CANADA:

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

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Note by FAO

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FOREWORD

This report has been prepared in two parts: part one - Agriculture, and part two - Forestry. It addresses the plant genetic resources of agriculture and forestry in Canada. It does not encompass the important roles that these sectors, particularly forestry, play as habitat for biodiversity - various animals, plants, insects, etc. It has been compiled with input from a number of sources and is considered to represent the collective opinions of all components of each of these sectors.

CHAPTER 1
Introduction to Canada and its Agricultural Sector

Canada is one of the largest countries on the planet with approximately 13 million square kilometres of land and water, 244,000 kilometres of coastline and approximately one quarter of its landmass in the Arctic region. Canada has almost 20 percent of the planet's wilderness, 24 percent of its wetlands, 20 percent of its freshwater and 10 percent of its forests. Many of Canada's ecological features contribute to global ecological processes. For example, our forests, wetlands and peat bogs serve as sinks for greenhouse gases; and the Arctic region acts as a global sink by cooling the air and absorbing the heat transported north from the tropics.

Total Land Area of Canada	920,000,000 ha
Total Cultivated Farmland	41,827,900 ha
Total Farmland in Summerfallow	7,920,948 ha
Grasslands, Pasturelands or Uncultivated Lands	35,011,000 ha
Cattle	14,173,600
Swine	16,146,900
Sheep	987,600
Horses	356,100
Chickens	410,361,000
Turkeys	19,861,000

(Statistics Canada; Livestock Feed Usage Study, 1993)

Canada's human population of approximately 27 million (Statistics Canada, 1992) is stretched out along the Canada - United States border, with most of the major urban centres being located in relative proximity to that border. In the late 19th century, Canada was largely a rural country but in 1931, rural people became a minority, and in 1956, farmers became a minority within the rural population, declining further to 13.1% of the rural population and 3.1% of the total population by 1991. These changes reflected the changing nature of farms and farming. By 1931, 60% of Canadian grasslands were under cultivation. It was on the Prairies, with the short growing season and droughts, that large-scale agriculture developed. As Canada urbanized and markets for food expanded, average farm size increased from 40 hectares in 1900 to 232 hectares by 1986. As well, small, mixed, farms evolved into larger more specialized operations with increasing amounts of mechanization and far fewer, but larger farms. This shift lead to increased productivity and efficiency. The 732,832 farms which existed in 1941 had declined to 293,089 by 1986, a trend which is continuing.

The agriculture and agri-food sector is a major contributor to the Canadian economy, accounting for eight percent of the Gross Domestic Product and 15 percent of employment. Agriculture covers seven percent of the total land base of Canada, and about 280,000 farmers are engaged in primary food production worth over C$20 billion annually. Furthermore, over one million individuals are employed in the food processing sector, which is the second largest manufacturing industry in the country, worth a total of $43.6 billion in 1992.

1.1 MAJOR ACTIVITIES BY REGION

The agro-ecosystems approach recognizes that more than 90 percent of Canadian agriculture is located within just five ecozones, viz Pacific Maritime, Boreal Plain, Prairie, Mixed-Wood Plain, and Atlantic Maritime. The criteria used to establish the boundaries for these ecozones are physiography, vegetation, soils and climate; these are the same factors that determine the characteristics of agriculture within each of these distinct areas. In simple terms, the agro-ecosystems approach entails the use of holistic management and production strategies that are tailored to the specific ecological characteristics of each zone.

In British Columbia (BC), livestock products, including milk, cattle and calves, poultry, hogs and eggs make up nearly two-thirds of farm sales with the remaining third dominated by fruits, vegetables and floriculture and nursery products. Most of the output of eggs, milk and poultry products, some feedlot beef, and a substantial amount of the hog production occurs in the Fraser Valley and on Vancouver Island. Tree fruit production is concentrated in the Okanagan region and the Fraser Valley. Berry, vegetable and nursery production is found mostly in the south coastal region, grains and oilseeds in the Peace River region, and cattle production is dispersed through the central interior of the province.

There are approximately 26.3 million hectares of cropland in production (not including summerfallow) in the Prairie provinces, of which half are situated in Saskatchewan, one third in Alberta, and the remainder in Manitoba. The cattle sector dominates the prairie livestock industry, accounting for almost 60 percent of farm sales, with hog production second at 15 percent. Wheat, canola and barley account for approximately 80 percent of the market cash receipts generated by crop production. In Manitoba, the horticulture industry is developing successfully with potatoes, carrots and cole crops.

Central Canada has superior soil and climatic conditions. Combined sales of primary agricultural commodities in the provinces of Quebec and Ontario exceeded 41 percent of the Canadian total in 1988, with 35 percent coming from sales of dairy products, poultry and eggs. These two provinces have a wide range of production alternatives, ranging from beef, hog and grain production to horticultural crops and tree fruits.

Livestock, dairy and poultry are important in the Atlantic provinces. In Nova Scotia, about 50 percent of the farm income is derived from the dairy and poultry sectors, with an expanding production of fruits and vegetables. Potatoes, apples and blueberries are important commodities in the Atlantic region.

1.2 MAJOR ACTIVITIES BY SECTOR

A) Crops

There is a national variety registration system run by the federal government, with the certified seed supply regulated by federal legislation and supervised by a non-governmental agency, the Canadian Seed Growers Association. The seed supply system in Canada is predominantly controlled by the private sector through approximately 160 seed companies. While the large majority of these are small companies (in many cases family-owned), large Canadian and international corporations are represented. Around 25 of these companies conduct research programs, mostly on seed cultivar development on hybrid corn, canola (oilseed rape), soybeans, forages and pulses, in approximate order of effort. A minor private effort is also directed towards cereals, mainly barley and oats.

Wheat is Canada's dominant field crop with about 97% of the current 11 million hectares planted annually being in the Prairie provinces. Over 23 million metric tonnes are produced with export markets taking about 67% of the production.

Coarse grains are produced on about 8 million hectares of land, mainly on the prairies (79%) and in Ontario (13%). The nearly 24 million metric tonnes produced are used primarily as feed grains for livestock and poultry. The chief grains are barley, oats corn, mixed grains and rye. Mixed grains are mainly barley and oats. Ontario is the main corn-producing area.

Oilseeds are produced on about 8 million hectares, of which close to 90% is in the Prairie provinces. Over 11 million metric tonnes of canary seed, canola, flaxseed, mustard seed, soybeans and sunflower seed are produced. Canola is the major oilseed crop grown, accounting for nearly 75% of the hectares seeded and 65% of the tonnage produced. Soybeans are virtually the only oilseed grown commercially in eastern Canada, primarily in Southern Ontario and South-western Quebec.

Canadian oilseeds have become a significant cash crop and component of Canada's agricultural exports. As a result, there has been a shift in crop plantings over the last few years. From 1990 to 1994, the number of hectares seeded to wheat declined by about 22% and those seeded to coarse grains by about 10%, while those seeded to oilseeds increased by 97%, virtually doubling, with canola accounting for 85% of the increase.

Horticultural crop production occupies over 300,000 hectares with Ontario being the most important production area, comprising 36% of the total. The Atlantic provinces account for 23%, Quebec for 20%, Prairie Provinces for 11% and British Columbia for 9%. In terms of farm cash receipts, however, the order of importance changes to leave Ontario first, followed by British Columbia and Quebec. Potatoes are the main vegetable crop produced. Processing vegetables (tomatoes, corn, peas, beans, etc.) and cole crops are produced on mineral soils while some storage vegetables (carrots, onions) and fresh market vegetables (lettuce, celery) are produced on organic soils. The greenhouse vegetable industry is also well developed, particularly in Ontario, BC and Quebec. Apples are the main fruit produced; production of other tree fruits, berries and grapes is concentrated mainly in Ontario and BC. Ornamental crop production is important to the Canadian horticulture industry, as farm cash receipts generated by the nursery and floriculture sectors exceeded the total fruit receipts by over 300% and those of potatoes by 63% in 1993. The value of the mushroom industry is slightly larger than that of the apple industry. Honey and maple products are important products as well. Fresh market vegetables, greenhouse crops excluded, are very seasonal and Canada relies heavily on imports from October to June.

B) Livestock and Poultry

The rigours of the seasonal changes of Canada's climate have forced Canadian domestic animals to be highly adaptive for survival under harsh conditions. They have developed insulation and anti-freeze compounds, circulatory heat exchangers, dietary changes, fat storage, migration and innumerable life cycle modifications, including hibernation.

Of Canada's population of just over 5 million cows, about 75% are beef, of which Alberta has the most at 42%, followed by Saskatchewan (23.5%), Manitoba (11%) and Ontario (10.5%). Quebec has 39% of the dairy cows, followed by Ontario (33.5%), Alberta (8%) and British Columbia (6%). The beef cow herd has increased by 36.5% since 1986, while in the corresponding period, increased production capability has resulted in the level of milk production being maintained with 13% fewer dairy cows.

Quebec and Ontario have over one-half of Canada's swine population at 29% and 27% respectively, followed by the Prairie Provinces of Alberta (16%), Manitoba (15%) and Saskatchewan (7%).

Canada's limited sheep industry is concentrated in Ontario (35.5%) and Alberta (32%), with 8% in British Columbia and 7% in each of Ontario and Quebec.

The poultry industry is concentrated in Ontario (34%) and Quebec (28%), followed by British Columbia (13%) and Alberta (9%).
Products of plant origin account for about 80% of the value of Canada’s agricultural exports.

CHAPTER 2
Indigenous Plant Genetic Resources

2.1 CANADIAN WILD PLANT GERMPLASM OF ECONOMIC SIGNIFICANCE

The conservation of Canadian wild plant germplasm has been of concern to Canada's germplasm specialists for many years. The Expert Committee on Plant and Microbial Genetic Resources (ECPMGR), as well as individual breeders and other interested parties, have identified use, erosion and conservation of our native genetic resources as an important priority. Many of the over 3,000 wild species native to Canada are related to crop plants.

Table 1.1 Reported numbers of native[1] Canadian plant species

Pteridophyta	33 *genera*	109 species
Spermatophyta	701 *genera*	3,160 species
Gymnospermae	10 *genera*	34 species
Angiospermae	691 *genera*	3,126 species
Monocotyledoneae	154 *genera*	925 species
Dicotyledoneae	537 *genera*	2,201 species

1Scoggan, H.J., 1978, The Flora of Canada

There are several native species that are important world genetic resources, for example, *Amelanchier*, *Fragaria*, *Rubus*, *Ribes* and *Vaccinium* species. In addition, Canada is home to several species of plants that are economically important in other parts of the world but have relatively limited acreage in traditional Canadian agriculture (e.g. *Lathyrus*). Many species of algae are also economically important. In particular, marine algae are becoming increasingly important as sources of new and novel products. Aquatic plant and algal species are not covered in this report. Bryophytes are also not included in this survey although many species of mosses are economically important, particularly those involved in the peat industry.

In studies of the importance of native wild plants and ethnobotany in Canada, a great diversity of material was identified as important to the original inhabitants of Canada. Those comprehensive studies provide an excellent overview of the diversity of native plant materials used as food (170 species), beverages (52 species), medicines (over 400 species) or other uses.

Among important Canadian crops, there is a full range of levels of domestication. For example, flax is one of the oldest crops in the world, dating back at least 5,000 years. Landscape plants and forest trees may be used directly from wild stands and relatively little improvement has been carried out.

For this report, crop species have been grouped into the following categories: cereal, oil seed and other field crops; fruit crops; nut crops; forage and turf grass crops; forest trees; vegetable, special and selected small acreage crops; and landscape plants.

In developing these lists, relationships were determined on the basis of taxonomy at the generic level. Species in the primary, secondary or tertiary gene pool will in most cases fall within these bounds. Inter-specific hybrids are more frequent and are more common than inter-generic hybrids, although in some species inter-generic mating, both natural and artificial is relatively common. For example, within the *Hordeum - Triticum* crop complex, successful crosses have been obtained between *Triticum aestivum*, *Psathyrostachys* and *Elymus*. Generic boundaries are by no means the only barrier to gene exchange. Differences in ploidy levels, fertility of hybrids plus a host of other factors need to be considered. The lists presented below are an attempt to identify potential genetic resources worthy of further review and study. Introduced species that have become naturalized in Canada have not been listed as possible genetic resources for the purpose of the present report.

Table 1.2 Cereal, oil seed and other field crops grown in Canada with related wild species native to Canada[1]

Crop	Genus	# of species	Potential native gene pools
Barley	*Hordeum*	3	*depressum, jubatum, pusillum*
Flax	*Linum*	5	*medium, perenne, rigidum,sulcatum, virginianum*
Sunflower	*Helianthus*	10	*decapetalus, divaricatus, giganteus, hirsutus, laetiflorus, maximiliani, nuttallii, petiolaris, strumosus, tuberosus*
Wheat	*Triticum*	0	introduced species - wide crosses possible with related genera, i.e. - *Elymus, Agropyron*

1Scoggan, H.J., 1978, The Flora of Canada

Sunflower comprises the largest native group of species. In the genus *Helianthus* there are many species that cross readily with the oilseed sunflower (*H. annuus*), as well as the Jerusalem artichoke (*H. tuberosus*) and varieties used as flowering plants in the landscape trade. In this genus, it has proven difficult to determine the exact number of native species or breeding relationships. Scoggan (1957) lists seven species and subspecies for Manitoba alone, while Looman and Best (1979) list six for the Prairie provinces. Scoggan (1978) lists ten (four tentatively) for Canada.

Hordeum is another valuable and interesting genus. Some of the intergeneric hybrids occur naturally, while others can only be obtained though controlled crosses. Wide crosses with *H. jubatum* and certain genera (e.g. *Elymus* and *Triticum*) have the potential for increasing salt and drought tolerance, two very important characteristics. Seed heads from *H. jubatum* shatter very readily and can easily overrun other plantings because of the weedy nature of the plant. If plants with tolerance to adverse growing conditions, ease of crossing and reduced seed head shattering could be found from wild populations, the speed of introgression could be increased significantly.

Several species of forage and turf grasses are members of the family *Triticeae* and represent important genetic resources to cereal crop breeding programs. Both *Elymus* and *Andropogon* can be crossed with cereal crops and the interspecific and intergeneric hybrids have been useful in studying phylogenetic relationships.

