International Tundra Experiment Update - May 1994 (No. 6)

Chairman's report

ITEX on the roll

Thanks to the hard work of a large number of enthusiastic collaborators, ITEX has now entered a new phase of development: the first results have been presented. The Fifth ITEX Workshop, held in St. Petersburg in March this year, cohesed the largest international attendance since the creation of the program in 1990. A particular sign of health was the high number of young participants, most of them Ph.D. students, representing ITEX parties from many countries. An extensive report on this very successful workshop will be provided below in this newsletter.

In most cases, the results reported during the workshop refer to one season of manipulation in the field, thereby reflecting an environmental „pulse" rather than „press". The average temperature effect of 23 degrees C in the ITEX devices simulates well the difference between subsequent climatic extremes of tundra summers. Nevertheless, the results from various sites in the circumpolar Arctic were not only fairly consistent within species, they also revealed enormous species-specific differences in response to experimental warming. Besides of several multi-authored papers focusing on one or a few species each, we intend to summarize the state-of-the-art of ITEX in two more general publications, one reporting on the climatic effects achieved by ITEX Corners and Open-Top Chambers in the tundra, the other one being an overview of the entire program, including some early results and trends that can be discerned.

Thanks to substantial fundings by the Arctic Systems Science (ARCSS) program of the National Science Foundation (NSF), several U.S. teams will now be able to implement ITEX in Alaska, and an intense summer season of 1994 is expected at Barrow and Toolik Lake. This encouraging development will doubtlessly give a positive feed-back to the entire ITEX for years to come.

ITEX is expanding geographically, and an alpine network of sites has developed within the program, including sites in Colorado (Niwot Ridge), Norway (Finse), Switzerland (Furka Pass and Val Bercla, a new site), and another new site in Japan (Taisetsu Mts., Hokkaido). The Ecological Center of Petropavlovsk also intend to contribute a site in Kamchatka.

ITEX is also expanding conceptually. We have now well-established collaboration agreements with the International Permafrost Association (IPA), the Pan Arctic Flora (PAF), and the Circumpolar Arctic Vegetation Map project. Many of the ITEX sites will from now on be involved in permafrost monitoring, PAF and ITEX will benefit from each other with regard to the species selected for experimentation, and the mappers can tell us about the circumpolar distribution and significance of the vegetation types we are working in, at the same time as we may provide data on the potential stability (or instability) of these ecosystems in an anticipated warmer climate. Higher levels of ITEX complexity (e.g., studies of competitive interactions at the community level, common garden experiments, and analyses of the genetic structure of species) will therefore be updated to meet these needs. As long as we do not lose sight of the basic cohesive idea of ITEX, the time for proliferation and development of the program has come.

Finally, at the end of the Russian meeting, our new mascot, the ITEX Viking provided by Peter Scott, was formally handed over to the CANTEX team, the organizers of the 1995 ITEX Workshop in Ottawa, Canada. On behalf of the Steering Committee, I am sincerely happy with the development of ITEX and look forward to its prosperous future.

Ulf Molau, chair

Report on the 5 ITEX Workshop

The Fifth ITEX Workshop was held in St. Petersburg, Russia, 16-18 March 1994. More than sixty participants had been attracted to this workshop, of which half were Russians half were foreigners. This is a high number of ITEX'ers, probably the highest since the founding of ITEX in Michigan in 1990. Workshop activities included a long series of site and species specific reports, recommandations and suggestions for future ITEX activities. In agreement with the agenda from previous meetings the program may be structured as follows, in order not to list the full program and all speakers:

1. Opening of the workshop
2. Report from the chairman
3. Report of special activities
4. Species specific reports from field sites
5. Working group discussions
6. Reports from the working groups
7. Suggestions for the future work in ITEX
8. Miscellanions

Iuri Chernov opened the workshop. He welcomed the Institute, especially Nadya Matveyeva and Vladimir Razzhivin, for organizing this conference, which is the 5. ITEX Workshop. He welcomed new members, e.g. Switzerland and Norway with alpine sites, Iceland, the British Antarctic Survey and the International Permafrost Association. Ulf showed the present status of 12 ITEX SITES, of which 9 have temperature manipulation with Open Top Chambers and 6 have ITEX Corners. By now four species are being monitored at three sites, five species at two sites and seven of the 16 ITEX species (group 1A and 1B) at one site.

