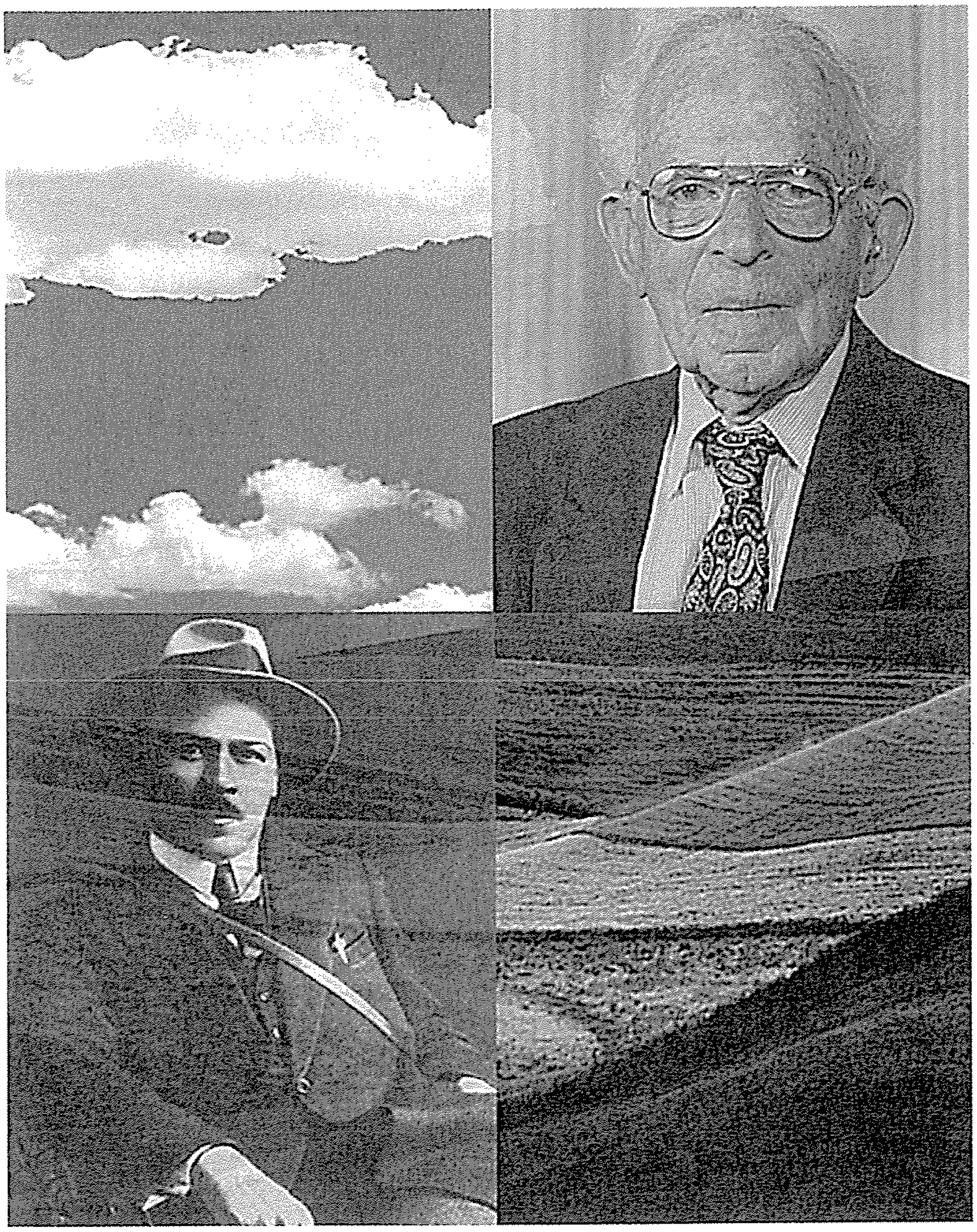
Scientists, plants and politics

A history of the plant genetic resources movement

by **Robin Pistorius** *(Vavilov-Frankel Fellow - 1993)*



International Plant Genetic Resources Institute
IPGRI

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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The international status of IPGRI is conferred under an Establishment Agreement which, by January 1997, had been signed by the Governments of Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovak Republic, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine. IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI works in partnership with other organizations, undertaking research, training and the provision of scientific and technical advice and information, and has a particularly strong programme link with the Food and Agriculture Organization of the United Nations. Financial support for the research agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, India, Italy, Japan, the Republic of Korea, Luxembourg, Mexico, the Netherlands, Norway, the Philippines, Spain, Sweden, Switzerland, the UK and the USA, and by the Asian Development Bank, CTA, European Union, IDRC, IFAD, Interamerican Development Bank, UNDP and the World Bank.

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Foreword

The Vavilov-Frankel Fellowships Programme was established by the IPGRI Board of Trustees to commemorate the unique contributions to plant science by Academician Nikolai Ivanovich Vavilov and Sir Otto Frankel. The first two Fellowships were awarded in 1993 to Robin Pistorius from the Netherlands and Igor Loskutov from Russia. The research of the 1993 Fellows focused on examining and recording the work of scientists in the plant genetic resources community, including those after whom the Fellowships Fund is named. This research has produced two books, the present one by Robin Pistorius: **Scientists, Plants and Politics - A History of the Plant Genetic Resources Movement** and a second volume by Igor Loskutov on **Vavilov and his Institute.** Together these two volumes aim to describe and analyze the historical background to today's efforts to conserve and use plant genetic resources. They are a salute to the early pioneers in this field and a record of the actions and debates that have done so much to shape the way the scientific community addresses conservation today, as well as the perspectives of the many other individuals around the world who are equally concerned with the maintenance of this priceless genetic heritage.

Geoffrey Hawtin, Director General, IPGRI

Acknowledgements

This book is the result of many informal discussions, structured and unstructured interviews and reading. A considerable part this work was done in Rome, at the International Plant Genetic Resources Institute (IPGRI). In June 1993, IPGRI provided Igor Loskutov (VIR) and me with Vavilov-Frankel Fellowships to study the history of plant genetic resources, examining scientific, historical and political factors that have shaped current genetic resources strategies and policies. The amount of research was twice as much as we had expected, took twice as much time, but also resulted in two, instead of one, products.

While the initial project proposal suggested covering Vavilov's achievements in one or two chapters, the final result was an impressive separate work by Igor on the achievements of Vavilov and his successors at the VIR[1]. I admire Igor for the way he managed to complete his research under the most adverse circumstances. While writing, a new phase of Russia's history was being written just outside VIR's front door. In spite of all this, he never failed to enjoy his work and, together with his wife Natalia, taught me much about the admirable principles of Russian hospitality and generosity.

During the research period, interviews with key persons often resulted in extensive discussions on how to approach subsequent items. At an early stage, I used much of Otto Frankel's advice. His hospitality in Canberra and his fascinating stories about what happened at FAO "only 30 years ago" I will never forget. To Erna Bennett I owe much as well. After some hesitation, she was willing to recall many painful memories about her period at FAO, stories she had wanted to forget.

During the frequent trips to Rome, IPGRI's staff never failed to provide me with assistance, and continued to discuss eagerly even the most politicized issues in a very open manner. Special thanks to Lyndsey Withers for her enormous patience and accuracy as regards content and the management of this project. I am also much indebted to other members of IPGRI's staff, especially Emile Frison and Toby Hodgkin. With Jan Engels I had many pleasant and informal discussions on the politics of conservation and use of plant genetic resources, within and outside the Institute. Dick van Sloten guided me through the highly complex decision-making processes in the Institute's past.

Crucial also was the help of Mauro Nocca and Julia Anne Dearing of the IPGRI library. Without them, the literature research for this project would have had a much more limited scope. And I should not forget Evelyn Clancy, for doing essential administrative work during the past two years, and Alberto Drago, responsible for the IPGRI Registry, for giving me some highly professional advice on how to improve my performance in the IPGRI soccer team.

Several people have read all or portions of the manuscript and offered good advice. I received very detailed and helpful comments from Jack Hawkes and Norman Simmonds. Special thanks also go to José Esquinas-Alcázar, Stephen Brush, Gerry Dempsey, my professor Gerd Junne, Jillian Lenné, Clive Stannard, Trevor Williams, David Wood and my colleague Jeroen van Wijk. Ditke Schwartz and Linda Sears did some very valuable editing.

Finally, I thank Karin for encouraging me at decisive moments as she, more than anyone else, understood how much this project meant to me.

Robin Pistorius
Amsterdam, February 1996

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[1] Loskutov, I. 1997. Vavilov and his Institute. In press. IPGRI, Rome.

Preface

The story of the travels of crop plants from country to country and continent to continent is a fascinating one. It tells of the fortuitous travels of seeds and plant material along the ancient caravan routes, in the ballast of ships and the packing of merchandise, in the bedding of slaves, the impedimenta of armies, and the simple bundles carried by pilgrims and monks. In more recent times, migrants from the Old World to the Americas, or to the various parts of the British Empire, took along seeds and plant material from the crops with which they were familiar in their own land. In due course, the New World made many important contributions to the cropping and eating habits of the Old and vice versa (FAO 1959:5). Good examples are the import of maize varieties to Europe in the wake of the discoveries of Columbus, and the work done by the Royal Horticultural Society of Great Britain and the Royal Botanic Gardens, Kew, UK.

However, it is only within the last 50 to at most 100 years that Western scientific principles and techniques have influenced the development of crop plants. Most significant in this respect were Mendel's laws (first developed in the 1880s) that helped to guide the searches for new material on the basis of known genetic characteristics. The geographical 'treasure map' that came out of these searches was developed by Nikolai I. Vavilov, who died in 1943. Since Vavilov, we have a good knowledge of the major centres of plant diversity, and of the wild relatives of the cultivated varieties. Vavilov's findings are of considerable scientific and historical significance and have made an important contribution to agronomic and genetic theory. On top of that, his efforts in collecting an enormous number of plants on the basis of their genetic content are of great value. Vavilov's findings pioneered many organized groups of scientists in later decades that took an interest in the introduction and study of plants not only for plant breeding but also for genetic study.

The scientific heritage of Vavilov was quickly integrated into conservation strategies in Western industrialized countries. While, during the 1940s and 1950s, the number of national plant introduction stations grew rapidly, modern genebanks were built in the early 1960s and 1970s. These developments brought several leading scientists to think about organizing the conservation and use of genetic resources at the global level: this will be the main subject of this book.