Table 1.3 Major fruit crops with native[1] representatives in Canada

Crop	Genus	# of species	Potential native gene pools
Apple	*Malus*	2	coronaria, fusca
Blueberry and relatives	*Vaccinium*	17	*alaskaense, angustifolium, atrococcum, caespitosum, corymbosum, deliciosum, membranaceum, myrtilloides, myrtillus, nubigenum, ovalifolium, ovatum, parviflolium, scoparium, stamineum, uliginosum, vacillans*
Buffaloberry	*Shepherdia*	2	*argentea, canadensis*
Cherry	*Prunus*	6	*besseyi, emarginata, pennsylvanica, pumila, serotina, virginiana*
Cranberry	*Oxycoccus*	4	*macrocarpus, microcarpus, ovalifolius, quadripetalus*
Currant and relatives	*Ribes*	18	*americanum, aureum, bracteosum, cereum, cynosbati, divaricatum, glandulosum, howellii, hudsonianum, irriguum, lacustre, laxiflorum, lobbii, sanguineum, setosum, triste, viscosissimum, watsonianum*

1Scoggan, H.J., 1978, The Flora of Canada

Crop	Genus	# of species	Potential native gene pools
Elderberry	*Sambucus*	3	*canadensis, cerulea, racemosa*
Grape	*Vitis*	2	*aestivalis, riparia*
Highbush cranberry	*Viburnum*	9	*acerifolium, alnifolium, cassinoides, dentatum, edule, lantana, lentago, rafinesquianum, trilobum*
Lingonberry	*Vaccinium*	1	*vitis-idaea*
Pawpaw	*Asimina*	1	*triloba*
Plum	*Prunus*	2	*americana, nigra*
Raspberrya nd relatives	*Rubus*	26	*acaulis, allegheniensis, articus, canadensis, chamaemorus, enslenii, flagellaris, hispidus, idaeus, laciniatus, lasiococcus, leucodermis, nivalis, occidentalis, odoratus, parviflorus, paracaulis, pedatus, pensilvanicus, procerus, pubescens, recurvicaulis, spectabilis, stellatus, ursinus, vermontanus*
Saskatoon	*Amelanchier*	15	*alnifolia, arborea, bartramiana, candensis, fernaldii, gaspensis, humilis, huronensis, intermedia, laevis, lucida, mucronata, sanguinea, stolonifera, wiegandii*
Strawberry	*Fragaria*	3	*chiloensis, vesca, virginiana*

These fruit crops and associated native species have had or may have potential in future crop development. Over 110 different species are listed. In some cases, the reported geographic range of some of these plants is very large (e.g. *Fragaria virginiana*) while in others (e.g. *Asimina triloba*) the natural distribution is very small. Of the fifteen crops listed, over half are economically significant: apple, blueberry, cherry, cranberry, plum, raspberry, saskatoon and strawberry. Wild relatives of these crops total 85 species or over 75% of the wild fruit germplasm listed. Many wild species have been used in breeding programs. For example, native plums are generally well adapted and possess excellent winter hardiness and have been used to improve adaptability of domesticated plums.

A review of the development of the cultivated strawberry in North America found that most *Fragaria* introductions were derived from a relatively small population of cultivars and numbered selections descending from a few clones developed prior to 1920. To maintain genetic diversity, plants were collected from 192 sites along coastal British Columbia. These plants have subsequently been evaluated for various diseases, insect resistance and other horticultural and genetic traits. Early indications show that this material could be useful in breeding programs. Another study found that *F. chiloensis* was better able to withstand drought than *F. virginiana*, and detailed screening illustrated that improvements in these attributes could be made by using selected different native plant germplasm. The original cross resulting in the forerunner of the strawberry needs to be re-examined and repeated with broader more diverse germplasm and this will hopefully lead to the development of new, better adapted plants.

Raspberry is another example of a crop developed from a fairly narrow range of germplasm. Many of the over 200 species of the subgenus *Ideobatus* which exist world wide and which could be used to increase the genetic diversity with this crop, occur in Canada. Many species are reported to carry useful traits, including resistance to major fungal pathogens and insect pests.

Many other native fruit crops have had an important historic role in the development of our country as well as a significant impact on our economy today. Much of the blueberry crop harvested in Canada comes directly from native wild stands. The diverse range of *Vaccinium* germplasm in Canada represents a significant potential for further development. Some of the many native fruit crops that have been evaluated include *Amelanchier*, *Prunus virginiana* and *Rosa*. Fruit harvested from these native species may be collected directly from wild stands or plants may be established in small, local, orchard-type enterprises ("U-pick"). These crops and potential crops are receiving much closer scrutiny with Canada's increasing emphasis on diversifying farm enterprises.

The 15 species of *Amelanchier* native to Canada are a valuable world resource. There is considerable potential for further development of this relatively new crop plant.

Table 1.4 Major nut crops with native[1] representatives in Canada

Crop	Genus	# of species	Native representatives
Chestnut	*Castanea*	1	*dentata*
Hazelnut	*Corylus*	2	*americana, cornuta*
Pecan/Hickory	*Carya*	6	*cordiformis, glabra, laciniosa, ovalis, ovata, tomentosa*
Walnut	*Juglans*	2	*cinerea, nigra*

1Scoggan, H.J., 1978, The Flora of Canada

Native nut species that are important in an economic sense are relatively sparse. Only four genera with 11 species are represented, and most of these do not produce material of high enough quality for human consumption.

Only *Corylus* or Hazel is of particular interest. In warmer regions of Canada, there is some commercial production of hazelnut or filberts. Our native representatives have considerable hardiness that may be of interest to nut breeders in the future. The native hazelnut has a broad range of distribution across Canada and was used by early settlers and aboriginal peoples. There may be additional traits that could be exploited from this material.

Table 1.5 Major forage and turf grass crops with native[1] representatives in Canada

Species	Genus	# of species	Native representatives
Bent Grass	*Agrostis*	5	*borealis, diegoensis, exarata, hyemalis, perennans*
Bluegrass	*Poa*	34	*abbreviata, alpina, alsodes, ampla, arctica, arida, canbyi, confinis, cusickii, eminens, epilis, gaspensis, glauca, hartzii, howellii, juncifolia, labradorica, laxa, leptocoma, lettermannii, macrantha, marcida, nemoralis, nervosa, nevadensis, occidentalis, palustris, pattersonii, pratensis, saltuensis, sandbergii, stenantha, trivialis, vaseyochloa (plus numerous varieties)*
Bluestem	*Andropogon*	3	*gerardii, hallii, scoparius*
Bromegrass	*Bromus*	12	*anomalus, canadensis, carinatus, catharticus, ciliatus, inermis, pacificus, porteri, pubescens, purgans, sitchensis, vulgaris*
Canary Grass	*Phalaris*	1	*arundinacea*
Clover	*Trifolium*	10	*bifidum, cyathiferum depauperatum, microcephalum, microdon, oliganthum, reflexum, tridentatum, varigatum, wormskjoldii*
Fescue	*Festuca*	8	*altaica, obtusa, occidentalis, ovina, rubra, subulata, subuliflora, viridula*

1Scoggan, H.J., 1978, The Flora of Canada

Species	Genus	# of species	Native representatives
Milk-Vetch	*Astragalus*	34	*adsurgens, agrestis, alpinus, americanus, beckwithii, bisulcatus, bodinii, bourgovii, canadensis, collinus, crassicarpus, drummondii, eucosmus, filipes, flexuosus, gilviflorus, gracilis, gilviflorus, gracilis, kentrophyta, lentiginosus, lotiflorus, microcystis, miser, missouriensis, neglectus, pectinatus, purshii, racemosus, robbinsii, sclerocarpus, spatulatus, tenellus, umbellatus, vexilliflexus, williamsii*
Sainfoin	*Hedysarum*	4	*alpinum, boreale, occidentale, sulphurescens*
Timothy	*Phleum*	1	*alpinum*
Trefoil	*Lotus*	5	*denticulatus, formosissimus, micranthus, pinnatus, purshianus*
Vetch	*Vicia*	3	*americana, carolinia, gigantea*
Wheatgrass	*Agropyron*	6	*albicans, dasystachyum, scribneri, smithii, spicatum, trachycaulum, (plus numerous inter-specific and inter-generic hybrids)*
Wild Rye	*Elymus*	12	*canadensis, diversiglumis, glaucus, hirsutus, hystrix, innovatus, mollis, piperi, riparius, sibiricus, villosus, virginicus, (plus 8 interspecific hybrids and 3 inter-generic hybrids-Hordeum)*

This table presents the major forage and turf grass species with wild native representatives in Canada. Native range grasses and forbs have not been included. These native plants have a significant value in all parts of Canada, whether for pasture, erosion control, benefit to wildlife or other usages.

A large number of native species are related to forage crop plants, with a total of 138 species representing 14 genera. The largest genera are the bluegrasses (34 spp.), brome grass (12 spp.), milk-vetch (34 spp.), and wild rye (12 spp.). Several important forage crops (e.g. Alfalfa and Sweet Clover) do not have native relatives in Canada.

Several species are members of the *Poaceae* family, tribe *Triticeae*, and represent important genetic resources for cereal crop breeding programs.

Many native grasses are receiving special attention in the conservation field. For example, in Manitoba, a great deal of effort is put into the conservation of the tall grass prairie. Very few undisturbed sites have been located so far but they are now being protected.

Table 1.6 Native[1] vegetable, special crops, crops or minor acreage crops with native relatives in Canada

Crop	Genus	# of species	Potential native gene pools
Amaranth	*Amaranthus*	4	*albus, californicus, graecizans, tuberculatus*
Evening primrose	*Oenothera*	13	*andina, biennis, breviflora, caespitosa, contorta, cruciata, flava, nuttallii, pallida, parviflora, perennis, pilosella, serrulata*
Fern	*Matteuccia*	1	*struthiopteris*
Horseradish	*Armoracia*	1	*aquatica*
Hyssop	*Agastache*	4	*foeniculum, nepetoides, scrophulariaefolia, urticifolia*
Lathyrus	*Lathyrus*	7	*bijugatus, japonicus, littoralis, nevadensis, ochroleucus, palustris, venosus*
Lesquerella	*Lesquerella*	4	*alpina, arctica, douglasii, ludoviciana*
Mint	*Mentha*	1	*arvensis*
Monarda	*Monarda*	1	*fistulosa*
Onion	*Allium*	10	*acuminatum, amplectens, canadense, cernuum,crenulatum, geyeri, schoenoprasum, stellatum, textile, tricoccum*
Onosmodium	*Onosmodium*	2	*hispidissimum, occidentale*
Proso millet	*Panicum*	30	*bicknellii, boreale, capillare, clandestinum, columbianum, depauperatum, dichotomiflorum, dichotomum, flexile, lanuginosum, leibergii, linearifolium, longifolium, macrocarpon, meridionale, occidentale, oligosanthes, pacificum, perlongum, philadelphicum, praecocius, rigidulum, sphaerocarpon, spretum, subvillosum, thermale, villosissimum, virgatum, wilcoxianum, xanthophysum*
Quinoa	*Chenopodium*	5	*capitatum, fremontii, hybridum, leptophyllum, rubrum*
Taxus	*Taxus*	2	*brevifolia, canadensis*
Wild Rice	*Zazania*	1	*aquatica*

1Scoggan, H.J., 1978, The Flora of Canada

This is a mixed assemblage of native vegetable, special crop, and small acreage crops. A total of 15 genera and 86 species have been identified. The economic importance of these crops varies. Some, such as wild rice (*Zizania*), are a well-known, important, economic crop in a large part of the country, with particular importance for indigenous people, while others, such as fiddleheads (*Matteucia*), are more regionally significant, representing a significant cash income potential to local residents.

Some species are related to crop plants that are economically important in other parts of the world. There are seven species of *Lathyrus*, an important crop in Asia, but also native to Canada where little, if any, production is occurring.

Their potential for use in the economic improvement and diversification of this crop is unknown.

Several essential oil crops are native to Canada (e.g. *Monarda* and *Mentha*). As these are minor acreage crops, often there are only small breeding studies associated with production programs and limited conservation programs.

The only economically important vegetable crop found with wild relatives is *Allium*. There 10 different native species of onion in Canada. Exploitation of these species is limited. Several have been or are being harvested by local residents as speciality crops.

Proso millet has been identified as a crop with some potential in Canada. There are 30 species of *Panicum* native to our country, but very few have been tested for economic production.

New crops are being identified in various sectors of the country. Until fairly recently, *Taxus brevifolia* was considered a weedy species in the Pacific forest. This plant now is a major source of taxol, a chemical that has shown activity against various cancers (melanoma, mammary, and ovarian). Serious genetic erosion of this species could take place if conservation measures are not implemented. Other medicinal crops and health food crops include evening primrose (*Oenothera*) and *Onosmodium*, both of which are sources of gamma linolenic acid. Horseradish (*Armoracia*) is being grown for the condiment market as well as for peroxidase production. The aquatic horseradish, found in the central part of the country, is one species of horseradish reported as native in Canada, and may be of value in future breeding programs. There are many more health food type crops, however, limited commercial production is known to exist.

There are many interesting native plants, many of which we are just learning about now. Few of the species listed are major economic crops at the present time, but with the increasing emphasis on diversification and processing (value-added), the potential for growth is significant.

Forest genetic resources need particular attention to conservation which is being undertaken by the Canadian Forest Service. Efforts are underway to collect, characterize and maintain genetic material at appropriate centres across Canada (Please see Part Two - Forestry.).

Landscape Plants are the last major crop grouping. It is very difficult, if not impossible, to estimate how many native plants provide important genetic resources to the landscape industry. Nearly every plant can be used in a landscape setting of one kind or another. A tentative listing of native genera with known potential and generally accepted in the trade today are presented in Table 1.7 (following). No attempt to list species was made.

A total of 137 genera are listed which represents a significant cross-section of woody, herbaceous perennials and grasses grown in the landscape industry of Canada. Many species have been previously listed in "other crops" categories.

For example, many forest trees are used in the landscape industry, several flax species are used as ornamentals and many fruit species serve a dual purpose in the landscape. Nevertheless, the plant material used in the landscape industry is the most diverse of all our crop plants.

There are many species that have been used in conventional breeding programs to develop superior plants for industry. The development of hardy shrub roses provides a good example of how native germplasm has been effectively used.

This new group of roses are propagated by cuttings, have good foliage and floral characteristics and are hardy (at least the roots) to zone 3. These plants are widely grown, and in many areas of Canada, are replacing the use of tender hybrid tea and floribunda roses.

Another example of native species being used in breeding programs is in *Populus* breeding. *P. x canadensis*, "Prairie Sky", combines the hardiness of the native female parent *P. occidentalis*, with the form of male parent, *P. nigra* "*Thevestina*". The resulting male F_1 hybrid also posses excellent vigour and disease resistance.

In addition to being used to hybridize with exotic plants, many landscape plant cultivars have been selected directly from wild populations. Shade trees featuring local or regional adaptation have been identified from native plant populations. "Fall Gold" black ash (*Fraxinus nigra*) was selected from a local population on the basis of hardiness, adaptability and fall foliage colour.

"Delta" hackberry (*Celtis occidentalis*) is a seed-propagated strain of hackberry that was selected from a remnant wild population near Lake Manitoba. In urban forestry, the use of native plant material is becoming a larger and larger issue. Concern is being expressed over the use of exotic species and more and more emphasis is being placed on utilization of native trees and shrubs in planting programs. Native species are usually better adapted to local climatic conditions and more resilient to pest-related problems.

Landscape plant material is not restricted to woody species. Many herbaceous perennials are valuable to the nursery industry. Some more important genera of herbaceous perennials with native relatives are listed in Table 1.7. This listing represents a broad cross-section of genera (46), some of which may be used directly in gardens while others have been used in breeding programs. *Heuchera* breeding is an example of incorporation of hardiness from the native species (*H. richardsonii*) with more tender relatives (e.g. *H. sanguinea*), resulting in release of "Northern Fire", a hardy red-flowered plant.

Many grass genera have landscape potential due to maintenance, hardiness and aesthetic considerations (Table 1.7). Some grasses are being used as alternative ground covers that require low maintenance (reduced costs). Many genera are adapted to xeric situations due to drought and/or salt tolerance while others are more adapted to more mesic situations. There is an increasing trend to use native grass species in a wide variety of traditional and non-traditional landscape situations as more testing is completed and information becomes available.

