STRATEGY AND ACTION PLAN FOR *EX-SITU* CONSERVATION OF THREATENED PLANTS IN FINLAND

Action 11: Assessment of the impacts of climate change on biodiversity in coastal ecosystems and the implementation of new policies and conservation strategies

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VACCIA

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Cover: Cypripedium calceolus (classified vulnerable) growing in the Botanical Gardens of the University of Oulu, Photo: R. Hiltunen.

Foreword

Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation (VACCIA) was a EU LIFE+ project in 2009–2011. VACCIA was coordinated by the Finnish Environment Institute and the participating institutes included the Finnish Meteorological Institute and the Universities of Helsinki, Jyväskylä and Oulu.

VACCIA was divided into thirteen Actions. Here we summarise part of the work carried out in the Action 11: 'Assessment of the impacts of climate change on biodiversity in coastal ecosystems and the implementation of new policies and conservation strategies' coordinated by Marko Hyvärinen. The present paper is the third deliverable from the Action. The two other ones are: 'Climatic and Habitat Contributions to Populations of Managed Forest Landscapes' by Markku Orell et al. and 'Between devil and (not a very) deep blue sea: Endangered sea shore species in a changing climate' by Sami Aikio et al. All reports of VACCIA are found in the web page of the Finnish Environment Institute (tinyurl.com/6vv8yvk).

The strategy and action plan for *ex-situ* conservation of threatened plants in Finland describes the essential links between Finnish national solutions in *ex-situ* conservation of native plants and international processes that started after the Convention on Biological Diversity in 1992. The schedule for the implementation of the action plan is left open. However, it should be understood that Finnish implementation of *ex-situ* conservation is bound to the Global Strategy for Plant Conservation and, hence, the overall aim is to achieve the desired level of *ex-situ* conservation by 2020.

We wish to thank the staff of the Finnish Environment Institute for coordinating the VACCIA project. Special thanks are extended to Martin Forsius, Jussi Vuorenmaa and Irina Bergström whose invaluable help in different stages of the process has been instrumental to the success of VACCIA. We are also indebted to Kari Laine, Jouko Inkeröinen, Riku Paavola and Raija Kivelä of Thule Institute, University of Oulu for their help in the financial administration of the Action 11.

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Abstract

As a part of an EU Life+ funded initiative "Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation" (VACCIA) the living collections of Finnish botanic gardens were investigated to find nationally threatened vascular plant species of known wild origin. In total, 77 accessions within 56 vascular plant target taxa were cultivated as living plants, representing 18% of the total nationally threatened taxa (314). The results of the survey formed were used to develop a national strategy and action plan for *ex-situ* conservation of threatened native plant species in Finland.

The action plan includes five targets that aim to (i) secure the extant *ex-situ* collections, (ii) increase in the number of *ex-situ* conserved taxa, (iii) development of *ex-situ* conservation to boreal and arctic-alpine species, (iv) incorporation of *ex-situ* conserved species into restoration and reintroduction programmes (v) and wider use of *ex-situ* collections in education and public outreach. These targets are achieved by taking thirteen specific and concrete actions that, for example, include an establishment of a national seed-bank for threatened native species. The overall target of the strategy and action plan is to reach the level of 40% of threatened species in *ex-situ* conservation by 2016 and 75% by 2020. In order to achieve this 180 new taxa (at the species, subspecies, or variety level) will be collected in addition to the 57 already *ex-situ* conserved. Moreover, the material would be maintained in conditions where there is no danger of cross-breeding with closely related taxa. For a genetically representative sample, seeds from as many populations as possible, and from 50–200 genetic individual in the ideal case, should be collected.

Introduction

Conservation of biodiversity

Conservation of biodiversity is one of the key ways to maintain both well established and potential future ecosystem services that, among other things, underpin our economy and well being. Biodiversity is our life insurance, giving us food, fresh water and clean air, shelter and medicine. It also mitigates natural disasters, pests and diseases and contributes to regulating the climate. Therefore biodiversity was seen as an important component in VACCIA project, in which the vulnerabilities of a variety of ecosystem services to changes in the environment were assessed.

The natural diversity of plant life is in a key role as it forms the basis of nearly all other life on earth and, hence, conservation of native plants is seen as high priority everywhere. Current rates of species extinction are staggering and comparable only to some major catastrophic events in the evolutionary history of life on earth (Quammen, 1997).

