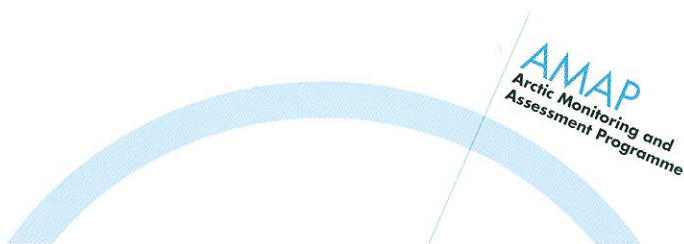


**AMAP/CAFF Workshop on Climate Change,
Rovaniemi, 24-25 March 1998**

Summary Report

Prepared by: Jarle I. Holten, Snorri Baldursson and Lars-Otto Reiersen



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Hosted and organised by: Finnish Ministry of Environment; Lapland Environment -
Centre; AMAP and CAFF Secretariats

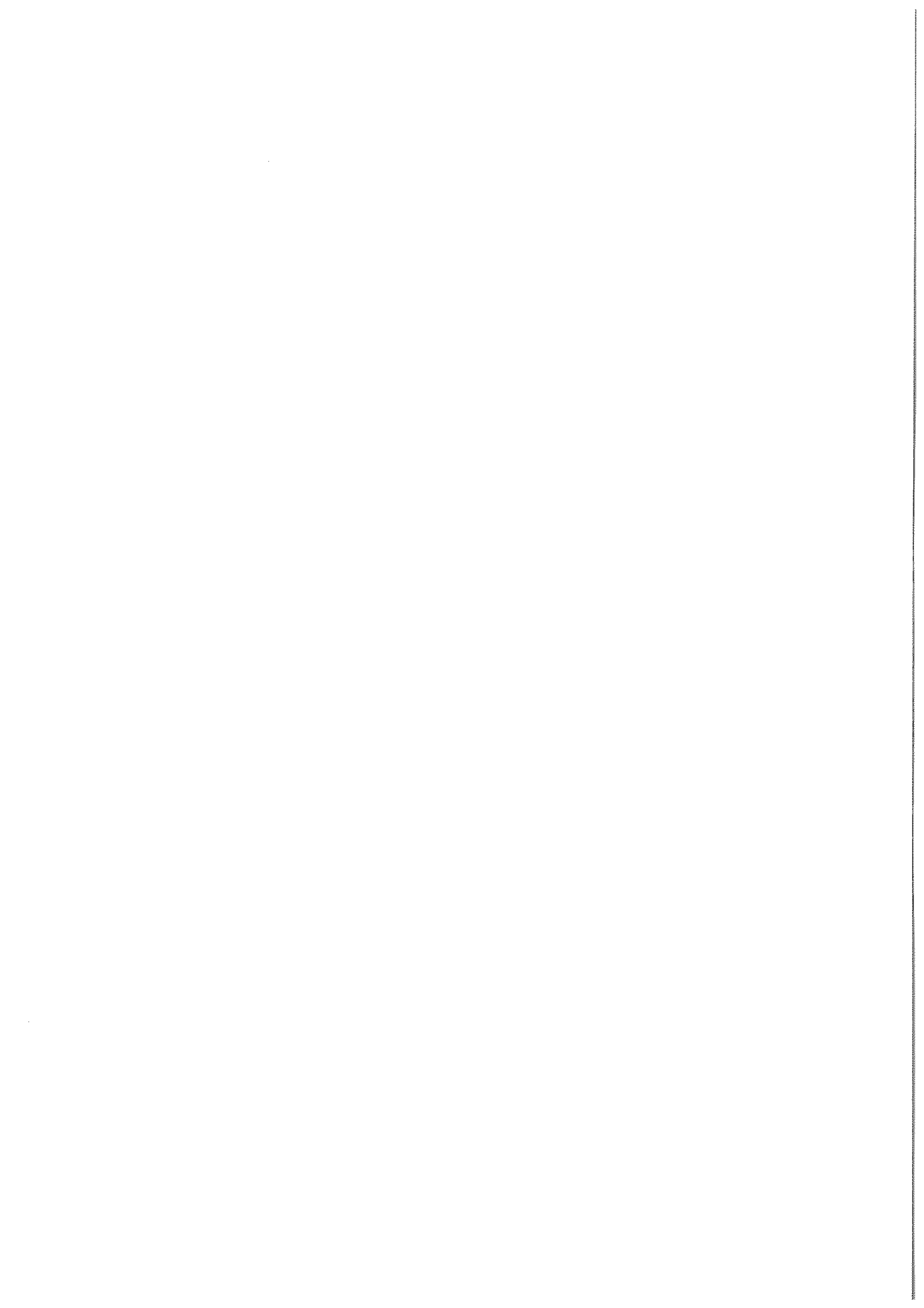


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1. Introduction

The Workshop was planned in response to the Ministerial request to AMAP in Alta (1997), to continue: "activities for monitoring, data collection, exchange of data on the impacts of the impacts, and assessment of the effects of contaminants and their pathways, increased Ultraviolet-B (UV-B) radiation due to stratospheric ozone depletion, and climate change on Arctic ecosystems".

At the AMAP Working Group (WG) meeting in Aarhus, Denmark, 17-20 November 1997, Finland offered to host the workshop. The AMAP WG also agreed to invite CAFF to join the workshop so that the two programmes could jointly discuss the potential impacts of climate change in the Arctic and provide holistic recommendations to the Arctic Council.

The AMAP/CAFF Workshop was arranged back to back with a SCANTRAN Workshop, sponsored by ARTERI (Arctic-Alpine Terrestrial Ecological Research Initiative), to advance the idea of a Scandinavian High Latitude Transect as a part of the International Geosphere-Biosphere Programme (IGBP) on global change. Many experts attended both meetings, providing a continuous discussion and a maximum use of expertise. Altogether twenty-eight experts and administrators from nine countries attended the AMAP/CAFF Workshop. List of participants is Appendix 1 and the Agenda is Appendix 2.

The Workshop focused on impacts of climate change to terrestrial systems. Its objectives were to:

1. Define and focus AMAP/CAFF work with respect to monitoring and assessing impacts of climate change.
2. Identify main Arctic and circumpolar programmes already engaged in such work.
3. Identify major existing gaps that might be filled by AMAP/CAFF.
4. Suggest projects or programmes to be undertaken by AMAP and CAFF separately and/or in collaboration.

The Workshop began with an introductory plenary, during which several ongoing activities were presented. After the plenary, three parallel working groups set out to address the objectives of the workshop in detail.

This report provides a summary of the plenary (Section 2) and a synthesis of the working group results (Section 3). Individual working group reports are attached in Appendix 3.

2. Report from Plenary

2.1. Opening

Paula Kankaanpää, Finnish Ministry of Environment and Outi Mahonen, Lapland Regional Environment Centre, welcomed participants and opened the workshop. Lars Otto Reiersen, Executive Secretary AMAP, introduced the agenda (Appendix 2) and explained the workshop format.