Table 1.7 Selected woody, herbaceous and grass genera with native representatives in Canada

Coniferous		Deciduous		Herbaceous	
Trees	**Shrubs**	**Trees**	**Shrubs**	**Flowers**	**Grasses**
Abies	*Abies*	*Acer*	*Alnus*	*Achillea*	*Acorus*
Larix	*Juniperus*	*Asimina*	*Amelanchier*	*Actaea*	*Alopecurus*
Picea	*Picea*	*Betula*	*Amorpha*	*Agastache*	*Andropogon*
Pinus	*Pinus*	*Carpinus*	*Arctostaphylos*	*Anemone*	*Anthoxanthum*
Pseudotsuga	*Taxus*	*Celtis*	*Clematis*	*Anaphalis*	*Arrhenatherum*
Thuja		*Cercis*	*Cornus*	*Antenaria*	*Bouteloua*
Tsuga		*Crataegus*	*Diervilla*	*Aquilegia*	*Brachypodium*
		Fraxinus	*Elaeagnus*	*Artemisia*	*Briza*
		Gymnocladus	*Hamamelis*	*Aster*	*Bromus*
		Juglans	*Kalmia*	*Calceolaria*	*Calamagrostis*
		Liriodendron	*Lonicera*	*Campanula*	*Carex*
		Magnolia	*Mahonia*	*Clematis*	*Chasmanthium*
		Malus	*Ostrya*	*Delphinium*	*Chrysopogon*
		Nyssa	*Philadelphus*	*Dryas*	*Deschampsia*
		Platanus	*Physocarpus*	*Echinacea*	*Elymus*
		Populus	*Potentilla*	*Erigeron*	*Festuca*
		Prunus	*Prunus*	*Gaillardia*	*Glyceria*
		Ptelea	*Rhododendron*	*Galium*	*Helictotrichon*
		Quercus	*Rhus*	*Gentiana*	*Keoleria*
		Salix	*Ribes*	*Geum*	*Miscanthus*
		Sassafras	*Rosa*	*Heuchera*	*Molinia*
		Sorbus	*Salix*	*Iris*	*Panicum*
		Tilia	*Sambucus*	*Liatris*	*Phalaris*
		Ulmus	*Shepherdia*	*Lilium*	*Phleum*
			Spiraea	*Linum*	*Phragmites*
			Symphoricarpus	*Lobelia*	*Schizachyrium*
			Vaccimium	*Lupinus*	*Sesleria*
			Viburnum	*Mianthemum*	*Sorghastrum*
				Mertensia	*Spartina*
				Monarda	*Sporobolus*
				Oenothera	*Trisetum*
				Opuntia	
				Penstemon	
				Phlox	
				Physostegia	
				Polygonatum	
				Potentilla	
				Rudbeckia	
				Solidago	
				Thalictrum	
				Tradescantia	
				Viola	
				Yucca	
				Zigadenus	
				Zizia	

Landraces ("Farmers' Varieties") and Old Cultivars

Few landraces of domesticated crops were developed by indigenous people in Canada. Flint maize and wild rice (*Zizania*) are two exceptions. Immigrants to Canada introduced much landrace germplasm from their countries of origin, little of which is in current use, except in crops which have not been the object of intensive plant breeding programs. No landraces are grown on a commercial basis among the cultivated varieties in Canada.

The Heritage Seed Program (HSP) has more than 1.800 members consisting of backyard gardeners, farmers, historical sites, museums, horticultural historians, botanical gardens and scientists who seek out and preserve heirloom and endangered varieties of vegetables, fruits, grains and herbs. More than 100 of its members are listed to grow and distribute heirloom or unusual materials. HSP has taken over a nursery with approximately 350 cultivars of heirloom and rare fruit trees which will serve as a genetic reservoir as well as a source of propagation material. A garlic collection was established and now contains about 30 accessions. Heirloom potato cultivars are of interest to the association.

There are numerous institutions, organizations and individuals across the country that have collections of landscape plant material. For example, Van Dusen Gardens (B.C.) has started a heritage garden for Canadian introductions, and AAFC's Morden Research Station has a significant collection of prairie hardy landscape plants. Because of the diversity of organizations, plant material and climatic zones, it will be a challenge to develop a national program or objective for landscape plants.

CHAPTER 3
National Conservation Activities

3.1 *IN SITU* CONSERVATION ACTIVITIES

In Canada, the first protected areas were established in the late nineteenth century, during the first decades after Confederation. Today, federal, provincial, territorial and municipal governments and indigenous communities, along with individuals and private organizations, acquire and manage lands to conserve biodiversity.

The World Conservation Union (IUCN) has developed a system for classifying protected areas. According to this system, about 8 percent of Canada is classified as "protected" with about 4 percent being removed from all commercial extractive activities. The National Conservation Areas Data Base (NCADB) developed by Environment Canada, the Canadian Council on Ecological Areas and others, identify approximately 3,500 publicly owned protected areas, covering about 788,000 km^2, and approximately 10,000 km^2 held by non-government groups.

Governments, conservation organizations and individuals are continuing to establish protected areas. Efforts have also been directed at developing better biological inventories, ecological land classifications and planning to support the establishment of protected areas. In 1992, the Canadian Agricultural Services Coordinating Committee (CASCC) supported a strategy on the conservation of native wild plants of economic significance.

3.2 *EX SITU* COLLECTIONS

Agriculture Canada, a federal government department, appointed the first Plant Gene Resources Officer, and established Plant Gene Resources of Canada (PGRC) in 1970. It is now part of the Centre for Land and Biological Resources Research.

The PGRC Seed Genebank on the Central Experimental Farm in Ottawa, as the agency which is central to Canada's germplasm system, acts as a clearing house for samples and information on seed of interest to breeders in Canada. Seed obtained through collecting expeditions or requests to other genebanks throughout the world is catalogued, tested for germination, rejuvenated if necessary, and samples are distributed free of charge, on request, for research and breeding purposes. Requests from Canadian researchers for samples from outside the country are processed through PGRC. As well, PGRC receives many requests each year from other genebanks for accessions stored in Ottawa.

PGRC has increased its seed collections from a total of 505 samples stored at PGRC in 1971, to over 100,000 samples in 1995. The level of activity is illustrated by Table 1.8 (following) which covers the past five years. Excluding domestic movement and exchanges with the USA, 21 shipments, 1,291 accessions were received from 10 foreign countries, and 206 shipments, 4,436 accessions were sent out to 40 foreign countries.

Table 1.8 PGRC: Seed Germplasm Exchange 1990 - 1994

Country		- OUT -		- IN -	
		Shipments sent	Accessions sent	Shipments received	Accessions received
1.	Albania	1	1	0	0
2.	Argentina	3	33	0	0
3.	Australia	19	78	0	0
4.	Bulgaria	2	65	2	72
5.	Canada	311	30,096	242	27,652
6.	China	2	43	3	157
7.	Croatia	1	18	0	0
8.	Czechoslovakia	5	32	0	0
9.	Denmark	1	3	0	0
10.	Egypt	4	694	1	201
11.	Finland	1	5	0	0
12.	France	26	665	0	0
13.	FRG	1	3	0	0
14.	Germany	12	110	2	24
15.	GRD	1	7	0	0
16.	Hungary	4	150	0	0
17.	India	17	168	0	0
18.	Israel	2	3	0	0
19.	Italy	17	65	0	0
20.	Japan	13	197	0	0
21.	Mexico	5	392	2	9
22.	Nepal	1	144	1	10
23.	Netherlands	8	52	0	0
24.	New Zealand	3	4	0	0
25.	Nigeria	0	0	3	221
26.	Pakistan	2	38	0	0
27.	Poland	6	92	0	0
28.	Portugal	1	1	0	0
29.	Romania	1	20	1	1
30.	Russia	8	272	1	3

Country		- OUT -		- IN -	
		Shipments sent	Accessions sent	Shipments received	Accessions received
31.	South Africa	3	36	0	0
32.	Spain	6	58	0	0
33.	Sweden	8	127	0	0
34.	Switzerland	1	9	0	0
35.	Syria	4	744	0	0
36.	Turkey	2	6	0	0
37.	UK	7	60	5	593
38.	Uruguay	1	11	0	0
39.	USA[1]	94	2,756	18	33,478
40.	USSR	4	24	0	0
41.	Venezuela	1	4	0	0
42.	Yugoslavia	1	1	0	0
43.	Zimbabwe	1	1	0	0
Total		611	37,288	281	62,421

1. USA accessions received include extra seed samples for the world principal base collection of barley and oats

PGRC preserves material of four Canadian collections:

1. The CN Collection. The permanent collection, designated with the symbol "CN", comprises 18,700 samples of wheat, barley, oats, tomato and alfalfa accessions which meet national criteria for permanent preservation.
2. The PGR Collection. This is a holding collection that contains over 26,600 samples of crops for which national criteria have not yet been defined, or samples which have not yet been tested for conformity to defined criteria.
3. The Canadian *Avena* (CAV) and Canadian-Scandinavian *Hordeum* (CHC) Collections. The accessions of these collections are almost exclusively wild species. The *Avena* collection has 7,400 samples and the *Hordeum* collection has 3,400 accessions.
4. World Base Collections. Through an exchange of letters with the then International Board on Plant Genetic Resources (IBPGR) [now known as International Plant Genetic Resources Institute (IPGRI)] Canada accepted responsibility for the preservation of world principal base collections of *Hordeum* and *Avena* (over 20,000 accessions each), plus duplicate world base collections of pearl millet and oilseed *Brassicas*.

The PGRC regularly grows out accessions to rejuvenate seed viability.

The Canadian Clonal Genebank located near Trenton, Ontario, was designated in 1989 as the primary germplasm repository for horticultural crops. For several other species which would not be hardy there, either Sannichton, B.C., or

Vineland, Ontario., were designated as primary locations. Secondary locations have been designated for backup material.
More than 2,500 accessions are now preserved. *Malus* and *Fragaria* clones are the most numerous; there is also germplasm of *Pyrus*, *Rubes*, *Ribes* and *Sambucus*. Most material is preserved in the field as clones and work is progressing well on preservation using tissue culture (e.g. native *Fragaria* accessions are *in vitro*). Seed has been collected from some *Fragaria* interpollinations as an additional safeguard.

A Multi-Nodal System was established in 1992 to respond to recommendations from study committees on the enhancement of germplasm conservation in Canada. This initiative links rejuvenation, evaluation, and documentation to research and development programs for specific crop plants; enhances maintenance and data management for Canada's microbial genetic resources; and builds on an animal genetic resource initiative at the Centre for Food and Animal Research in Ottawa.

The strategy behind the multi-nodal system is to establish nodes at locations where there are plant breeding programs. This is in line with recommendations of FAO; that the expertise of plant breeders be used to characterize, rejuvenate and document the diversity in collections. The Winnipeg Research Centre is responsible for cereals including wheat, oats and barley. Hardy ornamentals, new crops and specialty crops are handled by the Morden Research Centre.

The Saskatoon Research Centre is responsible for oilseed *Brassicas*, while the Fredericton Research Centre is responsible for potatoes. In 1994, the Lethbridge Research Centre assumed responsibility for the coordination of forage crop germplasm activities (both legumes and grasses), which will involve breeders at four research centres.

In the multi-nodal system, the two central agencies, PGRC and the Canadian Clonal Genebank, are still the primary contact points for germplasm entering or leaving Canada, and have responsibility for national and international contacts, distribution, database and technical information.

The multi-nodal system offers a number of opportunities for Canadian germplasm conservation. The rejuvenation of the major species will be done at the plant breeding locations responsible for the species, allowing the central agencies to concentrate on preservation technology. Characterization will be done by the plant breeders, who have the expertise in the field. This will permit an accumulation of information on accessions, for which there is currently insufficient information.

All of the preceding initiatives are funded exclusively by the federal government. The funding allocated to crop plant genetic resources activities has increased ten-fold over the past ten years.
The national program seeks to preserve a representative sampling of germplasm significant to Canadian agriculture. To this end, national criteria are being established, crop by crop, to determine which samples should be included in national collections. Future acquisitions will also be judged for inclusion based on these criteria. It is important to note, however, that the nature and extent of the genetic representativity of the collections is basically unknown so far.

Canada is very conscious of the fact that no country can pretend to preserve on its own all of the genetic diversity needed for all of its crop plants for all time. Our country recognizes the need to coordinate and share the work of conservation among countries. Canada strongly supports and effectively participates in international collaborative programs to this end, particularly the crop networks set up with the assistance of the International Plant Genetic Resources Institute (IPGRI).

Most collecting trips are focused, however, while there, opportunistic collections are made. Over the last three decades, slightly over 100 scientists have visited over 40 countries where they collected approximately 100 genera of nearly 50 different plant families. Most trips are according to a planned collecting program. The most of these collections were for breeding and selection, preservation of genetic diversity and taxonomic research. Collections were made also for botanical gardens, *ex situ* conservation of species, other research and other reasons. Depending on the location and species, samples are derived from roadsides, markets and remote areas, in order of frequency. Order of preference is: remote areas, roadsides, markets. Following collection, the accessions are tested for germination, disease and regeneration. As time permits, evaluations are carried out for a series of agronomic characteristics pre-determined for the species. Germplasm which does not correspond to criteria for preservation in our own national collections is offered to the appropriate world genetic resources centre, subject only to assurances that it will be well managed, and that Canadians will be able to maintain right of access to samples of the germplasm as needed.

Universities in Canada play a less formal role in germplasm conservation. There are plant breeding activities at seven Canadian universities where there are departments of agriculture. Germplasm collections at these universities are generally the working collections of plant breeders and taxonomists rather than genetic resources collections. Nevertheless, breeders are encouraged to supply fresh seed and the complete documentation for these lines so that germplasm with unique genetic traits, which meet national criteria, can be included in the government's gene bank.

In addition to supplying material to the genebank, many breeders have used plant introductions to create new characteristics in some varieties. Examples are resistance to stem rust (*Puccinia graminis*) in spring wheat and resistance to barley yellow dwarf virus (BYDV). Research into germplasm conservation is being conducted at four universities, and germplasm collecting expeditions have been conducted by staff from several of them.

Canadian seed companies with plant breeding programs have contributed in several ways to germplasm conservation. Because of competition, there are many varieties available in the market, thus increasing the deployed genetic diversity. Seed companies have incorporated foreign germplasm in most of their varieties, and, as these varieties are modified and improved, the new germplasm is carried along and preserved in the material being deposited in gene banks.

Industry has also assisted PGRC in rejuvenating and characterizing the germplasm of many crops. These efforts have resulted in a better supply of germplasm of interest to Canadian breeders. Germplasm preservation is also helped by the fact that most plant breeding companies have their own seed storage facilities.

Botanical Gardens conserve old selections of many groups of garden plants in systematic collections, maintaining collections of species in jeopardy, or studying their biology and culture. Some also manage nature reserves, or help coordinate the restoration of degraded habitats. A proposal has been made for a botanical garden system which would include a centralized inventory system for the wild and cultivated plant materials which they conserve.

Non-Government Organizations, notably the Heritage Seed Program (HSP), are involved in many activities that contribute to germplasm conservation. The HSP specializes in varieties of vegetables and fruits which are not suitable for large scale commercial production, and are working towards establishing national collections of specialty crops such as garlic, rhubarb, Jerusalem artichokes and short-season sweet potatoes. They have a long term plan to establish a National Fruit Tree Registry and a network of preservation orchards across the country. Three such orchards have already been planted. HSP publishes information in a magazine distributed to the organization's members throughout Canada. As well, they try to monitor clonal material from gardens, small growers, historic sites and small nurseries that maintain a diverse inventory.

3.3 STORAGE FACILITIES

Seed storage facilities at PGRC consist of long term, medium term and cryopreservation units. For long term storage, 247 m^3 of storage vaults is available in which seed is preserved in laminated envelopes at - 20°C. There is 162 m^3 of medium term storage, where seed is stored in paper envelopes at + 4°C and 20% relative humidity. After 30-60 days of medium term storage, the seed moisture level drops around 6-8% and the seed can be transferred to long term storage. There are also three liquid nitrogen storage units for cryopreservation of 3,000 samples.

