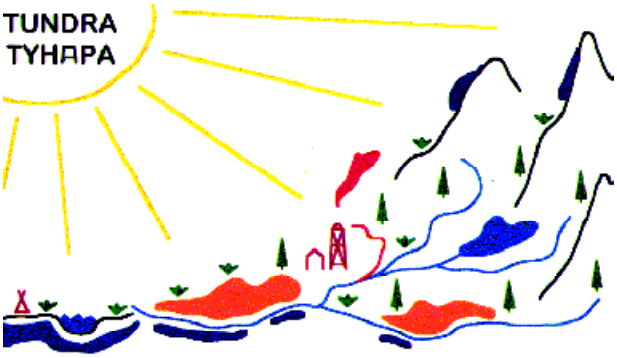
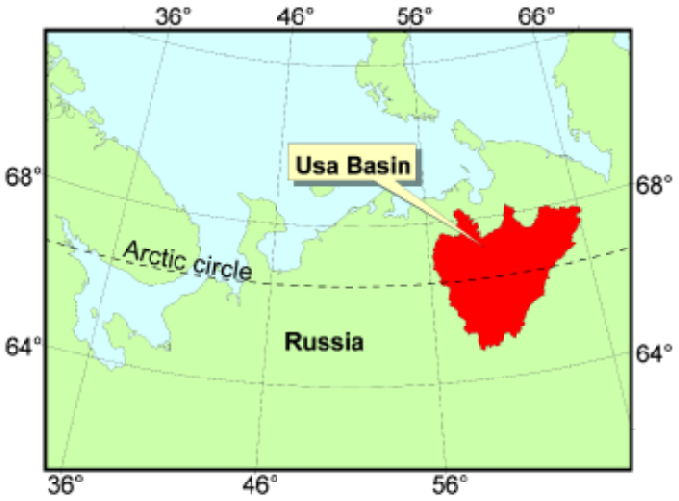
FULL TITLE OF THE PROJECT AND ITS ACRONYM

TUNDRA DEGRADATION IN THE RUSSIAN ARCTIC (TUNDRA)

PROJECT LOGO & MAP OF THE PROJECT TERRITORY





DATES OF IMPLEMENTATION OF PROJECT

1.1.1998-31.3.2001

FUNDING ORGANIZATION

4th Framework 'Environment and Climate' Programme of the European Commission,
Section Climatology and Natural Hazards
(Contract Nr. ENV4-CT97-0522)

PROJECT CO-ORDINATORS

Overall project co-ordinator:
Dr. Peter Kuhry (Arctic Centre, University of Lapland, Rovaniemi, Finland)
Russian co-ordinator:
Dr. Vasily Ponomarev (Institute of Biology, Komi Science Centre, Syktyvkar, Russia)

GOAL AND TASKS

TUNDRA investigated the effects of global change in the Usa Basin of the East-European Russian Arctic. The main focus of TUNDRA was to assess feedback processes to the global climate system that originate in the Arctic. Emphasis was given to changes in greenhouse gas emissions to the atmosphere and in freshwater runoff to the Arctic Ocean taking into account global warming, industrial pollution and the public perception of environmental degradation. TUNDRA was set up as an interdisciplinary project that involved climatologists, soil scientists, ecologists, palaeoecologists, hydrologists, pollution specialists and social anthropologists from Denmark, Finland, Russia, the Netherlands and the United Kingdom.

Global change will have considerable effects in tundra ecosystems, due to the magnitude of expected temperature increases, high levels of pollution (in some areas) and the fragility of the Arctic environment. One of the main objectives of the TUNDRA project was to understand the effects of climatic change on the Arctic environment. A prerequisite was to have good knowledge of the present climate and its natural variability. The following activities in the project addressed these issues: (a) Regional climate model: This model has a resolution of 16x16 km and adequately depicts topographic features in the Usa Basin, such as the Ural Mountains; (b) Past climate variability: This evaluation that covers periods of tens to thousands of years is based on the analyses of tree-rings, fossil pollen, and macroscopic plant remains.

In TUNDRA we paid special attention to global change processes in the Arctic that influence global climate, the so-called Arctic feedbacks to global warming. These included:

- Arctic treeline dynamics: The amount of carbon in plant material in treeless tundra is much lower than in taiga forests. A northward migration of the Arctic treeline due to warming of the climate replaces tundra vegetation with taiga forests increasing the total amount of carbon dioxide sequestered by plants.