2.2. Introduction

Lars Otto Reiersen reviewed the AMAP background for this initiative. He referred to the conclusions of the AMAP SOAER (*Arctic Pollution Issues: A State of the Arctic Environment Report*) which states that information on potential impacts of climate change in the Arctic is insufficient. He then cited the subsequent request by the Arctic Ministers at Alta (see above). Mr. Reiersen hoped that the workshop would come up with initial recommendations that could then be incorporated into AMAP's Second Phase after discussion and further refinement at the Symposium on Climate Change in Tromsø, Norway, August 1998, and the planned workshop on climate change and UV-B in USA in November 1998.

Snorri Baldursson, Executive Secretary CAFF, presented CAFF's priorities with respect to monitoring of Arctic biological diversity and impacts of climate change as outlined in the CAFF Strategic Plan. CAFF is currently engaged in preparing an overview of ongoing work on biodiversity monitoring in the Arctic and identifying existing gaps. A Monitoring Committee, led by Jonathan Bart (USA), has just been established to oversee this work and further define CAFF's potential role in circumpolar monitoring initiatives, including assessing the potential impacts of climate change on Arctic biodiversity. Mr. Baldursson hoped that the workshop could develop broad recommendations for consideration by the CAFF Monitoring Committee and the CAFF Management Board at their May 1998 meeting in Whitehorse.

2.3. Overview Presentations

Mr. Reiersen noted that a US policy paper, intended to provide the basis for the discussions, was not ready. However, an early draft "Climate Change and its Effects" had been received. This draft had not undergone a full US agency (NOAA) and interagency review. The draft identified 7 key climate change-related questions and issues to be addressed by AMAP.

Bill Heal (UK) gave an overview of the philosophy and ideas behind the IGBP's Terrestrial Transects, especially the High Latitude Transects (HLT) including SCANTRAN. The HLTs are intended to assist in the long-term assessment of the various impacts of global change on terrestrial eco- and socio-economic systems, using comparative observations along large-scale environmental gradients. Mr. Heal reviewed the main features of the HLTs and identified various other related initiatives (mostly EU initiatives). He noted that the main missing link was sufficient integration

among these initiatives and that AMAP/CAFF along with IASC (International Arctic Science Committee) and IGBP could provide a valuable service in that respect. Mr. Heal also stressed the importance of involving the sites, i.e. the site managers, since they represented the main resource on which such initiatives were based.

Jarle Holten (Norway) provided a brief summary of the status of work with respect to climate change and biodiversity monitoring in the Arctic, and gave a rough outline of what is meant by integrated monitoring. He agreed with Mr. Heal that there is an obvious lack of integration among the various existing initiatives and concluded that:

- A long-term circumpolar integrated monitoring program is lacking.
- A long-term circumpolar integrated monitoring program is necessary.
- Success will depend on simple approaches using several key areas and parameters.

Ulf Molau and Philip Wookey (Sweden) presented ITEX (International Tundra Experiment). ITEX was launched in 1990 as a grass-root program of scientists interested in Arctic botany and climate change. ITEX builds on approximately 20 fixed experimental sites or plots (see Appendix 3, Fig. 1) and makes use of the "3-M's" approach (monitoring, manipulating and modelling). Observations so far indicate e.g. that:

- Although all species respond uniquely to climate change, there are some common trends.
- Rapid changes will lead to reduced biodiversity (at least temporarily).
- "Arctic specialists" will be the most vulnerable species.

As is true for many long-term experiments, some of the ITEX sites have funding problems. Ensuring long-term funding for ITEX is a challenge that AMAP/CAFF might assist with. Similarly, ITEX could potentially provide a core network for AMAP and CAFF to build on.

Manfred Lange (Germany) provided an overview of global change and its tentative impacts. He then presented an IASC/EU sponsored program "Barents Sea Impact Study" (BASIS) launched in January 1998). BASIS is an integrated regional study attempting to assess the potential impacts of global change on several biological, cultural and socio-economic systems of the Barents Sea region. BASIS and its sister program in the Bering Sea region, BESIS, could be valuable links in a circumpolar program.

Ib Johnsen (Denmark) presented a recent report assessing the vulnerability of Greenlandic ecosystems to climate change. This report demonstrates *inter alia* how existing information can be used in such assessments. With respect to climate change studies and impact assessments, Mr. Johnsen highlighted the importance of: long-term studies, especially to capture catastrophic events (extremes); multiple stressors; the need for integration of sociological and biological aspects; and the need to focus on simple but correctly selected variables. In terms of indicators, Mr. Johnsen stressed the need to focus on sensitive species/ genotypes, processes, structures and places.

Ivar Myklebust (Norway) presented the Norwegian Monitoring Program for Terrestrial Systems. The program was initiated in 1992/93. Its main objectives are to detect changes in the ecosystem due to long-range transported pollutants and climate change. The program emphasises integrated monitoring, including precipitation, soil and soil water, plants and animals.

Thomas Björneboe Berg (Denmark) informed participants about the Zackenberg Field Station, NE-Greenland, which was opened last year. The station has a core staff of five and is operated from May to September. Monitoring activities include vegetation measurements at 120 fixed plots along an altitudinal gradient, number and species composition of insects captured in pit-falls, breeding and phenology of 15 species of birds, lemming nest counts etc.

Hanne Hvidtfeldt Christiansen (Denmark) gave a short overview of the International Permafrost Association (IPA), which monitors active-layer thickness at 69 sites within a circumpolar network. The thickness of the active layer is a simple parameter that can give valuable information on climate change. However many of the sites in IPA's network have funding problems and Ms. Christiansen suggested that AMAP/CAFF might benefit from and assist in that respect. Data has been reported to a database in Boulder, Colorado, and a CD ROM will be released in June 1998, presenting the first set of compiled data.

Stewart Cohen (Canada) gave a major presentation on "Mackenzie Basin Impact Study (MBIS): Reflections and Recommendations". The MBIS (1991-96) has gained international attention as a model for regional climate impact studies, e.g. the IASC BESIS and BASIS studies. In terms of climate change impacts the MBIS predictions include:

- Increased permafrost thaw and land-slides.
- Translocation of ecosystems such as peat-lands.
- Decreased basin runoff.
- Increased forest productivity , but decreased yield because of increased fire frequency.
- Increased uncertainty with respect to land-use and community planning.

With respect to lessons for other similar projects and integrators, Mr. Cohen emphasised:

- The importance of scientist-stakeholder collaboration and personal contact between these two groups.
- Plain language reporting.
- Region/country specific impact indicators.
- Involving the various sectors and many criteria in scenario and impact modelling.
- Common platform for GIS and other project information as well as a project secretariat.

After these presentations, the plenary was split up in three working groups (Appendix 5) that set out to address the objectives of the Workshop (Section 1) and,

in addition, to start defining the content and physical framework for an AMAP/CAFF program on climate change. The conclusions from the working groups were presented at the plenary the last day, see Annex 2.

3. Synthesis Report and Recommendations from the 3 Working Groups - by Jarle I. Holten

3.1. The AMAP/CAFF focus on climate change

Global change consists of climate change, changes in land use and pollution. A holistic view on global change in future research and monitoring programmes in the Arctic, will require integration of natural and social sciences. A new AMAP/CAFF program can contribute to this endeavour.

