SWEDEN:

COUNTRY REPORT TO THE FAO INTERNATIONAL TECHNICAL CONFERENCE ON PLANT GENETIC RESOURCES

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Note by FAO

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CHAPTER 1
Introduction to Sweden and its Agricultural Sector

1.1 BACKGROUND INFORMATION

Sweden is located between 55-69° N latitude and 10-24° E longitude and has an area of 450,000 km^2. In the west Sweden borders on Norway, and in the north Finland. The maximum length is 1,574 km and the maximum width 499 km. In many parts of the country the climate is maritime, but in the inner north and central parts the climate is more continental, with regular snow cover and cold winters. The average annual precipitation ranges between 500-1,000 mm. Due to the influence of the Gulf Stream the climate allows cultivation above the polar circle. In the west, on the border with Norway, the central Scandinavian mountain range rises. It is an old chain, usually below 2,000 m asl, but some peaks are higher (highest Mt. Kebnekaise in the north, 2,900 m). Most parts of the country are covered with spruce and pine forests.

The population is 8.7 million which gives an average density of 19.3 persons per km^2. Only some areas are densely populated, however, i.e. the province of Scania in the south, the area around the capital Stockholm, and on the west coast. The population is dominated by Scandinavians and the ethnic group, the Lapps, who manage reindeer in the north. In recent years there has been considerable immigration into the country.

1.2 INTRODUCTION TO THE SWEDISH AGRICULTURAL SECTOR

Agriculture came to Sweden some 6000 years ago. Some of the first crops to be grown here were wheat and barley. The 19th century saw a large expansion of cropland, with a concomitant decline in haymaking. The latter was superseded by ley farming, i.e. the cultivation of forage crops in fields. During the present century, hay meadows have virtually disappeared. Pastures occupy a considerably smaller area than before. The total arable land area is around 2.8 mill. hectares.

The annual net earnings from the production of crops amount to approximately SEK 6 billion. The average saving from nitrogen fixation from forage legumes is some SEK 200 million a year. A benefit difficult to estimate is the recreational value of the open landscape, much appreciated in Sweden.

Accessibility to and the aesthetic value of this landscape has diminished with the post-war shift to large scale farming. Over the entire period since the end of the Second World War, 700,000 ha of cropland has disappeared.

In recent years the use of pesticides has fallen appreciably. Between 1986 and 1990 utilization was halved, measured in terms of active ingredients. The aim is to further halve this figure by 1996. To minimize the detrimental impact of chemical fertilizers on nutrient leaching the amount used is to be reduced by 20 % by the year 2000.

The main agricultural areas are situated in the southernmost province, Scania, and the fertile areas of the provinces of Västergötland and Östergötland in south-central Sweden. However, there is a conscious intention by the Swedish government to subsidize agriculture in other areas, especially in the north.

In total, Sweden has ca 91,000 farm enterprises, of which 44,000 are privately owned while the rest are rented or a combination of ownership and rent. The average area of privately owned farm enterprises is 17.9 hectares, though the most profitable farms in southern and central Sweden are several 100 hectares.

1.3 ROLE OF NATIONAL AND FOREIGN PRIVATE COMPANIES

Plant breeding of agricultural crops in Sweden is dominated by two major private companies. Svalöf Weibull AB breeds most agricultural and vegetable crops of importance in the country. Svalöf Weibull is completely owned by the Swedish Farmers' Association (SLR), who also market the seed. The company receives special state grants for breeding non-profitable crops, such as vegetables and varieties for northern Sweden. It also owns subsidiary companies in Central Europe and North America.

Hilleshög AB, Landskrona, a subsidiary of Hilleshög NK, with headquarters in Toulouse, France, which is owned by the multinational company Sandoz Ltd., has the major responsibility for sugar beet breeding in Sweden. Hilleshög NK has the responsibility for the breeding of major cash crops in Central and Southern Europe, but in Sweden the company concentrates on sugar beet breeding. The cultivation of sugar beet is conducted on a contract basis.

Special breeding programmes for the processing industry, especially peas, are carried out by Nestlé, Bjuv, Scania. Their varieties are not introduced onto the Swedish variety list, but they are supplied directly to farmers, who grow the crop on contracts from the company.

Apart from the major breeding and seed marketing companies of agricultural and vegetable crops some smaller enterprises are marketing foreign varieties. The food processing industry is mainly privately owned, but some companies have shared ownership between the state and the private sector. Several of the major companies are foreign.

Breeding of fruit-trees and soft fruits is conducted by a public breeder, the Department of Horticultural Plant Breeding, Swedish University of Agricultural Sciences, Balsgård, Scania.

1.4 MAJOR CROPS FOR FOOD AND AGRICULTURE

Forage and ley

Forage and ley production is important in Sweden and occupies an acerage comparable to that of cereals. The total area of forage and ley is around 1.1 mill hectares, and cultivation occurs throughout the country. Since most fields are sown with seed mixtures of grasses and legumes, the acreage of each species cannot be estimated, but rather the amount of seed sold (tons, Table 1). Eight grass and four legume species are the major crops. All are native to the country. Varieties developed inside the country predominate, and the difference between landraces and varieties is relatively small. A range of wild plants are also used as livestock fodder. Several grass species are also bred as turf grasses for lawns and golf courses.

Cereals

Cereal production includes the four temperate cereals barley, wheat, oats, rye and in recent years also triticale. Barley has the largest area and is mostly grown as a spring crop, but winter barley has increased recently to 37 t hectares in 1993. It is grown in the southern part of the country. Spring barley is grown throughout Sweden, but mainly in the southern and central parts. 90% of the barley production is for fodder which is used in the country. The remaining 10% goes to the malting industry in Sweden or for export.

Winter wheat (with 271.8 t hectares) and spring wheat (32.6 t hectares) are exclusively grown in the southern and central parts of Sweden. The majority of the product is used for the milling industry, while the surplus is sold on the world market. Some wheat is used for vodka production which is mainly sold for export. Special qualities are also produced, e.g., for crackers.

Rye is traditional in Sweden and mainly used for crisp bread production in the country. It occupies a rather small area (46.4 t hectares) and is grown almost exclusively in the southern and central parts. The new crop, triticale, has expanded in area recently. It is used as an autumn sown fodder crop. Oats has a larger area than wheat and is grown throughout the country but primarily in central Sweden. It is mainly used as a fodder crop, though some production goes to groats. A special quality of oats is used as fodder for race horses (some is exported).

Swedish farmers currently have access to a total of around 90 varieties of the four cereal crops. Some fifty of these have been developed in the country, while the remaining forty or so are from abroad. Swedish grain production is dominated by a very small number of varieties. Indeed in 1992 a single wheat variety accounted for almost 90% of the country's total acreage of winter wheat. Over a twenty year period, however, there has been, an increase in the number of varieties grown of each crop.

Other food crops

The cultivation of peas has decreased considerably over a ten year period. The total production of dried peas for cooking is around 8.7 t hectares. An additional ca. 10 t hectares are sown in southern and central Sweden for the canning and freezing industry. Vetches and field beans have become less important.

Root and oil crops, crops for bioenergy

Numerous varieties of potatoes have been introduced or developed in Sweden over the years, but for a long time a small number of foreign varieties dominated food-potato growing. Potato growing is concentrated in southern Sweden, but it is grown for local consumption throughout the country. The main area is used for human consumption in Sweden, but some (8.5 t hectares) goes to starch and alcohol production.

Sugar beet has retained its position as a raw material for Swedish sugar production, while fodder beets have declined considerably in recent times. Sugar beet is grown only in southern Sweden, mainly on contract between farmers and the sugar company. Sweden is self sufficient in sugar and practically no export occurs.

Oil-seed rape and turnip rape are important crops, serving chiefly as raw materials for the food industry. In Sweden four oil crops are planted, namely

winter and spring oil-seed rape and winter and spring turnip rape. Winter oil-seed rape is the largest with 74.5 t hectares and is primarily grown in southern Sweden. Only 2.5 t hectares of winter turnip rape is grown. No oil crops are grown in the north part of the country. Although some vegetable oils are exported, Sweden is a net importer.

Over the last decade bioenergy production has increased, particularly willow coppice, which now covers (1995) ca 14 t hectares.

Vegetables

Commercial cultivation of vegetables in Sweden is small, but diverse including a large number of species. The most important outdoor vegetables grown are carrots, lettuce white and red cabbage, and onions. All vegetable crops, both outdoor and glasshouse, are grown in the spring and summer season. Most production is directed towards home consumption. The total area of outdoor crops is 6,250 ha. Fifteen taxa have an acreage of more than 100 hectares and in this context are considered as major crops. Additionally 13 minor species are grown, i.e. between 1-50 hectares. They are often used for specific purposes in the country. Most vegetables are used for fresh consumption, some also for pickles (e.g. cucumber and red beet). Others are used fresh or for the canning and freezing industry (e.g. carrots and spinach). Almost all varieties on the Swedish list are bred in the country, but several foreign varieties which are imported directly are also grown.

Vegetable production under glass is centred on tomatoes, cucumbers and lettuce. The total area of glasshouse cultivation in 1993 was 2,052 thousand m^2. The combined area devoted to other crops is small by comparison (112,000 m^2), the largest being melon with 22,000 m^2. Around 600 enterprises grow glasshouse crop.