Photo: Ye.Patova

- Soil and peat carbon dynamics: Tundra (and taiga) soils often accumulate thick layers of partly decomposed plant material in the form of litter and humus, due to low temperatures that prevent rapid decay. This process is even more accentuated under wet conditions such as those prevailing in mires, where peat deposits several meters thick accumulate. All this material in soils and mires represents an important sink for atmospheric carbon dioxide.
- Methane fluxes: The same mires are a major source of the greenhouse gas methane. Mires play a mixed role in greenhouse warming: peat acts as a carbon dioxide sink but it is also a methane source.
- Changes in freshwater runoff: Freshwater from Arctic rivers flowing into the Arctic Ocean affects ocean circulation patterns, which play a key role in the exchange of heat between tropical and polar regions. For the European Arctic it is particularly important to determine what will happen to the Atlantic Gulf Stream, which keeps climate in western Europe relatively mild. The Arctic
- Ocean is also an important sink for atmospheric carbon dioxide. Sediments, carbon, nutrients and pollutants carried by rivers into the Arctic Basin affect the uptake of carbon by the marine biota and environment.
- Albedo changes: Snow cover reflects much of the incoming radiation from the sun back into space, cooling the atmosphere. The taiga forest canopy, on the other hand, has a very low albedo. Any changes in the duration of snow cover and the type of vegetation cover will affect the global heat budget of the planet.

Also regional impacts of global change were evaluated:

Pollution in waters and on land: Pollutants were measured in lakes, rivers, snow, soils, lichens and mires. Their origin could be long-range transport from heavily industrialised regions at middle latitudes or local sources. Pollution is important for human health but can also affect ecosystem function at a regional scale.

Permafrost melting: Extensive melting of frozen ground affects the ecosystem hydrology and carbon balance, as well as the stability of urban, transportation and industrial infrastructure (including oil and gas pipelines). The latter aspect was studied in more detail by a 2-year project funded by INTAS (contract nr. 97-10984) under the title 'Permafrost in the Usa Basin: distribution, characterisation, dynamics and effects on infrastructure' (PERUSA), which was carried out in close cooperation with the TUNDRA project.

Global change is a global challenge. Ultimately it is collective human behaviour that determines levels of fossil fuel emissions and pollution. Within the framework of TUNDRA, sociologists and social anthropologists conducted interviews in towns and villages of the Usa Basin to assess perception of environmental degradation. These studies aimed to establish how people with different backgrounds relate to their environment.

We compared views as expressed by Indigenous Peoples with those articulated by the more recent Russian immigrants, who came to the Arctic to work in industry. Observations on social perception were compared to levels of pollution as measured in the Usa Basin by other participants in the TUNDRA project. Special emphasis was given to understanding of how social awareness might affect environmental legislation and its implementation in the future, with consequences for the Arctic environment and, indirectly, global climate.

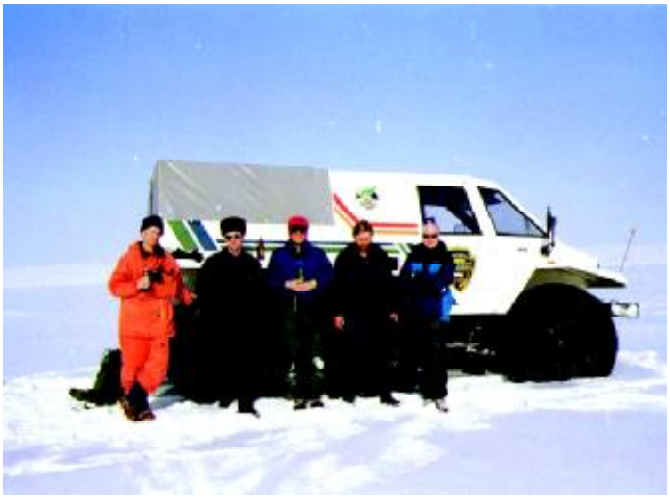
PROJECT STRUCTURE

Climatology

Regional climate model (workpackage 1), Danish Meteorological Institute, Denmark

Research Group I: Climate Change and the Carbon Cycle

- Past dynamics of the Arctic and alpine treelines (workpackage 3), University of Helsinki, Finland
- Modelling the effects of climate change on phytomass with GIS (workpackage 4), Finnish Forest Research Institute, Finland