3.2. Objectives of AMAP/CAFF in relation to climate change in the circumpolar Arctic

The ultimate objective of an AMAP/CAFF program on climate change is to provide policy advice on how pollution control and conservation planning in the Arctic should be modified to account for changes in climate.

AMAP/CAFF should:

- Have a clearly defined role in monitoring and assessment, related to climate change in the circumpolar Arctic.

Key functions are e.g. to:

- Provide a link between the scientific community and policy-makers.
- Collect, synthesise and integrate the existing knowledge of the direction and magnitude of climate change in the Arctic region.
- Predict how climate change will effect Arctic ecosystems and conservation planning.
- Support on-going research and monitoring activities within programmes such as ITEX and others that are dependent on short term funding, and contribute to long term funding.
- Initiate new efforts where gaps have been identified.
- Highlight the need for higher resolution predictive information on potential future climate change and its regional impacts in the circumpolar Arctic.
- Investigate policy options to mitigate the potential consequences of cumulative impacts in the Arctic region.
- Develop a data gathering strategy in regions that are currently warming, cooling and showing little change.
- Use an approach consisting of monitoring, manipulation and modelling (the three M's).

- Use climatic gradients and link with IGBP HLTs (High Latitude Transects).
- Link with key bases/monitoring initiatives further south. This is especially important in relation to migratory species.
- Assess impacts of climate change to human communities and provide input to a 'sustainable development program'.
- Incorporate expertise and knowledge of indigenous and other Arctic inhabitants into climate change projects, e. g. through community based sub-programs.

The list above represents a range of recommendations, including both broad and more specific goals. The list should go through additional review, resulting in 2 - 3 broad aims, and 5 - 10 more specific ones.

3.3. Key parameters

The AMAP/CAFF program should focus on a defined number of biotic and abiotic parameters that are capable of measuring climatic change. The suggested key parameters are described in Table 1.

Table 1. Key parameters to be measured and related scales in a climate change monitoring program of AMAP/CAFF. Ongoing CAFF activities are relevant to several of the biotic parameters. These activities are identified as footnotes. (Abbreviations: CALM = Circumpolar Active Layer Monitoring Programme).

| <i>Scale</i> | Micro/species/ population level (<10 cm - 100 m) | Community/ landscape level (100 m - 10 km) | Intensive (regional) level (100 km - 500 km) | Circumpolar level (modelling effort) |
|---|---|---|---|---|
| | Extensive level (Using the ITEX existing sites' network) | | | |
| PARAMETERS | | | | |
| 1. Abiotic parameters | | | | |
| Radiation (short wave + terrestrial) | | X | X | |
| Temperature | X (air + soil) | X | (X) | (X) |
| Precipitation | | X | X | X |
| Snow cover (pattern, depth, duration) | | X | X | X |
| Permafrost (extent/pattern) | | X | X | X |
| Active layer (depth) | X | X | X (CALM) | |
| Ground water level | X | X | | |
| Nitrogen deposition | (X) | X | X | |
| Pollutants ¹ | X | X | X | X |
| Soil organic carbon content | X | X | | |
| Mineralisation rates | X | X | | |
| 2. Biotic parameters | | | | |
| Species richness & distribution | (X) | X | X ³ | (X) ² |
| Demography (selected species) | X | | | |
| Habitat diversity & distribution | | X | X ³ | X |
| Species phenology (selected species) | X | X | X | X ⁴ |
| Vegetation phenology | | X | X | X |
| Displacement of ecotones (e. g. timberlines, snow-bed - ridge ecotone) | (X) | X ⁵ | (X) ⁵ | (X) ⁵ |
| Ecosystem processes (Nitrogen transformations, productivity, decomposition, trace gas fluxes) | X | X | (X) | (X) |

¹ To be harmonized with AMAP's core programme for pollutant parameters.

² Relevant CAFF activities are e.g.: Circumpolar Arctic Vegetation Mapping Project (CAVM), Atlas of Rare Endemic Vascular Plants of the Arctic, Pan-Arctic Flora Initiative, Migratory Species Database, Seabird Colony Database. Should be harmonized with AMAP's effect studies.

³ CAFF has prepared species habitat maps in the Russian Arctic in collaboration with the World Monitoring and Conservation Centre (WCMC) in Cambridge, and UNEP GRID-Arendal, Norway.

⁴ As a part of the International Murre Conservation Strategy and Action Plan, CAFF is preparing a circumpolar monitoring plan for murre (guillemots).

⁵ The CAVM will provide base-line information.

3.4. Key organisms and species

Identifying the organisms and species that are most sensitive to climate change is a difficult task. The selection of indicator species in the monitoring program, should therefore be based on a wide range of criteria:

- Choose species at the extreme ends of their range (Hypothesis: Outlier populations are typically the most sensitive to climate change, and extinctions or invasions are more easy to quantify at range limits).
- Choose both dominant, common and rare species.
- Choose both long- and short-lived species.
- Choose both migratory and non-migratory species.
- Choose species that are amenable to monitoring/research.
- Include all the main plant life-form types that occur in Arctic areas: Dwarf-shrubs, evergreen plants, graminoid plants, cushion plants, herbaceous plants, lichens, mosses (acrocarpous + pleurocarpous) and liverworts.
- Choose species that are representative of ecological webs (key-stone species, functional groups) and represent different trophic levels. Above-ground: Large herbivores, small herbivores, birds, vascular plants, mosses and lichens; Below-ground: Invertebrates, bacteria.

3.5. Methodology

- The monitoring and research activity related to climate change should ideally have a comparative element building on a gradient approach at some scale (from micro-scale to the circumpolar level - see Table 1) like that proposed for SCANTRAN
- The monitoring and research projects should aim at being integrative between the pure scientific needs and the regional socio-economic interests.
- The more expensive field manipulations should be concentrated to selected regions and field stations/sites with existing high infrastructure and easy access (the intensive level).
- The extensive part of the monitoring program should use remote sensing, complementing simple and in-expensive methodology on many sites and encourage community based initiatives.
- The monitoring should at each site (extensive level) be based on permanent plots (species/population level). Where possible the permanent plots should include an altitudinal gradient.
- For the abiotic and biotic parameters (community/landscape level), a systematic grid is proposed based on a quadrant subdivided into sub-units with permanent plots located in the corners of each sub-unit.

- The extensive network of sites should reach as far as possible (at a regional scale) and be integrated with the planned (SCANTRAN) or on-going four IGBP HLTs (High Latitude Transects).

3.6. Research and monitoring questions

All research and monitoring activities should, if possible, be a part of a program characterised as 'Long Term Ecological Measurements', and be based on latitudinal and west-east gradient approaches. At sites with mountainous topography, an altitudinal gradient approach is suggested as a supplement (cf. ZERO line at Zackenberg, East Greenland). The program should include activities of monitoring, manipulation and modelling (The 3 M's).

1. Monitoring

The monitoring should be based on a protocol like that developed for the ITEX program. However, for the identification of 'target' species and the definitions of functional groups and processes, a wide consultation in the scientific community is recommended. A database function for storage of data from the monitoring activity should be established/developed.

2. Manipulation

Field manipulations to determine the effects of climate change are in progress and are concentrated in areas with established field stations. Some expansion will be necessary; ITEX has shown the value of relatively simple (cheap) methods for more extensive use.