At Morden, long term storage consists of 105 m^3, which can be expanded; 52.5m^3 of medium storage with humidity control; and 1,100 m^3 of cool storage with rolling shelving units. This unit is used more for breeder seed storage at the present.

Winnipeg has approximately 240 m^3 of cool storage.

3.4 DOCUMENTATION

Canada was one of the first countries to initiate computerized documentation of genebank accessions, in the early 1970s. Information is maintained in the database management system in the form of "descriptors" which relate to individual traits used to characterize genebank accessions. These descriptors can be classified into three categories: "passport", "management", and "evaluation".

Passport descriptors identify the individual genebank accessions according to the origin and source of the accession, when and where it was collected or bred, the name of the crop, its scientific classification, alternative names, and basic biological information such as the nature of the stock, the life span, and the improvement status (cultivar, landrace, wild, etc.).

Management data is for the use of genebank personnel and keeps track of material and activity, including location and quantity, viability, exchanges, health status, and seed increase. These descriptors are designed to apply to every crop.

Evaluation (characterization) data gives information on the agronomic and genetic characteristics of the accessions, and are crop specific. For example, the wheat collection has "bread quality" and "resistance to lodging" as evaluation descriptors. "Agronomic " descriptors relate to characteristics controlled by many genes and are environment sensitive, including, for example, earliness and yield. "Genetic" descriptors relate to more specific, environmentally stable, highly heritable information, applying, for example, to morphological, biochemical (such as isoenzyme) or molecular (DNA) traits. Each descriptor is assigned different levels called "states", which describe such characteristics as fruit shape.

A new database system, the "Canadian Agricultural Plant Genetic Resources Information System" (CAPGRIS), has been under development since 1988. A version for the use of PGRC staff was implemented in September, 1993. A micro-computer local area network was implemented and connected to Agrinet, the departmental-wide area network in January, 1994. Interactive on-line services for external clients on the Internet are planned for 1995. Canadian genetic resources inventories containing information on the origin and characteristics of the CN collection samples were published for wheat, barley, oats and tomato. The information on the maize samples of the CN collection was published in collaboration with the United States Department of Agriculture (USDA) on a CD-ROM called LAMP (Latin American Maize Project). The Canadian Clonal Genebank distributes an annual inventory of its holdings. Information can also be sent out on micro-fiches, tapes, diskettes, E-mail or computer printouts.

3.5 EVALUATION AND CHARACTERIZATION

Agronomic evaluation has been the responsibility of the breeders and other crop experts, not the national genetic resources programme. This is changing to some degree with the multi-nodal system. In recent years, the Canadian Clonal Genebank has been working with *Malus*, *Fragaria*, *Ribes*, *Rubus*, and *Sambucus*, doing virus-indexing and gathering fruiting and flowering data on a number of accessions. Genetic diversity analysis has practically not been addressed in Canada.

3.6 REGENERATION

PGRC follows the guidlines established by the International Plant Genetic Resources Institute regarding the quantity of seed needed to ensure the conservation of the genetic diversity of genebank accessions. A standard seed sample consists of 5,000 seeds for a genetically heterogeneous accession, and 2,000 seeds in the case of a genetically homogeneous accession.

Plants are grown out when there is too little seed in stock or when seed viability falls below 85%. Seed viability is monitored by means of sequential germination tests. Samples with less than 76% germination in the first iteration will be grown out to produce fresh seed, according to available resources. Samples scoring between 76% and 92% are retested before a decision is made. About 25,000 seed samples have been tested over the years, and a few seeds of an additional 30,000 samples were germinated to establish regeneration priorities. As a result, some information is available on over 50,000 seed accessions.

Accessions are increased in the greenhouse if they meet one or more of the following criteria:

- when there is an extremely low amount of seed in stock: we want to be able to watch the germination and development of the plants closely to avoid loss of the accession;
- when there is risk of dispersal of a wild or weedy plant species if it were planted in the field: this is particularly the case for the wild oats and barleys in the CHC and CAV collections. By performing the increase in the greenhouse, we prevent dispersal of wild oats and barleys in breeders' plots, and we ensure harvest of shattering species' seeds;
- when vernalization is necessary;
- when cross-breeding species need isolation and/or hand-pollination.

Major clients are solicited also to participate in a collaborative Germplasm Revitalization Program. For example, in 1992, various collaborators returned a total of 5,481 increases. This included barley, *Brassicas*, corn, wheat, oats, field peas, beans, sunflowers, tomatoes, pearl millet and tobacco.

In October 1991, a Memorandum of Understanding was signed between the federal government's department of agriculture, represented by PGRC, and a non-governmental organization, the Heritage Seed Program (HSP). Under the terms of this agreement, PGRC and HSP decided to establish conservation plots for the preservation of the genetic diversity of crop plants. HSP growers have already rejuvenated dozens of seed samples preserved in the national crop genebank during the three growing seasons over which the agreement has been in effect. The HSP growers have the opportunity to enjoy a greater selection of crop diversity, because by taking advantage of the genebank's storage capacities, they are not obliged to regrow the same variety so often. The HSP growers have unrestricted access to samples of genetic resources for non-commercial purposes. Choice of the varieties to grow is guided by the need to rejuvenate accessions which have a small amount of seed left, or a low percentage of viability. An agreement has been established recently for potatoes and similar agreements are being considered for the conservation of clonal crops such as fruit trees and berries.

CHAPTER 4
In-Country Uses of Plant Genetic Resources

4.1 USE OF PGR COLLECTIONS

Referring to Table 1.8 in Chapter 3, during the last five years, the PGRC genebank received 39 shipments, 34,769 accessions from foreign countries, and sent 300 shipments, 7,192 accessions to foreign countries. The number of accessions received includes seed samples received from the USA for the world principal base collection of barley and oats.

Barley, wheat and oats are by far the three crops that are the most frequently used in national projects. Table 1.9 shows that 92% of the 30,096 seed samples shipped to Canadians by PGRC between 1990-1994 belong to these three crops (Hordeum: 12,841 samples, 43% of the total; *Triticum*: 8,442 samples, 28% of the total; and *Avena,* 6,403 samples, 21% of the total). Those three crops have also the largest number of users with 23, 23 and 13 respectively. Maize (*Zea*) shows in third place with as little as 2% of the total shipments (572 samples), but with a high number of users (16).

Table 1.9 National use of PGRC seed samples, by crop, 1990-1994

Crop	Users	Lots	Number of accessions shipped to:					Total
			Fed.	Univ.	Priv.	NGOs	Prov.	
1 *Hordeum*	23	47	11,106	1,642	7	14	72	12,841
2 *Triticum*	23	36	8,270	149	7	15	1	8,442
3 *Avena*	13	26	6,112	277	3	11	0	6,403
4 *Zea*	16	23	238	72	248	14	0	572
5 *Fagopyrum*	1	2	308	0	0	0	0	308
6 *Glycine*	8	19	226	1	38	18	0	283
7 *Lycopersicon*	7	10	193	0	12	34	0	239
8 *Brassica* (oilseed)	7	10	22	106	39	0	0	167
9 *Phaseolus*	8	16	100	0	0	63	0	163
10 *Pennisetum*	2	2	1	94	0	0	0	95
11 *Linum*	3	3	92	1	1	0	0	94
12 *Helianthus*	1	2	86	0	0	0	0	86
13 *Pisum*	7	13	31	1	0	36	1	69
14 *Bromus*	5	6	56	0	0	0	0	56
15 *Phalaris*	1	1	0	48	0	0	0	48
16 *Sinapis*	2	2	45	0	0	0	0	45

Crop	Users	Lots	Number of accessions shipped to:					Total
			Fed.	Univ.	Priv.	NGOs	Prov.	
17 Aegilops	2	3	10	25	0	0	0	35
18 Brassica (vegetable)	3	3	25	0	0	0	0	25
19 Secale	4	4	19	2	0	0	0	21
20 Sorghum	1	1	19	0	0	0	0	19
21 Medicago	4	4	8	0	0	1	2	11
22 Nicotiana	2	2	2	0	0	0	9	11
23 Agropyron	1	1	10	0	0	0	0	10
Other genera (19)	22	23	32	11	0	8	2	53
Total			**27,011**	**2,429**	**355**	**214**	**87**	**30,096**

Table 1.10 National use of PGRC seed samples, by clientele, 1990-1994

Type of organization	Users	Shipments	Samples
Federal government	87	155	27,011
University	31	48	2,429
Private company	30	35	355
NGO (including private citizens)	39	67	214
Provincial government	6	6	87
Total:	**193**	**311**	**30,096**

Table 1.10 shows that the federal government, through mainly breeders and scientists from AAFC's Research Branch, surpasses all other categories of clients in terms of users (87; or 45% of the total of 192), shipments (155; or 50% of the total of 311) and samples (27,011, or 90% of the total of 30,096 samples shipped). The very high proportion of samples shipped to AAFC research stations is partially a reflection of the recent increase in efforts over the last three years to evaluate, rejuvenate and rationalize the collection of genetic resources maintained by PGRC. The second largest category of users (39; or 20% of the total of 193 users) consists of NGOs, mainly members of the Heritage Seed Program, that are actively involved in a joint venture with PGRC to revitalize and promote use of traditional and heirloom varieties. It must be noted though that the number of samples involved in that program is rather limited, with 214 samples shipped (1% of the total of 30,096). University people are the third largest group of users (31; or 16% of the total). They received 8% (2,429 samples) of the total shipments. Private companies are very close to universities in term of users (31, or 16% of the total), but much lower in terms of samples used (355 samples, or 1% of all samples shipped); a proportion nearly identical to the NGOs and private citizens). Provincial governments are making very limited use of genetic resources held by PGRC.

There is no way to assess the proportion of all plant genetic resources used in Canada that are coming from the national genebank system. All research organizations involved in plant breeding activities have their own working collections of genetic resources. Scientists are constantly introducing new genetic material from a variety of national and international sources. PGRC is not involved in this heavy flow of new introductions unless it receives a formal request for assistance from a breeder. The impression is that the major current introduction sources for plant breeding activities in Canada are probably American.

Out of the genetic collections maintained by PGRC, forages have historically been little used. The collections consists of a large number of genera (48) and species (502 binomials) and a small number of samples (4,160). This is expected to change radically over the next few years, with the transfer in late 1994 of all of the forages (both legumes and grasses) to the new genebank node in Lethbridge, and the initiation in 1995 of a cooperative evaluation/rejuvenation program involving most forage breeders in AAFC research stations.

Genebank samples maintained by PGRC are available for research and breeding purposes. They are not generally directly accessible to farmers. Most field crop cultivars must be registered by AAFC to be available for sale in Canada. Genetic resources maintained in genebanks do not generally meet the agronomic performance standards required for commercial variety registration.

Backyard gardners have access to the genetic resources maintained by PGRC through the Memorandum of Understanding between PGRC and the Heritage Seed Program. The HSP does not sell seed. Growers are provided with a package of information which explains the rules for participating in the project and contains growing and seed-saving guidelines and record sheets.

4.2 Crop Improvement Programmes and Seed Distribution

National plant breeding programs develop improved cultivars of the major crops in Canada. Most of the advances are based on the improvement of quality, disease resistance and agronomic performance traits of currently registered cultivars. Occasionally, imported germplasm may be used to improve traits or to act as the base material for further improvements. Generally, their use is limited because of the high quality requirements of Canadian cultivars.

National plant breeding objectives are focussed on the improvement of performance through the incorporation of pest resistance factors as well as yield factors. Since a high percentage of the cereals are destined for the export market, quality is very important. Some crop breeding is done to develop crops to help diversify Canada's agricultural production, such as the increase in production of field peas.

Plant breeding activities currently meet national objectives, although additional resources would allow more crop diversification and the development of products for niche markets. The federal government is the major research organization involved in plant breeding in Canada. The level of activity varies by crop, however, with almost all the wheat breeding being done by the federal government and universities, while almost all of the hybrid corn breeding is done by the private sector. The seed is produced and made available to all farmers by both private industry and the federal government through a regulatory system that is coordinated by the Canadian Seed Growers Association.

Farmers have little involvement in the actual breeding of cultivars, but have input to recommendations on what should be made available and grown, through farm organizations and membership on various committees.

4.3 Benefits Derived From the Use of Plant Genetic Resources

Plant genetic resources have been used in Canada for about a century and all Canadian agriculture has benefited from their use through genetic improvements which have contributed to major increases in productivity and resistance to pests, diseases and adverse growing conditions. In more recent times, for example, wide crossing in *Hordeum* has the potential of increasing salt and drought tolerance; native plums have been used to improve adaptability of domesticated plums; *F. chiloensis* is better able to withstand drought; and many species of *Rubus* subgenus *Ideobatus* carry useful traits, including resistance to major fungal pathogens and insect pests. Shrub roses have been developed which are hardy to zone 3 and these are being widely grown, replacing the tender hybrid tea and floribunda roses. A male *F. Populus* hybrid possess excellent vigour and disease resistance. Many grass genera are adapted to xeric situations due to drought and/or salt tolerance while others are more adapted to more mesic situations.

As is the case everywhere in the world, the economic value of the contribution of crop plant genetic resources to the Canadian economy has never been systematically studied. However, some examples and indications can be provided. Canadian grain yields have increased from 1.5 tonnes per hectare in 1960-61 to 2.2 tonnes per hectare in 1989-90. The improved quality of our products has contributed to their prestige on world markets. Saskatchewan`s durum wheat is now being re-imported from Italy as pasta, and canola as bottled salad dressing from France. Canola exemplifies Canada's contribution to enriching the world's crop diversity as a result of our use of germplasm acquired in other countries. Germplasm from Chinese rapeseed varieties has been bred into Canadian canola varieties to increase canola's resistance to stem rot and root diseases. Research currently in progress with Chinese varieties is producing a new hybrid which will provide yield increases of up to 15%. Canada's exports of canola seed, oil and meal have increased from 733,631 metric tonnes in 1974, the year in which canola was first registered, to 2,513,106 metric tonnes in 1993. The value of Canada's exports of canola products and processed products in 1993 was approximately $2 billion and is expected to nearly triple that amount in 1994, exceeding the return from Canada's wheat sales. China now also grows improved canola crops, using the cultivars developed by Canadian scientists.

While Canada has benefited from access to foreign germplasm, in accordance with established policy of making samples of plant genetic resources, including the improved varieties, freely available for use as genetic resources to *bona fide* scientists or breeders anywhere in the world, over 7,000 accessions were sent to 42 different countries during 1990-1994 (Table 1.8).

4.4 Improving PGR Utilization

Three tools improve the use of plant genetic resources collections: better knowledge about the characteristics of germplasm accessions, making this knowledge more accessible to germplasm users, and germplasm enhancement programs which integrate new genes and traits into genetic backgrounds more easily used by plant breeders.

The multi-nodal system described in Chapter 3 was established to enhance the use of these tools through the ability to link rejuvenation, evaluation, and documentation to research and development programs for specific crop plants. Breeders will be evaluating and providing useful information for the database which will result in better characterization and greater use of PGR.