Driven mainly by human activities, species are currently being lost 100 to 1,000 times faster than the natural rate (Wilson, 1992). This is mainly due to changes in land use and entailing loss of habitats. Moreover, changes in climate are already adding to and enhancing this destructive trend. In order to mitigate these threats, new ways to adapt to rapid changes are needed. One of the outspoken aims for the whole humankind is to halt the loss of biodiversity (CBD, 2002) using a variety of means.

Plants are universally recognised as a vital component of the world's biological diversity and an essential resource for the planet. In addition to the cultivated plant species used for variety of purposes, many wild plants have great economic and cultural importance and potential, as future crops and commodities more so as humanity grapples with the emerging challenges of environmental and climate change. Every day new scientific discoveries of novel ways of using plants are made. Plants play a key role in maintaining the planet's basic environmental balance and ecosystem stability and provide an irreplaceable component of the habitats for the world's animal life. At present, a complete inventory of the plants of the world has not been assembled, but it is estimated that the total number of vascular plant species may be of the order of 400,000 (e.g. http://tinyurl.com/d3hr2a8).

Global Strategy for Plant Conservation (GSPC)

The Global Strategy for Plant Conservation (GSPC), which sets several outcome-oriented global targets for 2010, was approved in Decision VI/9 of the Conference of the Parties to the Convention on Biological Diversity in 2002. Botanic gardens and their international collaborative organisation Botanic Gardens Conservation International (BGCI) have actively promoted the Global Strategy for Plant Conservation (GSPC, CBD, 2002) and its implementation by publishing a specific agenda for biodiversity conservation (Wyse Jackson & Sutherland, 2000) and taking part in the revision process that lead to the adoption of a new GSPC in COP 10 in Nagoya, Aichi (COP 10), with a number of revised targets.

The updated Global Strategy for Plant Conservation consists of the following five objectives that are subdivided into a total of sixteen targets:

Objective I: Plant diversity is well understood documented and recognized

Target 1: An online flora of all known plants.

Target 2: An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.

Target 3: Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared.

Objective II: Plant diversity is urgently and effectively conserved

Target 4: At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration.

Target 5: At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.

Target 6: At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity.

Target 7: At least 75 per cent of known threatened plant species conserved in situ.

Target 8: At least 75 per cent of threatened plant species in ex-situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Target 9: 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.

Target 10: Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.

Objective III: Plant diversity is used in a sustainable and equitable manner

Target 11: No species of wild flora endangered by international trade.

Target 12: All wild harvested plant-based products sourced sustainably.

Target 13: Indigenous and local knowledge innovations and practices associated with plant resources maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care.

Objective IV: Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life on earth is promoted

Target 14: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes.

Objective V: The capacities and public engagement necessary to implement the Strategy have been developed

Target 15: The number of trained people working with appropriate facilities sufficient according to national needs, to achieve the targets of this Strategy.

Target 16: Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy.

Measures to implement GSPC are currently being put in place at international, regional, national, and subnational levels all around the world. In many countries, specific national targets and detailed plans for implementation are being incorporated into relevant programmes and initiatives, including national biodiversity strategies and action plans.

BGCI has published several handbooks to guide the practical implementation of GSPC in botanic gardens (e.g., Oldfield & McGough, 2007; Hawkins et al., 2008). Botanic gardens participate in various conservation, reintroduction, and restoration programmes (e.g., Burney & Burney, 2007). The study of living collections has contributed to the body of knowledge on threatened species (Norstog et al., 1986), and herbarium collections complemented by other data are used for conservation planning (Peralvo et al., 2007) and predicting species response to climate change (Primack & Miller-Rushing, 2009). However, the potentially great conservation value of the core resource of botanic gardens, the living collections with an estimated 80,000 plant species (www.bgci.org) all over the world, is unfortunately often compromised by inadequate databasing, narrow genetic representation, and various genetic problems (e.g., Badley et al., 2004; Rae, 2009; Sharrock & Jones, 2009). On the other hand, plant species globally extinct in the wild have been found in garden collections (Maunder et al., 2000, 2004a), and the populations of some species have been restored from that source (Fraga et al., 1997). Hence, each botanic garden should thoroughly survey its collections, to be able to contribute to the conservation of the world's flora.

European Strategy for Plant Conservation 2008-2014 (ESPC)

ESPC is a proposal by Planta Europa for an European subordinate for GSPC and it includes similar objectives. Those two targets that are relevant for *ex-situ* conservation are:

Target 8.1: "Store in gene banks 60% of European threatened species, or species and populations of particular interest (e.g., populations under extreme conditions, or at the edge of their distribution areas, species potentially at risk from the effects of climate change, including species with a trans-European distribution) and implement restoration programmes for 50 species"

Action 8.1: "Evaluate existing ex-situ collections, to improve their conservation benefit by evaluating the quality of associated data, such as provenance. Priority should also be given to threatened species with little information on their ecology, biology or conservation status."