The 1960s showed a slow development towards an official recognition of the need to design pragmatic and centrally coordinated efforts to counter genetic erosion while assembling genetic resources for breeding purposes. In this process, the 1961 Technical Meeting on Plant Exploration and Introduction organized by the Food and Agriculture Organization of the United Nations (FAO) can be considered as a starting point, culminating in a conference with a much greater political impact: the 1967 FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources, organized by the International Biological Programme (IBP) and FAO. The 1967 Conference resulted in a very important handbook: "Genetic Resources in Plants: Their Exploration and Conservation", edited by Otto Frankel and Erna Bennett in association with R.D. Brock, A.H. Bunting, J.R. Harlan, and E. Schreiner. It was first published in 1970 and set the parameters for much of the discussions and work on the conservation and use of plant genetic resources in the 1970s and 1980s. The third, very important starting point in scientific thinking on conservation issues was the 1973 IBP/FAO Technical Conference on Crop Genetic Resources, and the book that came out of it: "Crop Genetic Resources for Today and Tomorrow", edited by Otto Frankel and Jack Hawkes (1975). Contrary to its predecessor, it did not deal with the field of exploration and conservation as a whole. Rather it was more 'action' oriented, offering specific scientific, technical and organizational solutions to start programmes to collect and conserve threatened genepools. The three events laid the foundation for the scientific premises behind current international *ex situ* conservation. Particularly during the 1967 Conference, it was decided that *ex situ* conservation was considered preferable to *in situ* conservation for reasons that are explained in Chapter 2. During the 1973 Conference the scientific criteria for *ex situ* conservation were established. This decision and the scientific premises that supported it are treated in Chapters 1 and 2 respectively.

Although in the 1960s and early 1970s, a small group of scientists began the development of a methodology of conserving plant genetic resources for breeding purposes, the financial feasibility of their plans was questioned. The watershed in financial and organizational terms was the 1973 Beltsville meeting, in which donor support for worldwide conservation efforts was ensured. This development, however, also meant that the conservation and use of genetic resources was no longer an exclusively scientific issue (see Chapter 4). Support from public institutions for genebanks also invited greater attention from public pressure groups which, along the lines of the general criticism of the agricultural policies of the Green Revolution, started to focus on genebank policies. Emotive issues were raised by the publication of such books as Seeds of the Earth (Mooney, 1979) and, at a later date, by the dialogue at international fora such as the Commission on Plant Genetic Resources of FAO. The conservation and use of genetic resources were associated with the political issues on the control over and access to genetic resources. The 'genetic resources issue' is treated in Chapter 5.

The political pressure to alter conservation strategies in the 1980s developed into a new North-South (or rather Rich-Poor) issue and increased public awareness of the economic and strategic value of genetic resources. But it is questionable to what extent it was effective in changing dominant conservation policies. *Ex situ* conservation is still closely associated with mainstream breeding programmes which gave rise to the 'Green Revolution', even though in the early days it paid limited attention to small farmers' needs. The scientific-historical background of the close link between *ex situ* conservation and the Green Revolution is dealt with in Chapter 3. This chapter also attempts to illustrate to what extent alternative breeding and conservation strategies were postulated and/or neglected. This issue again takes us back to the 1967 Conference where various options for *in situ* conservation (and the associated genecological approach in breeding) were discarded. The fact that *in situ* versus *ex situ* discussion continues today, can be considered in the light of two different views of plant improvement, one supporting a much closer link between the plant and its habitat than the other. This will be discussed in the final chapter. Although discussions of this issue within agriculture have not ended, it is striking to see that, from the environmental side, *in situ* conservation has started to gain considerable support in recent years - but not primarily for utilitarian reasons. Will the 'biodiversity issue' overrule the 'genetic resources issue'? This book hopes to offer the reader some historical insights to answer that question.

Perhaps some readers will feel uneasy about the content of this book. Erna Bennett, for example, when reading some of the draft text, pointed out to me that "...breeding and genetics are not philosophical, but practical matters. That doesn't mean that philosophy does not have a place in our thinking and our conclusions, but that the role of plant breeding is to serve people in developing countries (mostly hungry and poor people) [...]. But the paper you ask me to comment on doesn't mention either nor does it consider the main issue, which is to improve and eventually enrich their lives." (personal interview, Bennett 1994). Although I think that Bennett's criticism is just, the focus of this book is deliberately not on practicalities, or, for example, farmers' day-to-day inventiveness to survive. Instead, the book deals with scientific, and to some extent philosophical, discussions held in the top echelons of international organizations. This focus was chosen to understand why the current conservation strategies of plant genetic resources are the way they are, and why they became dominant. And it cannot be denied that conservation and related breeding practices did and will continue to influence farmers' practices a great deal.

I have used Bennett's reaction to the first draft of Chapter 3 of this book to illustrate not only the many different angles that one can use to look at 'gene-politics', but also the many sensitivities that talking about this matter provoke. In many industrialized and increasingly developing countries, many professional careers continue to be built on the development of new regulatory and scientific tools to develop the conservation and use of plant genetic resources. During the research work for this book, I became aware, more than ever before, that I belonged to the growing group of privileged persons in "the North" with ready access to vastly more information on genetic resources issues than many people in the South. Being in the position of having ready access to this material, I decided that this book had to become a first attempt to analyze the body of literature that set the scene for current international negotiations on the conservation and use of plant genetic resources. These negotiations over the past 30 years were organized by developed countries in a successful attempt to increase food production in Latin America and Asia in the 1960s and 1970s.

Currently, as biotechnology has become a key technology in agriculture and the importance of information on genetic resources is increasingly understood, the focus on genetic resources has become a leading issue on political agendas. Both scientific and political decision-making still have to come to grips with this situation. This book may offer the reader an idea of the roots of the watershed.

Robin Pistorius

1 How plant genetic resources conservation became a global issue

After World War II, and especially after the 1950s, the rapidly increasing contacts between scientists on an international level cleared the way for more international assistance programmes, crop centres, and international training and educational programmes. But while research facilities and knowledge developed, along with yield increase, breeders more and more ran into problems related to disease resistance and susceptibility and planting methods. The need for germplasm not only grew, but became more specific as well.

The more specific demand for genetic material was the result of a higher rate of predictability of genetic characteristics in breeding in which Mendel's laws on heredity were increasingly applied after the turn of the century. With the introduction of hybrids in the 1930s, the Mendelian heritage had reached its full impact, and those involved in plant improvement programmes in industrialized countries started to rely less on genetically unchanged whole plant introductions and more on exotic genetic material with specific characteristics. Until today, plant introduction has remained a primary tool in plant improvement and adaptation programmes, although it has been much neglected in publications since 'genetic resources issues' began to receive wide attention (Williams 1995, personal interview).

While in industrialized countries more and more emphasis was placed on the improvement of already imported crops, the developing countries, owing to the export of 'advanced' breeders' lines from industrialized countries, witnessed a rapid replacement of the old adapted landraces by modern varieties. This problem had already been noticed by, among others, Harry V. Harlan in the 1930s[2], Sir Otto Frankel in the 1950s[3], and members of the European Society for Research and Plant Breeding (EUCARPIA), but it only received wider, institutional support in the late 1960s when the "Panel of Experts on Crop Genetic Resources" started to become active (see Chapter 2).

Collecting and Introduction Activities, 1900-1950

Until the late 1960s, the international exchange of genetic resources still functioned mainly among the network of plant introduction stations in western Europe (notably the United Kingdom), the United States, Australia, New Zealand and the Soviet Union (USSR). A worldwide network for exchange of information on the genetic characteristics of specific varieties was not yet in existence. While plant introduction had become a worldwide activity and extensive international exchange took place between both industrialized and developing countries, there were only a few genebanks ('introduction stations') that exchanged genetic material. Three stations with worldwide scope and enough evaluation facilities to research genetic characteristics were the All-Union Institute for Plant Industry

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[2] A classic story is Harlan's visit in 1948 to Turkey, where, criss-crossing the upper and lower reaches of the Cakit River, he found only one wheat variety, while the area had already been known by Vavilov as a centre of diversity for wheat. (See also: H.V. Harlan and M.L. Martini (1936), USDA Yearbook of Agriculture), pp. 303-346.

[3] Otto Frankel, for example, complained in 1950: "Our very efforts of producing high-yielding strains have the effect of reducing the variability of a species" (Frankel 1950:91).

in Leningrad, the Commonwealth Potato Collection at Cambridge[4] and the collections related to research programmes of the Rockefeller Foundation in the USA.

Most seed banks of introduction stations, however, were inadequate with regard to the later requirements of international agricultural research and most collections were considered to be erratic, often unreliable or both[5]. The main reason for this was that most collection institutes had never been designed to fulfil the role of accessible exchange facilities. Since they had been established for working collections, either for special research purposes, or for national or local breeding work, the scope of the collections was restricted. Moreover, most collections required frequent regeneration. Especially for asexually long-lived plants this was the only available method of preservation at that time. Short-lived sexually reproduced plants, however, are known to be subject to rapid genetic change when repeatedly reproduced, especially in environments to which they are not adapted (Frankel in Bennett 1968:3-4). (Other examples of rapid adaptive change can be found in Bennett 1964, 1965.) But, in spite of the circumstances in which most collections were held in the 1950s and the dearth of collections of truly international scope, the overall picture on a regional level is one of scattered but promising initiatives.

In West Africa, plant quarantine regulations were initiated in the second half of the 1950s. This started with the Inter-African Phytosanitary Convention of 1954 which, since 1965, has been the umbrella of the Organization of African Unity. Ghana was one of the few countries that established a Plant Exploration and Introduction Service. By the end of the 1960s more than 800 cultivars had been introduced, particularly food plants and specific introductions resistant to diseases. In other West African countries, particularly in Nigeria and the Côte d'Ivoire, there were a few universities and research organizations which employed staff for plant exploration and genetic conservation.

In the 1950s and 1960s, plant exploration and introduction of plant genetic resources in Latin America was carried out mainly in Argentina, Brazil and Mexico. These countries maintained large breeding collections which were quite intensively exchanged with other institutions in Latin America.

Argentina was the only country with a national service for plant introduction. Venezuela maintained extensive collections of papaya and its wild relatives, and of oil crops in Maracay. Colombia had collections of native potatoes, grasses and pasture legumes. Before World War II, the Interamerican Institute of Agricultural Sciences (IICA) at Turrialba, Costa Rica already had considerable collections of cocoa. Through the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) this collection grew into one of the largest in the world in the 1960s and early 1970s. Also the Trinidad Imperial College of Tropical Agriculture had extensive collections of cocoa collected from Mexico, Central America and the northern part of South America. The United States Department of Agriculture (USDA) maintained a cocoa cultivar collection in Puerto Rico (Mayaguez).[6]

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[4] The UK Potato Introduction Station was supported by the British Commonwealth as well as the UK through the Commonwealth (formerly Imperial) Agricultural Bureaux System.

[5] Otto Frankel in this critique referred to the inadequate collections as printed in the FAO Plant Introduction Letters 17 and 18 (FAO 1957-70).

[6] The USDA, from the beginning of the century, has been actively involved in the collection and exploration of various plants in Latin America. The continent had been searched for maize with opague genes; Mexico and the Andes had been searched for potatoes with disease resistant characteristics; Argentina and Brazil for beans with disease-resistant factors (of which large collections had been made in Mexico); the Andes of Peru and Bolivia for quinoa types with low saponin contents and high yields. Cocoa expeditions focused on the Amazon basin. Other targets for explorations had been medicinal plants, especially *Cinchona* and *Dioscorea*, and forage grasses

Most of the exploration work in Latin America had been done by scientists or institutions from other areas, often the USA. The Rockefeller Foundation executed an extensive programme on maize in Mexico in the 1940 and 1950s (see below).