Tables

Pat Webber was unfortunately trapped in administrative duties and was not able to attend the symposium, however, he had sent a letter with good wishes for the workshop and for the future of ITEX. He promised that although the Americans had a late start they would eventual catch up with the rest of the ITEX'ers as funding now seemed to be a reality in the States.

Report from the questionnaire

Esko Saari together with Urban Nordenhäll had extracted the information from the questionnaire sent to arctic sites with long term monitoring. The answars are now computerized and contains 3 kb of information. An extract from the database shows that more than 35 sites have monitoring of plants. Some meteorological observations have been carried out since before 1900. Plant studies go back to 1940 from one site, and at several sites to 1970. Information may be obtained from Esko Saari, Department of Botany, University of Oulu, Fin-Linnanmaa, Finland.

Climate station reports

Barrie Maxwell had received information from only few of the ITEX SITES, not from all of them. Based on older data he showed that most of the Arctic area had seen a slight temperature increase during the last 30 years, but a little decrease had occurred in Greenland. When comparing recent temperatures Disko was lower than the corresponding ITEX sites in Arctic Canada. The year 1992 was exceptionally bad for all sites, as shown by low temperatures, long persisting snowlayers and a low number of degree days in the spring. Barrie Maxwell calls for information from the remaining ITEX SITES, and for climatic information back in time from all sites. Please, send your information, preferably computerized, by post or E-mail. (See new mailing list).

Device for experimental warming

Giles Marion showed an extract of the proceedings from the meeting in..... on the effect of Open Top Chambers and ITEX Corners. There was various ways to present the effect of the two devices, however experimental warming was obtained in both ways. For field related, practical experiences see the section with reports from ITEX sites.

Per Mølgaard, April 1994

Reports from ITEX SITES

Canada: From the CANTEX meeting Joseph Svoboda and Greg Henry reported about funding, persons involved and sites. They called for enhancement of the Canadian involvement in ITEX, and suggested a series of activities, e.g. herbivory in Salix and the effect of warming.

At Baker Lake the number of degree days in 1993 was twice the amount in 1992. The flowering started 8. July in 1992, same day as was the end of flowering in 1993. However, there were more flowers/cushion in 1992 than in 1993 (*Dryas*). All plants died on the sunny side of a snow fence, but in the shade they did better than controls.

At Alexandra Fiord *Carex* was seen to grow for 35-40 days irrespective of the actual weather situation. As a general pattern is was observed that senescence was delayed in the OTC's. This applies f.x. to leaves of *Oxyria*, and new flowers were not produced inside the OTC's although they were outside. Male catkins of *Salix* continued to grow when artificially warmed, but not female, and the growth started later in cones than outside. As is also shown for other ITEX sites *Eriophorum* and *Cassiope* are both much responsive to temperature condi-

continued...

tions. In the latter species the number of flowers was significantly increased in the OTC's. (See also the Swedish report). Experimental warming speeds up flowering, and extends the growing season, as also shown for *Papaver* on Disko (see below).

Denmark/Greenland: Per Mølgaard reported from the ITEX site on Disko, that *Papaver* had higher biomass production in Corners than outside, they started flowering earlier, but had an extended flowering period compared to control plants. Flowers inside Corners suffered more from late frost than flowers outside. Corners facing West had the highest response!

England: In his ‚BRITEX' report Terry Callaghan stressed the importance of nutrient availability. The amount of green material in experimental plants (*Cassiope, Huperzia, Hylocomium*) was more influenced of applied fertilizer than of an experimental warming.

Norway: Frans Wielgolaski showed some present day results related to the old IBP experiments on Hardangervidda. Most surprisingly, the effect of trampling is still obvious after 18 years. An ITEX site is planned on Hardangervidda in the central Norway.

Russia: Nadya Matveyeva showed a gradient in flowering in the three tundra regimes: South, Typical and Arctic Tundra, of which South Tundra is in the Low Arctic and Arctic Tundra is in the High Arctic climate Zone. In flowering sequence the South Tundra is first and Typical Tundra latest. Flowering starts earlier in Arctic Tundra because the flowers are preformed from the previous year. Other Russian members called for extension of ITEX in subjects like entomology with emphasis on soil microarthropods, and plant physiology in the sense of respiration processes.