Fruits and Berries

Large scale tree fruit growing is local, with a stronghold in the east of Scania. Commercial cultivation is dominated by apple, which has 78 % of all fruit cultivation. The entire fruit producing area is 2,330 hectares and the total number of fruit enterprises is 460, concentrated mainly in eastern Scania, where some 300 enterprises exist. This area is particularly suitable for fruit production. Other fruits grown include pear, plum, and cherry.

Among the soft fruits, raspberries, blackcurrants and strawberries are grown commercially. The berry production is completely dominated by strawberries, which has 75 % of the entire acreage, 3,440 hectares. Black currants occupies

22 % and raspberries 2.5 % of this area. Considerable interest is being shown in the development of new crops, such as the hybrid *Rosa canina X R. dumalis* for hip production for the canning industry. Several other species, both native and introduced ones, are also being bred. Some local species, especially lingonberry (*Vaccinium vidis-idaea*), blueberry (*Vaccinium myrtillus*), cloudberry (*Rubus chamaemorus*) and arctic raspberry (*Rubus arcticus*) are picked from the wild and sold commercially. These species are also subject to cultivation trials and some breeding for commercial purposes is being practised.

Other cultivated crops

Growing of fibre plants, such as hemp or flax, has virtually disappeared. Indeed, the growing of hemp has been illegal since 1983. Growing of flax for oil has shown a resurgence. The main commercially cultivated herbs are horse-radish, caraway, black mustard and white mustard, but the area devoted to these crops is small. Medicinal plants and hops are no longer grown commercially. Private cultivation and home gardens are major undertakings for the individual Swede. They are therefore both socially and economically of some importance. In this context vegetables, fruits and ornamentals are in this context the major crops. About 1.7 million units exist in Sweden, each unit devoted about 200 hours/year in these activities. The cash value of vegetables, fruits and berries produced is around 1.5 billion SEK, with peas, broad and *Phaseolus* beans still fairly common.

1.5 TRENDS IN PLANT PRODUCTION AND BREEDING

Over production

As a consequence of the high input agriculture practised in most of the industrialized countries in western Europe, Sweden's agricultural production is a surplus to requirements. The superfluous bulk products can only be sold at low world market prices. There is a trend in Sweden, as in many other western countries, to reduce this surplus. The Swedish government has initiated a "change programme" also adopted within the European Union, aimed at limiting production by giving subsidies to take acerage out of agricultural production, either for planting forests or for alternate crop production of, for example. bioenergy (*Salix*) or other, non-food crops. This programme is likely to continue for foreseeable future.

Increase of winter crops

Over the last couple of years there has been a clear trend towards planting more winter crops than previously, particularly winter barley, triticale, and winter rape seed. Triticale is a new crop for Sweden, though it has been under intense breeding since the early 1970's. commercially In southern Scandinavia winter barley is at its northernmost limit. Formerly it occupied a very low acreage, but this increased in 1994 to 37 t hectares. Winter oil-seed rape has been a winter crop in southern Sweden for several decades but it is now extending its planting area. The reason for this expansion of winter crops is two-fold. Over the last 8 years winters have been extremely mild. This has favoured the higher yielding winter crops, even into the middle part of the country. The second reason is that the government has a conscious policy that at least 60% of the agricultural acerage should be planted in autumn to reduce nitrogen leakage.

Internationalization

In plant breeding there is an increased internationalization. The companies are becoming bigger and there is an increased import of foreign varieties. There is also an increased emphasis on breeding for broader adaptation which will probably reduce the total number of varieties grown, should it prove successful.

These trends are probably of a more ephemeral nature, but the main trend (or megatrend) which will certainly be of importance well into the next century is:

Sustainable agriculture development

The Swedish government, the Farmers Association, individual farmers and environmentalists have recently indicated that a change of farming system is absolutely necessary. There are only very limited possibilities for the export of bulk products (e.g. coarse grain), which is why the niche for Swedish agriculture is to concentrate on quality. Sweden could aim to have the cleanest agriculture in the world, which is important not only for the domestic consumption but also a powerful argument for export. This dramatic shift of emphasis will have a great influence on all sectors of agriculture, from plant breeding through farming practice and up to the food processing industry. Some major changes can already be discerned:

- **Considerable reduction in pesticide use.** Over a five year period Sweden has adopted a programme to decrease chemical usage by 50 %. This in turn will lead to increased breeding for resistance or tolerance in the crops and thus increase demand for new genetic sources of resistance.
- **Considerable reduction of nitrogen leakage.** There are increasing problems with clean water and there have also been increased problems with other

substances, e.g. heavy metals (esp. *cadmium*). Intense research both in plant breeding and farming management are getting increased grants.

- **Increased awareness of the damaging effects of fossilized fuel.** Research into the production of raw materials on agricultural land is also getting increased grants.

CHAPTER 2
Indigenous Plant Genetic Resources

With the exception of certain groups of species, chiefly bryophytes and lichens, Sweden is home to fewer species than the majority of more southerly countries. Around 1960 species of vascular plants are indigenous, including native species and species introduced before 1700. Repeated recent introductions, due to human activities, have enriched the flora. Around 500 species have been introduced and naturalized in recent times. Another 2,250 species have been noted as ephemeral. Around 20 taxa are endemic (apomictic "micro-species" are not included). The flora is cold temperate and typical of a recently glaciated area, with the species representing various floristic elements, with distinct distribution areas.

2.1 WILD SPECIES AND WILD RELATIVES OF CROP PLANTS

This chapter relates to crop relatives in the Swedish flora. Some indigenous species are of importance elsewhere, even though they are not cultivated in the Nordic countries. For these species the indigenous Nordic gene pool may be of interest. This gene pool contains possibly extreme and rare genotypes and/or genes resulting from the geographical location giving rise to unique ecological conditions and habitats. From a global point of view, about 400 out of approximately 3,500 native Nordic plant species are cultivated to some extent somewhere.

Forage and ley

All major grass and legume species are native to the country (Tables 8 and 9). Most of them are common throughout the country and show varying degrees of adaptation to different environmental conditions. Apart from the primary gene pool, most forage and ley species belong to large, temperate genera for which several related species occur in the country. Of the grass species related to major and minor forages *Lolium remotum* and *L. temulentum* are extinct, *Bromus secalinus* is endangered, *Alopecurus myosuroides* is vulnerable, and *Bromus arvensis*, *Festuca altissima*, and *F. heterophylla* are rare. Several legumes are also on the red data list. *Lathyrus tuberosus*, *Melilotus dentata* and *Vicia villosa* are vulnerable; *Medicago minima*, *Trifolium striatum*, and *Ornithopus perpusillus* are rare, while *Vicia dumetorum* is requires care.

Several other temperate grass genera important as forages elsewhere are native to Sweden.

Cereals

The four major cereals grown in Sweden have no representatives belonging to the primary genepool, except for *Avena fatua*, which is a noxious weed. Within the 2nd and 3rd genepool 12 indigeneous species occur, some of which are rare and/or vulnerable (*Elymus alaskanus*, *E. mutabilis*, and *Hordelymus europaeus*) and one is endangered (*Hordeum secalinum*). Meadow barley occurs only as a few populations in southern Sweden. A further species, *Avena strigosa* is extinct.

Root crops, oil crops and crops for bioenergy

For sugar beet, potato and oil-crops only a few, distantly related species are native to Sweden, except for *Brassica rapa*, which is indigenous. The wild beet *Beta maritima* is an endangered species. Although not endangered, *Solanum nigrum* and *S. dulcamara* have no foreseeable use in breeding.

Salix, grown as an energy crop, is a large genus with several native species.

Vegetables

Most of the major vegetable crops grown in Sweden are not native to the region. Several crops have, however, related species belonging to the secondary and tertiary gene pools. Of the minor crops several are native and have close relatives in the Swedish flora.

Fruit and Berries

Among the soft fruits several native and related species occur. Of the tree fruits, the crab apple (*Malus silvestris*) occurs, which is closely related to the cultivated apple, and the cherry, *Prunus avium*. The genus *Rosa* (used for hip production) comprises 13 species in Sweden. *Rosa villosa* is considered vulnerable and *Rosa pimpinellifolia* is extinct.

2.2 LANDRACES AND MODERN VARIETIES

The first agriculture occurred 5-6,000 years ago and since then a continuous cultivation of wheat and barley has taken place. These crops have thus passed through the same number of generations, and have become genetically very diverse and are adapted to many local environments and climates in Sweden. Rye and oats were domesticated later and have been introduced within the last 2,000 years. Other crops of comparable age are cabbage, flax and turnip rape. These crops have also become well adapted to Swedish conditions. When modern plant breeding began in Sweden some 110 years ago, its basis was the many landraces and some introduced varieties of Central European origin. The awareness of the importance of preservation of genetic material was not evident at that time and very few of these landraces or early varieties have been preserved. In the Nordic Genebank a small amount of this old material is stored (see Chapter 3). Apart from some locally used vegetables, potatoes, fruits and berries no landraces are cultivated, especially not of the major agricultural crops.