After World War II, there was a fairly limited number of expeditions to the Chinese, Indian and Indo-Malayan centres of diversity. Some foreign expeditions visited the area, but collections had been restricted to rice, soybean, crucifers and ornamentals. After 1949, access to China was no longer possible. However, by the late 1960s, the Indian Agricultural Research Institute had collected more than 6000 types of pulses, more than 1900 entries of crucifers and some 8000 grasses and forage legumes. In cooperation with the Rockefeller Foundation, the Institute had assembled more than 1700 entries of sorghum and millet. India and Japan had established national germplasm collections, with facilities for permanent storage. Other collections were in Calcutta (India), Peradeniya (Sri Lanka), Bogor (Indonesia) and other botanical gardens, and special collections of rice at the International Rice Research Institute, the Philippines, temperate cereals at Sendai, Tokyo, Kyoto and Haratsuka in Japan, and pulse collections in India (FAO Panel of Experts 1969:12). A Japanese fund for "Expenditure for Germ Plasm Maintenance" was created in Japan in 1952 (Matsuo 1975:200). In 1965, the Ministry of Agriculture and Forestry financed two specialized laboratories for the collection and maintenance of cultivated rice and wheat germplasm (*ibid.*). In 1966, the National Seed Storage Laboratory for genetic resources was opened in the Division of Genetics of the Department of Physiology and Genetics of the National Institute of Agricultural Sciences (Ito 1972:405).

Japanese rice collections were directed especially towards evolutionary breeding and study. At that time these were some of the most representative collections of wild relatives of cultivated plants in the world, and were meant to be stored on a long-term basis (Frankel in Bennett 1968:6). A revision of the germplasm storage system in Japan was proposed in 1975 by the "Gene Pools" research group of the Japanese International Biological Programme (JIBP).[7] In 1975 the Ministry of Education established a "Masterplan for a National Crop Breeding System" in which the role of genetic resources in breeding was, for the first time, clearly defined (Kawakami and Fujii 1981:17).[8]

The Near East is an area of primary importance from the point of view of plant domestication. Domesticated plants from the Near East had tremendous influence in Europe and Asia and, in recent centuries, in the New World. As primarily exporters of genetic resources, the countries of the Near East had been moderately active in the importation of plant materials. Turkey in this respect is an exception with its massive introduction of Mexican wheats replacing many native wheat races.

Australia, being poor in native germplasm resources for major food and fodder species, has always been extremely dependent on plant introduction. The aborigines of Australia were hunter-gatherers and had no agriculture before the arrival of Europeans. Australia, therefore, had every incentive to use the genetic resources of the rest of the world, where agriculture had developed thousands of years earlier. Many crops were introduced in Australia: by the late 1960s the Australian National Wheat Collection, for instance, contained some 10 000 entries. Australia did make an important contribution to forestry,

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and legumes.

[7] This programme was part of the International Biological Programme (see Chapter 3). The "Gene Pools" Subcommittee of the IBP conducted studies on the ways and means of exploration, collection, preservation and utilization of genetic resources.

[8] For a good overview of genetic resources activities up to the late 1970s see: J.T. Williams and J.L. Creech (1981) Crop Genetic Resources of the Far East and the Pacific. International Board for Plant Genetic Resources (IBPGR), Funny Press, Bangkok.

however, with many species of *Eucalyptus*. Not surprisingly, a plant introduction service was established as early as 1930, under the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). Since the 1950s, the Organization has pursued an active exploration policy. Between 1963 and 1968 alone, some 30 exploration expeditions were organized to all parts of the world. Because large parts of the more heavily settled southeastern regions of Australia have a Mediterranean climate, the expeditions focused particularly on Mediterranean pasture and crop plants. In the late 1960s, this emphasis shifted slightly towards subtropical plants. CSIRO was mainly in charge of maintenance of plant collections in Australia, but there were many working collections at various institutes (FAO Panel of Experts 1969:10).

Plant introduction in the United States of America

The USA had depended on many other countries for practically all their economically important crops. For example, the productivity of small grain cereals had been largely dependent upon disease-resistant varieties bred from parental lines originally introduced from Argentina, Ethiopia, Germany, Kenya and the Soviet Union.[9] Probably the most spectacular example is the development of the US soybean industry from the special explorations in China and Japan, mainly in the late 1930s. The introductions from China were especially used for daylength breeding. After selection, however, most of the collections were destroyed.

Official government recognition of the importance of this work to agricultural development first came in 1827, when President John Adams directed all American consuls to forward rare plants and seeds to Washington for subsequent distribution. The first funds were appropriated in 1839 when Congress allotted US$ 1000 primarily for collecting seeds and plants. It was not until 1898, however, that great impetus was provided through the creation of a unit known as the Office of Foreign Seed and Plant Introduction. In the early 1960s, this office was renamed the New Crops Research Branch, with headquarters located at the USDA Plant Industry Station in Beltsville, Maryland. The main responsibility of the Branch was to secure for cooperating federal, state and private research workers those plant stocks required to pursue their programme objectives. Plant materials were obtained through international exchange, purchase, or by foreign and domestic exploration (Hyland 1961:3).

Owing to increasing demands for food and fibre and the industrialization of agriculture, crop improvement between 1900 and 1930 was mostly concerned with adaptation and yield factors of new varieties. However, even before World War II, breeders had run into problems related to disease resistance and susceptibility, quality improvement, changes in planting and harvesting methods, and reactions to plant protection or weed control practices. Therefore, germplasm material in US genebanks was mainly collected for short-term use in specific breeding programmes[10] or for tests regarding agricultural diversification in certain regions.

Once the initial demand from research workers was satisfied, introduced germplasm was stored at the National Seed Storage Laboratory (NSSL) at Fort Collins, Colorado

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[9] Other examples are alfalfas from Turkistan, *Lespedeza* from Japan, wheatgrasses from Siberia, melons from Iran, potatoes and tomatoes from the highlands of South American countries, and hardy fruits from China (Hyland 1961:1).

[10] Frankel (1987:26) referred to this kind of collecting strategy with deliberate intent as 'mission oriented'. A 'mission oriented' exploration was only conducted when the plant materials could not be obtained by other means, or when an intensive survey was necessary to obtain germplasm for an important crop which was somewhat limited in its area of adaptation.

(Hyland 1961:9). This facility was created in 1958 and was the first genebank with long-term seed storage facilities.

The Rockefeller Foundation

Perhaps the most advanced and best-organized collection of germplasm in the 1940s and 1950s was coordinated by the Rockefeller Foundation in the USA. Its collecting work began in 1943 when the Foundation, in collaboration with the Mexican Ministry of Agriculture, began a programme of practical improvement of basic crops: primarily maize, wheat and potato. This was called the Mexican Agricultural Program. Under the auspices of the USA and American land-grant universities, similar projects (which basically initiated the Green Revolution) were carried out in Guatemala, El Salvador, Venezuela, Brazil, Uruguay, Argentina, Costa Rica, Cuba, Colombia, Peru and Chile. Most of them started in the 1940s. According to Trevor Williams, the collections established by the Foundation formed the basis for a global network recommended by the FAO Panel of Experts in the early 1970s (1995, personal interview).

The emphasis on wheat can be explained by its successful hybridization in the USA. The Rockefeller interests in maize, which were closely tied to US agricultural interests[11] and part of US development assistance in Latin America, generated a great need for fresh genetic material, as is illustrated by the following quote from Edward May (president of an Iowa maize seed company, 1949):

> We know how to build resistance into the corn plant. Now we must develop techniques for finding and evaluating this germ plasm. Past experience with other crops has taught us not to confine our search exclusively to unknown corn. Thus it is that the Tropical Research Centre has been located in Guatemala to search for genes or characters that will improve our corn and thereby contribute to greater freedom from hunger and improve the welfare and security of all nations (May *op. cit.*, Kloppenburg 1988:159).

The need for new material increasingly shifted to the need to prevent genetic erosion due to monocropping with new hybrid strains. By the late 1950s, new maize hybrids already covered about 90% of the total maize acreage in the USA. Action to prevent further losses was required. A special Committee on Preservation of Indigenous Strains of Maize was formed in the National Academy of Sciences. The project would arrange the "collection, preservation and study for future use of as many varieties of native and pioneer maize as possible" (Clark 1956). The Committee consisted of leading breeders, geneticists, botanists and administrators. Again a cooperation network with the Rockefeller Foundation was established, and this network formed the basis of an extensive exchange network throughout the Americas, with a centre covering four different regions in North and South America.

Collected material was compared for yield, disease resistance and other agricultural characters. As the collections grew and the extraordinary diversity of maize, especially in Mexico, was revealed, the need for a taxonomic classification of the great multiplicity of varieties became apparent (Wellhausen *et al.* 1952). Consequently, botanical, genetic and cytological studies were begun. Their classifications and descriptions of the principal races of maize became known as 'germplasm seed banks' (Brown 1953:292-93).

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[11] The initiative to set up plant surveys to Latin America came from the former Secretary of Agriculture and founder of Pioneer Hi-Bred Henry A. Wallace and Rockefeller Foundation President Raymond Fosdick (Kloppenburg 1988:158).

The significance of the Rockefeller programme for conservation can also be attributed to the intensive breeding programme throughout the USA to develop semi-dwarf spring wheats.[12] Of the thousands of hybrid seeds containing the dwarfing gene grown in the Mexican programme, only three plants were selected as showing promise. The selected progenies of these wheats possessed the short stature of the Norin 10 and the disease resistance of the Mexican parent. These three plants were the narrow bottleneck of vigorous selection from which literally billions of wheat plants have since been produced. But they yielded very well, especially in the irrigated wheat lands of Mexico, and promising lines were vigorously promoted in other wheat-growing tropical countries by the International Wheat and Maize Improvement Centre (CIMMYT). CIMMYT, therefore, grew quickly to become the programme's successor organization, initiated by the Rockefeller and Ford Foundation with a more international remit (Simmonds 1979:357). With the wheat model in view, a similar pattern was followed by the Rockefeller Foundation for rice a few years later.[13] After the release of the successful high-yielding rice variety IR8 in 1966, it became a huge commercial success in India, Pakistan and Indonesia. By 1970, about 10 million hectares were covered by IR8 and its immediate successors (*ibid.*). According to Simmonds the two programmes had much in common.

> Both sought to exploit dwarfness ... and day-length neutrality (hence wide latitudinal and seasonal adaptation); both recognized that no plant breeding could much improve yields if soil fertility were limiting so sought to exploit ... not the variety alone, but the appropriate variety-agronomy 'package'. In short, both programmes sought to do quickly, in one step, what temperate programmes on cereals had done over several decades. ... The agronomic parts of the packages were complex, containing water control, fertilizers, weed control and disease control as principal elements (Simmonds 1979:358).