Sweden: Mikael Steenström reported his experiences with OTC's and Corners: Snow accumulates in OTC's, Snow Buntings predate more fruit inside OTC's than outside and insects stay longer inside which may increase the near neighbour pollination. No influence was seen on the number, yield and weight of seeds in *Saxifraga oppositifolia*. No effect of Corners was observed apart from a very low number of seeds per capsule. Corners fill up with water! However, they all faced the same way, uphill?
On *Dryas* there was no effect on nutlet weight and germability due to the OTC's, but some influence on the prefloration time and leaf size.

For *Cassiope* Mats Havström showed that number of leaves is dependant on the previous years temperature whereas the size of leaves is determined by this years temperature. Plants in the high Arctic have few large leaves, plants in low Arctic many, but smaller leaves. Shading has an important influence on the growth and flowering. The actual number of leaves correlate well with the temperature at the habitat.
In *Salix herbacea* Urban Nordenhäll had observed male flowering every year, but females do not flower the year after a high fruit set.
Ulf Molau reported on the different behaviour of *Ranunculus* and *Eriophorum*, however they both have higher seed set and germability due to experimental warming.

USA: Gus Shaver informed of the database at Woods Hole with information on plants, animals and climate. Via the internet it is possible to call up and take down information as you may need. How to do it, see elsewhere in this issue of the ITEX update.
More reports on the response of *Eriophorum* may be summarized here in connection with observations from Alaska (Toolik Lake), however, this species was also reported from Canada and Sweden: Good years for flowering at one site are good years for flowering at all sites. There is a delay of two years after application of fertilizer before a massiv flowering is seen. It seems that accumulation of nutrients determines the biomass production and flowering, which probably can explain the fluctuations and simultaneous flowering. Two ways of looking for response was identified:
1) Initial vs. sustained response
2) Rate of response vs. amount of response

Marilyn Walker showed the results of a snow fence experiment at Niwot Ridge. A late snow melt gives shorter leaves in *Aconastylis rossii*. Response was observed in cones after three weeks of experiment. She called for standardization of measurements in ITEX. Skip Walker showed the layout of a 1 x 1 km ITEX grid with poles 100 m apart for large scale monitoring.

Inclusion of observation of soil related responses to experimental warming would extend the value of ITEX. Hence, Fritz Nelson advocated for implementation of active layer monitoring as ITEX baseline studies.

Reports from the working groups

Group 1: **Plant response variables**
Report from Urban to be included: E-mail

Group 2: **Extension of ITEX: Alpine Network and Southern Hemisphere:** Handwritten report from Felix

Group 3: **Technical device and experimental design** (Per Mølgaard)

As experiments are already running it it difficult to change layout now. However, based on reports from the field sites it should be stressed that ITEX Corners be placed in groups of four facing North, East, South and West, respectively.

It is difficult to compare the OTC's with Corners, but the reference observations must be as good as possible. Their value will increase with time!

Organize the reference plots so that they can be relocated. Use pegs, grids, photography or other device. The design depends of the plants structure, and must be decided by the experimentor.

Take into account the statistical method to be used when designing the experiment. For example, organize snow melt experiments in blocks to avoid a gradient in the terrain.

It is impossible to make a complete random layout of the experiment. Therefore, choose plots for experiment and control in the same way (parallel) and decide afterwards which is what.

Calibrate your instruments according to the proper manual.

Group4: **Extension of ITEX: Competition, community effects, phenotypic plasticity, soil processes, etc.**
Gus Shaver, Rapporteur

Most of the extensions of ITEX have been discussed at previous meetings and in previous reports. Among the most important extensions are:

1.) Competition/species interactions under working
2.) Comunity/ecosystems changes
3.) Phenotypic plasticity
4.) Genetic structure of populations
5.) Insects and other small animals, both above and below ground
6.) Soil processes (nutrient cycling, thaw)
7.) Changes in plant chemistry, especially 2^{o} chemistry
8). Distinction between short-term vs. long-term responses and their controls
9.) Distinction between changes in plant allocation versus changes in <u>total</u> productivity, growth, or biomass.

Current research designs need relatively little change to accommodate these extensions. However, some additions to the current designs and the current suite of measurements would be particularly useful. These include the following:

1.) <u>Common garden experiments:</u> These are particularly important to the extension of ITEX into the area of phenotypic plasticity, genetic structure of populations, and controls on growth in the absence of competition.