It is sad that so little of the older material is now available. But the few landraces, and particularly the large number of more modern varieties, have the gene content of the earlier, well adapted landraces. Much has been lost but much still remains. This material must be considered as an “indigenous” genepool of the cereals and other crops of Sweden.

CHAPTER 3
National Conservation Activities

National efforts for the preservation of plant genetic resources for food and agriculture are centered around the Nordic Genebank, which was initiated as a regional institution as a result of collaboration between the Nordic countries. The country has no national programme. There are other, minor holdings of *ex situ* material, mainly as working collections.

3.1 THE NORDIC GENE BANK

The Nordic Gene Bank (NGB) was officially established on January 1, 1979, as a joint Nordic undertaking. It reports to the Nordic Council of Ministers (NMR), an executive assembly which promotes cooperation between the Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. It is situated at Alnarp, southern Sweden, around 10 km north of Malmö.

NGB works within a budgetary framework agreed between NGB and the Nordic Council of Ministers. Roughly 1/4 of the budget is allocated to projects related to the use of genetic resources. International cooperation of direct value for the institution is also covered by the ordinary budget. Other activities, such as development projects or extra duties that NGB has to carry out as a consequence of the Convention on Biological Diversity, have to be funded from external sources. For the period from 1993 to 1995 the budget agreed upon between NMR and NGB is approximately 23.5 million SEK. Sweden contributes approximately 40%, which gives an annual contribution of 3.2 million SEK.

NGB is headed by a Board of Trustees composed of two members from each Nordic country, being chosen by the countries, one with a central position in agricultural or horticultural administration, the other with a central position related to plant breeding.

At the moment, NGB has six permanent inter-Nordic crop working groups: Cereals, Fruit and berries, Potatoes, Forage plants, Vegetables and Roots, and Oil-plants and pulses, each as a rule with one member from each Nordic country. The members are crop experts and they also act as NGB's extension arm in their countries, organizing collections, multiplications, observations etc. Presently, a further, temporary working group has been established to

deal with mandate species of NGB and issues arising out of the Convention on Biological Diversity.

Headquarters at Alnarp employs a staff of eleven, including two engaged by the Nordic donor agencies to handle a project for the Southern African Development Community (SADC) (see Chapter 6).

The NGB mandate is to preserve, document and encourage utilization of genetic diversity in Nordic agricultural and horticultural plants and their wild relatives, and to distribute both material and information freely to plant breeders, plant scientists and other *bona fide* users.

NGB has a general strategy stating that:

- the activities of NGB shall always be consistent with the convention, as will other international commitments concerning plant genetic resources;
- the primary aim of NGB is to be a prominent Nordic centre in the global network for the conservation and use of plant genetic resources;
- NGB takes long-term responsibility for the conservation of Nordic material of the mandate species;
- Besides material growing in the wild in the Nordic countries, NGB considers modern varieties produced in the Nordic countries by Nordic breeders, as well as all other material produced by Nordic researchers and breeders, as Nordic material;
- NGB will, in accordance with article 8 in the Convention, investigate if and how far *in situ* conservation of wild material may complement or replace *ex situ* conservation, and whenever possible, NGB will cooperate with national authorities in nature conservation;
- NGB will continue to increase and update information on the material stored, through initiating, taking part in and financing projects aimed at describing of the material;
- NGB is a Nordic information centre for plant genetic resources, making available information on the material in its collections, as well as material in international collections, including general information on plant genetic resources, so called non-accessional information;
- the material and information of NGB shall be freely available, without restrictions, as long as this is in accordance with the interpretation of the Convention on Biological Diversity made by the Nordic countries;
- NGB will be an important resource for the Nordic countries in the transfer of knowledge and technology to developing countries.

3.1.1 *In situ* conservation activities

There is a lack of information on genetic diversity and its distribution within and between populations of wild relatives of crops which have an indigenous gene pool in Sweden. The wild forms of many of these species have such a wide distribution in the Nordic area that a representative conservation of this diversity can only be achieved *in situ*. The intention of NGB is to link up with the national bodies in each country responsible for nature conservation. NGB is presently in the process of deciding on a Mandate Species List. The foremost reason is to have a clear-cut division of responsibilities between NGB and the national nature conservation authorities when implementing the Convention on Biological Diversity.

Species for consideration for *in situ* conservation are:

A. Species comprising cultivated as well as indigenous wild forms in the Nordic countries:

- woody species or species otherwise difficult to manage,
- species very widely distributed in the region,
- wild forms of threatened species.

B. Species indigenous to the Nordic region, but only cultivated elsewhere.

C. Species not cultivated anywhere.

Of particular importance to the *in situ* and on-farm conservation of cultivated crops are landraces of outbreeding crops, forages, fruits and vegetables indigenous to the Nordic countries. This material is genetically diverse and influenced by natural conditions. The landraces ideally require multiplication in a farming system characteristic of its time, and at or near the area of origin. NGB has hitherto regarded this as a form of *ex situ* conservation in a historical form of farming or gardening. Since subsistence farming and use of landraces is non-existent in the Nordic countries, this problem is fairly academic. When appropriate, however, NGB makes agreements with specific farmers to multiply landraces in suitable areas and under suitable farming practices. Collaboration with, for instance, different museums, is encouraged.

3.1.2 *Ex situ* collections

In *ex situ* conservation, the organism or parts of it, such as seeds, tubers, etc., are removed from the original habitat and transferred to a gene bank. The

collected material constitutes an accession which, for whole organisms, may be planted in clonal archives or, for seeds, stored under suitable conditions.

NGB holds three categories of *ex situ* collections, viz.:

- the Base Collection, stored in tightly sealed glass bottles to maintain viability for as long as possible.
- the Safety Base Collection, a duplicate of the Base Collection, stored in containers placed in a coal mine under the permafrost on the Svalbard Islands.
- the Active Collection, used for distribution and characterization/evaluation; stored in sealed aluminum foil bags.

NGB currently preserves less than 100 species *ex situ* and stores as seeds the following total number of accessions:

- Ordinary collection: 8,667
- Special seed collections (genetic stocks): 15,574
- Safety Base Collection: 3,780
- Duplicates for other genebanks: 3,102

Of vegetatively propagated crops NGB stores:

- onions, 10; rhubarb, 243; potato, long-term, 49; potato, pending, 43; fruits and berries, 2,856.

The regular seed collection

In NGB's regular collection ca 2,150 accessions of Swedish origin are stored. Around half are varieties or breeding lines of the major crops, particularly cereals. An inventory of older material in the country is currently being conducted, while a number of older varieties remain to be preserved. Comparatively few landraces are available. For the forage and ley species, which are native to the country, collecting missions have been undertaken and a large number of wild populations (ca 650) are preserved in the genebank.

Genetic stocks

As a result of lengthy genetic research in Sweden some special collections of genetic stocks have been built up and these have been transferred to NGB for long term preservation.

The barley mutant collection

The Swedish mutation research programme in barley began ca 50 years ago. The collection has been produced from different high-yielding Swedish spring barley varieties. X-rays, neutrons, and several organic chemical compounds were used as mutagens. Around 9,400 barley mutants are stored and documented in databases. The collection consists of the following nine categories with 94 different types of mutants: 1, changes in spike and spikelets; 2, changes in culm length and culm composition; 3, changes in growth types; 4, physiological mutants; 5, changes in awns; 6, changes in seed size and shape; 7, changes in leaf blades; 8, changes in anthocyanin and colour and 9, resistance to barley powdery mildew.

The barley translocation collection

The mutant research programme in Sweden has also yielded a series of lines containing structurally rearranged chromosomes. Most of these are reciprocal translocations of which about 700 have been isolated and identified. Only a few inversions have been obtained. The structural rearrangements were produced by ionizing radiation and very few were obtained by chemical mutagens. The chromosome breaks are distributed randomly on the seven barley chromosomes. Altogether 685 accessions are kept in NGB.

The pea collection

Genetic research with peas has a long history in Sweden, beginning around 1915. In 1930, the genetic pea collection was systematized at W. Weibull Ltd, and the work continued at that institute until 1987, when the collection was transferred to the Nordic Gene Bank. The collection then contained almost all type-lines for described and existing pea-genes, contributed by researchers from all over the world. By agreement the day-to-day work with the type-lines and genes has now been transferred from NGB to the John Innes Centre in UK, while the Base Collection remains at NGB. The pea collection at NGB now comprises 3,764 accessions, including Swedish landraces and, as for barley, a sizable number of induced mutants resulting from mutation breeding research in Sweden.

Vegetatively reproducing species

Fruit-trees are preserved in clonal archives at 8 different stations in the country in south and central Sweden. These are: Fredriksdal Museum, Helsingborg; Brunstorp County Museum, Jönköping; Skälby Kungsgård,

Kalmar; Munkagårdsskolan, Tvååker; Julia Open Air Museum; Bergius Botanical Garden, Stockholm: Linnaeus' Hammarby, Uppsala and Vadstena Monk Garden. Altogether 328 apple, 86 pear, 32 plum, and 21 cherry varieties are maintained. Varietal collections of fruit and berries are kept at: Institute of Horticulture, SUAS, Alnarp, Department of Horticultural Plant Breeding, SUAS, Balsgård and Capellagården, Färjestad.