An important initiative in the USA was the establishment of four Regional Plant Introduction Stations and one inter-regional programme on potato. These stations were established to provide research to encourage introduction and breeding, particularly of those crops and plants which could be adapted to utilization in the agro-(chemical) and manufacturing industries. Four stations were established: at Ames (Iowa, 1947); Geneva (New York, 1948); Experiment (Georgia, 1949) and Pullman (Washington, 1952). The

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[12] The wheat improvement programme was started by the Nobel Laureate Norman Borlaug in 1954 when a dwarf wheat (the Norin 10 x Brevor) was crossed with indigenous Mexican varieties. Following World War II, an agricultural adviser to the US Army of Occupation in Japan had observed Japanese farmers growing short, stiff-strawed wheat varieties that remained erect under heavy fertilizer application. The dwarfing short-stature gene came from a Japanese wheat which, in 1917, was crossed with Glassy Fultz, a selection of the American soft red winter wheat variety Fultz, at the Central Japanese Agricultural Experiment Station to produce Fultz Durama. The variety, in turn, was crossed with the American hard red winter variety Turkey. Following seven cycles of selection by plant breeders Norin 10 was registered and released in 1935 for Japanese farmers (Wilkes 1983: 141/2). The product was a series of dwarf wheats which were high-yielding if adequately watered and fertilized (Simmonds 1979: 357). The semi-dwarf wheat is commonly attributed to the North West of the USA. Japan, however, long preceded the US in understanding the crucial fertilizer tolerance. Before World War II, Danish barley breeders were growing dwarf barleys for the same reason.

[13] A cross of a dwarf, early maturing Japonica-type rice from Taiwan (Dee-geo-woo-gen) by the tall Indonesian variety Peta yielded an F_5 selection which was bulked up as IR8 rom 1966 (Simmonds 1979:357).

stations were coordinated by New Crops Research Branch, ARS, Beltsville. Simultaneously with the initiation of the Regional Stations, a National Seed Storage Laboratory for long-term storage and preservation of valuable plant germplasm propagated by seed was initiated at Fort Collins Colorado. While Fort Collins dealt with long-term storage, the smaller Regional Stations were to hold stocks for ongoing breeding work.[14]

The Soviet Union

Vavilov's achievements should be regarded in the context of the agricultural history of the USSR. Vavilov was not only a collector, but also a highly-skilled manager of extensive and long-term collecting expeditions, which were considered necessary in the 1920s when the USSR went through a rapid industrialization of its agricultural sector. Vavilov was also a brilliant geneticist, and had perhaps the broadest experience of any collector until that time. Few of his colleagues had established an international network of personal contacts as extensive as Vavilov's. These qualities allowed him to make successful collecting expeditions during the 1920s and 1930s, not only in the USSR, but also in over 50 countries in Asia, the Americas, northern Africa, Europe and the Mediterranean basin. The expeditions amassed over 50 000 seed samples of wheat, rye, oat, pea, lentil, chickpea and maize, providing the foundations for the establishment of modern genebanks in the USSR (Plucknett *et al.* 1987:62).

Vavilov's second major achievement was theoretical. Using his theory of climatic analogy, Vavilov was convinced that in "... selecting species and varieties for the Soviet Union [..], one has to take into account the climatic conditions under which plants introduced were growing and, wherever possible, to select varieties from regions more or less similar climatically to our country" (Vavilov 1951:45). These ideas led to the well-known division into the Vavilovian centres of Crop Diversity in: (1) Mexico, Guatemala, (2) Peru, Ecuador, Bolivia, (3) Southern Chile, (4) Brazil, Paraguay, (5) United States of America, (6) Ethiopia, (7) Central-Asia, (8) Mediterranean basin, (9) Indo-Burma, (10) Asia-Minor, (11) Siam, Malaya, Java, and (12) China. Although Vavilov called the areas 'centres of origin', critics state that we simply lack the information to determine the very first geographical origin of species. The term 'centre of diversity' is considered safer. As will be shown in the following chapters, the centres were, at least initially, used as a 'genetic treasure map' during many post-World War II European and American conservation efforts.

A third significant contribution of Vavilov was his ability to translate his rapidly growing scientific knowledge of the world's genetic resources into economic use, particularly with regard to adaptation and disease resistance. For example, Vavilov's concern with wild relatives of economic plants was far-sighted, as recent changes in collecting strategies illustrate. In spite of the fact that Vavilov became a victim of Stalin's totalitarian regime and although his ideas were systematically criticised by scientists more affiliated to the Soviet system (such as Lysenko), Vavilov's ideas and his collections have survived.

Progress in plant breeding techniques after Vavilov's death urged the USSR to collect new material. This was not an easy task. In the early 1960s, Zhukovsky (of the N.I. Vavilov All-Union Scientific Research Institute of Plant Industry, VIR, Leningrad) complained about the lack of a continuous introduction of new material of cotton, maize, potato, bean, pumpkin, tomato, pepper, tobacco and groundnut. This problem related especially to cross-pollinated plants which, to preserve the authentic purity of populations and forms, had to be replenished every ten years. But new material had to be imported

[14] For more historical information on plant introduction initiatives between USA and the USSR, see Yeatman *et al.* (1984).

from all over the world, including capitalist countries. In spite of Vavilov's tremendous collecting efforts, the Institute's collections contained considerable gaps with regard to the countries of Latin America, Australia, the Balkans and the Iberian Peninsula – the countries that Vavilov had been able to cover only partly or not at all. Zhukovsky, in the 1960s, was one of the few persons with direct contact with FAO, and complained in various meetings about the impossibility of organizing another expedition to Latin America to obtain potato varieties resistant to virus degeneration, aggressive races of *Phytophthora*, nematodes, Colorado beetle, *Epilachna* and other pests (Whyte 1958:83-84). Throughout the 1960s Zhukovsky continued to point out the lack of new material and the consequent need for collecting expeditions. In his own words: "We are suffering from a plant breeders' famine as regards original material for these crops", for which he was eager to condemn Soviet bureaucracy: "Unfortunately many leading personalities in the Ministries and the USSR Academy of Sciences do not understand this. I am trying to arrange such an expedition" (*ibid*).

Eastern Europe

Generally, genetic resources in Eastern Europe and in the USSR have had higher priority in agricultural research than in Western Europe. In the former socialist system, genetic resources programmes were coordinated by the VIR. This coordination was carried out through the Scientific-Technical Board for Wild Species and Cultivated Agricultural Plant Collection, as part of the Council of Mutual Economic Assistance encompassing the Soviet Union and all East European Countries. Bulgaria, the Czech Republic, former East Germany, Hungary, Poland, the Republics of Montenegro and Serbia and the Slovak Republic established conservation programmes after World War II with considerable amounts of landraces and old cultivars (Committee on Managing Global Genetic Resources 1993:351-352).

Western Europe

In Europe, the need for an international central organization was quite general, but can best be illustrated by referring to the situation in potato introduction and exchange. Although the Commonwealth Potato Collection was considered to be one of the best in the world, it had defects and there still remained many problems. Potato breeders in Europe found it extremely difficult to maintain genetic stocks of potato species and varieties in their initial purity and freedom from disease. Much money had been spent (especially by European countries) in attempts to bring together and maintain adequate collections for potato breeders. Yet, however hard breeders tried, they seldom had the time or facilities to maintain such stocks or to distribute them adequately to others. Since most work was previously organized on a national basis, duplication was the result. The lack of facilities and financial resources had caused the loss of a considerable amount of material. Meanwhile, each country had attempted to maintain its own collection of species and varieties.

An attempt to solve the problems had already been made by the British Commonwealth, which had established the Commonwealth Potato Collection, and by the USA with its IR-1, Inter-regional Potato Introduction Project at Wisconsin. But although a breeder could obtain material from any of these collections in theory, this was not always so easy in practice since adequate reports were not always published and so it was impossible to know what was in fact available (Hawkes 1961).

Furthermore, individual breeders were often interested in their material only from a limited point of view and quickly discarded anything that did not seem promising to them at the time without considering that it could be of value to other breeders interested in different problems (Hawkes 1961). This led to the conclusion that an international station would be the only possible next step. The situation in potato germplasm and exchange was typical for the level of international exchange of most other crops. Most exchange of material and information on the material relied on initiatives of the driving force of individual breeders and collectors maintaining their individual networks.[15]

The problem with regard to potato was picked up quite early by the European Society for Research and Plant Breeding (EUCARPIA).[16] During the 1961 FAO Technical Meeting on Plant Exploration and Introduction in Rome, EUCARPIA delegates had lobbied for a permanent bureau for exploration and introduction and the establishment of "various germplasm stations in various parts of the world" (Hawkes and Lamberts 1977:1). The establishment, however, did not materialize. Interestingly enough, some members of the Society used the argument for the need for better facilities for breeders. The Third EUCARPIA Congress in Paris in 1962 also, and very likely for the first time during an international congress, emphasized the danger of the loss of genetic resources. Later during the FAO 1967 Conference, the phrase "genetic erosion" was coined. Although again the matter did not materialize, in 1966 the EUCARPIA delegates, especially Akerberg, strongly advised the European plant breeding institutes to start a collaboration through several regional genebanks on the continent. Akerberg sent a letter around to breeders and geneticists he knew to provoke the establishment of a small committee consisting of Ellerström (Sweden), Hawkes (UK), Lamberts (the Netherlands), and Lein (West Germany). He first met with them in June 1968 in Vienna. The meeting resulted in a proposal to establish four regional genebanks which was sent to governments of several countries that were expected to be concerned with the importance of a regional approach. The group was convinced that national genebanks for each country were not necessary as long as each agroclimatic zone could have its own genebank (the term 'subregional genebanks' as such is perhaps more adequate) (Bommer 1990:4-6; FAO Panel of Experts 1969:13).

The proposals resulted in the establishment of the following four genebanks:

1. **Northwestern Europe.** The bank is now established as the **Institute of Crop Science and Seed Research** (now **Plant Breeding**) of the **Federal Agricultural Research Centre** (FAL) at Braunschweig-Völkenrode, West Germany. Professor Dieter Bommer was the main initiator in its establishment.
2. **Central and Eastern Europe.** In the original plan, the group suggested that more than one genebank would be needed, for example, in Leningrad, Gatersleben, Radzikow, etc.
3. **Southern Europe, including the Mediterranean region.** The bank has been established at Bari, Italy. The main initiator was G. T. Scarascia-Mugnozza.
4. **Scandinavia.** The bank has now been established at Lund, Sweden, as a cooperative effort amongst the Nordic countries, Denmark, Finland, Iceland, Norway and Sweden. The initiators were Ebbe Kjellqvist and Stig Blixt.

During the proposal phase of the project, it was foreseen that FAO would act as a coordinator in the development of a uniform recording system for more efficient use and distribution of the material. However, as will be shown in the following, FAO was not yet

[15] Early attempts to maintain clones collected in the Andes failed. "Many came in already infected with viruses and subsequent spread in the glasshouse simply could not be checked" (Simmonds 1979:330). The Commonwealth Potato Collection under K. Dodds did some pioneering work on long-term storage as dry cold seed.