2.) <u>OTC's and corners:</u>

a.) To document effects on whole communities and ecosystems, it will probably be necessary to make some destructive harvests. To accomodate these harvests, additional replicates should be added.

b.) To interpret effects on communities and ecosystems, better definition of the area affected by the manipulation is needed. Is a whole community being warmed or a single plant? What is the size of a plant's „neighbourhood" relative to the area being warmed?

c.) Measurement of changes in soil temperature and thaw should be made, and some measure of change in soil nutrient availability should be developed (buried bag incubutions? in exchange resins?)

d.) Manipulations of plant density, and species removal or addition, would be useful extensions to current studies.

e.) More work is needed on environmental changes within OTC's and corners to better define the variables plants are actually responding to (e.g. wind vs. radiation vs. temperature).

Group 5: **Collaboration with related programs and activities**

continued...

Participants, discussion group 5
Anisimov, Oleg
Gertsen, Margarita
Kotov, Anatoly
Leibman, Marina
Maxwell, Barry
Murray, Dave (recorder)
Nelson, Fritz
Sumina, Olga
Zhurbenko, Mikhail

Objectives

This discussion sought ways to improve ITEX coordination with other activities having similar and overlapping interests and thereby

1) promote collaboration and data exchange among these groups and to prevent duplication of efforts,

2) focus on sources of funding to improve financial support to ITEX and ITEX-related research.

Recommendations

1. ITEX secretariat develop specific assignments and expectations for liaison with other groups, taking advantage of joint memberships of ITEX participants in these other activities, e.g. International Permafrost Association (IPA), Panarctic Biota Project (PAB), Circumpolar Arctic Vegetation Mapping Project, Conservation of Arctic Flora and Fauna initiative of the Arctic Environmental Protection Strategy (CAFF), International Organzation of Plant Biosystematics (IOPB), Man in the Biosphere High Latitude Directorate (MAB), and International Arctic Science Committee (IASC).

2. ITEX secretariat, through the ITEX membership, seek endorsements of academics of sciences, royal societies, and governmental funding agencies in each of the participating countries as a critical step toward submission of proposals for funding.

3. ITEX secretariat through the Steering Committee prepare a journal paper in which ITEX objectives, sites, accomplishments, and prospects are presented.

4. ITEXC secretariat consider expanding its disciplinary composition to include more directly the field of systematics (perhaps through IOPB), for which the results of ITEX studies in reproductive ecology, genetic structure of populations, geographic variation, and phenotypic plasticity are also important topics.

Group 6: Extension of ITEX: Mechanism of temperature effects on plant growth

Report from Dr. I.M. Kravkina and Olga V. Kudriovtseva

Chairmen of the project:
Dr. I.M. Kravkina and Dr. O.V. Kudriovtseva
Komarov Botanical Institute
Prof. Popov Street 2
197 376 St. Petersburg

Russia
E-mail: binran@glas.apc.org

List of participants:
A.V. Sjutkina, BIN RAS
L.T. Bulola, BIN RAS
O.A. Sensichatova, BIN RAS
Y.V. Gamalei, BIN RAS
T.J. Bulik, BIN RAS
K.E. Chebotareva, BIN RAS
E.L. Kaipiainen, BIN RAS
E.V. Vosnesensky, BIN RAS
L.N. Burdinsky, Polar-Alpine Bot. garden
T.M. Balicher, Polar-Alpine Bot. garden
O.S. Yudina, BIN RAS
V.K. Jizov, Polar-Alpine Bot. garden

Research point
Kola peninsula, Polar-Alpine Bot. garden
(mountain tundra)

List of objects:

1. Dryas *octopetala*
2. Papaver lapp*onica*
3. Saxifraga o*ppositifolia*
4. Silena acaulis
5. Ranu*nculus nivalis*
6. Salix arcti*ca (polaris, reticulata)*
7. Astragalus subpolaris
8. Oxyria dig*yna*

Research methods:

I. Soil and air temperature measurements in natural conditions and in chambers
II. Phenological observations
III. Comparative research:
   1) Plant morphology and growth
   2) Leaf structure and tissue ultrastructure
   3) Gas exchange; photosynthesis and respiration
   4) Export and storage of assimilates
   5) Nitrogen metabolism

IV Diurnal and seasonal changes of the anatomical and physiological parameters in natural conditions and in temperature chambers.

continued...