Altogether 47 clones of potatoes, accepted for preservation, are stored *in vitro* at IVK Potatis AB. Many of the local potato varieties in the Nordic countries are foreign varieties which have been given Nordic names. Before accepting a local variety for preservation the NGB working group on potatoes compares it with reference material and the local varieties which have been accepted previously.

Storage facilities

Seeds are stored dry at -20°C in standard deep-freezers. Fruit, berries and landscape plants are maintained in clonal archives (field gene banks) and potatoes are maintained in vitro.

A seed sample delivered to NGB should preferably contain 20,000 seeds. In the collections of wild species and genetic stocks, it might be difficult to fulfill this requirement. About 5,000 seeds are stored in the base collection, 500 in the safety base collection while the remainder is placed in the active collection. The seed quantity in each distribution bag should be enough to start a small multiplication or to begin a normal crossing procedure in a breeding programme. Rejuvenation of an accession generally takes place when the germination rate falls below 75 %, or for collected material 50 %. For most species germination tests in plastic petri dishes covered with glass plate in a laboratory at room temperature and in daylight is sufficient. For some species a growth chamber is used which permits some control of humidity, light, and temperature.

3.1.3 Documentation

Information relating to the material is stored in computerised databases. The computer system at NGB consists of personal computers (IBM and compatibles) connected to a local area network. The database system dBASE IV is used to handle the information.

Catalogues for various crops are published to make the information available. Potential genebank users can also receive databases and request printouts of selected information. The information is now available on the Internet

network. At present, the Nordic Wheat Database is available trough Gopher, Lund University Electronic Library.

3.1.4 Evaluation and characterization

The terms characterization and evaluation have the following meaning here:

- characterization, gives information of hereditary characters expressed in most environments;
- evaluation, deals with characters normally affected by many genes and much influenced by environment and therefore having a low heritability, but being of interest for breeding , such as yield, baking quality, resistance to diseases, etc..

3.1.5 Regeneration

NGB has insufficient glasshouse space, fields or manpower to regenerate material of all of the different species stored in the gene bank. NGB relies heavily on the network of members on the different Working Groups for the crop concerned.

When regeneration is deemed necessary NGB approaches the station best suited to rejuvenate/multiply the material to inquire:

a) whether the station has the capacity to undertake the regeneration this year,

b) how many accessions the station can cope with,

c) how many of each species can be regenerated when considering isolation needs (insect or wind pollination).

For each accession successfully regenerated the station receives SEK 1,500 from NGB. One third of the amount is paid the first year, the remainder when the seed has been harvested, cleaned and delivered to NGB. This sum does not cover the actual cost of labour, however, especially for forage grasses propagated over several years. NGB depends on the goodwill of the research stations, and especially on the experts in the Working Group, who oversee the material during propagation.

In Sweden seed regeneration is performed at two different locations, differing in their geographical, agro-climatical and practical aspects. Forage grasses collected in the far north are sent to Röbäcksdalen, while material originating in southern Sweden is sent to Svalöv.

3.2 OTHER GERMPLASM MATERIAL IN SWEDEN

Beside the Nordic Genebank, domestic and foreign material has been collected and stored over the years by Swedish scientists and breeders. Some of these holdings can be considered as working collections and others more as "resting" collections.

There is no complete picture about the collections in Sweden held outside NGB. Such an inventory should be carried out in the near future in order to secure this material. Some categories will be mentioned here.

3.2.1 Department of Plant Breeding Research, Swedish University of Agricultural Sciences (Svalöv and Uppsala)

The *Triticeae* Collection

A worldwide holding of the tribe Triticeae (wheat, barley, rye and related wild species) in the grass family has been built up. It was started as a working collection to be used for botanic, genetic and applied research based on collaborative research programmes and collecting in several countries. It is comprised mainly of wild species from the central distribution areas of the species, but some cereal landraces are also included. The entire collection contains ca 6,300 accessions of which around 2/3 are unique. In total ca 185 species from 24 genera are included. The collection is concentrated on the genera *Hordeum* and *Elymus*, of which 4,830 accessions (82 species) are available. This collection will eventually be transferred to the Nordic Genebank as a special collection of genetic stocks.

Documentation of accessions, mainly passport data, is available on the database FileMakerPro for Macintosh. Evaluation data, e.g. resistance parameters, adaptative traits are available for some of the material, particularly for landraces. Information about individual accessions are also available in published papers. Determination and characterization of the wild species have had priority. Some studies of genetic diversity have been undertaken in the collection.

Since the collection is composed mainly of wild species which, for several reasons, are difficult to handle, not all the material can be multiplied. Only some of the unique accessions have been multiplied, and these have been chosen on ecogeographic criteria to represent maximum genetic diversity. In all ca 1,400 accessions have been multiplied and are available for distribution. For each multiplied accession at least ten distribution bags (sealed aluminium

foil bags) are put in a freezer at -18°C. The remaining material is bulked in a large foil bag and also placed in freezers. The original samples are kept in a dehydrated store room at ca +10°C in plastic boxes. Perennial species with self-incompatibility systems have not been multiplied to any extent. Of the original accessions several have lost viability.

Brassica genetic stocks

A special collection of genetic stocks of cultivated *Brassicas* is kept. It includes around 120 accessions, mainly different lines with resistance to *Plasmodiophora brassicae*.

Other wild species

Some important collections include bred and wild material from Sweden and elsewhere of the genera *Cikoria*, *Barbarea*, and *Lepidium*, in total ca 500 accessions. Wild Scandinavian material of the genera *Thinopyrum* and *Leymus* are used for intergeneric hybridization.

Genetic stocks of cereals

The department also holds working collections of isogenic lines of wheat, barley and oats and substitution lines of rye chromosomes in wheat; altogether ca. 300 accessions.

3.2.2 Department of Horticultural Plant Breeding, Swedish University of Agricultural Sciences, Balsgård

Over a number of years, and with international cooperation, considerable expertise has been acquired in conventional fruits and berries, such as apples, pears, plums, cherries, strawberries, currants, raspberries and blackberries. These activities expanded in 1986 to assess the potential of rose hips as a Swedish crop, for domesticating wild berries, such as buckthorn (*Hippophaë rhamnoides*) and lingonberries (*Vaccinium vitis-idaea*), and for using fruits and berries as raw material for producing dyes for food. The institute has also established a phytochemical centre, the aim of which is to create a continuous chain from breeding through the development of cultivation systems and pilot production schemes to market introduction, and thus produce raw materials for food and medicinal substances as well as raw material for the food industry. The point of departure is the market demands, which are mapped nationally as well as in a European and global context. This development

work demands access to a rich and varied genetic resource material. In cooperation with NGB a comprehensive collection has therefore been established. A number of activities, including the collection, evaluation, characterization and identification of active substances have been developed around these collections. The collections comprise 373 species, and more than 8,000 individuals. The normal breeding material of apples comprise 850 varieties, 150 promising selections and 8,000 genotypes, that of pears 210 varieties, 10 promising selections and 300 genotypes. Some 220 gentypes of *Rubus* and 1,600 of *Rosa* are maintained for various purposes.

3.2.3 Department for Horticultural Science, Alnarp, and Department for Forest Genetics, Uppsala, Swedish University of Agricultural Sciences

These two departments collect material of older ornamental plants which is kept in a field gene bank at Alnarp. Information on this collection is held in databases. In addition Uppsala holds a collection of particularly valuable landscape plants, mainly trees and bushes. These departments complement the Nordic Gene Bank, which has hitherto not dealt with ornamentals.

3.2.4 Breeding Companies, Svalöf Weibull AB and Hilleshög AB

The major breeding companies of the country hold their own breeding lines. Varieties scheduled for release are automatically sent to the Nordic Genebank, as are some of the more important breeding lines considered valuable by the companies but which are not actively used in the breeding process. The breeding companies have their own stock of breeding lines, stocks of marker genes and genes for quality traits. They also keep some wild and more exotic material in their stock. Some earlier collecting missions, especially for forage grasses, have been made mainly in Scandinavia.

3.2.5 Departments of botany

University departments of botany there has been a long tradition in Sweden of working with Scandinavian and foreign flora, particularly conducting experimental research of living material based on collected material. Several of these collections from temperate areas other than Sweden, and from tropical areas, contain mainly wild species, some of which are of interest to PGRFA. The status of these collections and the viability of seeds are not known but should be investigated. Many of the departments and researchers have considerable knowledge of both domestic and foreign conditions which have not been adequately exploited in the context of PGRFA, worldwide.

3.2.6 Botanic gardens in Sweden

The activities at the major Botanical Gardens in Sweden, i.e. in Gothenburg, Lund, Stockholm, and Uppsala are directed primarily towards aspects other than preservation of PGRFA, namely education and exhibitions. Each botanic garden has its own profile and speciality. However, they also keep special collections which have been mainly used for ornamental or educational purposes, but they may also be of importance for preservation and utilization of PGRFA. These materials include especially temperate vegetables which have been grown in the gardens for a long time and may represent particular landraces not present in the genebanks. Several of the botanical gardens have collaborated in collecting missions both in temperate and tropical areas. No survey of PGRFA has so far been done in these gardens, but should be performed.