[16] EUCARPIA, in 1962, had already passed a resolution on the danger of genetic erosion in wild species and primitive forms (Bommer 1990:4).

in a position to carry out such a task. The contacts with FAO became easier only after the establishment of the Unit of Crop Ecology and Genetic Resources in 1967 under the guidance of R. Pichel and with Erna Bennett as a part-time consultant. Then later in the early 1970s, when the Unit started to focus more seriously on the use and conservation of genetic resources, she was accompanied by Trevor Sykes in 1973.[17] Initially the Unit was in charge of agro-ecological zoning.

But the network also had its difficulties. The subregional function of both Bari and Braunschweig was never quite realized. Brauschweig's impact soon narrowed down to a very limited number of crops, notably potato for which a German-Dutch potato genebank in 1974 was set up (Bommer and Beese 1987). The ideas for a potato genebank were as old as those for a regional genebank. In 1961, EUCARPIA had tried to establish a cooperative project between Germany, the Netherlands and the UK but because of the lack of interest of the UK government it was postponed. The matter was taken up again by Akerberg, Ross, Hawkes and Lamberts to see whether it could be financed through the Organization for Economic Cooperation and Development (OECD) and, although many countries were interested, the proposal was not accepted, mainly for financial reasons (Hawkes 1986:4). Finally the German and Dutch governments, mainly through the lobby work of Bommer, agreed to establish a German/Dutch potato genebank in Braunschweig.

EUCARPIA started to mature in the 1970s when a special Gene Bank Committee (an official unit within EUCARPIA and formally linked to the section "Wild Species and Primitive Forms") was established by Hawkes who was appointed chairman. The Committee, in its extended form, held annual meetings to which genebank directors from Eastern Europe were also invited in spite of Cold War politics. This resulted in a remodelling of the Committee in 1977 when, at the Triennial EUCARPIA Congress in Madrid, it was agreed that it would consist of eight elected members: four from West and four from East Europe, together with a Chairman and Secretary (Hawkes 1986:5). The first of these meetings was held in Izmir, Turkey, in 1972, under the title "European and Regional Gene Banks" (Hawkes and Lange 1973). After 1974, collaboration was sought with the International Board for Plant Genetic Resources (IBPGR).

Early Collecting by the Food and Agriculture Organization of the United Nations

Collecting expeditions usually did not take into consideration the interests of countries[18] other than those running the expedition. FAO, however, not being a research institution

[17] Trevor Sykes (a horticulturist) and Erna Bennett knew each other well from a UN genetic resources conservation project carried out in the 1960s. In 1969, Sykes went to the University of Birmingham for a year M.Sc. course (see below) because he decided he needed some extra training. This is where he met Trevor Williams. Jack Hawkes was his teacher and Williams helped Hawkes to set up the course. Here Williams also met Erna Bennett who visited to give some seminars (Williams 1995, personal interview). Hawkes ran the M.Sc. course on Conservation and Utilization of Plant Genetic Resources at the University of Birmingham, UK from its foundation in 1969 until his retirement in 1982. Many of the more than 600 former students are prominent in national genebanks worldwide.

[18] Nor were there channels by which international expertise could be applied to, for example, the evaluation of the resulting collections. The expertise that did transcend international barriers was related to a very restricted number of major industrial crops and their maintenance. For example, after the initial introduction of hybrid maize varieties from the USA and Canada into Europe and the Mediterranean region, national collections of local varieties were established in many countries and, in addition, regional collections in Bergamo (Italy), Wageningen

itself, owning no land and conducting no plant breeding programmes, was in a unique position to serve as a 'clearing house' for the exchange of seed.

As early as 1948, FAO held a conference attended by 44 nations to take further steps to draw up and promulgate a World Charter for Forestry. This evolved into ideas on how to set up a network of biological research stations with laboratories "located in places where natural or other conditions permit the investigation of phenomena, specimens, etc. which cannot be studied to advantage in the average research institution" (UN Department of Social Affairs 1948:101, 103).[19] The biological stations would, according to a proposal submitted to the UN Department of Social Affairs, function more or less independently from the UN, and would be located in the tropics (former research stations were mostly located in Europe[20]). Although the network of biological stations was never established, the stage had been set for more thinking about the use and exchange of genetic material on a world scale.

The same year, the FAO Subcommittee on Plant and Animal Stocks discussed the establishment of a world 'clearing house' to increase cooperation in plant exploration, the recording of living collections and the removal of "artificial barriers" to the interchange of plant stocks (Whyte and Julén 1963:12). The clearing house would consist of a classified catalogue of cultivars, while all participating countries would maintain and make available varieties which were cultivated in their area. Also breeders' lines of particular interest and usefulness to colleagues in other countries would become subject to the new system.

The clearing house would not be accompanied by a physically central collection under the aegis of FAO, but would maintain diverse collections in their own habitats. Descriptions of varieties in their national collections would be sent to FAO to be classified and made available to breeders all over the world. Immediate prospects were for catalogues of wheat, rice and other self-fertilized; ultimately, cross-fertilized plants such as maize were to follow (Frankel 1950:92).[21] However, as Frankel once stated, a significant problem related to the clearing house system was that it partly excluded gene-rich developing countries.[22]

Ultimately, five collections of rice (as part of national collections) were established, mainly on the basis of some form of international exchange via FAO between breeders

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(Netherlands), Belgrade and Zagreb (former Yugoslavia), for study, screening and the provision of seeds to breeders (Whyte and Julén 1963:13).

19 The preliminary idea was to fashion these biological stations after the International Zoological Station at Naples, Italy. This large, well equipped international laboratory on the shore of the Gulf of Naples was established chiefly to permit workers from all parts of the world to study the Mediterranean marine flora and fauna, and related biological and oceanographical problems "at a place where living specimens of all kinds are available in great abundance." The station in Naples was financed by grants of governments from nearly all over the world and had become a working space for a certain number of their most promising biologists (UN Department of Social Affairs 1948:101-3).

20 For example, London had its Royal Society, and the Kaiser Wilhelm Institute had the Harnack Haus.

21 Some indication of the scope of this work can be obtained by reference to items 101, 140 and 169 in the FAO Plant Introduction Newsletter (FAO 1957-70).

22 Otto Frankel, during the 1949 UN Scientific Conference on the Conservation and Utilization of Resources, referred to this problem by stating that the system made "no provision for the collection and classification in non-participating and especially in primitive countries, in fact in some of those with the greatest wealth of plant types, which are still awaiting full exploration by collecting expeditions" (Frankel 1950:92).

organized in so-called Working Parties. Forming a focal point for an increasing number of breeders, the Working Parties were able to lay the foundation for several World Catalogues of Genetic Stocks. These Catalogues were published not only on rice (FAO 1950a), but also on wheat (FAO 1950b), tropical grain legumes (FAO 1958) and barley (FAO 1959).[23]

Another FAO initiative was the Crop Production and Improvement Branch of the Plant Production and Protection Division that dealt with a continuous stream of enquiries for samples of seed or vegetative material for use by breeders. Through this service, some form of seed exchange between plant breeders to obtain their stocks was gradually set up. At the end of the 1950s, about 20 000 individual seed envelopes were sent out each year. By way of the Branch, a number of crops and varieties were introduced to developing countries, for instance rice in Brazil, Iraq, Tunisia, the Sudan and Jamaica; cotton in Ethiopia, Afghanistan and Syria; sugarcane in Iran, Haiti and Ceylon; fruits in Yugoslavia, Syria, Libya and Morocco; berseem in Chile; and many grasses and legumes for pasture improvement and soil conservation in several other countries (Whyte 1958:91-92).[24]

For many years, one of the primary interests of FAO in the field of plant exploration, collecting and introduction was in the many types of herbage and fodder plants required for projects of grassland and fodder development in low latitudes, especially in Australia. This interchange even evolved into a system of Mediterranean nurseries.[25] The bias towards herbage and fodder plants was very likely to be related to the great involvement of R.O. Whyte, the head of the grasslands unit of the Crop Production and Protection Branch of FAO in the 1960s. In a later comment, Erna Bennett referred to Whyte as one of the very first staff members within FAO who saw the significance of more activities in the field of international exchange and introduction of genetic material (Bennett 1994, personal interview).

Whyte's commitment to the exchange of herbage and fodders generated several other activities on plant introduction and exchange within FAO. The early activities regarding grasses, for example, resulted in an early link between the FAO and CSIRO in the exchange of material. In 1954, a joint project in the Mediterranean region was arranged. The objective was to collect pasture species from the natural vegetation for introduction and

[23] See also: FAO, Plant Introduction Newsletters Nos. 1-9. Mimeo. (1950) World catalogue on genetic stocks: Rice, with 7 supplements (No. 8 was published in 1961); (1950) World catalogue on genetic stocks: Wheat, with 7 supplements (No. 8 was published in 1961); (1958) Tabulated information on tropical and subtropical grain legumes (trilingual), 367 p. (supplement published in 1962), and (1959) World catalogue of genetic stocks: Barley (supplement published in 1961).

[24] A few extra examples may be given here. Quinoa, *Chenopodium quinoa*, which grows on the high plateaux of the Andes where most wheat varieties fail to mature, was introduced through FAO in mountain regions of the Belgian Congo, Madagascar, India and even in Iceland. Cold-resistant varieties of tea from Iran, Japan and Turkey were introduced into Morocco, where a few areas offered possibilities of tea growing on a limited scale. Drought-resistant shrubs from the Karoo of South Africa were introduced in certain difficult Mediterranean areas such as in Kuwait (Whyte 1958:91).

[25] The nurseries were established as part of the co-operative research activities of the FAO Working Party on Mediterranean Pasture and Fodder Development. In 1953, some 25 Uniform Mediterranean Nurseries were established by the member countries of the Working Party for Mediterranean Pasture and Fodder Development. About 250 samples of seed of annual and perennial grasses and legumes were obtained by FAO from the region itself and from comparable environments throughout the world, and these were distributed to collaborating nurseries for observation according to a standard layout and procedure (Whyte and Julén 1963:13).

testing, both in the member countries of the FAO Working Party on Mediterranean Pasture and Fodder Development and in Australia.[26,27] The collected material was distributed to both the participating countries in the Mediterranean area and to Australia. Whyte was also one of the organizers of the Seventh International Grassland Congress, held in New Zealand in November 1956. The Congress was the first international conference with specific recommendations to the FAO for international exchange and conservation of seeds and information (FAO 1957:1, 2). Later, Whyte, together with William Hartley, became the main driving force behind the first FAO Technical Meeting on Plant Exploration and Introduction in 1961.

In the 1950s, FAO continued to process a continuous stream of enquiries for samples of seed and vegetative material from breeders, while at the same time it was increasingly confronted with requests to assist governments in arranging access to national plant introduction and quarantine facilities in other countries. The significance of the FAO services was first recognized at the 8th Session of the FAO Conference in November 1955. Consequently, the initial plan to set up a clearing house under the aegis of FAO had to be enforced by international agreements to guarantee a truly international exchange of material. Both the exchange of material and the number of multilateral, coordinated expeditions had to increase. Since not all countries could afford to send an expedition on their own, FAO was expected to set up an organizational infrastructure to send expeditions on the basis of international collaboration (FAO 1957:6).