Summary - ITEX Steering Committee Meeting, 18 March 1994, Lakhta, Russia

COMMITTEE MEMBERSHIP: Josef Svoboda resigned from the committee and was replaced by Greg Henry representing Canada. Volodya Razzhivin was added representing Russia. Kari Laine was added representing Finland. There is no desired representation from the UK, Norway, or Switzerland. The committee now consists of Ulf Molau (Sweden, Chair), Marilyn Walker (USA, Co-Chair), Per Molgaard (Denmark, Secretary), Greg Henry (Canada), Kari Laine (Finland), Volodya Razzhivin (Russia), Pat Webber (USA, ex-officio). All members were present with the exception of Pat Webber.

COORDINATION FUNDING: The Danish Polar Center is now funding the ITEX Secretariat at 100% through the MAB NSN.

IGBP GCTE: The link to IGBP is still not formalized. Although IGBP remains interested in the idea of an extensive experiment, they have not yet embraced the low-tech concept of ITEX. Walt Oechel is the most important ITEX link to IGBP-GCTE.

ITEX POSTDOC: The idea of an ITEX postdoc who would work on a synthetic/modeling level as well as on coordination of data was discussed. There were lots of enthusiasm for such an idea as well as a feeling that ITEX is now at a point where it would benefit from such a person. The problem of how to fund the position and where it would be housed was discussed but not resolved. Some ideas were a NATO fellowship could fund an American to work in a NATO country (such as at the DPC), the possibility of EC fellowships were discussed although no one had any details, competitive funding through a granting program in an individual country, etc. Possible candidates included Esther Levesque, Peter Scott, and Hope Humphries, with the recognition that there are undoubtedly many other well-qualified recent graduates who might be interested in such a position. All members agreed to consider funding possibilities within their own countries. Marilyn Walker agreed to contact Pat Webber for funding ideas within the US.

AMENDMENTS TO MANUAL: Amendments to the manual are to be sent (in binhexed Microsoft Word form if possible) to Ulf Molau who will incorporate them into the manual. Please do this as soon as possible since Ulf is moving to Alaska in mid-April. Manual updates will be new pages rather than an entirely new manual. Updates include changes to the species list to include Silene acaulis and Polygonum viviparum, particularly as alpine target species.

NEWSLETTER: The next newsletter will be written and distributed by Per Molgaard, who will send a draft to Marilyn Walker for editing. It will include a summary of the Lakhta meeting.

BIOSCIENCE PAPER: It was agreed that a multi-authored paper explaining the ITEX program would be submitted to BioScience. Marilyn Walker will coordinate and interact with the journal editors. Although BioScience is an American journal, it is well read internationally, and its format was considered the most appropriate for such an overview. The basic outline that was agreed upon was:

Introduction (Walker)

- Historical Perspective (IBP program etc)
- What is ITEX?
- Why ITEX?
- Objectives and Hypotheses

The Sites

- Climate (Maxwell)
- Map (Marion)

The Experiment

- Site by Species Matrix (Henry)

Results

- Summary of initial responses (Molau)

Discussion (Walker)

- Extensions of ITEX
  - Community and ecosystem responses
  - Links to other programs
- Challenges of an international program
  - Funding
  - Coordination
  - List # of students, postdocs, PIs, etc.

Postscript (following main article)

- How to get involved in ITEX

[My notes were rather sketchy on this section, and I think that I may have left off some contributors of specific sections. Please send corrections and I apologize for anyone not on here. I am sure other SC members had specific assignments.]

Future Meetings

The next meeting will be in May 1995 in Ottawa, Canada, hosted by Greg Henry with funding from the Canadian government. The 1996 meeting will be in Denmark.

E-MAIL ADDRESSES

continued...

The e-mail addresses of committee members are:

pm@charon.dfh.dk
userghrh@mtsg.ubc.ca
kari.laine@oulu.fi
ulf.molau@systbot.gu.se
pwebber@nsf.gov
mwalker@taimyr.colorado.edu
binran@glas.apc.org

Publications

Time has come now to present ITEX in a more broad sense to biologists and climatologists. After some discussion it was agreed that the steering committee works out two publications of which the one should present the scope of ITEX, the general organization of the work, the sites involved, methodology and some species specific short term results. Also the event of a ‚very bad year' in 1992 could be highlighted. BIOSCIENCE seems the best periodical for this paper, which should be prepared as soon as possible, preferably before the field season 1994.