3. Modelling

AMAP/CAFF should consult the modelling experts working with the IGBP transects (IGBP Report No. 36).

A separate workshop should be organised (see Table 3) to make a specified and prioritised list of key scientific questions and related hypotheses (under the 3 Ms). The same workshop should also decide on key species ('target' species) for the program, and discuss which geographical areas are best for doing the intensive part of the program.

3.7. On-going and planned initiatives

A high level of climate change related scientific research is already taking place in the Arctic region, especially under the EU 4th Framework. However, there is a distinct need for co-ordination of the many EU projects (see Table 2). Some of the projects, such as BASIS and ARTERI, are integrative, incorporating socio-economic interests.

Table 2. Some multi-site, multinational research projects across European environmental gradients. Total value of projects c. 20 mECU (The acronyms are defined below).

| | AASER | BASIS | BERI | CALM | CONGAS | DART | ITEX | LAPP | MOLAR | ICP/IM | TUNDRA |
|-----------------------|-------|-------|------|------|--------|------|------|------|-------|--------|--------|
| Terrestrial Ecology 1 | | X | X | (X) | X | X | X | | | | X |
| Atmospheric chem 3 | | | X | | X | | | | | | X |
| Hydrology 2 | X | | | | | | | X | X | | |
| Past change 4 | | | | | | X | | | X | | X |
| Biogeochemistry | X | | | | | | | X | | | X |
| C sequestration | | | X | | X | | | | | | X |
| Trace gas flux | | X | | | X | | | | | | X |
| Biodiversity | X | | | | | X | X | | | | |
| Human dimension | | X | | | | | | | | | |

Project list of larger projects and responsible co-ordinator:

| | |
|--|------------|
| AASER - Arctic and Alpine Stream Ecosystem Research (John Brittain, Oslo, Norway) | 1.6 mECU |
| BASIS - Barents Sea Impact Study (Manfred Lange, Muenster, Germany) | 1.6 mECU |
| BESIS - Bering Sea Impact Study | (??) |
| BERI - Bog Ecosystem Research Initiative (N van Breeman, Wageningen, Netherlands) | 1.4 mECU |
| CALM - Circumpolar Active Layer Monitoring Program (Jerry Brown, Woods Hole, USA) | (??) |
| CONGAS - Biosphere Controls on Trace Gas Fluxes in Northern Wetlands (T. Christensen, Lund, Sweden) | 1.481 mECU |
| DART - Dynamic Response of the Forest-Tundra Ecotone to Environmental Change (Brian Huntley, Durham, UK) | 1.5 mECU |
| ITEX - International Tundra Experiment (Phil Wookey, Uppsala, Sweden) | (??) |
| LAPP - Land Arctic Physical Processes (Colin Lloyd, Wallingford, UK) | 1.5 mECU |
| MOLAR - Measuring and Modelling the Dynamic Response of Remote Mountain Lake Ecosystems to Environmental Change. A Programme of Mountain Lake Research (S. Patrick, London, UK) | 2 mECU |
| ICO/IM - ICP Integrated Monitoring Programme | (??) |
| TUNDRA - Tundra Degradation in the Russian Arctic (Peter Kuhry, Rovaniemi, Finland) | (??) |

Integrative and concerted actions and initiatives in the Arctic region:

- AMAP** - Arctic Monitoring and Assessment Programme (Lars-Otto Reiersen, Oslo, Norway)
- CAFF** - Conservation of the Arctic Flora and Fauna (Snorri Baldursson, Akureyri, Iceland)
- CPAN** - Circumpolar Protected Areas Network - a subprogram of CAFF
- ARTERI** - Arctic and Alpine Terrestrial Research Initiative (Bill Heal, Edinburgh, UK)

Other relevant national programmes:

- Monitoring at Zackenberg** (Greenland) including the ZERO line monitoring
- Programme of Terrestrial Monitoring** (Norway)
- Ecological Monitoring and Assessment Network (EMAN)** (Canada)

3.8. Sites

The sites and areas proposed below are based on four main criteria:

- The circumpolar network of ITEX sites
- The position of planned and existing IGBP High Latitude Transects
- The location of recent 'warming' and 'cooling' areas in the Arctic and Sub-arctic.
- The position of the proposed 10 Key monitoring areas of AMAP

The workshop focused mainly on the Eurasian part of the Arctic and Annex 3 shows two Figures that present proposed terrestrial areas for detailed studies. Proposals for North America and Siberia will have to come in addition.

Remote sensing plays a particular role in detecting change in vegetation, ice and snow cover etc. over large areas and at particularly sensitive sites, e.g. glaciers that are not otherwise accessible. The potential to combine such methodologies with field based observations needs further consideration.

Extensive level (see parameters in Table1)

The ITEX network of sites is suggested as one of the bases for the future monitoring at the extensive level. ITEX currently consists of about 20 sites in Arctic and sub-arctic areas. However, there is a need for extension of the ITEX network, first of all to cover important Arctic areas in the Russian and Canadian Arctic. In Russia two new ITEX sites on Taymyr can function as an extension of the West Siberian IGBP High Latitude Transect into low and high Arctic areas. Taymyr is unique in being the only place on earth with continuous terrestrial gradient through all the boreal and Arctic eco-zones! In the Canadian Arctic, one or two ITEX stations in the west Baffin Island/Boothia Peninsula can function as an extension between the Canadian High Latitude IGBP Transect and the ITEX stations at Devon and Ellesmere Island.

The ITEX network of sites could be supplemented by a community-based monitoring network based phenology (e.g. arrival and nesting of migratory birds, flowering of key plant species) and ice - and snow conditions.

The CAFF CPAN (Circumpolar Protected Areas Network) could also provide a valuable function for extensive and intensive monitoring efforts. The network now consists of 294 protected areas, many of which have their own monitoring programs in place.

Intensive level (see Table 1)

The intensive level of research and monitoring will include high cost manipulations and associated observational studies of Arctic ecosystems in only 2 - 4 areas, whereas the extensive level will represent low-cost research and monitoring in many areas.

The intensive level of research and monitoring in the future AMAP/CAFF is suggested to be located at 2 - 4 of the following candidate areas in the circumpolar region:

- **Northern Fennoscandia including Svalbard**

Arguments: Location of the IGBP High Latitude Transect SCANTRAN, steep west-east gradient in continentality, the highest positive winter temperature anomalies on earth, very good infrastructure, high capacity/quality of field stations for international co-operative research teams (e. g. Abisko, Kilpisjarvi, Kevo, Oulanka, Ny-Ålesund), high activity and long experience in Arctic scientific issues and multi-national scientific co-operation, fairly high population pressure and potential threats from exploitation, potential interaction with the integrated program BASIS.