As a follow-up to the recommendations, two informal meetings were held: one at the Linnean Society, London, July 1956, and one at the CSIRO Division of Plant Industry, Canberra, Australia, in October of the same year. Specialists attended from Australia (with William Hartley as chairman), the USA, the Netherlands, France, Sweden and the United Kingdom (FAO 1957:1). These meetings further paved the way for international collaboration and served as one of the first fora to develop scientific principles and practical techniques applicable in the field of plant exploration and introduction.[28]

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[26] The 1954 mission was limited to a relatively small number of countries in order to exploit their available resources as fully as possible. The region selected was North Africa (Morocco, Algeria and Tunisia) and two of the provinces of Libya (Tripolitania and Cyrenaica). Some supplementary collections were made in Egypt, Cyprus, Israel, Portugal and Greece. The material was shared between the member countries of the FAO Working Party on Mediterranean Pasture and Fodder Development and CSIRO, Australia. Seeds and tillers were distributed from Rome to agronomists and plant breeders throughout the Mediterranean Basin and also in some countries of western Europe, USA and elsewhere (Whyte 1958:77).

[27] Some indication of the scope of this work still can be obtained by reference to items 101, 140, and 169 of the FAO Plant Introduction Newsletter (FAO 1957-70).

[28] The complete list of participants was as follows: W. Hartley (CSIRO, Canberra); A.R. Beddows (Welsh Plant Breeding Station, Aberystwyth); G.D.H. Bell (Plant Breeding Institute, Cambridge); G.P. Carson (National Institute of Agricultural Botany, Cambridge); J.C. Dorst (Instituut voor Veredeling van Landbouwgewassen, Wageningen); H.S. Gentry (United States Department of Agriculture, Beltsville); J.W. Gregor (Scottish Plant Breeding Station); L. Hedin (Laboratoire des plantes fourageres), A.G.G. Hill (Commonwealth Bureau of Pastures and Field Crops, Hurley); P. Hudson (Commonwealth Bureau of Plant Breeding and Genetics, Cambridge); G. Nilsson-Leissner (Statens Centrala Frokontrollanstalt, Stockholm); H.H. Rogers (Plant Breeding Institute, Cambridge); H.A. Shoth (United States Department of Agriculture, Beltsville); R.O. Whyte (Plant Production Branch, FAO). The group was later extended by O.H. Frankel (CSIRO); F.H.W. Morley (CSIRO); C.A. Neal-Smith (CSIRO); and J.P. Botha (Department of Agriculture, Pretoria).

Because FAO was now willing to play a role in streamlining the ever more specific requirements of breeders, the Organization first of all had to offer a good overview of the existing collections, and increase their access. By the 1950s, with the increasing exchange of material within and outside FAO, such an overview and the associated difficulty of access had already become a problem. FAO first had to comply with the need for more stringent collection strategies, and more information about the existing material in collections.

In various meetings in the late 1950s, delegates of countries with the best storage facilities (especially the UK and USA) feared that these facilities would be swamped with germplasm from collecting expeditions. As the delegate from the USA stated during the Ninth Session of the FAO Conference:

> There is a need to consider how collections should be made, and how extensive they should be in order to obtain a representative sample of the species or population being collected. The days of massive and random collection of hundreds or thousands of samples which completely swamped the limited facilities of plant introduction gardens are surely over and must be replaced by better scientific planning and conduct of the exploration (FAO 1957:3).

The FAO Plant Introduction Newsletter

In a further attempt to assist breeders' requirements, FAO in 1957 tried to act as intermediary by publishing the FAO Plant Introduction Newsletter. The Newsletter (published by the FAO Crop Production and Protection Branch) gradually became one of world's best media for disseminating information on an international basis between breeders.[29] Although the Newsletter initially concentrated on specific collections and entries, its focus gradually widened. Some consider this to be the first indication that FAO was already moving from acting as a service for seed exchange and plant introduction (as pursued through the World Catalogues) to become a service geared towards the maintenance and management of crop diversity (Wilkes 1983).[30]

Nevertheless, for many years the FAO Crop Production and Improvement Branch decided to take a low-key approach, confining itself to the knowledge of where collections existed without necessarily having details of all the individual strains, varieties or ecotypes within each collection. Usually, the Branch would make requests to plant breeders, asking them to provide up-to-date entries for an FAO World List of Plant Breeders, which could lead to the establishment of an FAO World Bureau of Plant Introduction.[31] On the basis of its continuous contacts with individual breeders and institutions, the Branch managed to publish two volumes of the World List of Plant Breeders, seven issues of the World Catalogue of Genetic Stocks of Rice, and the FAO Forest Seed Directory. In addition, a similar catalogue of varieties and seed sources of tropical and subtropical grain legumes was published in 1959.

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[29] The FAO Plant Introduction Newsletter was first published in November 1957, and in 1971 was renamed the Plant Genetic Resources Newsletter, which since 1978 has been published jointly with the IBPGR/IPGRI.

[30] This tendency was especially significant in issue number 6 of the Newsletter (FAO 1959) when the FAO Crop Production and Improvement Branch published a world list of germplasm banks and their custodians.

[31] Such had already been proposed at the Third FAO Regional Conference for Asia and the Far East, with a special emphasis on the general exchange and introduction of wild ecotypes and indigenous or improved varieties of crops (Whyte 1958:4/5, 103).

Another significant outcome of the informal meeting in London in July 1956 was the plan to conserve and describe genetic resources on a regional scale. The support for this plan came especially from delegates representing the European Commission on Agriculture (FAO 1958:1, 3). Two months earlier, a similar request had come from the Swedish government which had approached FAO and the OECD to discuss the possibility of organizing some type of plant introduction service in western Europe.[32] The Swedish proposal for the establishment of an "inter-European system for plant exploration, collection and introduction" was further supported by delegations from Denmark, France, Finland, Germany and Norway.[33] The FAO Commission took the proposal seriously and:

> Recommended that FAO proceed as far as possible on the lines indicated in the discussion in consultation with other inter-European organizations and organizations of plant breeders which are also interested in this question (such as EUCARPIA, etc.) and report progress to the 10th Session of the Commission (FAO 1958:3).

However, the Commission also had to recognize that FAO did not have the funds to appoint experts to study the possibility of the requested European network (FAO 1959:3). Consequently, FAO's contribution remained limited to the formal statement that every opportunity had to be taken to arrange a further informal exchange of views between the leading plant breeders in the European countries (Whyte 1958:5).

FAO's willingness to remain committed to the international exchange of germplasm on the one hand and the structural difficulties it had in allocating funds to it on the other, resulted in a policy of modest and formal cooperation with ongoing initiatives, such as within EUCARPIA.[34] This development partly ran parallel to the increasingly strong interest of public and private breeders in genetic resources. This not only resulted in stronger support for the establishment of national and regional genebanks. The worldwide interdependence on germplasm demanded collection activities and strategies on a global scale. The existing collections could not live up to such a task, partly because of the problem of 'swamping' which to a large extent was the result of a strong crop, or, rather, goal-oriented conservation strategy tightly connected to the demands of breeding programmes. As this goal-oriented approach was particularly prevalent in the USA, it excluded the strongest candidate for the coordination of a true world collection. The involvement of FAO should be regarded in this context. Far from being an ideal candidate, it was the sole forum where initiatives with a global reach could be discussed without

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[32] Preliminary notice of this proposal was given to the Eighth Session of the European Commission on Agriculture (ECA) in May 1956. The matter was again raised in the Ninth Session of the ECA in June 1957.

[33] The proposal received additional support at the Ninth Session of the FAO Conference, mainly from European breeders. Also delegates from the USA, Australia, France and the UK were outspoken proponents of the regional approach.

[34] At this point, the word "policy", however, should be treated with care. It should be remembered that FAO's interest in genetic resources was recognized only by very few people (especially around Whyte) and that until that time there existed no real goals with regard to the conservation and use of genetic material. Erna Bennett in this respect states: "Early emphasis on plant introduction and on forage crops may not reflect any deliberate policy (or even any definite early stage of thought in the field of genetic resources). Whyte, who got the early [1961] conference going seemed to understand quite early what genetic resources were and what the importance of genetic diversity was. Whyte was head of the grassland unit at FAO, and from that position stimulated the 1961 conference" (Bennett 1994, pers. comm.).

being swept off the table as being incompatible with the interests of individual countries. Meanwhile, FAO could have started to realize that an international exchange of genetic material might well add to its mandate.

A strong claim for immediate action in conservation, particularly for landraces and wild relatives, came during the 10th Session of the FAO Conference in Rome, November 1959. In a few sweeping recommendations, it was agreed that many existing crops had too narrow a 'genetic base', that the genetic resources in the main areas of origin and maximum variability had not by any means been fully exploited and, most of all, that the natural vegetation and primitive cultivated forms were rapidly being eliminated through overgrazing, burning, cutting for fuel, clearance for new cultivated land and the introduction of superior varieties (Whyte and Julén 1963:22; Anishetty and Esquinas-Alcázar 1991:53; Frankel 1985:28). The wish to broaden its focus (and remit), with regard to the conservation and use of genetic resources, now really started to gain ground within FAO. A broader focus involved not only contact with breeders' collections, but also new efforts on *in situ* conservation.

> It would be highly desirable that countries in regions containing important centres of origin of crop plants should collaborate, under the Organization's ecological programme, by establishing protected areas in critical regions, to ensure the preservation *in situ* of important native material for future use (FAO 1959).

Until then, collections had been made by individual scientists travelling to areas of origin of the wild species and landraces during relatively short periods. They gathered seeds, tubers, etc. in places within the habitat which were easily accessible. Much of the material was bought in local markets. However, the scientists were not able to collect representatives of the total variability of different species on these expeditions, because the points of collecting in the field by no means covered the total area of a given taxon, and the places from which specimens were obtained were too scattered to allow sufficiently comprehensive collecting. In addition, seasonal occurrence of species could hinder collecting. Only a very limited number of scientists (e.g. Hawkes with the Commonwealth Potato Collection) had been able to circumvent the problems related to short-term expeditions by actually living for a time in specific gene centres. A first and serious indication that FAO was interested in the conservation and use of genetic resources came two years later during the Technical Meeting on Plant Exploration and Introduction, Rome, 1-20 July 1961.

The 1961 FAO Technical Meeting

It is difficult to assess the significance of the 1961 Technical Meeting on Plant Exploration and Introduction when judged on the basis of its concrete effect on later developments in the history of conservation and use of plant genetic resources. Otto Frankel (1985) related the significance of the meeting mainly to the generating effect of its follow-up: the FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources, Rome, 1967 (see Chapter 2). But perhaps the relevance of the 1961 Meeting can also be understood when looked at in the context of former FAO initiatives.

To begin with, the 1961 Meeting was the first initiative on a wide multilateral basis with the aim of extending initiatives in the field of plant introduction. For this purpose, national and regional introduction stations had to be set up under the aegis of FAO. From the point of view of most participants, the Meeting was nothing more than an attempt to elaborate common practices of plant introduction (often without much genetic change) to new environments, as often happened with pasture species. It should be mentioned, therefore, that since the Conference was mainly organized by people from FAO's grassland unit (notably Whyte), it also reflected grassland perspectives (Bennett 1994, personal interview).