The other paper should cover the temperature enhancement devices, Open Top Chambers and ITEX Corners. This publication could be based on some of the information already presented by Giles Marion and coworkers (1993), but the temperature values should be more plant related, and in that way closer to the aims of ITEX. This paper should be adapted to Arctic and Alpine Research.

The steering committee in extensu will take hand on the first publication, whereas Giles Marion, Greg Henry and Per Mølgaard together with Terry Callaghan are responsible for the second one. Both papers must be published as soon as possible, short term response data are available, and simultaneous publication would give the advantage of crossreferences. After the 6 workshop, which is planned to take place in Ottava in 1995, a series of species specific papers can be published in Arctic and Alpine Research, with reference to these two parts in preparation now. No further organization of publishing groups was attempted, as this matter was left for individual initiatives. See below.

Call for papers

In connection with the 6 ITEX workshop planned in Ottava in 1995 the species specific presentations should be organized so that a joint publication in Arctic and Alpine Research can take place. Well in advance for the meeting contributions to the proceedings must be sent to the organizers, alias Greg Henry.
Manuscripts will be accepted no later than end of December 1994!

Call for ITEX collaborators in Yamal

We are interested in joint work with a botanist working for an ITEX project. The botanist should perform climatic and other needed measurements on his own with own equipment. We can offer good field sites for this work and very cheap accomodation and food supply.

If interested, please contact Station NSO (Manual)
Vaskiny Dachy, Yamal Peninsula, West Siberia, Russia

Leibman Marina - geocryology, management, Russia, 129085 Moscow-Zvezdny Blv., 5/2-28 tel. 095 215-86-66, e-mail: promanovsky@glas.apc.org

Zvereva Tatyana - cryopedology, Russia, 195269 St. Petersburg, Svetlanovsky Pr. 93-292; tel. 812 532-45-80.

Rebristaya Olga - geobotanist, Russia, 196211 St. Petersburg, Kasmonavtov Pr. 19/3-23, tel. 812 264-13-47.

Objectives:	Stability of north ecosystems study: topography, geocryological conditions, cryopedologic geobotanic descriptions, plant and soil restoration study on disturbed areas.
Measures:	Soil temperature to the depth of 10 m, active layer depth, landslides and ravins morphology, mechanical, physic-chemical, agrochemical properties of soils, soil micromorphology. Botanic measurements were done only in natural and disturbed surfaces (not ITEX manipulating) by Bruce Forbes: forbes@envisci.uoquelph.ca. You can communicate with him for more information.

We are interested in joint work with a botanist working for ITEX project if he perform climatic and other needed measurements by himself. Food and accomodation will be rather cheap.

British Antarctic Survey now in ITEX

From the British Antarctic Survey Ron Lewis-Smith reported on BIOTAS (Biological Investigations of Terrestrial Antarctic Systems). Colonization processes was a main subject. Spores and plant fragments (lichen and moss) may survive for centuries! Experiments were carried out with ‚closures', closed but ventilated chambers to manipulate temperatures and UV-radiation. The ozon-hole over the Antarctic is by now spreading to S.America, New Zealand and Tasmania. The effect on the terrestrial ecosystems in the Antartic may precede what we anticipate for the Arctic. Having BIOTAS associated with ITEX is beneficial for both parts.
In a late night slideshow Ron visualized the life for biologists and the very few animals and plants native to South Georgia, where the Scientific Station literally was placed in the breeding area for the Fur Seals and Elephant Seals.

Seeds from arctic circumpolar plants

From literature studies and from measurements of seeds from Kilen in North Greenland it seems evident that the seed size is smaller in Greenland plants compared to conspecific plants from the rest of the Arctic area. The seed size may be crucial for the dispersal over long distances, even for plants with generally small seeds. In order to prove the hypothesis that Greenland plants have smaller seeds than their specific counterparts in other regions of the Arctic, I ask ITEX'ers from all sites, kindly, to send me samples of seeds from their localities in order to obtain a general coverage of at least a few selected species. These would primarily include:

Draba bellii
Draba gredinii/oblongata
Draba subcapitata
Cochlearia groenlandica
Minuartia rubella
Papaver dahlianum/polare/radicatum
Potentilla hyparctica

One or a few pressed plants with mature seeds sent in a paper bag would be excellent. Thanking you in advance

Per Mølgaard
Royal Danish School of Pharmacy
Universitetsparken 2
DK 2100 Copenhagen
Denmark

E-mail address: pm@charon.dfh.dk