf. www.ipy.org). The following procedures and principles will be implemented. *Metadata*: All projects will register descriptive information characterizing measurements and sites in a data base developed for *PPS Arctic* at the NINA Database, Trondheim, Norway. The metadata base and updates will be announced at the web site. *Primary data and processed data:* Individual projects will be responsible for their own data storage, security routines, data validation, and quality control. The data collected within individual projects will be made available after quality control, full documentation, and publication, at the same web site as the metadata.

Task 3: Each year, the results of the work will be presented and discussed at international conferences.

Task 4: Major dissemination will be scientific publications covering all themes of BENEFITS. Thus, strongly contribute to the integration of the scientific fields which is desired for future

predictions of environmental effects and feedback mechanisms at regional to global scales. The papers will be published in journals of the highest possible reputation. We expect that BENEFITS will generate additional publications after the project period because of the developed network.

Organization of the work: The responsibility for the work relies on **All** PIs, postdocs and graduate students, but **Hofgaard** supported by **Tutubalia, Lukina, Isaeva** and **Vlasova** will have major over all responsibility. Further **Zimin** and **Hofgaard** have key responsibility for Task 1.

PROJECT MANAGEMENT STRUCTURE AND COMPETENCE OF PROJECT MEMBERS

Project coordination: BENEFITS will be administrated through NINA and led by Senior Scientist **A. Hofgaard** in close co-operation with all PIs in the project. In addition, the research team will be associated to the *PPS Arctic* which provides BENEFITS with an extensive international and interdisciplinary research network. The association with *PPS Arctic* activities at the circumpolar level is coordinated by **A. Hofgaard** and **G. Rees**. Further, BENEFITS will have three Section Coordinators: Natural science, ecology **N. Lukina**; Natural science, remote sensing **O. Tutubalina**; and Social science **T. Vlasova**. The Project coordinator and Section coordinators have, in addition to research related responsibilities, main responsibility for workshop planning, development and realization; and for promoting and organizing exchange of scientists, but see details under Work packages above.

Competence of Principal Investigators: (in alphabetic order; CVs and confirmation letters are provided as attachments): **Prof. Elena Golubeva** (MSU) is a biogeographer with specialized in diagnostics of ecosystem state using bio-indicators. **Senior Scientist Annika Hofgaard** (NINA) is a vegetation ecologist with special expertise in structural changes and population dynamics in northern forests and the forest-tundra zone with focus on climate effects and land use. She is also the lead international coordinator of *PPS Arctic*. **Senior Researcher Ludmila Isaeva** (RAS) is an applied forest ecologist with expertise on disturbances and forest system health. **Senior Researcher Elena Kasatkina** (RAS) is an atmospheric physicist with interests in natural and man-made factors affecting past, present and future climate. **Senior Researcher Natalia Lukina** (RAS) is a vegetation ecologist specialized in environmental impacts on status of northern forest communities. **Senior Lecturer Gareth Rees** (Scott Polar Res. Inst., Univ. of Cambridge) is a physicist & remote sensing scientist with expertise on techniques for detection of environmental impacts on forest & tundra vegetation. He is also the co-coordinator of *PPS Arctic*, a partner in *PPS Arctic Norway* and collaborator at MSU. **Head of Lab, INEP, Oleg Shumilov**, (RAS) geo-physicist with special expertise in climatology and dendrochronology. **Senior Scientist Hans Tømmervik** (NINA) is a vegetation ecologist with expertise on remote sensing methods in mapping and monitoring of boreal and arctic-alpine vegetation with focus on impact variables such as pollution, logging and herbivores. **Dr. Olga Tutubalina** (MSU) is a remote sensing ecologist with special expertise in environmental conditions in northern systems. **Dr. Tatiana Vlasova** (RAS) is a socio-economic and political geographer with special expertise on northern communities at national and international levels.

RECRUITMENT AND POST GRADUATE TRAINING

3 postdocs, 5 PhD students, and 8 master level students are working on projects making up the BENEFITS research network. In addition, a number of undergraduate students (not presented) will be linked to different components of BENEFITS.

Postdocs: **Dr Anna Govorova** (MSU) is a biogeographer specialized in geo-biophysical response of plants to industrial and natural stress, using floristic-, morphological- and pigment analysis, with focus on Kola Peninsula. **Dr. Alexandr Kanatjev** (RAS) is a dendroecologist specialized in tundra-boreal forest ecotones and timber line changes. **Dr. Mikhail Zimin** (NINA 2008-2009) is a remote sensing ecologist specialized in environmental and human caused spatiotemporal changes in northern forested systems.