CHAPTER 5
National Goals, Policies, Programmes and Legislation

5.1 NATIONAL PROGRAMMES

In Canada, agriculture is a shared jurisdiction between the federal and provincial/territorial governments. The National Program on Plant Genetic Resources, however, is made up of the Plant Gene Resources of Canada (PGRC), the Canadian Clonal Genebank and the Multi-Nodal System, and was established under the authority given to Agriculture and Agri-Food Canada (AAFC) by the Experimental Farms and Stations Act of 1886. PGRC was created following the appointment of the first Plant Gene Resources Officer in 1970.

The National Program Leader is accountable to the Program Chair of the Biological Resources Division of the Centre for Land and Biological Resources Research, Research Branch, Agriculture & Agri-Food Canada. The heads of nodes are accountable to the Directors of their respective responsibility centres. PGRC and the Canadian Clonal Genebank have their own budget lines. Decisions affecting PGRC are taken under the responsibility of the executive of AAFC.

The **program mandate** is to protect, preserve and enhance the genetic diversity of Canadian crop plants and their wild relatives by acquiring, evaluating, researching and documenting plant genetic resources in order to provide fundamental genetic building blocks for crop variety development and plant genetic studies nationally and internationally.

The **Expert Committee on Plant and Microbial Gene Resources** (ECPMGR) is the policy advisory component of the national program responsible for the general policy and direction of the programs for the recording, utilization and conservation of Canadian plant and microbial genetic resources. It was originally established in 1971 as the Expert Committee on Plant Gene Resources under the Canadian Agricultural Services Coordinating Committee/Canadian Agricultural Research Council (CASCC/CARC). It now reports to the successor of these two organizations, the Canadian Agri-Food Research Council (CARC), and draws its representation from Canadian federal and provincial government agencies, universities, industry, non-governmental organizations and scientific societies.

More specifically the committee:

1) discusses and advises on the activities of the national program in plant genetic resources;

2) makes recommendations to CARC on issues relating to plant and microbial genetic resources;

3) participates in the formulation of national plant and microbial genetic resource policy and its relationship to international programs.

A "Workshop on National Policy Issues in Plant Genetic Conservation" which was held in 1991, produced a number of recommendations. The following is a pertinent example:

- that the Canadian government provide support for germplasm conservation activities in lesser developed countries. This support should be in the form of scientific services, technology or scientific infrastructure, with the objective of developing local expertise to conserve and make use of plant genetic resources.

- This policy is recommended on a multilateral basis, with the intention of encouraging conservation and open, non-paid access to genetic resources worldwide. Plant Breeders Rights constitute a reward and incentive to support plant breeders, and in return society insists that material covered by these rights be made available for research and further breeding. In the same way, Farmers' Rights can be implemented as an international fund to provide reward and incentive to local people conserving traditional landraces, who would also provide open, non-paid access to germplasm for research and further development. We consider this form of support to be more appropriate than fee-for-sample approach.

The overall thrust of programs and policies within AAFC's Research Branch are directed towards sustainable development, therefore, this same thrust applies to the plant genetic resources program. In 1990, the Government of Canada launched Canada's Green Plan, our national blueprint for implementing sustainable development. In order to pursue this thrust, what is now the Environment Bureau was established within AAFC to provide the linkage between the Branches of the Department on the implementation of the Green Plan. The Green Plan is in line with the standards set by UNCED in Rio in 1992.

In developing a national strategy for identification and conservation of the genetic potential of forest trees, there will need to be a concerted effort on behalf of foresters and tree improvement personnel from the public as well as private sectors from all across the country. There are a many different species and special problems to be considered.

Federal, provincial and territorial governments are proceeding with the development of the Canadian Biodiversity Strategy in fulfillment of a key obligation of the Convention on Biological Diversity (CBD). Within AAFC, an officer of the Research Branch chairs the Interbranch Biodiversity Committee and leads the Departmental representation in the Interdepartmental Committee and the Federal/Provincial/Territorial Working Group on Biodiversity. AAFC's Environment Bureau also is represented. This provides the linkage between the national plant genetic resources program, the national thrust on environmental development, and the Canadian Biodiversity Strategy for the implementation of the CBD.

5.2 TRAINING

Most of the professional staff in the national program were originally trained in allied fields such as plant breeding, taxonomy and horticulture, and acquired supplementary training on the job, or through short courses such as those offered by the University of California (Davis) in the United States. The curators of the PGRC and the nodes are all scientists, most of whom have their doctorates. The National Program Leader obtained a doctorate in plant genetic resources from the University of Paris-Sud (Orsay) in France. The Canadian genebanks have provided on-the-job training to young professionals from developing countries.

No post-graduate university degrees are offerred in plant genetic resources in Canada, although lectures are commonly included in plant breeding courses. The Department of Crop Science and Plant Ecology of the University of Saskatchewan provides a credit course in plant genetic resources as part of its Ph.D. program in Plant Breeding. The educational capacity to develop post-graduate level training certainly exists in a few Canadian universities.

5.3 NATIONAL LEGISLATION

The Plant Protection Act, which is in conformity with the International Plant Protection Convention administered by FAO, provides the Canadian plant quarantine legislation. Under this Act, the entry of plants, including genetic material, is regulated to prevent the entry of pests of quarantine concern. Decisions regarding entry are made on the basis of a pest risk assessment. The level of regulation then varies according to the risk of introduction of a pest posed by the material. This depends on the pest profile of the country of origin, the probability of infestation or infection, and the possibility of taking mitigating action to prevent entry of pests.

Material considered to pose a low risk may be released on import. For material of higher risk, a permit to import is required. A phytosanitary certificate may be required from the country of origin. Material of the highest level of risk may be prohibited entry or only be allowed entry via a post-entry quarantine facility. There are federal government post-entry quarantine facilities for perennial plants such as fruit trees and grape vines, and for potatoes.

The Plant Protection Act became law in 1990, replacing and strengthening the previous Plant Quarantine Act. New Regulations under the Act are going into effect in 1995.

The **Canada Seeds Act and Regulations** governs the importation, advertising and sale of seeds in Canada. Varieties of agricultural crops, including potatoes, may not be sold unless they have been tested for merit in Canada and are registered. There are no limitations on the sale of varieties of fruits, vegetables, flowers, herbs, lawn and turf crops since they are exempt from registration.

In the case of agricultural crops, farmers have access to a wide range of crops developed by public institutions as well as private companies from within as well as outside of Canada.

Canada has had **Plant Breeders' Rights** (PBR) legislation since 1990, to provide effective support to our plant breeders. The rights apply only to the commercialization of the material. Under this legislation, farmers may retain seed of protected varieties for their own use, but may not sell seed without paying a royalty. Since protected varieties may be used for research and breeding, PBR should have no impact on plant genetic resources.

Canada has **Intellectual Property Rights Legislation** which covers all aspects of patenting, trademarks, integrated circuits, copyright, industrial design and trade secrets. This legislation has been developed in accordance with the international Treaties to which Canada, and other OECD countries, are signatories (Berne Convention etc.).

Canada is currently investigating the IPR implications of the recently finalized GATT negotiations and the Convention on Biological Diversity. Canada's understanding of the impacts of these international agreements is evolving with international developments in this area, but we are not currently planning any changes to legislation. Industry Canada has begun to research the IPR issues raised by the CBD, beginning with two background studies. They will review international developments and activities, and the various interpretations and proposals found in the literature on this subject.

The effects of IPRs on our genetic resources are fairly well understood by those involved in the area. Public understanding is certainly at a lower level.

5.4 OTHER POLICIES

Agriculture and Agri-Food Canada's official policy on access to plant genetic resources has been to provide free access to samples of plant genetic resources preserved in the Department's genebanks to any *bona fide* scientist or breeder, anywhere in the world, for purposes of research and breeding. Access to germplasm in the research and development stages is at the discretion of the developer.

There is a network of agricultural credits, subsidies and safety nets in Canada. Their effects on the conservation and utilization of plant genetic resources have not been assessed.

The draft Canadian Biodiversity Strategy contains specific sections dealing with agriculture and forestry strategic directions, which include the conservation and sustainable use of biological resources important to these sectors. This strategy was developed with the full participation of the agricultural sector, in its governmental, industry and non-governmental components.

The first national strategy on environmentally sustainable agriculture was developed through participative consultations lead by AAFC in 1992. It is currently in the process of being reviewed and updated.

5.5 TRADE, COMMERCIAL AND OTHER INTERNATIONAL AGREEMENTS

Any effects of Canada's international trade and commercial policies on Canada's national PGR program have not been assessed.

CHAPTER 6
International Collaboration

6.1 UNITED NATIONS INITIATIVES

Canada adopted **UNCED's Agenda 21**, and signed and ratified the **Convention on Biological Diversity (CBD)** in 1992. In support of this commitment, the "Canadian Biodiversity Strategy" is in the final stages of development. To assist with this work, the National Program Leader, Plant Gene Resources of Canada, was seconded to Environment Canada.

Concerning the **FAO Global System**, Canada is a member of the FAO, currently paying annual dues of about C$14.5 million. Canada joined the Commission on Plant Genetic Resources in 1991, but has not signed the IUPGR, for reasons specified to FAO in 1988. However, since joining the CPGR, our concerns relating to the International Undertaking have been resolved except for the need to attain clear international agreement on terms of access to samples of genetic material. Canada is looking forward to satisfactory resolution of this issue, which would allow our country to sign the revised Undertaking. Canada has always felt that the highest priority for the Commission on Plant Genetic Resources should be to create an international climate such that countries can best coordinate their activities to share in the work of conserving and facilitating the use of plant genetic resources. In that respect, revising the International Undertaking, setting priorities for action, and organizing the exchange of information on the status of the global plant genetic resources are priority activities. We continue to encourage the Commission to improve its capacity to review the activities of relevant national and international organizations, particularly the FAO, towards these goals.

The Commission, or its eventual successors, should have an important role in securing international funding for plant genetic resources activities, in determining program priorities and eligibility criteria for their use, and monitoring to ensure that their use is transparent and addresses established priorities. At the program level, Canada has responded to the FAO survey of country activities in plant genetic resources and the information provided is now part of the FAO database. In general, however, FAO needs to be more transparent about its own programs in plant genetic resources, and the programs which the organization supports in other countries.

Canada has and is continuing to support preparations for the ICPPGR by:

a) providing C$180,000 to sponsor a regional forum for Francophone Africa on national planning on biodiversity and plant genetic resources which was held May-June, 1994, in Abidjan, Côte d'Ivoire. This was planned in consultation with FAO officials.

b) sponsoring an Assistant Professional Officer to work in the Secretariat of the ICPPGR, at a cost of approximately C$90,000.00;

c) providing C$38,000 to the FAO to assist delegates from developing countries to attend the extraordinary meetings of the CPGR Working Group and of the CPGR, which were held in November, 1994;

d) planning by Canadian Forest Service to sponsor a sub-regional workshop on Boreal Forest Genetic Resources, tentatively scheduled for May/95 in Toronto. This also is being planned in consultation with FAO officials;

6.2 INTERNATIONAL AGRICULTURAL RESEARCH CENTRES, REGIONAL AND BILATERAL INTERGOVERNMENTAL INITIATIVES

In almost all documentation, books and articles, and in many conversations related to genetic resources, reference is made to the wealth of resources that have been obtained from the developing countries. This "wealth" refers to the perceived value of the genetic resources in their raw state as obtained from the sources of diversity and used by the developed nations of the world. However, benefits flow both ways, as indeed they should. There is considerable redistribution or repatriation of specific genetic resources to the developing countries, with fourteen percent (14%) of the shipments of germplasm sent outside of Canada in the last five years having gone to developing countries. The unfettered exchange of germplasm is crucial to worldwide breeding success.

Major wheat breeding efforts in Canada combine yield, quality improvement and disease resistance into adapted cultivars. In some cases these new cultivars have contained specific genetic material obtained from developing countries. A great deal of time, effort and resources (millions of dollars) goes into putting this material into a useful genetic background. This material is evaluated in international tests, and the genes obtained from wild species and landraces become available in genetic backgrounds which will yield commercial quantities of grain. These are available to all breeders worldwide. Cultivars developed for the CPS (Canada Prairie Spring) class of wheat are more closely related genetically to cultivars from the International Maize and Wheat Improvement Centre (CIMMYT) than many other canadian varieties. These cultivars will become increasingly important when distributed throughout the world as CIMMYT germplasm, and undergo further refining in the developing countries.

The value of germplasm is only demonstrated when incorporated and developed into adapted backgrounds. The daylength insensitive gene in oats was obtained from Turkey. Cultivars (AC Lotta, AC Neuman, and Donald) have been distributed to Bangladesh, China, Brazil and Argentina. We have no way of knowing the value of the contribution of this gene, and the particular gene combinations, to the developing countries. The role of the Consultative Group on International Agricultural Research (CGIAR) is crucial in this technology transfer to developing countries.

Canada's annual collective contributions to CGIAR components exceeds US$15 million (C$20 million). In relation to national programs, one of the main goals of the CGIAR centres should be to enable national programs, individually or in collaboration as appropriate, to progressively take charge of all plant genetic resource activities. Canada interacts with a number of CGIAR commodity centres, particularly CIMMYT, ICARDA, CIAT and CIP, which concentrate on crops which are also grown in Canada.

As an example, a Memorandum of Understanding (MOU) was signed between CIMMYT, the University of Ottawa, and the Plant Research Centre (PRC), for the PRC to develop multi-host plant insect resistance. This genetic material would flow to the developing countries through CIMMYT.

The germplasm, in the form of adapted cultivars, is freely available to developing countries for research and breeding purposes.

Canada has supported and provided funds to the International Plant Genetics Resources Institute (IPGRI) and its predecesor, the International Board on Plant Genetic Resources (IBPGR), since its inception. In 1974/75, C$100,000 was provided. This level of support has increased over the past two decades with C$550,000 being provided annually in 1993/94 and 1994/95. Furthermore, Canadians have served in key positions in IPGRI's activities. Two have been members of its Board of Trustees, one as chairman, and the present Director General is also Canadian.

Canada is a member of the Inter-American Institute for Cooperation on Agriculture (IICA), currently paying an annual quota of about C$4 million, some of which is in turn used by IICA to support crop research projects.

As examples of bilateral activities, between 1967 and 1976, the Canadian International Development Agency (CIDA) sponsored the Njoro wheat breeding project in Kenya. Many scientists and considerable resources from Canada were employed in Kenya to develop a wheat breeding system which forms the basis for wheat production to this day. Stem rust resistant genes were pyramided into locally adapted varieties which could not survive without the resistance. These varieties also have become established in Tanzania, Ethiopia, Zambia (wheat research), Uganda and China (Hebei Province).

In the corn (maize) program, development work is done in collaboration with Chile, Argentina and Peru. This material is considered mutually owned and a proportion of the royalties go back to the collaborating country involved.

Official Development Assistance Projects are in place at four Agriculture and Agri-Food Canada (AAFC) Centres to work with four developing countries on food, soils and crops projects.

During 1993-94, ten visits were made by developing country scientists to AAFC Centres.

MOU's are in place between AAFC and seven developing countries for training/exchange of scientists, and/or cooperation in Plant Genetics Resources.

CHAPTER 7
National Needs and Opportunities

The most important national needs are well reflected in recommendations and reports of the meetings of various representative groups.

The 1988 Meeting of the Expert Committee on Plant Gene Resources (ECPGR) recommended that the various expert committees involved in plant breeding would be asked to identify and priorize potential types of germplasm appropriate for PGRC storage. This would be to facilitate identification of germplasm of crops for which Canada does not have world responsibilities mandated by the International Board on Plant Gene Resources (IBPGR), but which should be preserved at Plant Gene Resources Canada (PGRC). The aim of this recommendation was to define key criteria for identifying material for Canadian national germplasm collections.