Target 8.2: "At least 10 priority species in each country held in gardens undertaking conservation activities or research institutes active in that country, and research initiated into storage

methods, recalcitrant seeds, autecology, propagation methods including germination and cultivation techniques, and re-introduction methods".

Finnish implementation of the *ex-situ* conservation targets of GSPC

In Finland, many elements of the GSPC are incorporated into the national strategy and action plan for conservation and sustainable use of biodiversity in Finland 2006–2016 (Heikkinen 2007), which is currently being revised and up-dated in order to take into account the accumulating evidence of rapid changes in climate and to extend the scope period of the strategy to 2020. Moreover, another important strategic paper in preparation by Finnish Environmental authorities is the National Action Plan for Species Conservation, which will direct, for example, species-specific measures to be taken to achieve the best possible protection state of endangered species (http://tinyurl.com/cks039w).

In Finland, crop genetic resources (GSPC Target 9) are conserved under the National Plant Genetic Resources Programme (Veteläinen et al. 2008) and the development of the national strategy for the conservation of their wild relatives has recently been started by FMNH and MTT Agrifood. However, protecting native wild plants outside their natural habitats (GSPC Target 8) is in its infancy. This is largely due to extensive, seemingly intact natural and semi-natural areas in comparison to more fragmented landscapes in most other European countries. Still, the changing climate and the decline of valuable habitat types (Raunio et al., 2008; Normander et al., 2009; Auvinen et al., 2010) render it important to nationally evaluate the current situation and future needs of *ex-situ* conservation of plants. In Finland numerous plant species (e.g., the arctic *Primula sibirica* group, e.g. Rautiainen et al. 2007b) occur at the edge of their distribution area and distinct subspecies or races can be distinguished for many widely distributed species (Hämet-Ahti et al., 1998). Thus the notably poor Finnish native flora nevertheless provides invaluable genetic variation to the European flora as a whole (Lesica & Allendorf, 1995).

In short, Finland has adopted the GSPC but when it comes to *ex-situ* conservation of native plants has neither implemented it nor officially planned out the implementation yet. Hence, there is an urgent need to fulfil this obligation in the face of the rapid changes in the environment brought about by climate change. However, for ages there has been *ex-situ* conservation and research activities in botanic gardens, which represent a unique source for conservation biology worth exploring in more detail.

Ex-situ conservation status of threatened wild plants in Finland

As part of an EU Life+ funded initiative "Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation" (VACCIA, tinyurl.com/6vv8yvk), we surveyed the

existing *ex-situ* collections of nationally threatened vascular plant species in Finland (Miranto et al. 2011). To assess the value of the accessions for eventual reintroduction programmes, the quality of data on origin and genetic intactness were evaluated. The results presented in Miranto et al. (2011) form a basis for this provisional national *ex-situ* conservation strategy and action plan for native plants.

According to the results only 77 accessions within 56 vascular plant target taxa were cultivated as living plants, representing 18% of the total nationally threatened taxa (314). The results of the survey are consistent with results from similar studies carried out at botanical gardens in other countries, showing deficiencies in intra-species and within-population diversity, but the accuracy of origin data and genetic intactness of the accessions were found to be good.

Current methods and facilities

European native plants are, in general, suitable for seed storage as they tolerate 3.5 – 6.5% water content and temperatures of -20°C (i.e. orthodox species, ENSCONET 2009b). Some species, however, either do not tolerate this (e.g. *Najas flexilis* and some *Salix* spp.; Liu et al. 2008) or they do not produce living seeds (e.g. *Arctophila fulva*, Rautiainen et al. 2007a) and they have to be conserved either in living collections or in micropropagation and cryogenic storage. Seed-banking is, of course, the primary method for *ex-situ* conservation.

In Kumpula Botanic Garden (Finnish Museum of Natural History, FMNH) there is room reserved for the infrastructure of a national seed bank. Funding of the seed-bank is, however, still not secured. The Botanical Gardens of the University of Oulu has got a new cryogenic storage unit in its micropropagation facility. Moreover, Oulu has a long experience in micropropagating different plants species (Fig 1.).

Fig 1. Endangered grass species, Arctophila flulva, in micropropagation. Photo: M. Hyvärinen.