The other main, but often neglected, subject of the 1961 Meeting was plant exploration. The Meeting recommended the establishment of Exploration Centres which were to serve all crops. Exploration Centres were to be built in regions of greatest genetic diversity, and were expected to add knowledge on landraces and wild species of cultivated plants (Rudorf 1961:1). But most of all they would serve as centres for research on the interaction of the environment on the one hand, and the landraces and wild relatives of cultivated plants on the other.

The idea of Exploration Centres was not in line with prevalent conservation strategies supporting major plant breeding programmes.[35] However, the link with these programmes would be guaranteed by FAO Introduction Centres acting as intermediaries between the Exploration Centres and plant breeding institutes and private firms. Introduction Centres would be grouped according to the species of greatest economic interest.[36] Thus while Exploration Centres were to focus on developmental programmes in developing countries in the centres of genetic diversity (such as Turkey and Costa Rica), the Introduction Centres would provide promising genes either for other Exploration Centres or for breeding programmes in research institutes and firms in industrialized countries. Introduction Centres had to maintain living stocks large enough for delivery to interested institutes and firms for exchange with other introduction centres (Rudorf 1961:3).[37]

An important outcome of the 1961 Meeting was that FAO would start establishing a pilot Exploration Centre in Turkey.[38] The plant genetic resources unit of the Agricultural Research and Introduction Centre at Izmir in Turkey was to act much later as a regional Centre for Afghanistan, Iran, Iraq, Pakistan, Syria and Turkey, and to organize germplasm collecting, conservation and evaluation. In 1964, the Centre started under a joint project between the Turkish government, the UN Development Programme/Special Fund and FAO.

In spite of initial international support, the Izmir Centre was plagued with political, financial, administrative and personnel problems. In a technical report prepared by FAO for the government of Turkey, a commission referred to unsynchronized activities of the different crop sections of the Centre, inadequate procedures for plant exploration, incomplete recording, inadequate sampling and a lack of herbarium specimens for identification, concluding that "Achievements were therefore less than they could have been" (FAO/UNDP 1970:4). Problems were aggravated by the fact that the institute's mandate covered all crops. Frankel in a later comment would state that the Exploration Centres were "too expensive and cumbersome" (Frankel 1985:27). Bennett, who had been

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35 Rudorf's proposal for Exploration Centres was in line with his genecological ideas on the related importance of developmental physiology. In 1960, he published a review of the subject in relation to plant breeding (Rudorf 1960; Whyte 1958:180/1).

36 Species of the same or similar regions of greatest diversity could be included in the same Introduction Centre according to the existing or rising interests, such as potato, tomato, beans, lupins and maize.

37 Examples of interested research institutes were the newly established Interregional Potato Introduction Laboratory, Sturgeon Bay, Wisconsin, USA and the All Union Institute, Leningrad, USSR.

38 Two others were planned in North Western Argentina, and in Northern Pakistan.

closely involved with the Centres' activities, would later comment that apart from existing inadequacies, conflicts over political prestige made things much worse than necessary.[39]

The case of Izmir probably generated many worries about a centralized international system of conservation and use of plant genetic resources. Exploration Centres, such as in Izmir, in which both national and international (FAO) interests were reflected could, sooner or later, cause technical, managerial and associated political problems. Partly functioning on the basis of genecological premises (see Chapter 3), centres would become directed towards national or local inputs and needs, and would not automatically run parallel to international demands. How controversial this matter was is perhaps best reflected by a statement of Frankel during the 1967 Meeting. After expressing his support for an international exploration network of scientists and institutes with a deeper knowledge of the local environment, he raised the following objection:

> I am ... not of the opinion that the setting up of special centres for plant exploration, with all the expense, difficulty of staffing, etc., this would involve, is justified. The close and continuing study of the vegetation and environment, though an essential part of ecological or genecological studies, is not the essential condition for plant exploration. Nor do I regard it as necessary that collections be maintained in the country or region in which they have been assembled.... [E]xperiment stations conditions will always vary from the natural habitat, whether the station is 10 or 10 000 miles away from the original site (Frankel in Bennett 1968:10).

The problem with Exploration Centres did not relate specifically to the type of material they were to conserve. Some scientists have attributed the limited success of the Centres to the growing realization that crop-specific collections were what really worked (although they were slowly developed at that time) as they found it hard to be deeply committed to a collection that had no direct near-to-hand use.

The need for landraces and wild relatives was widely acknowledged in the 1950s. The real difficulty referred to their use: a genecological approach would not guarantee a selection of material that would also benefit research institutions worldwide, since most of these institutes would not be interested in resistance built on the basis of local gene complexes. This matter was of particular relevance, since finance for the Exploration Centres would be the task of countries outside the centres of greatest variability – often industrialized countries interested in the use of landraces and wild relatives.[40] The difficulties with Izmir, and the fact that the scientific premises behind the Exploration Centres did not receive general approval, may have been the reason why FAO, in spite of its initial support after the 1961 Meeting, in the words of Frankel, "failed to appoint a single officer responsible for initiatives or an action plan" (Frankel 1985:28).

Conclusions and Summary

The call for national and international genebanks after World War II came not only from within circles of the FAO, but also (and perhaps more strongly) from European and US breeders' organizations. Therefore, in the 1950s and 1960s, the emphasis was on

[39] "Too many people were playing for prestige, and too few were genuinely concerned with creating a centre of excellence. The Turks wanted it to be theirs, and the UNDP and FAO administrators wanted it to be theirs" (Bennett 1994, personal interview).

[40] Financing was to be arranged within the developmental programmes of "countries with a high standard of life and scientific training, which are economically interested in those cultivated plants being the objects of certain introduction centres" (Rudorf 1961:4/5).

developing germplasm collections for availability to those who could use them; conservation was not a major thrust, although it was maintained. It only came to the fore as a major aspect from the late 1960s onwards. While hybridization was first applied in Europe and the US, the consequences in terms of genetic erosion also led to early initiatives in conservation. The US Rockefeller Foundation was the first organization to finance and organize an extensive and targeted (goal-oriented) collection of wheat and maize germplasm. In the 1950s, the USA managed to set up four Regional Plant Introduction Stations and a long-term cold storage facility at Fort Collins. The collections formed not only a basis but also a model for later *ex situ* collections outside the US.

In Europe, the European Society for Research and Plant Breeding (EUCARPIA) in the early 1960s was the first organization to set up a collection network. EUCARPIA's initiatives started off with a more generalistic ecogeographical orientation (to result in ecoregional genebanks) but this approach was gradually replaced by a crop-specific approach as, for example, the potato genebank in Braunschweig, Germany.

In the 1950s and early 1960s, the other major actor in the conservation of genetic resources was FAO, although with limited budgets and support from senior staff. Nevertheless, several World Catalogues of Genetic Stocks (wheat, rice, maize, barley) were set up in the late 1950s, while the FAO Plant Introduction Newsletter was seen as a key initiative and intermediary between breeders worldwide. In the 1960s, the FAO Plant Production and Production Service dealt with a continuous stream of enquiries for samples of seed or vegetative material for use by breeders. FAO gene policies show a significant distinction between planning and actual programming. A strong call for immediate action in conservation, particularly for landraces and wild relatives, had already been made during the 10th Session of the FAO Conference in Rome, November 1959. The need for a truly intergovernmental initiative to streamline germplasm conservation and distribution was recognized during the 1961 Technical Meeting on Plant Exploration and Introduction, but was not worked out during later years. One practical outcome was the Exploration Centres, of which a pilot version was established in Izmir, Turkey, but with little success.

It should, however, be questioned to what extent FAO, with the limited funds, experience and staff available, could have supported initiatives that went beyond the modest intermediary function which it had acquired during the 1950s and early 1960s. Collecting and conservation efforts established through breeders networks and existing collections in the USA and Europe served the interests and requirements of the breeders involved. Perhaps FAO could not, in practice, have served the vaster and increasingly specific demands of breeders worldwide, while the Green Revolution was in full swing. From a breeders' perspective, crop-specific networks were the logical and correct outcome. Under the same view, regional genebanks and FAO Exploration Centres with more generalized aims remained problematic.

The dominance of breeders in early conservation efforts in the 1960s had a double impact, namely that, first of all, conservation and use were closely linked, and secondly, that storage in the first instance took place in industrialized countries and was tied to plant breeding institutes. The following chapter will show how this resulted in a preference for *ex situ* conservation instead of *in situ* conservation.

2 The 1967 FAO/IBP technical conference: *ex situ* conservation takes the lead

The 1967 FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources, organized by the International Biological Programme (IBP) and the Food and Agriculture Organization of the United Nations (FAO), was an early occasion in which a group of experts gathered to define a global strategy for the conservation of plant genetic resources. This group was later referred to as the "Panel of Experts on Plant Genetic Resources". The Panel, however, was not the first to stress the importance of collection work. As shown in Chapter 1, international crop-specific exchange and conservation networks had been proposed and explored, the potato network being an important example.

The group of experts that first gathered on Monday, 18 September 1967 had several intentions. The participants meant to present state-of-the-art conservation practices and future plans of the world's most active genebanks and research stations. Further, they wanted to achieve worldwide recognition for the need to conserve crop genetic resources, as well as to devise clear action programmes to meet this end. The success of the Panel of Experts had great impact: it set the stage for later action programmes which, in their turn, created the basis for today's global *ex situ* plant genetic resources exchange system, which largely functions as part of the Consultative Group on International Agricultural Research (CGIAR).

The Conference was instrumental in promoting scientific recognition of the need for a global network. But the road to developing institutional arrangements to support such a network had more unexpected turns than the members of the Panel of Experts had foreseen. In addition to these problems, they never agreed enough with each other to come to unanimous decisions. In this chapter we shall focus on the obstacles that the Panel encountered.

The importance of the 1967 Conference should be understood not only in terms of the incentive it gave for further initiatives in the field of the exchange of plant genetic resources. Firstly, and perhaps most importantly, it offered a close look at prevailing ideas on the conservation and use of genetic material. The debates on these concepts affected current discussions on optimum conservation strategies. The concepts, mainly developed within the disciplines of genetics and ecology, will be discussed in Chapter 3. This chapter focuses on the impact of the concepts on actual political decision-making. Secondly, it is interesting to note that the incentive to organize the Conference, i.e. concern about rapid loss of genetic diversity, is still current. At the Conference, the term "genetic erosion" was coined to describe this process. Otto Frankel remembers that the idea of rapid genetic erosion first became a matter of urgency to him when he met Hermann Kuckuck, a German economic botanist and geneticist, who had spent some years in Iran and Turkey in the mid-1960s. "He painted a vivid and sombre picture of what we were soon to call 'genetic erosion'..". (Frankel 1985:28).[41]

[41] Bennett (pers. comm., 1996) remembers that B.P. Pal in India already spoke of "gene erosion" in the early 1960s. Bennett started to cite Pal in the mid-1960s, but did not like the use of the word "gene" as an adjective and changed the term to "genetic erosion".