Existing funding programs do not provide long-term support to research in this field. As a result, few plant genetic resources research projects are carried out in Canada. For example, very little is known about the nature and extent of genetic diversity preserved in our own genebanks.

A widely representative "Workshop on National Policy Issues in Plant Genetic Conservation" held in 1991, recommended that jurisdictions interact more in order to back up germplasm which is conserved *ex situ*; and that the Natural Sciences and Engineering Research Council (NSERC) examine the development of a strategic long term mechanism to fund requirements in plant genetic conservation research.

The subsequent 1991 Meeting of the ECPGR, which followed, recommended that Agriculture Canada and other agencies take appropriate measures to increase the amount of research carried out to analyze the genetic diversity of germplasm collections and to improve and implement conservation technology; that high priority should be given to this type of research in strategic funding programs at NSERC and Agriculture Canada; and suggested that an additional way to ensure that priority projects are undertaken would be to establish a research fund with grants to be awarded by a peer-review process, possibly involving the ECPGR.

That meeting was concerned also about the lack of a national strategy for crop diversification, given the need to diversify Canada's crop and forest production base in order to ensure its continued competitiveness, and to develop alternatives for the social and economic well-being of these sectors. The Expert Committee felt it would be desirable to develop such a strategy and implement an action plan for the development and introduction of new/alternate and modified crops for food and/or industrial purposes based on: (1) necessary systematic work to improve understanding of plants and their economic potential; (2) collection, preservation and use of underexploited and wild plants and wild relatives of crop plants; and (3) determination and introduction of appropriate technologies for the production of alternate and modified crops.

Genetic enhancement, up until recently, meant utilization of standard hybridization, segregation, and selection techniques. With the advent of molecular and related biotechnological approaches, a new kind of breeding or prebreeding (genetic enhancement) becomes possible. In this way, unavailable genes for stress tolerance and resistance to insects and other pests may be transferred from alien species into elite genotypes. Broader and more distant relatives may be used in crosses employing specialized techniques such as embryo rescue. These technologies will present new challenges and opportunities to breeders, however, the genetic building blocks must be available. Traditional breeding methods will likely remain the backbone of plant breeding programs and will hopefully be expanded with the prospect of including new and interesting germplasm into breeding programs. Inherent with that, will be the continuing and increasing need for new germplasm to meet the challenges of the future. It is only with a broad, far reaching conservation program will our genetic resources be maintained.

Canada has much wild native plant germplasm of economic importance that is often taken for granted. In this report, over 200 genera were identified, or approximately 30%, of the native genera that have direct use or potential in crop development and breeding programs. This includes over 370 species of plants (excluding landscape plants). Much more information is needed. Of particular concern is the identification of genotypes that are rare or endangered. Specific research is required to identify these plants so steps can be taken to ensure this genetic material is not lost. In addition, several species are world resources (e.g. Amelanchier) and increased attention should be provided in terms of conservation strategies.

Our native trees, shrubs, wild flowers and grasses are often overlooked as important resources. Unfortunately, their taxonomy and nomenclature are still too often confusing. With more detailed biological information, breeders and other users of our genetic resources would be better able to make informed decisions concerning utilization of wild or native material in a research program. It is, however, difficult to establish priorities. Specific characteristics that are of interest to breeders today may not be important tomorrow. Ultimately, studies of breeding relationships and outlining of primary, secondary and tertiary gene pools are needed.

With this background, at its 1992 meeting, the ECPGR recommended development of an informational database for the conservation and use of native wild germplasm of economically important plant species, including taxonomic information on candidate species which are rare, endangered, or unique to Canada. This would initiate implementation of a long-range strategy, the objectives of which are: (1) to identify Canadian wild germplasm of economic significance, with emphasis on germplasm which is endangered and/or unique to Canada; (2) to increase the scientific knowledge base on wild germplasm of economic significance by stimulating systematics research; (3) to preserve representative, endangered, and unique genetic variability of Canadian wild plant germplasm of economic significance; (4) to make representative genetic variability in native wild plant germplasm of economic significance available to breeders and researchers in Canada and elsewhere, and arrange for the evaluation of useful traits; (5) to provide a national strategy as a reference or framework for the elaboration of specific projects in the conservation of wild plant germplasm of economic significance; and (6) to identify all possible collaborators and sources of support.

This was supplemented in 1993 by a recommendation of the ECPGR Subcommittee on Policy that in order to increase the efficiency of native germplasm protection in Canada, the Canadian Parks Service and Provincial and Territorial departments concerned with natural resource protection should be encouraged to play a more active role in maintaining and monitoring important native plant germplasm on lands within their jurisdictions. In the planning and management of parks and similar reserves, the species often featured for priorization are of little known economic value. *In situ* conservation may often be the most cost effective means of conserving valuable germplasm.

The network of parks across Canada provide a unique and valuable resource to all Canadians; however, efforts aimed at maintaining and monitoring important germplasm resources are often inadequate.

More effort is needed to implement Canada's strategy on wild native plant germplasm of economic significance. However, the amount of time needed to identify important resources and the numbers of genera and species involved makes such an undertaking very difficult, particularly in light of fiscal restraints.

Canada is a large country with abundant natural resources. We have a large storehouse of genetic material that is valuable for today, as well as for future generations. Our plant material is a resource that needs to be better identified, studied and conserved. There is a great deal of untapped genetic potential in our native flora that could be of considerable value in the development of our crop plants.

CHAPTER 8
Proposals for a Global Plan of Action

The Global Plan of Action must establish conditions of international cooperation so that the planet's plant genetic resources are conserved and used sustainably. The approach should be two-pronged. On the one hand, each country must be able to determine and act upon its own priorities. Each country should, as necessary, be able to count upon the international community to assist in building its capacities to achieve these goals. We put great importance on the Global Plan of Action as a mechanism to assist and encourage countries to clearly focus their priorities on the development of core conservation and sustainable use activities. On the other hand, at the international level, countries need to agree on the terms and conditions for supporting each others' efforts. There will continue to be a need for an international forum on policy matters, which has been the role of the FAO Commission on Plant Genetic Resources, as well as an international scientific and technical body such as IPGRI.

Canada wants to ensure that plant genetic resources (PGR) are properly preserved by the international PGR community; and that mutually agreed terms are developed so that the samples will be openly accessible for research and breeding purposes. Every country of the world needs access to some genetic resources found in other countries. Canada will participate in the global effort to preserve them for posterity and to make them available to users world-wide. Workable international arrangements in this area are critical to ensure the unrestricted exchange of germplasm and to facilitate international agricultural trade. All governments and other institutions having plant genetic resources under their control should allow access to samples of such resources, where samples have been requested for the purposes of scientific research, plant breeding, or genetic resources conservation. Such access should be non-restricted and non-paid. It is only on this basis that countries will be able to cooperate in sharing the enormous amount of effort needed to conserve plant genetic resources, including safety duplication, and ensure their sustainable use. Again on this basis, countries can agree on the conditions of support for the plant genetic resource activities in countries where the support of the international community is needed.

It has become increasingly important for the agricultural sector to reach a global accord in view of the entry into force of the Convention on Biological Diversity (CBD) which provides another potential forum in which decisions on PGR could be taken. Agriculturists are less well represented in that forum than in the FAO Commission on Plant Genetic Resources.

8.1 REVISION OF THE INTERNATIONAL UNDERTAKING ON PLANT GENETIC RESOURCES (IUPGR)

Revisions to the IUPGR will have a direct bearing on the content of the Global Plan of Action. To this end, it must be adapted in harmony with the CBD to:

a) establish mutually agreed terms for non-restricted and non-paid access to samples of PGR;

b) implement the concept of Farmers' Rights, i.e. - put in place a financial mechanism for projects for the conservation and sustainable use of PGR in developing countries, and in particular, to have recourse to the financial mechanism of the CBD;

c) determine the nature of the re-negotiated Undertaking, i.e. - to decide, for example, whether it retains its current status or becomes a protocol of the CBD. The revised IUPGR might ultimately represent multilateral sectoral agreement on Plant Genetic Resources for Food and Agriculture in fulfilment of UNCED Agenda 21 and Nairobi Final Act of the CBD. In establishing this, due consideration must be given not only to functionality, but also to the supporting administrative infrastructure requirements and their contingent resource implications;

d) determine institutional arrangements, i.e. - the respective roles of FAO and the International Plant Genetic Resources Institute (IPGRI), etc.

The revised Undertaking should:

- settle outstanding issues so that the largest number of countries, including Canada, can sign it and carry out its provisions;
- promote equitable balance to satisfy those countries which need to ensure access to samples of plant genetic resources, and those countries which need to build their capacity to conserve and sustainably use plant genetic resources; and
- pursue the negotiation of such issues as terms of access to samples of plant genetic resources, implementation of farmers' rights, scope of the revised IUPGR, and legal and institutional questions.

Canada will need to ensure the revisions are consistent with Canada's rights and obligations under relevant trade and biodiversity agreements.

8.2 INTERNATIONAL NETWORK OF *EX SITU* GERMPLASM COLLECTIONS

On the basis of mutual free access to samples of germplasm, Canada supports the development of such a network, as evidenced by our support for the development and signing of an agreement between FAO and the Consultative Group for International Agricultural Research (CGIAR) placing the latter's genebank collections under FAO auspices. These collections contain more than 600,000 accessions of more than 3,000 crop, forage, and pasture species, one of the world's largest *ex situ* collections of old and new varieties of the crops on which it works, and in substantial measure, the wild species from which those crops emerged. Canada considers this agreement as a good model for preserving plant genetic resources in trust for the international community, and does not interpret the agreement as binding the International Agricultural Research Centres (IARCs) to release samples of germplasm only on the basis of "material transfer agreements" or similar contracts.

Canada is concerned about the low level of genetic evaluation of germplasm collections preserved in plant genebanks worldwide. Many of the germplasm collections are of little use to plant breeders and geneticists because they have not been genetically characterized. Genetic diversity analysis, using modern methodologies, should be made a priority issue and adequate resources should be directed towards this goal. This support should be provided in particular for internationally mandated collections.

ANNEX 1
Introduction to Canada and its Forestry Sector

There are 416 million hectares of forest land in Canada; half of this area is capable of producing timber but only about 119 million hectares are currently being managed for timber production. More and more Canadians value their forest resources as habitat for a great diversity of animals, plants, insects, etc. An estimated 50 million hectares (12% of the land base) are protected from harvesting by policy or legislation.

Canada covers a geographically and ecologically diverse landmass that includes both Boreal Zone and Temperate Zone forests (Fig. 1). Most of Canada's forested landmass (88%) falls into what is widely recognized as the Global Boreal Forest Zone of the Northern Hemisphere (Kuusela 1990), a zone dominated by coniferous forests. Rowe's (1972) attempt to outline the geographic distribution of the forest regions of Canada is widely accepted within the forestry community as an useful description of the distribution of Canada's forest resource. Rowe (1972) recognized eight forest regions (Fig. 2) with some 90 forest sections, and described the tree species associations within each forest section. The total area by Rowe's (1972) Forest Regions and Forest Sections has been compiled by Gray (1995). There are 31 coniferous and 104 deciduous trees native to Canada (Table 2.1; see Hosie 1973). Introduced tree species that have become naturalized in Canada are not included in these lists.

For purposes of forest genetic resource conservation and management, the Boreal Zone forest of Canada includes the Boreal, Subalpine, and Montane Forest Regions of Rowe (1972). The main tree species of the Subalpine and Montane Forest Regions that would be included within Canada's Boreal Zone are listed in Table 2.2. The principal Boreal Zone tree species are listed in Table 2.3. The Temperate Zone forest includes the Coast, Columbia, Deciduous, Great Lakes/St. Lawrence, and Acadian Forest Regions of Rowe (1972). The principal Temperate Zone tree species are listed in Table 2.4. The Grassland Region (Rowe 1972) is not considered a forested region but contains disjunct tree populations of both boreal and temperate zone species. The Tundra Region (Rowe 1972) contains isolated patches of forest cover consisting entirely of boreal zone species. This partitioning of Canada's forest regions between Boreal and Temperate Zones has been accepted by inventory and ecological classification specialists within the Canadian Forest Service (Lowe 1995, pers. comm.).

The genetic resources of tree species that characterize the Boreal Forest Zone are relatively well protected within a network of protected areas and are currently not perceived to be a major conservation issue. However, marginal populations of Temperate Forest Zone species that enter the Boreal Forest Zone may contain genetic resources of special interest for conservation due to evolutionary processes unique to such isolated, marginal populations (Table 2.5). These disjunct populations may be of special genetic interest as a result of evolutionary processes associated with small effective population sizes. It is often in the small populations at the margins of species ranges that genetic drift and natural selection may be expected to produce novel genetic varieties.

ANNEX 2
Canada's Indigenous Forest Genetic Resources

The conifers of the Boreal Forest Zone are mainly harvested and managed in natural forests through clear-cutting. Both natural and artificial regeneration techniques are used to regenerate these forests. However, increased use of natural regeneration is being promoted due to financial constraints on artificial regeneration. Temperate Zone conifers such as white pine, red pine, and white spruce have experienced significant population declines over the past 150 years, and an erosion of the white pine and white spruce gene pools is probable. These species are now the focus of conservation programs across central Canada. Concepts such as minimum viable population size have been introduced to increase awareness of the necessity of maintaining population viability following commercial harvesting operations. The maintenance of viable populations is likely to become a key component of sustainable forest management in Canada.

Nevertheless, it is the remaining 12% of Canada's forested landbase - the Temperate Zone forests - that represent the greatest source of concern regarding threats to genetic resources. Most of Canada's rare, vulnerable, threatened, and endangered species are found within a single Forest Region: the Deciduous Forest Region of southern Ontario. Many of the species of the Deciduous, Great Lakes/St.Lawrence, and Acadian Forest Regions of eastern Canada reach the northern limits of their geographic ranges in these Regions. These populations may be of special significance to Canada in view of northward migrations anticipated under climatic warming.

Following many years of dysgenic, selective harvesting, or "highgrading", the shade tolerant angiosperm tree species (sugar maple, beech, etc.) of the Temperate Zone forests of eastern Canada are increasingly being harvested and managed based on single-tree selection silvicultural systems. Government sponsored private woodlot tree improvement programs have been responsible for significant improvements in silvicultural practices aimed at protecting these resources. Group selection and patch cutting is used to foster natural regeneration of less shade-tolerant hardwoods such as yellow birch, white ash, black cherry, and red oak. Natural regeneration is widely relied upon for the regeneration and maintenance of most hardwood gene pools. Programs are available in most provinces to assist private land owners to manage their forests on a sustainable basis, however, financial constraints are beginning to endanger these programs as governments reduce expenditures. Threats to these worthwhile woodlot improvement programs now pose a threat to the conservation of genetic resources of the Temperate Zone. As governments remove their support for forest management expertise, inappropriate harvesting techniques may once again begin to undermine these genetic resources.

The Deciduous or Carolinian Forest Region of Southern Ontario has been reduced to a highly fragmented set of small, isolated populations due to extensive land clearing for urbanization and agriculture. The remnant forests of this area contain marginal populations of rare species at the northern limits of their natural ranges that may no longer consist of viable populations. Ontario has introduced a Natural Heritage Program to monitor the status of these species and will develop recovery plans where appropriate.