Living collections of botanic gardens are at the moment and will be an important way for *ex-situ* conservation. Living outdoor collections are also important in teaching propagation of these plants and increasing

public awareness. For instance in Britain and Ireland PlantNetwork formed by botanic gardens has initiated a so-called 'Target 8' project in, which gardens 'adopt' certain threatened plant species to be grown in the garden. Gardens in the network try to develop best possible methods for the propagation of their adopted species and find ways for re-introduction (Frachon et al. 2005). In Finland there are only few botanic gardens that could operate in the field, but even more so, efforts for *ex-situ* conservation need to be coordinated.

Strategic plan

Ex-situ conservation of native plants in relation to other conservation strategies

The National strategy and action plan for the conservation and sustainable use of biodiversity in Finland 2006–2016 (Heikkinen 2007) is currently being revised and up-dated in order to take into account the accumulating evidence of rapid changes in climate and to extend the period to 2020. At the current stage of preparation it seems that the GSPC and its implementation in Finland will receive more attention than before. However, *ex-situ* conservation will remain an insignificant part in the palette of methods and actions in these most central base documents of Finnish biodiversity management and conservation. This accentuates the need for a separate in-depth strategy and action plan on *ex-situ* conservation. The current paper fills the gap concerning native plant species.

Moreover, another important strategic paper in preparation by Finnish Environmental authorities is the National Action Plan for Species Conservation. In the preparation of this, *ex-situ* methods have been considered as an additional means to conserve native species, albeit at a rather superficial level. The plan includes priority setting as regards the urgency of measures to be taken to save the most severely threatened species. In most taxon groups no or only one species have been considered to be in need of *ex-situ* conservation. However, within vascular plants, eleven critically endangered species are evaluated as possible targets for *ex-situ* conservation action. It is clear that the current paper will add much-needed insight on *ex-situ* conservation to the up-coming national species conservation action plan.

Since 60% of Finnish native plant species can be classified as crop wild relatives (CRW; Korpelainen et al. 2008), collaboration between Finnish botanic gardens and MTT Agrifood as well as NordGen - the Nordic Genetic Resource Center is utterly important. Quite recently MTT Agrifood and Finnish Museum of Natural History (Botanic Gardens in Helsinki University) started planning the Finnish CRW strategy.

Setting priorities

A new priority list of those endangered vascular plant species that need urgently to be *ex-situ* conserved is one of the starting points in the process of GSPC implementation. According to

the latest Red List of Finnish species there are 197 nationally threatened (IUCN categories VU, EN, CR) vascular plants and 122 Near Threatened (NT) vascular plant taxa occurring in Finland. Moreover, 183 bryophyte species are classified as nationally threatened (categories VU, EN, CR), and 124 Near Threatened (NT) in Finland. 13 bryophyte species, all of which are included also in the national Red List, have additionally been included in the Habitat's Directive.

In selecting the focal taxa for ex-situ conservation, the national Red List and the Habitats Directive are used as starting points. The Habitats Directive species with unfavourable conservation status and high national threat category should be of top priority. Moreover, those Habitats Directive species that are not under sufficient protection by the Natura 2000 network and mainly occur outside protection should be taken into account.

As the national Red List is rather extensive, prioritisation is needed, first, because resources are limited and, second, *ex-situ* conservation may not be the best solution for all taxa. The aim is to find first 50-70 vascular plant taxa, which have the highest risk of regional extinction and which, at the same time, would clearly benefit of *ex-situ* activities (such as reintroductions to the disappeared sites, assisted migration or strengthening the populations with *ex-situ* propagated individuals). Also those taxa, whose genetic uniqueness need to be ensured by taking material to seedbank, cryopreservation or outdoor collection of gardens will be identified. This list will then be combined with the one prepared in ENSCONET by the Botany Unit of FMHN for the collection of boreal and subarctic taxa (http://tinyurl.com/7ltgg6h). After this the list will be constantly reviewed and completed during the course of the project so that the selection of 180 taxa is possible.

The following criteria will be used to rank the taxa:

(i) the taxa in highest threat categories (CR, EN) or with strongest decline

(ii) taxa with problems in reproduction for example due to too small population size

(iii) threat status in the neighbouring areas (Baltic area and Europe). If the taxon is threatened both in Finland and in wider geographical area it's status will rise in our assessment

(iv) disjunct populations or lower taxa with high genetic differentiation may need to be preserved in permanent seed bank collections

(v) taxa threatened by hybridisation should be spared from genetic deterioration by keeping them separate from close relatives that may impair their genetic integrity

(vi) taxa clearly threatened by climate change

Initial selection between different ways of ex-situ conservation will also be made at this stage according to the principles put on by Pence (2011, see Fig 2).