In Sweden there is at present an increased interest among the public for older, cultivated material, partly because of an increased interest in cultural history *per se*, but also for actual cultivation in home gardens. Three of the major open air museums which have a more specialized mandate, i.e. Fredriksdal, Julita and Jamtlia, are functioning as clonal archives for fruit trees in cooperation with NGB. They also have other material. These open air museums have recently started exhibitions of older plant material in cooperation with the public, and some of this material, representing older landraces, especially of horticultural crops, may be of great value.

3.2.7 Other organizations and private persons

When the Nordic Genebank was created a massive effort was mounted to rescue the germplasm material available at the breeding companies and other major enterprises. Some missions were despatched to northern Sweden to collect especially native forage, ley and soft fruit. However, no general survey of the country was conducted at that time and has not been done thereafter. Over the last two years it has become evident that older, local material, especially of vegetables, but also of fruit-trees and minor crops are still present locally. It has been preserved by local societies or interested private persons throughout the country. The NGO organisation SESAM of Sweden has collected around 50 old, mainly landraces in Sweden that are not represented elsewhere. It comprises mainly vegetables (especially peas, broad beans, and swedes) but also some cereals (rye and barley). A more comprehensive survey of the country has to be carried out before it becomes too late.

3.3 NATURE CONSERVATION IN SWEDEN

Conservation of nature has a long tradition in Sweden. The foundation of national parks has to be decided by the parliament and the government. At present 23 national parks are established covering a total land area of 581.2 thousand hectares. Nature reserves are decided locally by the County Administration Boards. The 1,511 nature reserves cover a total land area of 2.1 million hectares. National parks and national reserves have about the same kind of protection. A third category, national management areas, have a somewhat lower degree of protection, but the management is similar to that in national parks and reserves. The 111 national management areas cover a land area of ca 126 thousand hectares. The number of protected areas are spread rather evenly throughout the country. However, the protected areas are significantly larger in the north than in the southern part of Sweden.

Most of the major plant genetic resources for food and agriculture, viz. wild relatives to forage grasses, forage legumes, fruits and berries (Chapter 2) are common throughout the country and are probably also well represented in the protected areas. It seems that the major parts of the most important plant genetic resources are well protected *in situ*. A survey of the distribution and diversity of wild plant genetic resources has, however, not been undertaken.

CHAPTER 4
In-Country Use of Plant Genetic Resources

4.1 UTILIZATION OF *EX SITU* COLLECTIONS

The Nordic Gene Bank

In 1993-94 NGB received 211 requests for material and sent out 3,407 accessions

During these two years the requests fall into four categories: (1) demonstrations and teaching; (2) cultivation of old material; (3) research; and (4) breeding. It is evident that, except for potatoes, the breeding side is not well represented. There were 45 requests in all to NGB in 1993 and 1994 from Sweden. Of these 15 were from universities, 7 from breeding companies, 13 from museums and other public institutions, and 10 from private individuals. Public museums, private individuals and universities are well aware of the existence of the genebank and utilize it for obtaining material. For potatoes most requests to NGB for material came from Swedish scientists, museums, and private persons.

The *Triticeae* collection

Over the years 1993-1994 393 accessions of wild species of *Hordeum* have been sent out on request mainly for research purposes, from the Triticeae Collection held at the Swedish University of Agricultural Sciences in Svalöv.

4.2 UTILIZATION OF PGRFA IN CROP IMPROVEMENT PROGRAMMES

The different breeding programmes carried out in Sweden, both private and public, were summarized in Chapter 1. In this section a general survey of the importance of different germplasm components in the breeding programmes is presented.

Green fodder and ley species

All the major grass and legume species are native to Sweden. The cultivation and breeding of these particular species was started here. Swedish breeders use mainly indigenous material in the production of synthetic varieties. Occasionally varieties produced in other northern and western European countries are included in the breeding programme. No material from the Nordic Genebank or from other genebanks has been utilized recently. When particularly severe winters have occurred, causing "outwintering" of varietal components, wild Swedish material has been collected and incorporated in the breeding programme. Apart from being important forage and ley grasses, some native species are bred and used as turf grasses. The species *Festuca rubra, Lolium, Agrostis spp., Poa pratensis* and *P. annua* are particularly widely used.

Cereals

For all major cereals (both coarse and bread grain) used in Sweden, breeding is carried out in the country. To a large extent breeders utilize their own stocks of adapted material from northern and western Europe. Sometimes more "exotic" germplasm is included in screening for disease resistance or quality traits. A very small proportion of this foreign germplasm has had an impact on varietal production.

Root crops, oil crops, crops for bioenergy

Potato breeding in Sweden is almost exclusively based on existing highly bred material. No wild species or exotic germplasm are included because of risk of introducing viral diseases. When particular traits for resistance or quality are required the gene sources are obtained from breeding lines where these characters are present. These lines are produced in collaboration with other companies outside the country.

In sugarbeet the screening of exotic germplasm is a joint exercise between different companies. Here especially the genebanks of the Netherlands and USDA have been used. A few wild species have been tested, e.g. *Beta maritima* with resistance to *Rhizomannia*. These genes have been transferred into advanced stocks. In the breeding strategy the sugar beet breeder invests resources in the use of exotic material only when necessary.

The breeding of oil-seed rape and turnip rape is mainly based on existing varieties of northern European origin. A low percentage (ca 5 %) of material from other sources is included in the programmes, but very little of gene bank stocks.

The breeding of willow coppice began about 15 years ago in Sweden. The starting point has been native material especially of *Salix viminalis*, but also a few other species. Newer varieties under production include interspecific hybrids between *S. viminalis* and northern boreal species from central Russia.

Vegetables

Today only limited commercial breeding of vegetables occurs in Sweden. For cauliflower, white and Chinese cabbage, lettuce, spinach, carrots, leek, parsley and outdoor cucumber major breeding programmes are carried out.

The main material used for the breeding in Sweden is varieties from other western European countries. Some genebank material chiefly from the UK and the Netherlands, have been studied, with additional material from USA. In an interspecific hybridization programme other species are investigated on a small scale. Since none of the major vegetable crop species bred in the country is of a native origin, no wild Swedish material can be used.

Fruits and berries

Many foreign provenances are tested and bred as well as native wild material. There is also an effort to domesticate new crops such as *Hippohae* and *Rosa* for hip-production. Northern temperate species are of particular interest for trials and breeding. Outwintering of cherries following the severe winters at the end of the 1980s led to the collection and description of wild *Prunus avium*.

4.3 RESEARCH AND PRE-BREEDING

In Sweden research and some pre-breeding on plant genetic resources for food and agriculture are carried out in various university departments and plant breeding companies. At the Swedish University of Agricultural Sciences two departments devote considerable resources in these projects, though other departments may have individual projects in the field. The department of Plant Breeding Research is divided into two sections, one in Svalöv, southern Sweden and one in Uppsala. The main research areas include wild species and exotic material of the grain cereals (wheat, rye and barley), disease resistance

and stress parameters in *Brassicas* and the cereals, biotechnology in *Brassica* and potato based on germplasm material, and the domestication of wild species of the Swedish flora. The department of Horticultural Plant Breeding, Balsgård, is responsible for practical plant breeding in fruits and berries, and conduct research in this area. Some of the financial resources of the two departments are directed towards research on the utilization of plant genetic resources. At other university departments individual projects related to plant genetic resources are carried out.

The breeding companies have their own research and development departments. Their research is generally more applied than in the universities. In some interspecific hybridization programmes (wheat, barley and oats) pre-bleedings conducted, some in collaboration with the Swedish University of Agricultural Sciences. Wild species as well as exotic landraces are studied. External grants for basic and applied research and development are available from various sources, The two major grant agencies being The Research Council for Forestry and Agriculture and The Swedish Foundation for Agriculture. Overall 32.5 million SEK was awarded in 1993 as grants to breeding, pre-breeding and research projects. The projects can be divided into various categories:

- plant breeding for non-commercial crops
- biotechnology projects
- evaluation
- breeding for quality
- breeding for resistance.

Besides the conservation and documentation mandate, the Nordic Gene Bank promotes the rational coordination of plant breeding activities in the Nordic countries by funding cooperative projects to utilize plant genetic resources. Projects supported during 1993 include potatoes, several horticultural crops, forages, and some on the cereals. projects evaluating gene bank material will have priority. The total sum invested in joint Nordic projects in 1994 was 2.5 million SEK (1 million SEK of Swedish funds).

4.4 BENEFITS FROM THE USE OF PGR

The immediate benefits of plant genetic resources for the country cannot be estimated at present. A more thorough investigation in some crop species should be initiated to study the importance of PGR both in the short and long term.