ANNEX 3
National Conservation Activities

COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is a committee of federal, provincial, territorial, and non-governmental wildlife agencies that determines the status at the national level of wild species, subspecies, and separate populations in Canada (Cook and Muir 1984). The plants listed by COSEWIC tend to be rare Canadian peripheral species that are also known to be in jeopardy in their adjacent U.S. ranges (Haber 1986). Eight of the nine native tree species listed by COSEWIC (1994) as either vulnerable, threatened, or endangered (Table 2.6) are native to the Deciduous Forest Region of southern Ontario. COSEWIC has comissioned status reports for these species that will form the basis for the development and implementation of recovery plans.

REGIONAL CONSERVATION ISSUES AND STRATEGIES

To facilitate reporting on forest genetic resources issues, this report has been divided into the five main regions of Canada: British Columbia and the Yukon Territory, the Prairie Provinces and the Northwest Territories, Ontario, Quebec, and the Atlantic Region. Ex situ forest tree gene conservation activities have been compiled by Boyle (1992). The following presentation of regional forest genetic resource conservation issues, needs and strategies is based on the proceedings of a national conference on Forest Genetic Resource Conservation and Management that was held in Toronto in 1993 (Nieman et al. 1995).

BRITISH COLUMBIA AND THE YUKON

Forest tree gene conservation efforts in British Columbia (BC) are managed by the British Columbia Ministry of Forests. The main emphasis is on protecting genetic resources of the 23 native conifers used within the provincial tree improvement program. Other initiatives are underway to promote *in situ* conservation within a protected areas network where the main aim is to represent the different ecosystems typical of B.C..

Ex situ collections of B.C. conifers consist of an extensive array of provenance tests, progeny tests, clone banks, etc. (Yanchuk 1995). Unfortunately, many potentially important peripheral (marginal) and outlier populations are not included within these tests. The strategy for *in situ* protection began with a survey of the network of protected areas for each of the 32 terrestrial ecoregions in the Province for the presence of the 23 conifers of special interest. This was to determine the representativity of these species within some form of protected area across a range of biogeoclimatic zones. In the B.C. approach, species tabulations were made according to important biogeoclimatic zones so that each species was represented in a "core" ecoregion. The B.C. system recognizes three distributional categories for analysing biogeoclimatic representativity including: "core" ecoregions which are areas at the centre of the species range; peripheral ecoregions; and "outlier" ecoregions, where populations are found outside the limits of their continuous distribution. This system of stratifying population samples is noteworthy because it recognizes the importance of peripheral and outlier populations in terms of their potential importance as sources of unique genetic variation in adaptive traits. This classification system then forms the basis for identifying areas where additional protection is recommended.

The presence of a population of about ten thousand reproductively mature trees per ecoregion/biogeoclimatic zone in a reserve is considered adequate protection for the population. In a population of 1,200 trees, alleles at a frequency of 1% will be conserved with a 99% probability (Gregorius 1980). The next step in this strategy is to prioritize species in need of conservation activity based on a set of criteria such as rarity, size of range, reproductive success, representation in protected areas, level of *ex situ* preservation, and current and potential economic value. Pacific yew and whitebark pine were identified as the two conifers most in need of conservation activity in B.C.

The Province of British Columbia has taken a lead in developing strong legislation to ensure that sustainable forestry practices become a reality. The Forest Renewal Plan (B.C. Forest Renewal Act 1994) represents a long-term commitment to restore and protect the health of the province's forests. British Columbia has also passed into law, a stringent piece of legislation to govern codes of forestry practice and to protect a range of forest resources including wildlife and biodiversity (The Forest Practices Code of B.C. Act 1994).

PRAIRIE PROVINCES

The extensive forests of the prairie region are largely of fire origin. They consist of the typical Boreal Forest associations of pioneer species such as black spruce, jack pine, lodgepole pine, tamarack, balsam poplar, and trembling aspen, followed in later successional stages by white spruce and balsam fir. Late successional species such as white spruce have become an important conservation issue because the habitat for such species is often adversely affected by harvesting practices such as clear-cutting. A deterioration of forest quality due to inadequate natural regeneration of white spruce following harvesting has become a conservation issue in the prairies.

Although no tree species in the prairie provinces are considered threatened or endangered, three species (western larch, western white pine, and western hemlock) from the Montane and Subalpine Forest Regions of Alberta have been listed as rare (Packer and Bradley 1984). These species occupy a very limited range in Alberta as outlier populations on the eastern slopes of the Rocky Mountains. However, they are much more abundant throughout British Columbia. In recent years, concerns have been raised regarding *in situ* conservation of river valley cottonwoods in the Grassland Region (Rowe 1972) where agricultural expansion and irrigation development projects have had a significant impact on flood plain ecology.

In situ protection within parks, wilderness reserves, ecological reserves, etc., and *ex situ* protection within tree improvement programs afforded to forest genetic resources in Alberta has been reviewed by (Dhir and Barnhardt 1995). Gaps in the protected areas network are being addressed by "Special Places 2000", a program aimed at protecting the full range of natural environmental diversity in Alberta. Alberta also has a "Rare and Exceptional Stand" program aimed specifically at the *in situ* conservation of forest genetic resources as wild stands exhibiting special phenotypic traits or rare characteristics.

ONTARIO

Ontario covers three Forest Regions: the Boreal, the Great Lakes/St. Lawrence, and the Deciduous Forest Regions. These Regions have been further subdivided into 13 ecoregions based on physiography-vegetation relationships. The primary ecological concern with the boreal forest centres on the impact of harvesting, artificial regeneration, and deterioration of the conifer forest. The Great Lakes/St. Lawrence Forest Region represents a transition zone between the Boreal and Deciduous zones and contains a mixture of tolerant hardwoods and coniferous forest. However, this zone is characterized by its own unique species associations and is perhaps best known for its component of white pine and red pine. These two species once supported an important logging industry, but they are now the focus of environmental concern because of declining populations and the disappearance of most of the old growth forest as a direct result of harvesting.

The forests of the Deciduous Forest Region have been highly fragmented through land clearing for agriculture and urbanization and contain all of the species listed by COSEWIC (1994) as threatened and endangered. The formation of the Southern Ontario Forest Gene Conservation Association in 1994 represents a major step towards addressing forest gene conservation issues for the most vulnerable trees species in Canada. This association is preparing species status reports and will develop and implement recovery plans as necessary.

A Genetic Heritage Program has been implemented to address the following goals for forest gene conservation and management: (1) to provide scientific and technical expertise in support of the development of provincial policy and the implementation of resource management regarding genetic diversity; (2) to establish baseline biological and demographic information on all native tree species as a first step towards developing strategies for conserving genetic diversity; (3) to develop management options and strategies that will conserve genetic diversity as well as maintain and/or restore evolutionary capacity; and, (4) to conduct and foster applied research in direct support of policy and operational programs related to issues of genetic diversity and species conservation.

Forest genetic resource management in Ontario is focused on the conservation of the adaptive gene complexes among populations adapted to different biogeoclimatic zones or ecoregions (Joyce 1995). Thus, the genetic resource management strategy being developed by Ontario will be based on the classical concept of the seed/breeding zone or "genetic resource management units" (GRMU). These GRMU's will be based initially on a climatic model of the province to delineate seed zones according to climatic gradients, under the assumption that patterns of adaptive variation or adaptive gene complexes reflect these gradients. The presence of adaptive gene complexes will be verified through short-term genecological tests to confirm that the seed zones are indeed biologically sound.

The Province of Ontario has also passed legislation aimed at sustainable forestry practice (Crown Forest Sustainablity Act 1994) to replace the Crown Timber Act that has been in place since 1952.

QUEBEC

In Quebec, *in situ* conservation efforts are undertaken by the provincial government which owns 90% of the landbase. However, *ex situ* conservation in the form of provenance and progeny tests, breeding archives, etc. has been a shared responsibility between federal and provincial governments. Responsibility for the *ex situ* programs administered under tree improvement programs was delineated by species, with the federal government accepting responsibility for white spruce and white pine and the *Ministere des Ressources Naturelles du Quebec* for all other forest tree species of interest to the province (Plourde *et al.* 1995). *Ex situ* conservation of forest genetic resources is jointly managed as breeding arboreta, provenance and progeny tests, seed orchards, seed production areas, clone banks, and seed banks within tree improvement programs (see Villeneuve 1995).

On a broader level, biodiversity issues are managed by an interdepartmental committee consisting of seven provincial government ministries. An hierarchical system of ecological land classification based on climate, physiography, and vegetational associations is being developed and should be used to guide forest genetic resource management (Villeneuve 1995). Based on ecological land classification, marginal populations are identified and receive special attention for conservation. This special emphasis on marginal populations recognizes the special effects of genetic processes such as natural selection and genetic drift that may produce novel sources of variation.

Although Quebec has no formal conservation strategy yet, legislation has been passed for the protection of vulnerable and threatened species. Quebec is now proceeding to develop conservation programs. Twelve tree species (see list in Villeneuve 1995) are among the 374 indigenous species that have been identified as vulnerable or threatened. These are all tree species that reach the northern limits of their geographic range in southeast Quebec, a region where natural habitats are increasingly threatened by agriculture and urbanization. A network of protected areas has been established that includes IUCN categories I, II, IV and IX covering 178 sites and more than 1 million hectares (Villeneuve 1995).

Quebec is also addressing the issue of the impacts of forest harvesting practices on biodiversity and, particularly, on genetic changes following forestry operations. Natural regeneration is being promoted wherever possible to maintain natural ecological processes. Quebec is also refining its system of seed zones based on genecological studies to verify the ecological regions now being used to control seed transfers within the province, and is also developing a forestry "code-of-practice" to regulate the impacts of the forest industry.

ATLANTIC REGION

The Acadian Forest Region covers most of the Maritime provinces (New Brunswick, Nova Scotia and Prince Edward Island) (Rowe 1972), except for the Cape Breton Highlands in Nova Scotia, which are Boreal in character, and portions of northern New Brunswick which are included in the Great Lakes/St. Lawrence and the Boreal Forest Regions. All of forested Newfoundland falls within the Boreal Forest Region. New Brunswick is completing a detailed ecological land classification, which is perceived as an important step in establishing a biodiversity conservation strategy. The other provinces are not as advanced in this process.

None of the Altantic provinces has an explicit gene conservation strategy. The area of *in situ* reserve, prohibiting forest harvesting, mining and hydroelectric development, is less than 2% of the total land area. Other temporary, or partially protected reserves, such as stream buffers, constitute a significant area; for example, about 20% of New Brunswick's forested land has some degree of protection (Loo 1995b). Forest harvesting is generally delayed or reduced rather than prohibited in these areas.

A survey has been conducted to determine the degree of *in situ* protection afforded to forest genetic resources within the major forest types of the Acadian Forest Region (Loo 1995a). On the basis of this work, the need for additional *in situ* conservation was highlighted for types such as the wet cedar, late successional mixed wood and floodplain forests. The Acadian Forest contains some potentially important but small, isolated populations of several tree species at the northern limit of their ranges. Bur oak, ironwood, butternut, and eastern hemlock were identified as tree species that may require special attention for protection of their genetic resources (Loo 1995a).

The Canadian Forest Service has established an extensive network of *ex situ* genetic resources within its tree improvement program for maritime species (reviewed by Loo 1995b). The J.D. Irving Company is also a major player in managing the forest resources of the Acadian Forest Region. It practices *ex situ* forest tree gene conservation in the form of seed banks, clone banks, seed orchards, provenance tests, and progeny tests within its tree breeding program (Adams 1995).

The genetic resources of Newfoundland may be of special significance because of the island's climatic and ecological diversity and its geographic isolation from mainland populations. Evolutionary processes such as genetic drift and natural selection may have had a special influence in shaping the genetic structure of the island's tree populations. Some of the rarer trees such as white pine and red pine have experienced significant declines in population numbers and sizes with the advent of human intervention, particularly through harvesting activities since the turn of the century (Mosseler *et al.* 1995). While recommendations for a protected areas network are in place, currently only 2% of the Island is protected under some form of legislation. This network does not adequately protect the Island's less common tree species such as white pine, red pine, black ash, and yellow birch, each of which is vulnerable to local extinction for reasons of rarity alone. Introduced pest problems currently threaten the survival of the island's red pine and white pine. The need to protect these tree species *in situ* is now recognized by several government departments (Newfoundland Forest Service and the Newfoundland Parks Department) and steps are being taken to ban cutting and increase representativity within the ecological reserves network.

ANNEX 4
In-Country Uses of Forest Genetic Resources

In the commercial forestry sector forest genetic resources are exploited to maintain natural regeneration following timber harvesting and to support provincial tree breeding programs for genetic tree improvement and artificial regeneration. However, native tree species are only in the very early stages of domestication. Most seed for artificial regeneration is collected from wild stands.

In the past, the Canadian Forest Service played a major coordinating and research role in tree improvement programs but has steadily moved away from this research area to refocus its genetic research efforts directly on molecular biotechnology and gene conservation issues. Responsibilities for tree breeding and improvement are now largely with the provinces. Tree improvement programs are largely aimed at increasing forest productivity. Tree seed handling and distribution for domestic afforestation purposes are also handled by the provinces, while most of the international seed exchanges are handled by the National Tree Seed Centre at the Petawawa National Forestry Institute (CFS). While there is no national program/system for better seed production and supply, many provinces try to exert internal control over seed distribution through the designation of biologically meaningful seed zones and conduct research to support this aim. However, some areas of Canada still have poor control over tree seed distribution for afforestation.

Increased emphasis on ecosystem management (National Forest Strategy) for conserving biodiversity and promoting natural regeneration of forests requires that population viability be maintained *in situ* to ensure that reproductive success and genetic diversity, and thus adaptive potential, are not compromised.

ANNEX 5
National Goals, Policies, Programmes and Legislation

Forest management is a matter of provincial jurisdiction. The provinces manage 71% of the nation's forests, with the federal and territorial governments responsible for about 23%. Only 6% of Canada's forests are on private property. Each province has its own set of legislation, policies and regulations to govern the management and protection of its natural resources and wildlife. There is no Federal Endangered Species Act, although there are discussion papers on this subject (S. Normand 1994, pers. comm.). The federal government's role in forest resource conservation pertains to areas such as research, national leadership and international affairs. The "Department of Forestry Act" commits the federal government to sustainable forestry practice and the Canadian Forest Service has developed a national forest strategy (Sustainable Forests: a Canadian Commitment, 1992) that outlines a progressive agenda to make sustainable forestry a reality. This national forest strategy aims to track the domestic implementation of commitments made during the UNCED process, and must undergo independent evaluation to review progress in its implementation.

THE NATIONAL FOREST GENETIC RESOURCES CENTRE

A National Forest Genetic Resources Centre (NFGRC) was established at the Petawawa National Forestry Institute (PNFI) in 1992 to provide a national centre and focus for the conservation of forest genetic resources. The research program of the NFGRC is focused on the major issues of public concern with the sustainability of forestry practices, especially with regard to genetic diversity, and was established to address genetic aspects of the three major themes outlined in the Convention on Biological Diversity sponsored by the United Nations Environmental Program: (i) the conservation of biological diversity, (ii) the sustainable use of ecosystems, and (iii) the sharing of information on genetic resources.