After producing the initial priority list for species it is possible to identify the exact sites where the various activities (seed or plant tissue collection) can be carried out. In this work the Taxon-database (In Finnish: Eliölajit-tietojärjestelmä) maintained by SYKE is of great help and support. This database includes extensive data on threatened species and their present and former sites. In selecting the sites for the activities of this project, the following issues are to be taken into account: the site has to be ecologically suitable for reintroduction and it should situate on a protected area to ensure the future success of the introduction, when operating on private land the land-owner must be willing to co-operate.

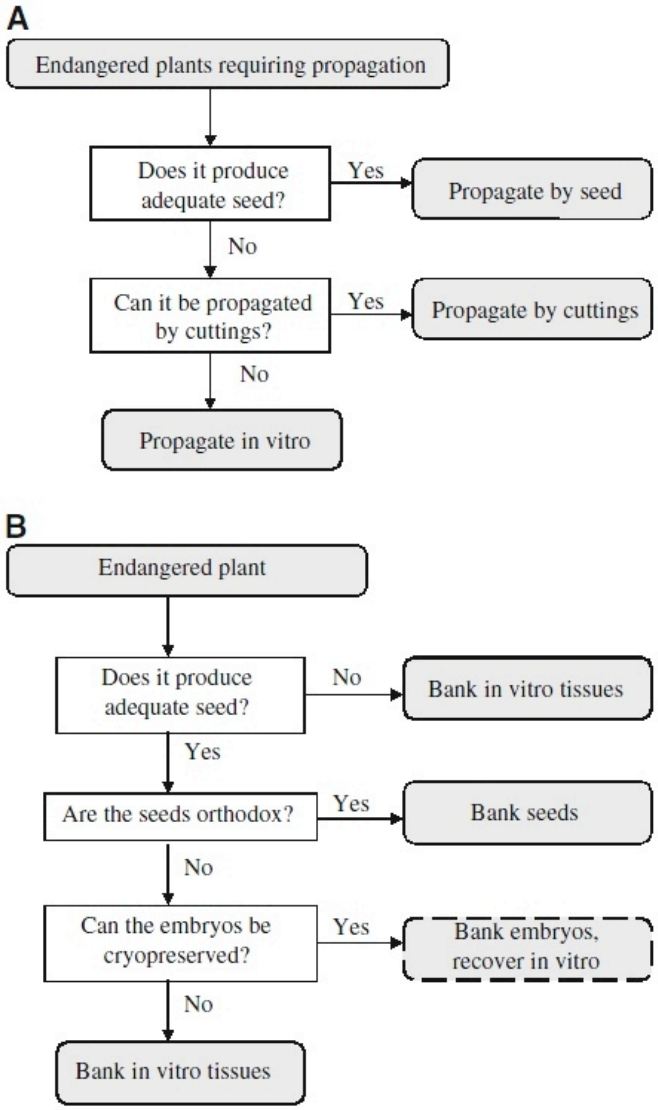

Fig 2. Ex-situ conservation: method selection procedure (Pence 2011)

A permit is needed to collect any living parts of protected species and to collect living material from protected areas (Nature Conservation Act 20.12.1996/1096). SYKE will assist and give necessary supporting statements in applying permissions from the relevant authorities (ELY Centres and Metsähallitus). After the species selection has been implemented, and the list of species and habitats is known, the required permissions will be applied from the local conservation administration offices (regional Centres for Economic Development, Transport and the Environment for privately owned areas, and Metsähallitus for state-owned areas). SYKE will contribute on the permission application by advice on the application process and contacts to local threatened species and habitats responsible officers. Furthemore, SYKE has a role as background support for the permit applications. SYKE will assist also in reporting the use of admitted permits to the local administration, which is in most cases a requirement for permits. The permit applications and reports need to be made carefully in order to avoid potential conflicts with authorities and land-owners.

For meeting the national targets, a workable infrastructure, including a national seed bank, should be established. Moreover, for those native plants that do not set seed, *ex-situ* conserva-

tion can be developed on the basis of vegetative propagation, micropropagation, and cryogenic conservation of plant tissues. In cryogenic storage, totipotent plant material is stored for long periods in liquid nitrogen (e.g., at -196 °C) or in its gaseous phase (approx. –150—160 °C). Together with these two *ex-situ* methods, living outdoor collections in botanical gardens, which form the basis for current *ex-situ* collections, should be maintained and developed. Also, the conservation of some special organisms, such as cryptogams (ferns, mosses, fungi, and lichens), needs a great deal of attention, including basic research, if it is to be successfully incorporated into *ex-situ* conservation schemes.