- **The Pechora Basin/Northern Siberia**
Arguments: High potential pressure of exploitation, good opportunities for interaction/integration with indigenous people, includes the western part of the Central Siberian 'warming' area.
- **Taymyr/Central Siberia**
Arguments: The only area on earth including all boreal and Arctic vegetation in one terrestrial transect - West Siberian IGBP transect, active reindeer herding (Taymyr) and potential interaction between 'hard sciences' and the socio-economic interests, 'warming' area the last decades, the pollution source Norilsk in the lower Yenisey.
- **The Bering Sea area**
Arguments: Includes amongst others the integrated monitoring program area of BESIS - Bering Sea Impact Study.
- **North Slope of Brooks Range to Barrow, Alaska**
Arguments: Good existing infrastructure, location of active ITEX sites and the US LTER (Long Term Ecological Research) site at Toolik Lake, long and strong tradition of climate change-related research, especially within ecophysiology of tundra plants and field manipulations. The area includes the National Petroleum Reserve which is proposed for oil and gas development.
- **Western Greenland/Baffin Bay**
Arguments: 'Cooling' area over the last decades, fairly good infrastructure for intensive research and monitoring at Disko and Thule.

The following scientific activities should be central in the intensive areas:

1. Modelling/observational studies:

- Mapping of biodiversity patterns, community structure and composition
- Mapping species distributions along altitudinal, latitudinal and continental gradients. Identifying/defining important biotic boundaries in relation to cryospheric boundaries (snow cover and permafrost patterns)
- Vegetation map (1:500000 or 1:1 mill.)
- Continue on-going monitoring based on ITEX/IPA methodology.

2. Field manipulations:

- Further develop, design and test and later use simple/low-cost devices for field manipulations of climatic parameters in terrestrial ecosystems (cf. the OTCs - Open Top Chambers used at the ITEX sites).
- Conduct controlled experiments with increased nitrogen in various terrestrial habitats.

3.9. Organisation and co-operation

Principle: Build on existing Arctic organisations, research/monitoring networks and indigenous and local communities

A high number of organisations exist in the Arctic region with bordering and overlapping responsibilities for nature and culture. A future AMAP/CAFF climate change program should try to involve all these organisations, and other interest groups, at an early stage (see Table 3). AMAP/CAFF, Arctic Council, IGBP and IASC could be the central organisational/administrative bodies in the new program, with the latter two providing scientific advice. A contact forum between these organisations should be considered. IGBP/GCTE Focus 3 should take care of the socio-economic interests (reindeer herding etc.). The indigenous people's organisations should be included in the regional programmes at the extensive and intensive level.

3.10. Time schedule

A specified plan should be made for a long term AMAP/CAFF program lasting at least 10 - 15 years. At present, a preliminary draft plan of activities is proposed for the next 3 years to conduct a pilot phase of the program as described in Table 3. A long-term program is proposed to begin in 2001.

Table 3. A draft plan including important milestones in an Arctic terrestrial and climate change related research/monitoring program of AMAP/CAFF in the pilot phase (1998 - 2000)

| | |
|--|------------|
| Draft report from Rovaniemi to be circulated to participants | April 20 |
| Reporting to AMAP WG | April 23 |
| US policy paper update | April 23 |
| Comments back from participants | May 1 |
| Presentation at CAFF NR/PP Meeting | May 7-8 |
| Discussions between AMAP/CAFF, ARTERI etc. at SAO | May 10 |
| Final report | June 5 |
| Policy paper finalised | June |
| Workshop on Climate Change in Tromsø, Norway | August |
| Consultation with different groups | September |
| Workshop on marine and terrestrial aspects | October |
| Draft program for presentation to AMAP/CAFF WG's | November |
| AMAP WG to discuss the proposal | December |
| CAFF WG to discuss the proposal | April 1999 |
| Further development of the program and necessary co-operation. National Implementation Plans to be developed and implemented | 1999-2000 |

Support activities to existing programs (e.g. ITEX), and funding organisations (e.g. EU 5th Framework Program) have to be developed simultaneously.

4. Closing remarks

Although the Workshop and report identify the most important aspects of a program to monitor the effects of climate change on biotic components of Arctic terrestrial ecosystems, additional aspects may need further consideration. These include:

- The approach presented here is basically "plot based". A different strategy may be needed for large and mobile animals and for particular species/habitats which are rare and sensitive.
- Background information is critical to future interpretation both on the intensive scale (e.g. fire history, flooding, lemming outbreaks) and extensive scale (e.g. past history of land use, time since last glaciation).
- Examination of existing protocols and experiences from other monitoring programmes.
- Application of remote sensing, which is particularly important in the more remote areas of the Arctic.

Appendices

Appendix 1: List of Participants

**AMAP/CAFF WORKSHOP ON CLIMATE CHANGE
March 24-25, 1998, Rovaniemi**

(March 25, 1998)

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Appendix 2: The Agenda

Agenda for the AMAP/ CAFF workshop March 24-25, Rovaniemi. Tuesday 24.3.

- 0900 Opening of the Workshop and Practical arrangements by Paula Känkaanpää and Outi Mähönen
- 0910 Presentation of the AMAP/CAFF draft monitoring plans and strategies for 1998 – 2003
Presentation of the goals of this workshop and the main questions to be discussed.
- What are the likely impacts of Climate change on Arctic ecosystems?
 - What are the likely combined effects of Climate change, change in UV and different pollutants?
- Presentations by Lars-Otto Reiersen & Snorri Baldurson
- 1000 Coffee
- 1015 Introductory papers regarding
- Presentation of a draft policy paper prepared by USA
 - Presentation of conclusions and recommendations from SCANTRAN. Jarle Holten and Bill Heal
 - Ongoing research and monitoring related to effects of Climate Change on Arctic ecosystems and biodiversity, e.g. ITEX and SCANTRAN. Snorri Baldurson, Ulf Molau, Jarle Holten
 - Planned activities, of BASIS, Manfred Lange
 - Important gaps in ongoing programmes and projects
- 1200 Lunch
- 1300 Introductory papers regarding lesson learned from terminated related programmes, e.g. the Mackenzie study
Presentation by: Stuart Cohen
- 1400 Discussions related to the presentations made with the aim to prepare a document that describes (or Working groups):
- ongoing activities of relevance for the AMAP/CAFF programme
 - planned activities of relevance for the AMAP/CAFF programme
 - new activities that AMAP/CAFF should try to implement, and which of the already ongoing activities we should try to make close cooperations.
- 1500 Coffee
- 1520 Discussions (Working groups) cont.
- 1800 End of the day
- 1900-2200 Dinner hosted by the Finnish Ministry of Environment

Wednesday 25:

0900 Working groups detailing parts of a draft proposals for the AMAP/CAFF programmes related to:

- The content of ecological monitoring and research; What to monitor, e.g. soil, freshwater, plants, animals; Sampling strategy to be applied.
- Geographical areas of importance for pilot project e.g. three areas of variable sensitivity?.
- Ongoing/new programmes that could be the fundament for the pilot projects, how to establish the necessary links.
- Other issues to be filled in.