The NFGRC consists of five research projects that directly address forest gene conservation issues. The **Forest Genetic Resources Services** Project maintains the many *ex situ* forest gene conservation plantations and manages Canada's National Tree Seed Centre (NTSC) which acts as a national gene bank for both domestic and international seed exchanges. This project is also developing a national database to refine earlier work by Boyle (1992) on *ex situ* conservation of forest genetic resources to maintain a national information system. Due to increasing financial constraints, the tree seed collections of the NTSC cannot be regarded as adequate to support a viable *ex situ* repository of forest tree genetic resources for the most vulnerable and threatened populations. The NTSC has been forced to focus on commercially important tree species to meet current demands. However, it is widely recognized that not enough attention is paid to presently non-commercial species that may have some commercial potential. The recent flurry of economic interest in *Taxus brevifolia* as a source of the anti-cancer agent taxol emphasizes the importance of focusing more attention on conservation of non-commercial species. With improved financial support the NTSC could focus more of its attention on gene conservation where it is most urgently required: the many tree species of the Temperate Zone forests. While several Canadian provinces manage their own tree seed centres, the National Tree Seed Centre of the the Canadian Forest Service is central to the conservation of Canada's forest germplasm and international exchanges of germplasm. The storage facilities of the NTSC consist of long-term, medium term and cryopreservation units.

To address the issue of climate change and adaptability of forest tree populations, the **Physiological Genetics and Plasticity Project** investigates ecophysiological responses to increased CO_2 concentrations, drought, photoperiod, and temperature to quantify genetic variation in responses to anticipated climate changes.

The **Seed Science and Reproductive Development Project** focuses on seed germination requirements, seed storage protocols, and reproductive biology, with special emphasis on protocols for longer-term storage of recalcitrant seed.

The **Molecular Genetics and Tissue Culture Project** conducts basic research on gene regulation, gene expression, and genetic transformation of trees. This project also focuses directly on germplasm preservation through development of protocols for long-term germplasm storage through tissue cultures and maintains a cryopreservation facility for long-term storage of tissue cultures.

The **Genetic Diversity and Reproductive Success** Project investigates the genetic and demographic effects of small population size with the aim of defining the minimum viable population (MVP) sizes required to maintain population viability (genetic diversity and reproductive success) in rare and declining native tree populations.

The NFGRC also supports research projects across Canada on various forest gene conservation issues through funding under Canada's Green Plan to the following universities: University of British Columbia, University of Alberta, McGill University, University of New Brunswick, Laval Univeristy, and Memorial University of Newfoundland. This forest gene conservation network of government research facilities and university-based research laboratories is training technical specialists both for Canadian needs and for other countries in need of this expertise. The research network has expertise in statistical analyses, sampling procedures, molecular biology, reproductive biology, seed science, data management, genetic diversity analyses, development of conservation strategies, physiological genetics, etc. This expertise is readily available to anyone requesting assistance in developing forest conservation strategies or with techniques used in gene conservation.

A national workshop was convened by the NFGRC in 1993 to bring together representatives from the forest industry, provincial land management agencies, and from the regional laboratories of the Canadian Forest Service (CFS) to review forest genetic resource conservation and management issues. This workshop prepared an outline for the development of a national strategy for the conservation and management of forest genetic resources. The goal of this national strategy is "to promote and perpetuate the genetic diversity, adaptive potential and evolutionary capacity of forest tree species". The strategy outline consists of a statement of guiding principles, objectives, research priorities, and the role of the Canadian Forest Service. The published proceedings of this workshop (Nieman *et al.* 1995) describes the various regional programs on forest genetic resources in more detail.

The NFGRC is also preparing to host an International Workshop on Boreal Forest Genetic Resources as part of the FAO's commitment to the Global Action Plan of the International Conference and Programme on Plant Genetic Resources. The goal of this boreal forest meeting will be to review forest genetic resource issues globally for the Boreal Forest Zone and to develop a state-of-the-world report in preparation for the Global Action Plan. Canada recognizes that its national strategy for dealing with forest genetic resource issues cannot be developed in isolation from global programs.

FORESTED ECOLOGICAL RESERVES

There is no federal authority or legislation for establishing ecological reserves in Canada. Enhancement of the network of protected areas is thus a provincial responsibility. The federal role of the CFS has been to conduct research of national importance with regard to forest genetic resources, make recommendations regarding conservation, and publicize the national interest in genetic resource protection.

The Canadian Forest Service program for conservation of forest genetic resources recognizes that *in situ* conservation of forest genetic resources within a network of protected areas is fundamental to the protection of these resources. To this end, the CFS has supported an Ecological Reserves Initiative under the Green Plan to document the representativity of different forest types within a network of protected areas (according to IUCN categories) and to identify and address weaknesses in the protected areas network (Pollard 1995). Representativity is based on the Ecological Regions of Canada (Environment Canada) and will be documented as a National Register of Forested Ecological Reserves within the context of the National Conservation Area Data Base (State of the Environment Reporting, Environment Canada). A first approximation of a national list of protected areas shows some large gaps in protection, with 46 of the 148 non-Arctic ecoregions having no legal protection of their forest resources under some form of IUCN recognized categories for protected areas. The Ecological Reserves Initiative has compiled a National List of Protected Areas that can serve as a basis for promoting the *in situ* protection of forest genetic resources.

ANNEX 6
International Collaboration

With respect to germplasm exchanges, Canada has been willing to fill any reasonable requests for native tree seed for research purposes free of charge. The National Tree Seed Centre has always been open in its policy with respect to filling the tree seed requests of other nations. The exportation of native tree seed by Canada has been particularly important to the forest industry of the European Economic Community, particularly the United Kingdom and the Scandinavian countries, where a significant portion of the forest industry is based on Canadian seed sources.

Canada has long recognized the value of global cooperation in defining and implementing sustainable forestry practices and promoted this view at the 1992 United Nations Conference on Environment and Development. In 1990, Canada issued a comprehensive environmental action plan entitled Canada's Green Plan, a key element of which was the establishment of a national network of "Model Forests" by the Canadian Forest Service, under the "Partners in Sustainable Development of Forests" program to demonstrate sustainable forest management. This Model Forest network has since been expanded internationally. Model Forests have now been established in Mexico and are being negotiated for Russia and Malaysia.

One of the stated goals of the International Model Forests network is to address gene conservation issues and conserve forest genetic resources within the Model Forest area. Canadian Forest Service scientists and representatives from the ten Canadian Model Forest associations now have an opportunity to share and exchange technical expertise in the area of forest gene conservation internationally as the global network of Model Forests is expanded. The NFGRC has modern laboratory facilities and scientific expertise that is available for training students, establishing scientific and technical exchanges, and developing conservation strategies for the International Model Forest network.

The Canadian Forest Service is the Canadian Executing Agency for two six-year projects funded by the Canadian International Development Agency. The ASEAN Forest Tree Seed Centre Project based in Muak Lek, Thailand, has an annual budget of about C$1.4 million and is primarily a research project directed towards the improvement of the quality and quantity of tree seed and vegetative propagation material in five ASEAN countries. The SADC Tree Seed Centre Network based in Harare, Zimbabwe, has an annual budget of about C$2 million and is directed towards the establishment of a network in the ten South African countries for a program of training and exchanges, seed exchange and up-grading of facilities. Both of these projects involve Canadian personnel in those countries.

A strong basis for trilateral cooperation in forest gene conservation involving Mexico, the United States, and Canada was established under the auspices of the North American Forestry Commission which has promoted various forestry issues related to sustainable development for many years. These ties have recently been strengthened through the North American Free Trade Agreement.

ANNEX 7
National Needs and Opportunities

Besides specific regional issues and conservation programs, the wider issue of the impact of forestry practices on biodiversity in general, and on forest genetic resources in particular, are now being considered across Canada. Canada's forestry practices continue to dominate the forestry agenda with respect to sustainable forest management. Forest management practices such as clear-cutting, "high-grading", artificial regeneration, and tree breeding affect genetic resources and are coming under increased scrutiny. Financial constraints on artificial forest regeneration have promoted a move towards increased reliance on natural regeneration and the implementation of silvicultural practices that will foster natural regeneration wherever possible by maintaining local seed sources on site following harvesting. These silvicultural systems will be based on the maintenance of minimum viable populations of trees to ensure that the reproductive capacity and genetic diversity of natural populations is not impaired or otherwise compromised. Nevertheless, it must also be recognized that natural regeneration may fail to maintain forest productivity at desired levels. Thus, there will still be a role for planting seedlings in many situations.

FOREST GENE CONSERVATION ISSUES IN CANADA

The following issues were identified as important to the conservation and management of forest genetic resources in Canada at a national workshop held in Toronto in 1993:

1. Recognition that it is easier to maintain genetic diversity than it is to restore it.
2. The development of status reports and effective protection, recovery and conservation plans for the rare, vulnerable, threatened, and endangered forest tree species, particularly in the Temperate Zone Forest Regions of Canada.
3. Development of a representative protected areas network for the *in situ* protection of plant genetic resources.
4. An increased focus on research aimed at understanding and mitigating the impacts of land use, and particularly forestry practices (harvesting, silvicultural operations, artificial reforestation, tree breeding, and improvement practices, etc.), on the maintenance of population viability (genetic diversity and reproductive success).

5. Establishment of a genetic resource conservation working group either within the Canadian Tree Improvement Association or within the Canadian Forest Service.

6. Development of a national action plan for genetic resource management and conservation, particularly for protecting valuable or threatened forest genetic resources.

7. Establishment of a coordinator or a coordinating committee to monitor a national strategy for genetic resource management/conservation and reporting on progress.

8. Establishment of a national genetic resource information system or database that integrates with other related information systems to catalogue genetic resources preserved *ex situ* within gene banks, provenance tests, progeny tests, seed orchards, etc., that would be coordinated by the Petawawa National Forestry Institute with information provided by provincial land management agencies.

9. Development of federal guidelines to identify (measure) genetic diversity, its vulnerability, and relationship to biodiversity (ie., COSEWIC, RENEW, etc.).

10. Establishment of common principles, guidelines, terminology, and systems for documentation.

11. Development of a communications plan for genetic resource management so that results can be disseminated and incorporated into forestry practices.

12. The development of mechanisms for international information exchange and cooperation.

13. The integration of gene conservation and genetic resource management into forest management practices and operations.

14. A recognition that an understanding of the genetic system and reproductive biology provides the foundation for the sound management of the genetic resources of a species.

The following research priorities for forest gene conservation were also identified at a national workshop on Forest Genetic Resources Conservation and Management (Toronto, 1993):

1. Population viability analyses and life history investigations.

2. Identification of minimum viable population sizes and the effects of small population size on genetic diversity and reproductive success.

3. Identification of specific threats to genetic diversity.

4. Development of protocols for germplasm storage, especially for non-commercial and threatened or vulnerable species which are currently somewhat neglected.
5. Development of new/better estimates of genetic variation, structure, and diversity.
6. Documenting the impacts of forest management practices on genetic diversity and structure.
7. Identification of mating systems and genetic architecture, particularly for minor forest tree species.
8. Characterization of metapopulation dynamics.

The following national roles in forest gene conservation were identified for the Canadian Forest Service:

1. Conducting research on genetic resource management and conservation issues.
2. Addressing international commitments with regard to forest gene conservation (e.g., Convention on Biological Diversity, International Model Forest network, the North American Forestry Commission, the International Union of Forest Research Organizations. etc.).
3. Maintaining a national centre for tree seed and germplasm storage for conservation and research purposes.
4. Identifying gaps in the conservation and management of forest genetic resources and providing direct funding to address these issues.
5. Fostering collaboration among provinces.
6. Maintaining national databases on genetic resources.
7. Acting as a catalyst in facilitating surveys on the status of Canada's forest genetic resources.
8. Facilitating the coordination of a national strategy for ensuring effective genetic resources management and conservation.

ANNEX 8
Proposals for a Global Plan of Action

The following elements would be proposed for inclusion in a Global Action Plan for conservation of forest genetic resources:

1. The development of mechanisms for international information exchange and cooperation (ie., establishment of forest genetic resource conservation working groups under the auspices of the International Union of Forest Research Organizations -IUFRO).

2. Increased support for documenting the geographic distribution and biology of species.

3. The development of representative and viable protected areas network for the *in situ* protection of forest genetic resources.

4. The development of status reports, protection and recovery plans for rare, vulnerable, threatened, and endangered forest tree species.

5. An increased focus on research aimed at understanding the impacts of land use, and, in particular, forestry practices, on the maintenance of population viability (genetic diversity and reproductive success).

6. Support for the Convention on International Trade in Endangered Species.

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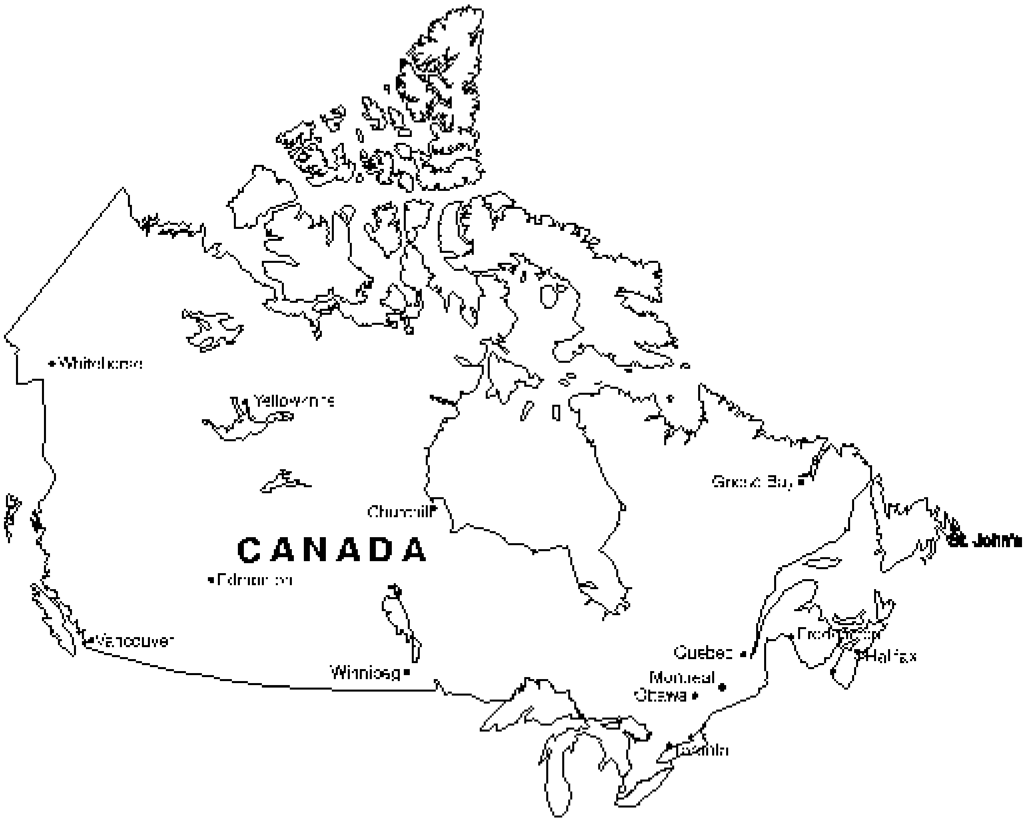
Table 2.1 The native trees of Canada (Hosie 1973)

Common names	Genus	# of species	Species names
Conifers			
Cedar	*Thuja*	2	*occidentalis, plicata*
Cypress	*Chamaecyparis*	1	*nootkatensis*
Douglas Fir	*Pseudotsuga*	1	*menziesii*
Fir	*Abies*	4	*amabilis, balsamea, grandis, lasiocarpa*
Hemlock	*Tsuga*	3	*canadensis, heterophylla, mertensiana*
Junipers	*Juniperus*	2	*virginiana, scopulorum*
Larch	*Larix*	3	*laricina, lyallii, occidentalis*
Pine	*Pinus*	9	*albicaulis, banksiana, contorta, flexilis*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