EX-SITU CONSERVATION CRITERIA

The percentages of GSPC deal only with numbers of taxa, not with the quality and genetic representativeness of *ex-situ* accessions. So, in principle, it is possible to fulfil GSPC requirements with a minimum effort without consideration of the quality of material. However, this would hardly be an ideal solution for underlying problems in biodiversity loss. It is generally accepted that it is more important to *ex-situ* conserve in a proper manner those taxa that are in immediate danger for extinction than increase superfluously the percentage of taxa nationally *ex-situ* conserved.

German network of botanic gardens -- Verband Botanischer Gärten -- has defined ex-situ collection as follows: 'German native plant taxa are recognised as ex-situ collections i) if their provenance from a wild population in Germany is documented. Further, ii) genetic identity of the garden population must be safeguarded if the plants are propagated by seeds, i.e. cross-breeding with other plants of the same taxon or close relatives in the garden must be excluded.' This is a good and practical starting point and was anticipated in the survey of Finnish *ex-situ* collections by Miranto et al. (2011). The suggested measures (see the Action Plan below) in Finland are largely based on the same principle as in Germany.

The question of how many populations should be collected depends largely on the structure of genetic variation with the taxon concerned. In many cases there is only one viable population left so this question is not relevant. If there are many populations left and if their genetic differences are know, a detailed plan of collection can be made. Otherwise some rules of thumb can be applied. If the geographical distribution of the taxon concerned is very narrow and there are one or few populations it might be a good idea to collect from all populations. If there are several populations left and there is no specific information about the genetic structure of them, one must carefully consider if the breeding system of the species and population structure give any indication of the level of genetic differentiation between populations; for example wind pollination together with short distance between populations may indicate gene flow between populations and low level of differentiation. Also differences in habitats may indicate that populations dwelling on them may be genetically differentiated. If data regarding the structure of population and habitats is insufficient as it usually is and/or there is urgent

need to get material conserved an often used rule of thumb is to collect from five populations from the whole distribution area of the species or subspecies (ENSCONET 2009a).

The sufficient number of genetic individuals collected per population usually varies between 50 and 200 (Marshall & Brown 1975, Brown & Briggs 1991). If collecting seeds this usually means a total of c. 5000 of them, but the number of ripe seeds collected should never exceed 20% of the total (ENSCONET 2009a). Timing in seed collection is essential since immature seeds do not germinate well. Certain randomness of seed genotypes collected is a benefit and a disadvantage with regards to ex-situ conservation. Some seeds may well harbour genotype that is better adapted to new conditions (e.g. after assisted migration), but may also turn out to be worse. In turn, cuttings and other vegetative material is bound to include a genotype that has gone through a selection process in different stages of its life cycle and hence is probably well adapted to extant conditions (Brown & Briggs 1991). When introducing a species to a new environment from seeds it is a good idea to sow them directly to wild in order to let selective forces eliminate non-viable seeds. Nevertheless, seeds are the primary form in which plants can be ex-situ conserved as they are easy to collect, take out little space and are much cheaper to store.

General objective

By 2016 40 % of threatened plant species (VU-CR) and by 2020 75% of them are found in Finnish ex-situ collections. In practice this means the collection of 180 taxa on top of those already found in botanic gardens. Those taxa in *ex-situ* conservation will represent a known accession of native Finnish origin and it will be stored separately from any potential sources of cross-breeding (e.g. close relatives). Moreover, in order to conserve the genetic diversity of a species a sufficient number of its populations must be collected. Once a solid and sufficiently large collection is established, the material should preferably be used for re-introductions *in-situ* or for assisted migration (AM) programmes.

Action plan

Targets and actions

Target 1. Maintenance of the extant *ex-situ* collections

Parties in Actions 1-6: Finnish botanic gardens

Action 1. Changes in the status of *ex-situ* collections since the survey of Miranto et al (2011) will be checked periodically at an interval of five years.

Action 2. Duplication of accessions in living collections (excluding seed-banks) between botanic gardens in a way that every accession is found in at least two gardens. Different populations of the same taxon should be kept separate, however.

Action 3. In each garden alien accessions (of unknown, commercial or foreign origin) posing a risk of cross-breeding with *ex-situ* conserved native ones will be eradicated.

Action 5. All methods and best practices in breeding and growing each taxa will be recorded in garden databases and this information shared between gardens.