4.5 IMPROVING PGR UTILIZATION

The relationship between the Swedish breeders and researchers on the one hand and the Nordic Genebank on the other hand is good but could be improved. The breeding companies were extremely helpful during the establishment of NGB, and they deposited most of their material early in the genebank. Their interest in this material can be expected to be moderate. There seems to be a major lack of awareness of the existence and value of the material. Improvements will consequently be mainly in ways of disseminating information, i.e. the improvement of catalogues and the further increased use of computer based systems. It is vital that the facilities and expertise available at the gene bank are more fully utilized. There are several reasons for this:

- NGB is a new unit and during the initial phase it has been mainly occupied with the building up of the collections. It has therefore had limited resources for other activities.
- There is an evident lack of a National Swedish Programme on plant genetic resources (see Chapter 5), which could act as a link between the genebank and the practical breeders. The national programme should include long-term planning for information, education, research and pre-breeding activities.
- Since the core funding for the genebank is low, other priorities (e.g. conservation) sometimes have to be done.
- The evaluation data on the material in the genebank have not been readily accessible.
- The Swedish breeders have little knowledge about the genebank, its material, data and expertise.
- So far breeders have generally had enough material of their own to work with. When new gene sources are needed (e.g. for disease resistance) the importance of the genebank materials (worldwide) will increase.
- Researchers have often made their own collections of material, but with the increasing difficulties of collection. particularly in other countries gene bank material will be used more frequently. It is also of importance that research material, which has been widely used and has good documentation, should obtain as genetic stock status and be preserved in the genebanks.

4.6 IMPORTANCE OF PLANT GENETIC RESOURCES IN SWEDEN

There are several categories of plant genetic resources present in the Nordic genebank, in other institutions in Sweden, and under *in situ* conditions in the country. Generally both *ex situ* and *in situ* material represent particular adaptive traits, since many crops and wild species constitute marginal, sometimes also isolated populations from a larger distribution area. The greatest value of PGR in Sweden may lie in the availability of a wide range of material when the concepts for sustainable agriculture is more developed. The increased interest in historical and cultural aspects of agriculture may also be a factor of importance for conservation efforts.

The wild gene pool of grasses and legumes

Northern Europe is a centre of diversity for several forage genera of importance in the area and elsewhere. Most species are common and show a high degree of genetic diversity as well as wide adaptation to various environmental conditions. The *ex situ* collection at the Nordic Genebank and the living material under *in situ* conditions in Sweden makes this a very valuable category.

Cereals

Cereal breeding has been very intense in the country and mainly based on Swedish local landraces. The breeding has been directed to different regions with varying climatic and edaphic conditions, which has made the gene pool, most of which is present in the gene bank, very diverse. Genes for specific resistances or qualities are present in this material.

Genetic stocks

The genetic stocks preserved in the Nordic Genebank and in other institutions in Sweden are unique. They have a particular value for research and breeding. For example, the mutant collections are particularly valuable for genetic work with molecular markers.

CHAPTER 5
National Goals, Policies, Programmes and Legislation

5.1 NATIONAL PROGRAMMES

When the Nordic Genebank was founded in 1979 it was considered at that time that a national programme was not needed, and that the genebank should be able to handle all questions relating to the preservation and utilization of plant genetic resources for food and agriculture. Although NGB has the mandate has insufficient financial resources to cover all aspects. There are also particular questions in Sweden which are of national concern, for example, information, education, research, data and material collecting of those plant groups for which NGB has no mandate or resources to work with. Over the years it has thus become evident that there is a need for a planned, long term national programme for Sweden, but this has not yet materialised.

5.1.1 Government and authorities

In Sweden issues concerning the conservation and utilization of plant genetic resources are treated by different units of the Ministry of Agriculture, Ministry of Environment, and Ministry of Foreign Affairs, and special legislative topics are handled by the Ministry of Justice.

The Swedish Board of Agriculture, which handles practical agricultural matters, deals with the plant genetic resources matters at a national level. The Board of Environmental Protection is responsible for protection of endangered species and habitats. It is thus the authority dealing with general *in situ* conservation. For particular species on the red data list, which also belong to the crop gene pools, the board takes action together with provincial governments and municipalities.

Officially two representatives from Sweden are members of the board of the Nordic Gene Bank and there is a Swedish delegate on each of NGB's working group. There is, however, no Swedish board or committee, which has an explicit mandate for PGRFA questions.

Recently a Swedish National Committee for Biodiversity has been established and two members of this group are specialists in different areas of plant genetic resources for food and agriculture. This committee should deal with all aspects of biodiversity in Sweden.

5.1.2 Institutions and organizations

At the universities, especially the Swedish University of Agricultural Sciences (SUAS), some research groups are working on the preservation and utilization of PGRFA. There are also individual projects at other university departments. No national institution has a mandate to work with central issues of conservation of PGRFA. Apart from the department of Horticultural Plant Breeding at Balsgård (SUAS), which has responsibility for breeding of fruits and berries, no other public organization has a defined mandate for pre-breeding and evaluation of agricultural crops and vegetables.

For general biodiversity and endangered species and habitats some institutions have a long-term mandate. The Centre for Biodiversity is a joint undertaking between Uppsala University and the Swedish University of Agricultural Sciences. The Centre, which will function as a national network centre, was started in 1994 and is not yet fully operational. It has special state funding. Apart from research work on the wild flora and fauna the Centre will also have responsibility for including domesticated animals and cultivated plants. However, there is little financial support for this work.

The Swedish Threatened Species Unit, which is a part of the Centre for Biodiversity, at the Swedish University of Agricultural Sciences, has a mandate from the government for data collection on endangered species. When wild species belonging to the gene pool of crops are endangered, this unit will collect information and also suggest measures for *in situ* conservation.

5.1.3 Financial situation for PGRFA

Research and developmental projects with PGRFA obtain financial support from several sources, mainly from government boards, but there are also some grants from private foundations. The annual support from various, external sources can be summarized:

- Support for practical plant breeding (mainly to the company Svalöf Weibull AB): 25.6 million SEK.
- Development of biotechnology in plant breeding (universities and Svalöf Weibull AB): 5.3 million SEK.

- Pre-breeding (including evaluation, mainly to universities): 3.1 million SEK.
- International work with preservation and utilization (particularly support to developing countries): 39.7 million SEK.
- Preservation in Sweden (including the Swedish contribution to NGB): 2.1 million SEK.

Additional finance, which cannot be quantified is used by some university departments partly involved in the work with PGRFA.

5.2 TRAINING, EDUCATION AND INFORMATION

5.2.1 Training, education and competence

Education in genetics, biotechnology and plant breeding is of a high standard in the country. Genetics is taught at all major universities and some also have education in biotechnology. Plant breeding courses are restricted to the Swedish University of Agricultural Sciences in Uppsala and Alnarp. The entire educational programmes and individual courses in these subjects are well established and attract Swedish as well as foreign students. Expertise in genetics, biotechnology, and plant breeding is thus good in the country, but for the particular area of PGRFA the number of educated teachers and researchers should be increased.

During the last year a few courses particularly directed towards plant genetic resources have been initiated, but there is a lack of a complete educational programme. There is an ambition at some university departments to create such programmes for Swedish and foreign students, and providing the necessary funds can be set aside, such programmes will be operating before long. The programmes are planned at different levels: B.Sc., including training in basic subjects (genetics, taxonomy etc.) combined with courses on fundamental aspects of biodiversity and plant conservation; M.Sc, comprises 1-1.5 years with advanced courses and restricted research projects; Ph.D. with major research projects on PGRFA. The educational programme is planned by the Centre for Biodiversity in Uppsala.

The Centre will arrange the education for general biodiversity while the particular programme for PGRFA will be conducted in collaboration with other departments and universities. Single basic courses directly related to PGRFA are also planned for foreign students (10 or 20 weeks), hopefully in collaboration with the Nordic Gene Bank.

At the Nordic Gene Bank courses have been conducted in gene bank management, especially for African students from the SADC countries. These courses will probably be expanded to include students from other areas.

The company Svalöf Weibull AB organizes a course in seed technology twice a year for students from developing countries out of the Swedish aid budget (BITS). The course lasts 6 weeks and besides the major topics in seed handling technology it also includes some aspects of genetics and plant breeding.

Ex situ conservation of PGR is concentrated at The Nordic Gene Bank. The length of contract for all employees working under the Nordic Council of Ministers is a maximum of 8 years service. Considering the fact that no specific training and education in PGR conservation is available in the country, staff have to be gathered from related fields of science, and trained after arrival at NGB.

5.2.2 Information

Information about various aspects of plant genetic resources to the public, professionals and authorities is vital for successful and continuous work with PGRFA. For general biodiversity, endangered species and habitats The Swedish Threatened Species Unit has an excellent rate of quality publications. Likewise The Nordic Gene Bank has over the years published papers of good quality, mainly aimed at professionals. There is, however, a great need for increased and continuous publication and information in Sweden concerning plant genetic resources for the authorities and the public.

5.3 THE BIODIVERSITY CONVENTION

The Convention, which came into force in December 1993, has been ratified by Sweden. The general aim of the Convention is the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The definition of genetic resources, “genetic material of actual or potential value”, places the PGRFA material in Sweden squarely under the Convention. Most urgent is that, when national strategies, plans or programmes for the conservation and sustainable use of biological diversity as requested in article 6 are drafted, the PGR conservation and utilization are included. The number of species in Sweden may not be that great from a diversity point of view, but from an economical one the PGR material is extremely important for the future of mankind and for developing a sustainable agriculture.