1030 Coffee

1045 Working groups cont.

1200 Lunch

1300 Plenary, summing-up the working group proposals

1430 Coffee

1445 Plenary cont.

1600 End of the workshop

Appendix 3: Reports from the 3 Working Groups

Group 1:

AMAP/CAFF workshop on climate change March 24-25, 1998 Rovaniemi

Working group 1

Ulf Molau, University of Gothenburg, Sweden (chair)
Stewart Cohen, University of British Columbia, Canada
Vivien Ford, Inuit Circumpolar Conference
Bill Heal, University of Edinburgh, UK
Manfred Lange, University of Münster (first day)
Ivar Myklebust, Directorate for Nature Management, Norway
Hanne Petersen, National Environment Research Institute, Denmark
Frank Riget, National Environment Research Institute, Denmark
Jan Idar Solbakken, Saami Council

I) AMAP/CAFF focus on climate change

Global change consists of several components: Climate change, changes in land use and pollution. A holistic view on global change requires integration of natural and social sciences.

- It is the view of the group that the present structure of working groups under the Arctic Council does not stimulate to a holistic view on global change. The need for cooperation and "cross-fertilization" between existing groups is absolutely necessary.

Important issues for AMAP/CAFF is to detect if change will affect:

- Biodiversity
- Mobilization and distribution of pollutants
- Trace gas flux
- (Non) renewable resources

Focal areas for AMAP/CAFF:

- Develop a strategy to sample in regions currently warming, cooling and little change. Ensure sufficient density to cover the unexpected.
- To detect changes AMAP/CAFF should develop (in cooperation with others) an approach consisting of monitoring, manipulation and modelling (the three M's).
- Use gradients of climate and relate the selection to IGBP HLTs (High Latitude Transects) which will generate much relevant data. Some IGBP transects need extension.
- Recognise the importance of monitoring/sampling of pathways in relating the Arctic net to key bases/nets further south. This is important also in relation to migratory species.
- In practice monitoring also requires to assess impacts to human communities. The proposed AMAP areas need to assess this. AMAP/CAFF should give input to a "sustainable development programme".
- The proposed AMAP areas are monitoring areas not limited (as implied) by lines on maps. Key bases should act as focal points (see part III)

II) Ongoing/planned research activities

The most relevant activities in relation to AMAP/CAFF are:

- International Geosphere-Biosphere Programme (IGBP) High Latitude Transects
- Several regional impact studies e.g.
 - Barents Sea Impact Study *
 - Bering Sea Impact Study *

- International Tundra Experiment (ITEX) *
- International Permafrost Association (IPA)
- Some relevant national monitoring programmes are identified:
 - Monitoring at Zackenberg (Greenland)
 - Programme for Terrestrial Monitoring (Norway)

* Programmes/projects under the International Arctic Science Committee (IASC)

Reccomandations on collaboration

- AMAP/CAFF should invite IASC/IGBP to make a synthesis of data on climate change in the Arctic. The synthesis should include both historical data and data from existing programmes/projects.
- AMAP/CAFF should explore the possibilities of making a synthesis of social sciences ("human dimension") related to global change. Identify the "expert groups" and invite them to cooperate.

Some relevant "expert groups" are:

International Human Dimensions Programme (IADP)

International Social Sciences Committee (ISSC)

Man and Biosphere (MAB)

International Arctic Social Sciences Association (IASSA)

Other Reccomandations

- AMAP/CAFF should stimulate to community based monitoring, e.g. the North Yukon Monitoring Cooperative
- AMAP/CAFF should consider remote sensing as a tool regarding monitoring of snow and ice cover, vegetation (Circum Arctic Vegetation Map) and land use. (ground thruth ?, processing ?, archive ?)

III) Some comments to the reccomended AMAP areas

- The proposed AMAP areas are monitoring areas not limited (as implied) by lines on maps. Key bases should act as focal points within gradients. The "extended areas" proposed here can also be suitable for CAFF and their monitoring needs.

1: Russian-Norwegian-Finnish border area:

Must include: Abisko, Sweden

Kilpesjärvi, Finland

Tromsø/Dividalen, Norway

There are possibilities to implement monitoring at Russian sites as a part of the joint Norwegian- Russian cooperation on environmental issues.

3: Norilsk area and Taimyr Peninsula, Russia

The Taimyr Peninsula is very important from the biodiversity point of view, and must be included in future activities.

4 and 5: Mouth of the Lena river and Chukchi Peninsula, Russia

There is a strong need for economic support.

6: Arctic Tundra LTER Station, Toolik Lake, Brooks Range, Alaska

This "area" should be extended in a north-south gradient. Barrow must be included.

7: Mouth of the Mackenzie river, Canada

This "area" should be extended in a north-south gradient.

8: Alert Station, Canada

This is a very important "cooling-area" in the high-Arctic. Should include Thule, Greenland.

9: South-west Greenland

This is a very important "cooling-area" in the low-Arctic. Must include Baffin Island, Canada. Very important area for covering the "human dimension".

10: Ny-Ålesund, Svalbard, Norway.

Ny-Ålesund is an important science-platform in the Arctic. This "area" should possibly include Zackenberg at North-East Greenland.

Group 2:

AMAP CAFF Working Group

Chair: Jarle Holten
Rapporteur: Philip Wookey

i. The focus of AMAP/CAFF

The broad aims contained in the draft document entitled "CLIMATE CHANGE AND ITS EFFECTS" were endorsed in our working group. However, we have the following recommendations:

In our view a key function of AMAP (in relation to climate change and its effects) is to provide a clear link between the scientific community and policy makers.

In relation to the specific Objectives amend the wording to:

1. Synthesise and integrate the existing knowledge of the direction and magnitude of climate change in the Arctic region, both contemporary and in the past. Assess the current state of knowledge relating to the links between global climate change and anthropogenic activity, with specific reference to the Arctic region;
 2. To act as a catalyst to highlight the need for higher resolution predictive information on potential future climate change and its impacts (this activity must not only relate to general climatic models but must also include integrated regional impact studies);
 3. Investigate policy options to mitigate the potential consequences of cumulative impacts.
- ii. An obvious potential for collaboration exists between AMAP/CAFF, ITEX and IPA (in close contact with the IGBP system; more specifically BAHC, IGAC and GCTE).

iii. Important gaps:

Specific aims:

- identify and define important biotic and cryospheric boundaries in relation to modern range limits;
- mapping species distributions along N-S and W-E gradients and relate to cryospheric lines (e.g. Pechora to NZ and FJL, and Ural-Pechora-NZ-FJL, W-E across polar Urals);
- mapping of biodiversity patterns in 3 intensive sites;
- vegetation map of intensive areas (e.g. 1:500,000) - to improve impact models (link with CAVM; 1:10,000,000);
- Design and implement a major large-facility temp. change experiment;
- Continue on-going monitoring using ITEX/IPA methodology in an extended (e.g. ITEX/IPA) network;
- Establish a network of extensive monitoring sites in representative areas along climatic gradients;
- Establish GIS lab and databases.

Key variables/organisms

Abiotic variables (extensive sites):

- T (plus vertical profiles);
- Precipitation (plus snow depth and duration);
- Active layer depth;
- Sunshine hours (radiation).

Biotic variables:

- (also refer to previous AMAP CAFF Workshop);
- Species richness (nested permanent quadrats; e.g. Franz Josefs Land);
- Habitat diversity (not easy to monitor);
- Gradient monitoring (e.g. ZERO line in Zackenberg; Ural Putorana; North Scandes; Canadian archipelago; Alaskan Brooks);
- Demography (and developmental stability) of selected plants and animals;
- Ecosystem processes (e.g. nitrogen transformations, decomposition and traces gas fluxes).