Action 6. Multiple *ex-situ* methods will be applied on those taxa either in immediate danger of extinction or already extinct in the wild. For example, if in wild collections tissue samples should be taken into micropropagation and, if possible, seeds stored in a seed bank.

Target II. Increasing the number of taxa in *ex-situ* conservation

Action 7. A priority list of 180 threatened native plant species to be taken into *ex-situ* conservation will be prepared. Depending on the distribution of a taxon, material will be collected from at least 1-3 populations. Within populations 50 individuals (preferably seeds) will be collected.

Parties: Environmental administration, Universities (inc. botanic gardens), Finnish Museum of Natural History (FMNH).

Action 8. A national seed bank for threatened native plant species is launched.

Parties: Botanic gardens (FMNH), environmental administration.

Action 9. Collected material will be stored in a seed bank and/or a as micropropagated tissue in a cryogenic storage in Finland or abroad.

Parties: Botanic gardens, environmental administration.

Target III. Development of *ex -situ* conservation to boreal and arctic-alpine species.

Action 10. Methods will be developed in close collaboration between Finnish and foreign institutes. Responsibilities of different species will be shared between Finnish botanic gardens and MTT Agrifood.

Parties: Botanic gardens and MTT Agrifood.

Target IV. *Ex-situ* material is incorporated into restoration and reintroduction programmes.

Action 11. With all *ex-situ* conserved taxa/accession a preliminary plan for reintroduction or other way to support *in-situ* conservation is drafted. Also possibilities for assisted migration are mapped together with parties in neighbouring countries.

Parties: Environmental administration, botanic gardens, Natural Heritage Services of Metsähallitus.