5.4 NATIONAL LEGISLATION

Rules on nature conservation in agriculture have been included in the Act on the Management of Agricultural Land, drawn up by The Swedish Board of Agriculture (Statens Jordbruksverk) in 1948 (see also Chapter 3). For example, Fertilizers are banned on pastures and meadows not previously fertilized.

According to the Nature Conservation Act, all activities resulting in a substantial modification of the natural environment have to be sanctioned by the County Administrative Board. This Act also provides for the possibility of general habitat protection; if protection means that the owner has more than a certain loss, he is entitled to compensation. The Act provides for the possibility of establishing reserves. Presently farmland is included in about 230 such reserves as well as in 3 national parks and 16 nature conservation areas. In all, 26,500 ha of arable or improved grazing land and at least as large an area of unimproved meadows and pastures have been protected in this way (see also Chapter 3).

Another method by which the government protects nature is to make agreements with a farmer who receives payment for managing the land in a certain way, according to nature conservation measures in the agricultural landscape (NOLA). This has been in operation since 1986.

A new allocation was introduced in 1990 for landscape conservation measures. For the 1993/94 financial year 250 mill SEK, roughly 13,000 agreements relating to some 310,000 hectares, have been settled.

Livestock breeding is regulated by the Act concerning Controls on Domesticated Animals, to promote production, ensure availability of suitable breeds and prevent diseases. Plant breeding is not subject to such detailed statutory regulation as livestock breeding and is mostly carried out on a commercial basis.

Matters concerning import of plants is regulated in the Act on Introduction and Export of plants (1994). The Swedish Board of Agriculture is authorized to formulate new decrees. As a consequence of the Swedish membership in the European Union new regulations are expected to be adopted.

The Act of Seed (1976) and the following Decree on Seed (1993) regulate, for example, seed release, certification, quality declaration, seed import, supervision, and sanctions. The Swedish legislation is now adapted to the EU terminology.

Sweden is since 1971 a member of the International Union for the Protection of New Varieties (UPOV). This means that our legislation is in conformity with the UPOV-convention of 1961 in its 1978 version. Sweden has signed the 1991 Act of the UPOV-convention but has not yet ratified it.

The provisions of the Swedish Plant Variety Rights Law allow protection for more than 100 taxa. Protection is granted for breeders with connection to Sweden or to any other UPOV-country. The scope of protection comprises the sole right of the breeder to produce, reproduce or import propagation material of a protected variety for the purpose of commercial marketing. This means that using the protected variety for these purposes requires the consent of the breeder or the holder of the grant, who is entitled to a license fee.

The period of protection is 20 years from the year after which protection was granted. The competent Swedish authority for granting plant breeders rights is the National Plant Variety Board, which is also responsible for the National List of Cultivars entitled for certification.

CHAPTER 6
International Collaboration

6.1 UNITED NATIONS INITIATIVES

The Convention on Biological Diversity request the Parties to "develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes". In Sweden, a Country Study has been developed and published (1994), and the Country Action Plans are under way (1995).

FAO's Global System on plant genetic resources is strongly supported by Sweden. The International Conference to be held in 1996 is seen as a major event with adoption of the pioneering State of the World's Plant Genetic Resources and Global Plan of Action. The agreed harmonization of the International undertaking to the Convention on Biological Diversity, preferably in the form of a protocol, is also a matter of great importance and urgency.

6.2 REGIONAL INTERGOVERNMENTAL INITIATIVES

In the European Cooperative Programme for Plant Genetic Resources (ECP/GR), now in its fifth phase, the Nordic Gene Bank has proposed membership in the following working groups:

Allium, Avena, Barley, Brassica, Forage crops, Grain legumes, Prunus.

In the EU-programme for plant genetic resources, Swedish involvement, either from different Swedish institutes alone or in conjunction with NGB, is proposed in the following projects:

- Cereals: A proposal concerning documentation of wheat, another on documentation of barley, a third on evaluation of *Avena* species, and a fourth on *Hordeum spontaneum.*
- *Brassica*-collections for broadening agricultural use; NGB is here proposed as a coordinator for *B. napus.*
- Establishment of a European Union plant genetic resources documentation network (EUGENE).

- Conservation, characterization, evaluation and collection of *Allium* crops and wild species.
- *Daucus*: A project under development.
- Conservation and maintenance of small fruit genetic resources. Presently, the project involves *Fragaria, Hippophaë, Ribes, Rubus, Vaccinium*, other minor crops breeding, computerized databases and information retrieval systems, cryopreservation, and interspecific hybridization.
- Development and implementation of a European *Malus* database for the harmonization of the European collections.

6.3 THE SWEDISH AID PROGRAMME

The Swedish aid organization SIDA (Swedish International Development Agency) and SAREC (Swedish Agency for Research Cooperation with Developing Countries) have over the years funded several programmes for plant genetic resources for food and agriculture in developing countries.

In 1994 SIDA supported plant breeding projects in Zambia and Mozambique and the joint Nordic effort to establish a gene bank for the SADC countries in southern Africa (see under NGB). SIDA also supports NGOs active in preservation of biodiversity and utilization of plant genetic resources. The main support from SIDA is aimed at the tropics and the total budget for 1994 was 22.2 million SEK.

SAREC is supportive of the CG-system in general and IPGRI in particular. Moreover SAREC supports a number of research and developmental projects in Ethiopia, Zimbabwe, Mozambique, Sri Lanka, Nicaragua, Chile and Argentina/Uruguay. The total budget for SARECs support in 1994 was 15.9 million SEK.

In 1994 the International Foundation for Science (IFS) supported a number of scientists in developing countries carrying out research projects in the area of preservation and utilization of plant genetic resources. Sweden's contribution to IFS in 1994 was 11 million SEK.

6.4 THE INVOLVEMENT OF SWEDISH SCIENTISTS IN INTERNATIONAL WORK

Comparatively few Swedish institutions and scientists participate in international research and development of PGRFA in developed as well as developing countries. Joint collecting missions and collaborative works have

been undertaken by university departments in taxonomy, genetics and plant breeding research, but at comparatively low rate. University or other state grants have been utilized for Ph.D. education in Sweden by foreign students, in later years primarily as sandwich programmes.

Swedish scientists have been engaged on the boards of several of the CG centres, but surprisingly none have been employed at any of the centres on a more permanent basis.

The plant breeding company Svalöf Weibull AB (earlier Svalöf AB) has worked with plant breeding projects in southern Africa (Zambia and Mozambique) as a part of the Swedish aid programme for several years.

6.5 THE NORDIC GENE BANK (NGB)

NGB defines four main areas of international cooperation:

1. General international cooperation within organizations such as FAO and IPGRI;
2. Cooperation within our neighbouring country area, a prerequisite for achieving a comprehensive conservation of the plant genetic resources of the area;
3. Cooperation regarding crops of economical importance in the Nordic area. This will include participation in international networks and cooperative projects concerning domesticated plants, essential for achieving a rational conservation and effective utilization;
4. Transfer of knowledge and technology to developing countries and the countries in eastern Europe, for which the low technology and cost effective conservation activity at NGB is well adapted.

6.5.1 The SADC genebank project

Since 1989, NGB has been involved in a Nordic Development Project in the SADC countries in southern Africa. The primary objective of the project is to establish a regional centre for plant genetic resources, the SADC Plant Genetic Resources Centre (SPGRC), and a network of national plant genetic resources programmes. The SADC project is a commitment from NGB to act as Management Consultant to the Nordic development agencies to develop a regional genebank for the SADC region i.e., the countries Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. NGB will continue as Management

Consultant in the project for the period 1994-1997 and provide any backup required including financial administration and management of project funds.

The new SPGRC building was opened in October 1993. The total cost of construction amounted to 15 million SEK. The total area of the complex is 1,400 m^2. The genebank has a current storage capacity of 25,000 samples of base collection. The building is situated on a 86 ha farm 25 km east of Lusaka and houses the seed bank, technical section, processing unit, library and administrative block. All these units are served by a local area network of computers in a PC environment. In 1993 each of 10 national centres received a 4 wheel drive vehicle to be used for the exploration and collection of germplasm. Storage equipment, computers, printers, fax machines, photocopiers, generating sets, driers and other genebank facilities were also supplied.

6.5.2 The genebank project in the Baltic countries

The Baltic countries, Estonia, Latvia and Lithuania, have initiated a programme for the conservation and utilization of plant genetic resources. The initial phase of the programme is supported by the Nordic Council of Ministers, which will allocate approximately US$ 200.000 to the programme from 1994 to 1996. In this initial phase the programme will be coordinated by the Nordic Gene Bank, who will also provide technical support and training.

The Nordic and Baltic countries are geographically, climatologically and historically closely linked to each other. The Baltic countries have not until now started a programme of their own. Collections kept at breeding and research institutes in the Baltic countries are mainly working collections, maintained for breeding and research purposes. These consist of varieties from foreign countries, as well as old Baltic varieties and landraces.

A detailed inventory of these collections is not presently available and the viability of the collections is in some cases alarmingly low, due to inappropriate storage conditions and a lack of funds needed to rejuvenate the material. Institutes conserving vegetatively propagated crops also report problems in keeping the material.