- Carbon pools in soils, peat and limnic sediments (workpackage 2), Arctic Centre, University of Lapland, Finland
- Soil GIS of the Usa Basin (workpackage 2), Institute of Biology, Komi Science Centre, Russia
- Carbon Dioxide and Methane fluxes (workpackage 5), University of Kuopio, Finland

Research Group II: Climate Change and the Hydrological Cycle

- Water balance model (workpackages 6 and 7), Utrecht University, The Netherlands
- Past river dynamics (workpackage 8), Free University Amsterdam, The Netherlands

Research Group III: Industrial Pollution and Social Awareness

- Terrestrial pollution in the Usa Basin (workpackages 9 and 10), University of Nottingham, UK
- Aquatic pollution in the Usa Basin (workpackage 11), University College London, UK
- Public perception of environmental change among rural inhabitants (workpackage 12), University of Manchester, UK
- Public perception of environmental change among Russians (workpackage 12), University of Oulu, Finland

MAIN SCIENTIFIC RESULTS

(1) There is no fingerprint yet of global warming in the Usa Basin.

(2) The regional climate model proved very important for the implementation of the TUNDRA research plan. The few weather stations in the Usa Basin are all located in lowland areas. The climate model had a sufficient spatial resolution to adequately represent the Ural Mountains. Model results correctly predict much higher precipitation in the mountains, which is corroborated by measurements at one climate station in the northern Urals.

(3) Paleoecological studies provide a clear analog for future global warming during the Early Holocene. Temperatures were at least 3-4°C warmer than at present. Under those conditions, taiga forests grew nearby the Barents Coast and at greater elevations along the slopes of the Ural Mountains. During the last 5000 years only minor climatic fluctuations occurred with limited consequences for biome distribution. Remarkable is the absence of a well-defined Little Ice Age signal in a treering record on the western slopes of the Prepolar Urals during the 19th century, in contrast to a clear signal in a previously published treering record from the eastern slopes of the Polar Urals. Apparently, the Ural Mountains form a natural barrier between climatological provinces in the Eurasian North.

(4) A total of 21 landscape / vegetation classes have been identified in the Usa Basin based on remote sensing of Landsat TM5 images and groundtruthing plots.

(5) A GIS-based soil classification was developed for the Usa Basin in the international WRB system, based on a Russian database and newly obtained TUNDRA data.

(6) A carbon flux experiment near Vorkuta showed that moist to wet peaty tundra represented a sink for carbon on an annual basis. The calculation of the annual balance included winter fluxes. Under warmer conditions, especially relatively dry areas could become sources of carbon. Methane production in these tundra ecosystems was especially high in wet habitats.

(7) The GIS-based hydrological model developed for the Usa River and its tributaries made good use of other GIS layers developed within the framework of the TUNDRA project (topography, climate, vegetation, soils) and the closely associated PERUSA project (permafrost). Future changes in discharge will be primarily associated with changes in temperature and precipitation. Vegetation redistribution (through changes in evapotranspiration) and permafrost dynamics (through changes in base flow) will

(8) An analysis of past fluvial dynamics and morphology in the Usa River and some of its tributaries show important periods of river incision and terrace formation in the central and northern lowland areas during the Holocene. An important period of new incision and changed morphology (in parts of

the Usa River itself) is associated with climatic cooling, retreat of the Arctic treeline and permafrost aggradation during the Middle Holocene. It is possible, therefore, that climate instability related to future global warming might result not only in changed patterns of river discharge but also affect portions of the Usa River morphology itself.

(9) An analysis of terrestrial pollution in snow, soil and lichens indicates impacts at two scales. One is related to local pollution sources in the Usa Basin, especially the town of Vorkuta. High levels of dust emissions from the cement factory and the coal-burning power plant has resulted in an alkalinization of the environment that can be measured up to 30-40 kms away from the emission sources. Heavy metal concentrations are also significantly higher. In addition, dust particles in the snow result in an earlier snowmelt.

(10) A historical analysis of spheroidal carbonaceous particles (derived from coal combustion) in lake sediments near Vorkuta indicate that highest levels of emissions were reached in the 1970's, with a significant reduction in the 1990's associated with the economic downturn in Vorkuta.

(11) Environmental concerns are not considered a priority by both urban and rural inhabitants of the Usa Basin. Social aspects such as employment, standard of living, housing and health are considered particularly important in these difficult economic times. Among environmental concerns, land, air and water pollution are considered most significant (as they relate to human health). Also the reduction in fish stocks, an important subsistence sector, is often mentioned.

MAIN PRODUCTS

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