Graduate and undergraduate students (supervisor within BENEFITS is given in *italic*): **Elena Khorokhorina** is a PhD student at MSU (*Tutubalina*) who specializes in pollution in ecosystems, using south Kola Peninsula as example. **Valentina Kostina** is a PhD student at RAS *(Isaeva)* who

specializes in vegetation structure and composition across the tundra-taiga zone. **Ingrid E. Mathisen** is a PhD student at NINA (*Hofgaard*) who specializes in forest dynamics and regeneration capacity in the forest-tundra zone; Northern Norway and Kola. **Andrey Medvedev** is a PhD student at RAS (*Vlasova*) who specializes in geo-information from socially-oriented observations in Northern regions and multimedia presentations. **Ekaterina Shipigina** is a PhD student at MSU (*Golubeva*) specializing in remote sensing of ecosystem response to industrial impact in forest and tundra ecosystems in the North European Russia, including Kola, Komi republic, and Archangelsk Autonomous region. **Peter Glasov** is a young researcher at RAS (*Vlasova*) working on socio-environmental conditions and phenology in northern regions, and on development of methodology for socially-oriented observations; focus on Nenetsk AO and Kostromskaya Oblast. **Anna Mikheeva** is a diploma student at MSU (*Tutubalina*) specializing in recent vegetation dynamics at forest-tundra ecotone, Khibiny Mountains, Kola. **Sigrun Aune** is a MSc student at NINA (*Hofgaard*) specializing in recent birch treeline development and recruitment in tundra environments; northern Norway and Kola. **Staffan Dovärn** is a MSc student at NINA (*Hofgaard*) specializing in conifer growth response to environmental change at the forest-tundra zone, northern Norway and Kola. **Marina Ivanova** is a MSc student MSU (*Tutubalina*) specializing in vegetation mapping using medium-resolution MODIS satellite imagery; Kola Peninsula. **Svetlana Nikolaeva** is a MSc student at RAS (*Lukina*) specializing in tree and shrub structure in the tundra-forest zone. **Valentin Rasputin** is a MSc student at RAS (*Shumilov*) specializing in dendrochronology and its usefulness in ecotonal studies. **Sergey Zharenov** is a student at MSU (*Tutubalina*) specializing in sustainable forest management.

ENVIRONMENT, ETHICS, GENDER EQUALITY

Environment and ethics: The principal objectives and the methods used in the projects within BENEFITS will have no environmental impacts and will be carried out in accordance with Norwegian and Russian laws. We conclude that out activities will not cause ethical problems.

Gender equality: The project has a female dominance at PI level, but has a better gender equality at graduate and post graduate level, which we believe promote student development into resource talented, broad minded, and insightful high quality scientists well equipped for diversified challenges in future scientific, environmental and political spheres.

TIME SCHEDULE AND BUDGET

Funding is requested for a three-year program i.e. January 2008 – December 2010, including costs for: ***i)*** fieldwork in Russia (support); ***ii)*** data analyses (support); ***iii)*** exchange of PIs, postdocs and graduate students; ***iv)*** annual project workshops; and ***v)*** a final conference. The main fieldwork will be carried out in Norway in 2007 and is not included here, and in Russia in 2008 and 2009. Analyses of collected data will be carried out during all years. Publication of obtained results will take place in 2009-2010 and onwards (cf. WP IV), with the final report to NFR in 2010. Main activities, milestones, and budget information are provided in the grant application form.

COMMUNICATION, PUBLICATION AND INFORMATION STRATEGIES

Communication and dissemination is defined and organized as a separate WP (cf. WP IV above).

REFERENCES

ACIA 2005. Arctic Climate Impact Assessment. Cambridge University Press, 1042p.

Beach, H. 1997. Negotiating nature in Swedish Lapland: ecology and economics of Saami reindeer management. *In* Smith, E.A. & McCarter, J. (eds.) *Contested Arctic. Indigenous peoples, industrial states, and the circumpolar environment.* pp 122-149. Univ. of Washington Press, Seattle.

Betts, R.A. 2000. Offset of the potential carbon sink from boreal forestation by decreases in surface albedo. *Nature* 408: 187-190.

Callaghan, T.V., Werkman, B. & Crawford, R.M.M. (editors) 2002. The tundra-taiga interface and its dynamics. *Ambio Special Report* 12.

Chapin III, F.S. & Körner, Ch. (editors) 1995. *Arctic and alpine biodiversity. Pattern, causes and ecosystem consequences.* Ecological Studies 113. Springer Verlag.

Harding, R, Kuhry, P., Christensen, T., Sykes, M.T., Dankers, R. & van de Linden, S. 2002. Climate feedbacks at the tundra-taiga interface. *Ambio Special Report* 12: 47-55.

Hofgaard, A. 2004. Feedbacks between northern terrestrial ecosystems and climate. *Polar Research* 124:23-25.

Houghton, J. T., L. G. Meira Filho, B. A. Callander, N. Harris, A. Kattenberg & K. Maskell, (ed.), 1996. Climate Change 1995: The Science of Climate Change. Cambridge University Press, Cambridge.

IPCC 2001. Intergovernmental Panel on Climate Change. The Scientific Basis. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Rees, G., Brown, I., Mikkola, K., Virtanen, T. & Werkman, B. 2002. How can the arctic treeline be remotely monitored? *Ambio Special Report* 12: 56-62

Scheffer, M., Carpenter, S., Foley, J.A., Folke, C. & Walker, B. 2001. Catastrophic shifts in ecosystems. *Nature* 413: 591-596.

Sveinbjörnsson, B., Hofgaard, A. & Lloyd, A. 2002. Natural causes of the tundra-taiga boundary. *Ambio Special Report* 12: 23-29.

Vlassova, T.K. 2002. Human impacts on the Tundra-Taiga zone dynamics: The case of Russian Lesotundra. *Ambio Special Report* 12: 30-36.

ATTACHMENTS

1) *PPS Arctic Norway* project description
2) Curriculum Vitae (short) for all principal investigators
3) Letters of confirmation from Russian partners: institutes and principal investigations
4) Budget details