The scope of the programme and to what extent it should be integrated with the Nordic programme for the conservation and use of genetic resources has to be decided. During the initial phase, a network of Baltic institutes holding collections will be established. A Plant Genetic Resources Coordinator has been appointed in each Baltic country and an overall coordinator has been

appointed at NGB. Computers and software for database management have been provided by NGB and staff training will be organised in 1995 both at NGB and in the Baltic countries. Funds will be sought in the individual Nordic countries to provide seed drying and packaging equipment and to increase the training component of the programme.

CHAPTER 7
National Needs and Opportunities

From the preceding chapters it can be concluded that the most urgent points for the Swedish work with plant genetic resources for food and agriculture would be:

The importance of PGRFA for sustainable agriculture

A necessary ambition for Sweden is to develop towards a more sustainable agriculture. In turn this will put pressure on increased utilization of new gene sources for resistance, stress and quality traits. Sweden, situated at the climatological margin of agriculture, is extremely dependent, particularly for the northern parts, upon a strong and viable in-country research and breeding. No continental country can be expected to spend the necessary funds and efforts on Swedish problems. The need for a strong research and breeding programme supported by the government, is therefore evident. A climatological border-line also results in a relatively low pressure of pests and diseases. The opportunity for developing a sustainable agriculture, with high quality products, is therefore considerable.

National programme

The need for a national programme for plant genetic resources in Sweden is obvious. It should comprise the following components:

- Expertise and organization at the authority level (government and board) must be increased.
- A new organization (or institution) with special responsibility for work with PGRFA including information, education, research and pre-breeding in Sweden should be established. It could be created within the existing framework through reorganization and special economic resources. This organization should work in close collaboration with The Nordic Gene Bank in order to pool resources and avoid duplication. The organization should work in those areas where The Nordic Genebank has no mandate and where it has insufficient resources.

There is a shortage of funds for work on plant genetic resources. In 1994 practical plant breeding received ca 31 mill SEK, International engagements 39 mill SEK, pre-breeding 3 mill SEK, and conservation in Sweden only 2

million SEK. An increased investment in conservation and related research in Sweden is clearly necessary.

Education

Sweden has a long tradition and a high standard in plant genetics, taxonomy and plant breeding research, but experience in PGRFA should be increased. University programmes at different levels have to be developed for both Swedish and foreign students.

The Nordic Gene Bank

NGB has a mandate for long term conservation of PGRFA, but the core funding is too low to permit work on all aspects for which NGB has a mandate. It is especially important that the NGB collection is fully evaluated.

The Swedish gene pool

Insufficient information is available about the indigenous Swedish gene pool. This omission should be rectified. Presently, 505 species, indigenous to Sweden, are either grown in Sweden or in countries outside Sweden or belong to the common gene pool of a cultivated species. Studies on genetic diversity and adaptive traits are vital for optimal ex and *in situ* conservation. Particular studies on the gene pool of the indigenous Swedish gene resources and their wild relatives should be conducted, hopefully leading to suggestions for *in situ* conservation. Sweden uses over 800 documented foreign species, of which about 450 are landscape plants and/or ornamentals, in cultivation and breeding, and an unknown number in earlier research and breeding. This shows that no country is self-reliant on plant genetic resources.

Landraces and old cultivars

A thorough survey of landraces and old varieties in Sweden should be performed. This could be done in collaboration between different organizations.

Swedish germplasm collections

A survey of germplasm collections held outside The Nordic Gene Bank should be conducted in order to secure what is now available in the country.

Increased utilization of PGRFA

The facilities offered by the Nordic Gene Bank are more utilized by countries outside Sweden than by Swedish breeders and researchers. This trend can be changed only through increased information about the gene bank, especially by the country coordinators of the gene bank.

International engagement

It is unsatisfactory that so few Swedish scientists are involved in international work with PGRFA and in the international centres (CG-institutions). Sweden supports several programmes, particularly in the developing countries, but there is certainly a need for an increased engagement by Swedish scientists.

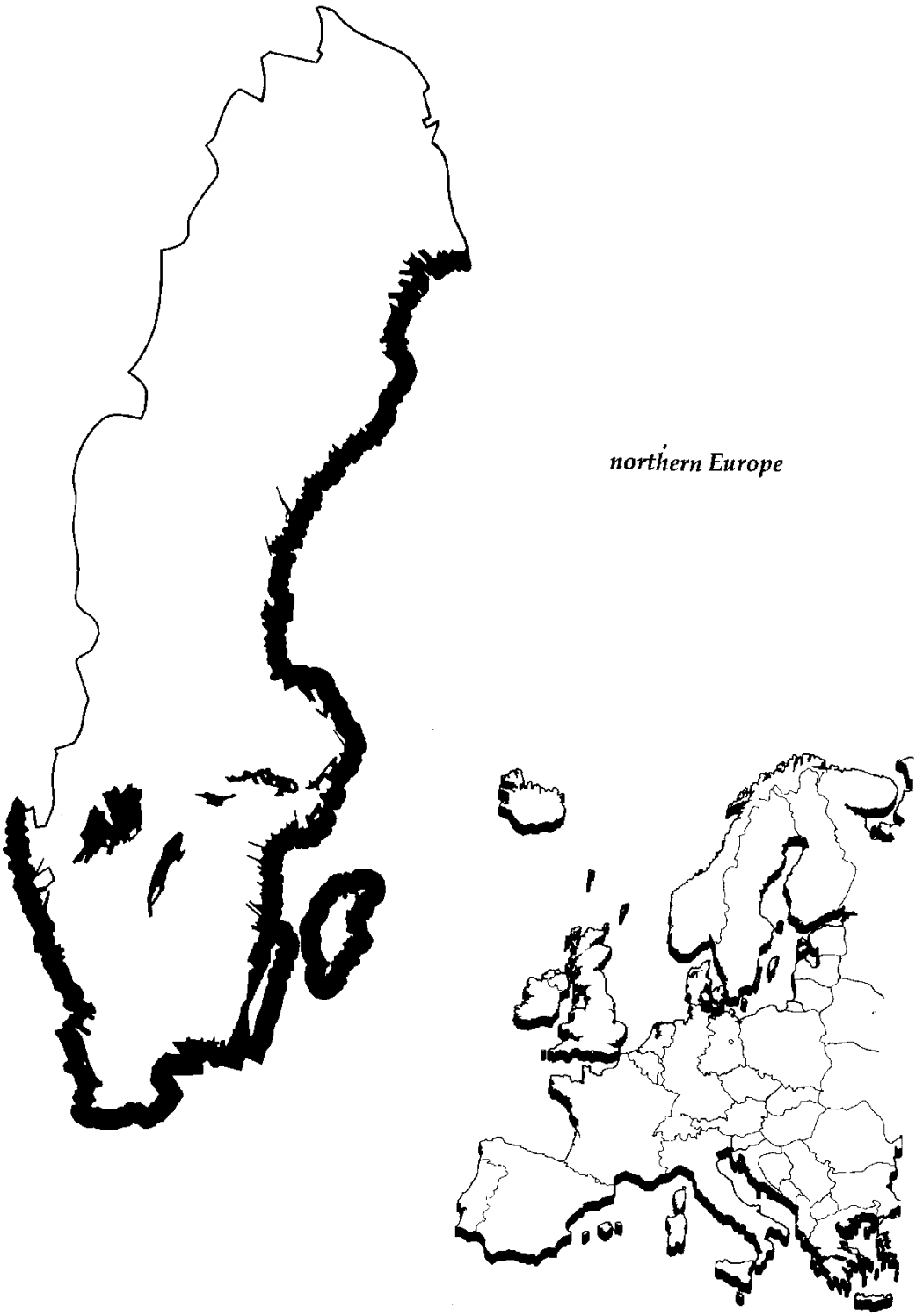
By tradition, much support has gone to tropical areas where there is only limited competence in Sweden. If some support could also be invested in temperate areas this would immediately lead to greater participation by Swedish scientists.

CHAPTER 8
Proposals for a Global Plan of Action

- For a State of the World and a Global Plan of Action to function properly, it is vital that it can be updated, for example every second year so that it can serve as an Early Warning System.
- The harmonization of FAO's Undertaking in the Commission of Plant Genetic Resources for Food and Agriculture with the Convention on Biological Diversity is essential if the former is to be adopted as a legally binding protocol under the Convention.
- In the present information-centred culture, it is imperative that both the FAO and IPGRI databases are available through the Internet System.
- In order to streamline long-term conservation, at least within Europe, it is essential that the recently initiated Nordic Gene Bank/Baltic cooperation is formalized and strengthened.
- To satisfy Resolution 3 of the Nairobi Final Act, and have an unimpeded and uncomplicated exchange of germplasm in the future it is important that at least for PGRFA a multilateral system of benefit-sharing is adopted which embraces Farmers Rights.
- It is appropriate that multilateral, as opposed to bilateral, agreements are based upon a species list, issued by FAO and agreed upon in the Commission.

Appendix 1

FIGURE 1 THE COUNTRY OF SWEDEN AND POSITION IN NORTHERN EUROPE



Appendix 2

FIGURE 2 CHARACTERISTIC TYPE OF FARMING IN THE COUNTRY OF SWEDEN IN 1993 (YEARBOOK OF AGRICOLTURAL STATISTICS 1994)