We recommend wide consultation in scientific community to identify 'target' species (e.g. we see a juxtaposition here between the objectives of AMAP/ITEX and CAFF). Equivalent functional types are needed if spp. are not circumpolar in distribution.

'Species of common conservation concern'

Murres/eiders/endemic plants - existing CAFF activities

Protocol/database relating to migratory birds

Sites:

3 pilot study areas for AMAP/CAFF?

Extensive/intensive site networks (maybe with 3 main areas in the first instance)

Build on ITEX network in close contact with IPA

- SW Greenland
- Severnaya Zemlya/Gdanski Peninsula/Novaya Zemlya

Intensive network:

L-O.R.'s perspective

- (Ia) Pechora region (Norway may help with funds here);
- (Ib) Taimyr (proposed AMAP research area due to transport of pollutants in the Yenisey - perhaps related to Norilsk emissions). Local government keen to have involvement from AMAP, but funding by no means certain
- (II) Northern Fennoscandia (including Svalbard);
- (III) Western Greenland/Baffin Bay.

Other possibles:

- Canadian high arctic (likely to be supported financially)
- Norway/Finland/Russia (Pasvik/Svalbard/Pechora) - links with SCANTRAN and BASIS and allows access to high quality phenological data from FFRI and Karelia (Paanajärvi NP - 150 years data on birds etc.)

Organisation:

- Site IA - Komi Science Centre, Syktyvkar
- Site IB - Komarov Botanical Institute, St. Petersburg
- Site II - Kola Science Centre, Local Reserves, Oulanka/Oulu, Kevo/Turku, Kilpisjärvi/Helsinki, Abisko, Skibotn/Troms, Ny-Ålesund/Longyearbyen/NPI
- Site III - Disko/DPC

Economy:

AMAP/CAFF and the IGBP (and broader) science community have the potential for symbiosis. It is extremely difficult to obtain resources from the science funding agencies for long-term work with a strong monitoring component: AMAP/CAFF can aid this process by formally reinforce the need for longer-term monitoring (e.g. by writing letters of support or contributing resources directly). Similarly, existing science programmes with a circum-polar perspective (e.g. ITEX/IPA) have the potential to contribute data directly to AMAP/CAFF within a common workprogramme.

Group 3:

**AMAP/CAFF workshop on Climate Change, 24-25
March 1998**

Report from Working Group 3

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Henrik Elling
Ib Johnsen
Thomas B. Berg
Outi Mähönen
Eva Furman
Richard Luxmoore
Ingibjörg S. Jónsdóttir (*rappporteur*)
Geir W. Gabrielson (*Chair*)

Is there a role for AMAP/CAFF in Climate Change research?

YES

What is it?

1. Collect existing data/information related to terrestrial impact of climate change - assessment of this information. Important to have focused questions in this process

What type of data?

1. past changes both in long and short time perspectives.
2. present terrestrial changes

Note: Take marine parameters into account. Necessary because of high degree of land - sea interactions in certain regions.

Problems: Will existing data be available? (unpublished data belongs to scientists and institutions, valuable data in foreign languages)

2. Support ongoing research and monitoring activities within programs such as ITEX and others that are dependent on short term funding or depending on retiring scientists - make them long term!
Pay special attention to certain key sites that have difficulties to get running.
3. Initiate new effort where gaps have been identified.

What to Monitor in a Climate Change monitoring program?

Separate in our approach:

1. Pristine areas
2. Areas of intense interactions between human populations and changes in the arctic

CAFF is already looking into other impacts (tourism, land use etc.)

Make table like AMAP did for pollution over types of variables to be monitored at different sites

Inter annual variability important - long term monitoring of climatic variables important

Atmospheric variables (Physical and chemical properties of air)

- CO₂
- radiation both short wave and terrestrial
- Precipitation and
- snow cover pattern
- air and ground temperature - observe the impact of topography on temperature

Soil

- Depth of active layer
- Extent of permafrost (need for recommendations from CALM)
- ground water levels
- Soil organic carbon content
- Mineralisation rates

Biotic variables -

- 1. Species -**
- 2. Vegetation -**
- 3. Phenology**

Species

some criteria for choosing indicator species:

- choose species at their northern limits
- distinguish between long- and short-lived species
- distinguish between common and rare
- distinguish between migratory and non-migratory

Variables to monitor

- range
- abundance
- growth patterns
- productivity
- phenology
- *demography*

Type of species

- Lichens mosses
- Vascular plants
- Insects
- rodents
- Terrestrial birds

Communities

- Plant community structure
- Plant community phenology
- Interactions: Outbreaks (birch - insect interactions, rodent - plant interactions)

Physical properties

Fresh water

- Landlocked lakes and lakes connected with river systems
- Hydrology
- Ice cover
- Humus
- River water
- Biota - same variables as for terrestrial species

Marine

- Polinias and sea ice
- Sea birds

Glaciers

- interactions between glaciers and terrestrial environment

Coastal erosion and land slips

Forest fires

Using Oil company data from their environmental impact studies

Other base line data

- Circumpolar vegetation maps and permafrost

How shall we approach ?

Geographic areas of importance - can be difficult to point out, risk for leaving out important key areas

Emphasise the Circumpolar picture

Acknowledge the importance of costal and continental gradients

Important areas:

- North Atlantic region
- North west America
- Central Siberia
- Siberia a mJOR focus
- High Arctic Canada

Transect approaches important

Not only focus on the 30 year temperature changes! Look for longer term changes.

Can be used as hypothesis but not as a good evidence for what is happening. use control sites.

* Important to have focussed questions about climate change impact.

Exsisting data sets make them regional and identify the gaps.

Need for more ITEX sites in Canadian Arctic and Siberia.

Ongoing research programs

Build on Bill Heals overview of existing European programs

SCANTRAN needs to be developed

Additional programs to be checked out relevant for Climate Change

GTOS
GCTE
BESIS
FATE
EMAN
BA HC
PAGÈS

Global programs related to climate change:

- IGBP
- Wetland international
- CAFF-seabird group
- Bird life international

This should be filled in for

- American programs
- Meteorological programs
- Sea ice initiative
- Global terrestrial productivity
- National programs

Some recommendations

Use web-sites for international/global programs

Need of establishing a data centre in the beginning for data collections for data controls and assessments.

AMAP/CAFF together with IASC should get involved NOW in formulating the 5th EU-program get some of these recommendations for Northern issues into the program.

Gaps

No program looking into remote sensing in the arctic: Can be used to detect changes of ecotones and phenology.

Methods

- Permanent plots
- Remote sensing - identify key-spots
- GIS

The methods depend on the scale!