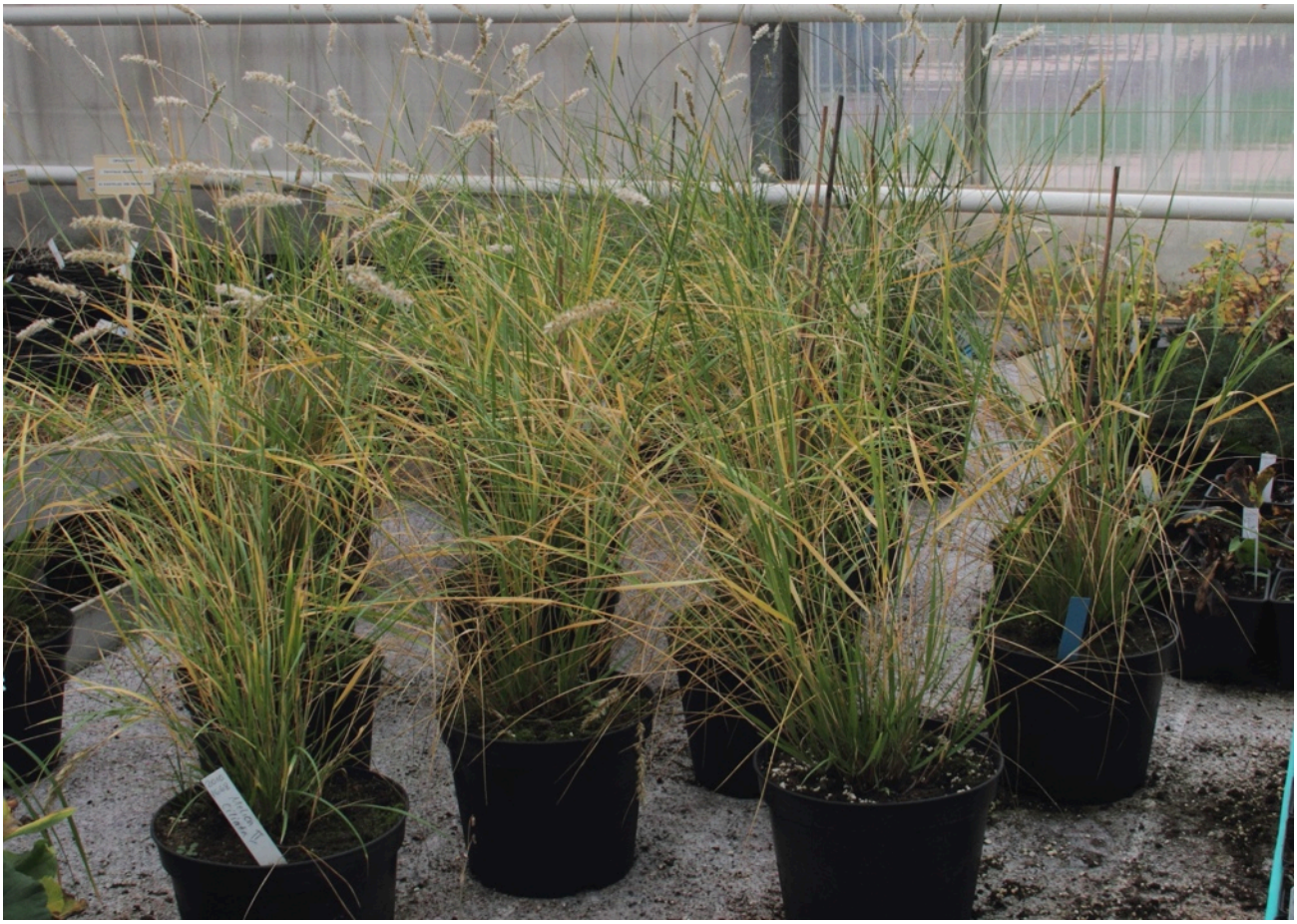

Fig 3. Melica ciliata that has got only one population left in the wild in Finland, is ready to be re-introduced from the Kumpula botanic garden (FMNH) in Helsinki. Photo: M. Hyvärinen.

Action 12. The need for *ex-situ* conservation of cryptogams will be evaluated.

Parties: Universities, botanic gardens, environmental administration.

Target V. *Ex-situ* collections used in public outreach

Action 13. A nationwide educational program on threatened species and their *ex-situ* conservation is launched.

Parties: Ministry of Education, botanic gardens, FMNH, environmental administration, sponsors.

Recommended additional research topics

- Evaluation of the conservation status of cryptogamic taxa and assessment of feasible *ex-situ* methods for them
- Development of scientific criteria for the selection of plant taxa to be conserved *ex-situ*
- Development of scientific criteria for the selection of plant taxa to be considered for assisted migration
- Analysis of scientific criteria with socio-economic constraints and development of potential new solutions for economically viable *ex-situ* conservation

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Appendix: instructions for the collection of plant material

The general objective is to collect genetically representative sample of the population without damaging their prospects for continued survival and, naturally, small populations of the rarest taxa will be the ones handled with the greatest care. Before collecting plant material an estimate must have been made of the size of the population and the status of the taxa as a whole in Finland and a brief evaluation of the status must be done on spot.

General rules for the collection of seeds are found in ENSCONET Seed Collection Manual (http://tinyurl.com/cxcw8lr). Some steps can be elaborated as follows:

(i) Prior to collecting seeds, the target plant needs to be accurately identified. Therefore a separate botanical specimen known as a voucher can be collected for identification and included in herbarium collections. Sometimes high quality photographs can be used in confirming identification.

(ii) Generally seeds must be mature, even though in some cases under-ripe fruits can be collected.

(iii) Plants should be randomised and, if it possible seeds from at least 50 individual plants should be collected, preferably 10-20 seeds from each.

(iv) Seeds should be collected directly from plants and on dry weather to avoid fungal contamination.

(v) Temporary storage during transfer should be in cool and dry environment.

(vi) Seeds from different individuals should be kept in separate bags.

(vii) Data on the collection event and the site should always be recorded (date, gps-coordinates, description of the habitat and its vegetation)

Collection of plant material for micropropagation will be carried out following the same steps with some exceptions: First of all the collected material should contain undifferentiated tissue (buds etc.). Also the collection of several samples from a single individual is usually not necessary as there is no genetic variation between somatic tissue samples. Tissue samples unlike seeds may also be sensitive for desiccation and, hence, need special treatment right after collection (e.g. rapid freezing).

Even though the above protocols are generally assumed to be suitable for most species, there is probably still need to do some testing for some species in order to achieve maximal survival in storage and these trials will be carried out in a rigorous scientific manner and fully documented.

Similarly the viability of seeds in the seed bank will be monitored by annual germination tests. Accessions will have a sub-sample removed for germination testing both for monitoring viability and elucidating conditions such that the seed can be used. If it is noticed the viability of seeds in storage has eroded exceptionally fast, a thorough investigation on the information available about storing the seed of the taxon in concern or its relatives and changes are made to be able to make changes in the storage protocol. If the reduction in germination ability is about normal, the taxon in concern will simply be scheduled to be re-collected in the next season.

The seeds stored will be registered in collection database of the Botanic Garden of University of Helsinki and in the international ENSCONET web-database together with collection information Moreover, together with the garden database the information will be made available in the Plant Search database of Botanic Gardens Conservation International (BGCI).