Learn from remote sensing studies in Finland

CAFF is in the process of developing circumpolar vegetation maps

Important to include national efforts in the assessment process

Appendix 4: Proposed Monitoring Areas

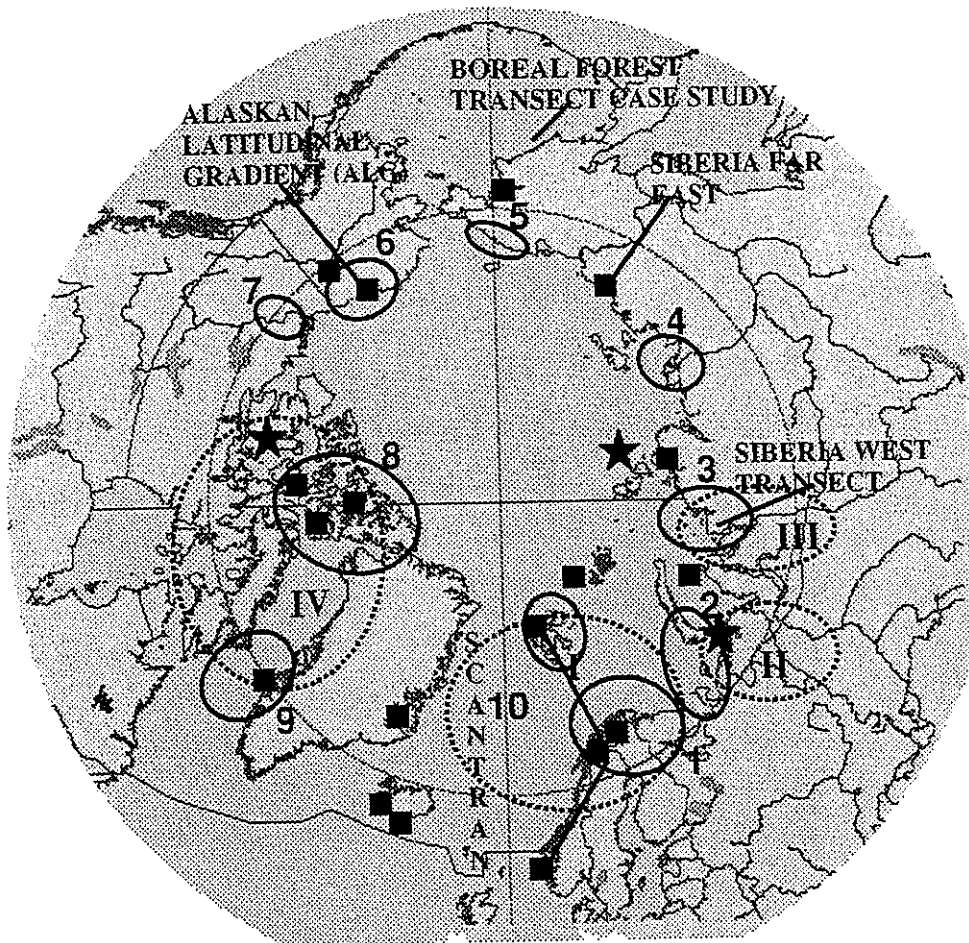


Figure 1.
Monitoring areas for climate change in the Arctic

- - Existing ITEX Network
- - IGBP High Latitude Transects
- ★ - New ITEX Sites (candidates)
- ⊖ - Candidate areas of intensive climate research
- - Proposed Key Areas for AMAP monitoring:
 - 1 - Russian-Norwegian-Finnish-Swedish border
 - 2 - Mouth of the Pechora River
 - 3 - Norilsk / Taimyr Peninsula
 - 4 - Mouth of Lena River
 - 5 - Chukchi Peninsula
 - 6 - Northern Alaska
 - 7 - Mouth of Mackenzie River
 - 8 - Canadian Arctic Islands
 - 9 - West Greenland
 - 10 - Svalbard

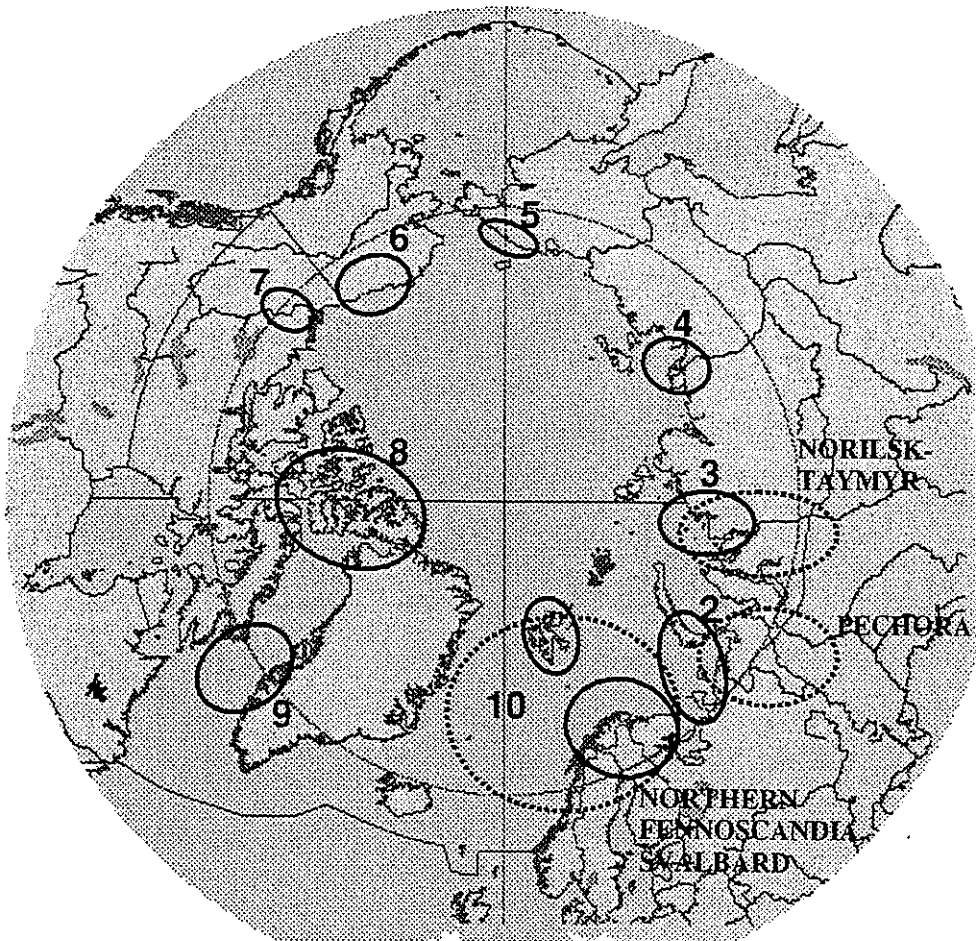


Figure 2.
Suggested location of 3 candidate areas for intensive climate research within Euro Asia (for West Greenland, see Figure 1.)

- - Suggested locations
- - Proposed Key Areas for AMAP Monitoring:
 - 1 - Russian-Norwegian-Finnish-Swedish border
 - 2 - Mouth of the Pechora River
 - 3 - Norilsk / Taimyr Peninsula
 - 4 - Mouth of Lena River
 - 5 - Chukchi Peninsula
 - 6 - Northern Alaska
 - 7 - Mouth of Mackenzie River
 - 8 - Canadian Arctic Islands
 - 9 - West Greenland
 - 10 - Svalbard

Appendix 5: The Members of the 3 Working Groups

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Vivien Ford (CAN)

Bill Heal (UK)

Manfred Lange (D)

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