Genetic Erosion of Major Crops

It was the leading goal of the Panel of Experts to link the rising environmental awareness with the growing but scattered actions to buffer material against seemingly unavoidable genetic erosion. But the concern for genetic erosion in the late 1960s, in spite of rising environmental awareness, was mostly due to agronomists. Erna Bennett, who worked in close collaboration with Otto Frankel for many years, formulated this as follows:

> ... 'erosion' of our biological resources may gravely affect future generations which will, rightly, blame ours for lack of responsibility and foresight. But at this very moment we are equally deprived, because many, one might say most, of these genetic resources are **not available** for general utilization by plant breeders, agronomists, foresters, horticulturists all over the world (Frankel in Bennett 1968:4; emphasis added).

The Panel of Experts emphasized that there would be little purpose in assembling material unless it was effectively utilized and preserved. "The efficient utilization of genetic resources requires that they are adequately classified and evaluated" was one of the primary messages of the handbook that came out of the 1967 Conference: Genetic Resources in Plants: Their Exploration and Conservation (Frankel and Bennett 1970:15). "Utilization" primarily stood for a more efficient and effective use of genetic resources by breeders for crop improvement (see Frankel and Bennett 1970:427-457).

The purpose of the Conference was to set up a global network, but a great deal of work had to be done to accomplish this. Collection activities, especially in the public sector, had to be greatly improved, the only exceptions being the collections within CSIRO (Australia), the United States Department of Agriculture (USDA), the Rockefeller Foundation in the Tropics, Russia (VIR), Sweden, the UK, West and eastern Germany. Valuable collections were maintained without the use of adequate *ex situ* storage facilities, and had to be rejuvenated every few years, because they were exposed to genetic erosion. In developing countries the situation was usually much worse. Perhaps the largest problem was that most, if not all, initiatives in the field of genetic resources conservation were oriented to the interests of single nations and institutions, and the contents of genebanks were neither generally available nor even known.

To meet this need, an organization with a high level of expertise, preferably one that was 'neutral', had to be found. In Frankel's words, the programme demanded "international co-ordination, guidance and administrative backing at the highest level, which can only come from a United Nations agency" (Frankel and Bennett 1970:16). Frankel's expectations towards the UN went in the direction of FAO, it being the only UN organization with long-standing interest and participation in plant exploration and introduction: a suitable candidate for the role of "clearing house available to all nations". The publication of the Plant Introduction Newsletter after 1959 had considerably increased the status of FAO; not surprisingly, since some FAO collections contained material of great value (see also Chapter 1).[42] The 1961 Technical Conference had already added somewhat to FAO's credibility as an international platform for negotiations on plant genetic resources. In addition, FAO in the late 1960s had established a new unit dealing with crop ecology and genetic resources and a Genetic Resources Information Centre with facilities to start the computerization of data storage retrieval and analysis. Although quick

[42] Such as the collections of Iranian wheats by H. Kuckuck, the collections of wild species made in Central Asia by Kihara and his colleagues, and the 1968 FAO collection of primitive wheats from Afghanistan (Frankel and Bennett 1970:15).

accomplishment was implied, the computerization of data would remain a very difficult matter.

Although FAO was a logical candidate to carry out Frankel's plans, he feared some hesitation on its part because there were no clear answers yet to the important questions of what material was to be collected, and most of all, how. Although these issues were to be decided during the 1967 Conference, the meeting needed a starting point. In this respect Frankel's chairmanship of a special working group on genetic resources of IBP appeared useful.[43]

After its inception in 1964, the International Biological Programme (IBP, a British initiative) had focused on 'plant gene pools', although its primary interest had been in defining new biological principles (see also Chapter 3). In 1966, this had resulted in the publication of a categorization of plant resources in cultivars, wild relatives of domesticated species, and wild or 'semi-domesticated' species. The cultivars were subdivided into advanced cultivars, landraces and cultivars with special connotation in genetics, physiology, pathology, etc. (IBP 1966). IBP was the first international institutional to do this and implicitly set the standard in discussions on the conservation of genetic resources (Astley 1987:245-257).

IBP recommended that priority for collecting and conservation be given to landraces (then referred to as "primitive cultivars"). IBP had special interest in landraces because of their value as "a reservoir of genes and gene combinations which may not be present in advanced cultivars" (IBP 1966). Under IBP guidance, information had been gathered to prepare the ground for 'ecological reserves', and Frankel had suggested that such reserves could be used to protect 'gene pool reserves'.

Until then, landraces had not been surveyed extensively, and an international platform such as FAO could help to design a cooperative programme to support the collecting of landraces. FAO, better than IBP, could also help find the legal and administrative ways of building an exchange network depending on access, availability and maintenance. Frankel, therefore, assumed long-term international support from FAO.

Soon Frankel, then still affiliated to IBP, met with the director of the FAO Plant Production and Protection Division, J. Vallega. A division of labour was arranged whereby FAO was to focus on agricultural issues, while IBP would continue to concentrate on the more fundamental biological issues. IBP, furthermore, contributed to the financing of the 1967 Conference and the publication of the handbook which resulted from it three years later – Genetic Resources in Plants: Their Exploration and Conservation. Edited by Frankel and Erna Bennett, it still stands out as one of the best in its field.[44]

The short involvement of IBP created an atmosphere of goodwill towards FAO. The division of labour between FAO and IBP as such was not decisive for future developments within the Panel of Experts. What should be noted is that soon after the 1967 Conference, members of an IBP seminar merged with others from the Forestry Division and the Plant Division of FAO, forming the FAO Panel of Experts. The achievements of the Panel of Experts will be discussed later.

With the categorization of plant resources in hand, the Panel of Experts was able to set clear goals for the 1967 Technical Conference. The Conference was to discuss genetic erosion in terms of the danger of the increased loss of landraces and their wild relatives. Most collections of landraces were, in Frankel's words "less than effective [and] very few

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[43] Before Frankel took this position, he had been the Vice President of the Special Committee of the International Biological Programme (Worthington 1975:86).

[44] IBP contributed US$ 4000 and published the book, FAO contributed US$ 10 000 and offered its services (Frankel 1987:32).

can be regarded as genebanks. They are, rather, working collections maintained temporarily by breeders to meet specific needs" (Frankel in Bennett 1968:9).

Most experts assembled at the conference would agree with this. What was more difficult was the fact that many divergent views existed on how and to what extent the landraces and their wild relatives should be collected. Indeed, any 'Panel of Experts' would soon cease to exist if these different views were not unified under a few guidelines, which Frankel later would refer to as "guiding principles" (Frankel 1986:30).

Apart from the decision that highest priority would be given to endangered landraces, the following principles were agreed upon during the Conference:

1. The strategy taken would be 'generalist' rather than 'mission driven' (or 'goal oriented'). The generalist, in contrast to the mission-driven, approach of collecting would not discriminate on economic grounds.
2. Large collections would be developed. Large quantities were considered to provide the best protection against genetic erosion.
3. Regular evaluation of the collections was considered to be essential. It was expected that computerized information systems would facilitate evaluation.
4. Long-term *ex situ* storage facilities were to be developed to replace the procedure of frequent regeneration which was considered to be expensive and susceptible to genetic erosion. It was decided that long-term conservation *ex situ* was the most suitable conservation strategy for short-lived plants (Frankel 1986:30; 1987:32).[45]

The decision to create long-term *ex situ* low-temperature storage was more or less a logical outcome of the other three principles. A 'generalist' collecting strategy which was to form the basis for large, long-term collections of landraces and their wild relatives (which in their turn would be subject to regular evaluation) would only be possible if conservation procedures would become as surveyable and accessible as possible. Looking back, Frankel in 1987 noted that *ex situ* preservation of landraces, using low-temperature storage, had become "standard practice, and that with sound management, the predicted pitfalls could be avoided" (Frankel 1987:31).

The pitfalls included, for example, attrition in collections, genetic drift and erosion, problems of evaluation of large collections, lack of use, poor funding and status and political problems related to centralized *ex situ* storage. Since the first critical analysis by R.W. Allard in 1970, the pitfalls have become commonplace (Allard 1970:491, 494).[46] Instead, I concentrate on the debates held during the Conference which questioned the prevailing conservation strategy which was devised during the Conference, and which has become the prevailing model for the conservation of genetic resources in general.

Some participants (of whom Bennett, Kuckuck, Harlan and Allard were most explicit in their opinions) did not disagree in principle with concentration on *ex situ* conservation, since all participants agreed that quick and effective action had to be taken to prevent further loss of genetic resources. Their suggestions pointed toward alternative conservation strategies. They were worried that if *ex situ* conservation became dominant, crop development and conservation would become too separated, reducing genes to 'stocks' for breeding purposes. This would bear the risk that locally improved crops

[45] It should be noted here, however, that these targets were never formulated as such in the conference papers, but rather became the *de facto* outcome of a course of political events which would influence decision making within and especially outside FAO regarding *ex situ* conservation (see Chapter 3).

[46] For a literature review see: G.J. Dempsey (1990) Genetic Diversity and Disease Resistance in Crops: Two Debates Over the Conservation and Use of Plant Genetic Resources. PhD Thesis, University of Sussex, United Kingdom.

(landraces) would lose their adaptive complexes and therefore become more susceptible to pests and pathogens (Bennett 1968).

This argument was not unique to the 1967 Conference. It was also raised by a school of thought which had gathered support, especially in the 1960s, and which is referred to as the 'genecological approach'. Perhaps the 1967 Conference stopped the genecological approach from spilling over into the conservation movement. Chapter 3 will focus on the genecological approach in a wider scientific context. This chapter focuses on the position of genecological arguments during the 1967 Conference.

The Genecological Alternative

Genecology (the study of population genetics in relation to habitats) was especially prevalent in the 1950s and 1960s. In 1956, J.W. Gregor, Director of the Scottish Plant Breeding Station, had described the results he obtained when plant populations were transferred from their native habitats to the environment of an experimental garden: such samples "are often found to possess much higher genetic variance than is suggested by the character expressions appearing on the phenotypic surface in the original habitats" (Bennett 1965:59, 60; Gregor 1956).[47] A similar 'automatic' release of visible variability had been noted by J.B. Hutchinson, who referred to the introduction of *Eucalyptus* spp. into east Africa, which under favourable nursery conditions started to show a range of diversity that could not be expected to be maintained in their natural environments (Hutchinson 1958).

On a more fundamental level, the genecologists were gathering proof for the assumption that the genetic basis of an organism's (phenotypic) adaptation to a new environment could not be attributed to single genes, but to the joint action of many of the constituent genes. The argument was that although changes in yield, resistance, etc. have been attributed to single gene changes, most crop improvement by breeders and farmers has been based, historically, on selection of complex polygenic variability (Dempsey 1990:79).

The assumption that gene complexes in plant populations[48] had the ability to adapt to changing environments was not exactly new. More interesting was the idea that this flexibility depended on combinations of many genes, not on single ones.

From this assumption, it was only one step to the idea that crop improvement could best be achieved through a combination of genes and **not** through concentrating on one or a few. Therefore, in the genecological approach, variability in a plant relying on several non-allelic genes all affecting the same character (or 'polygenes') was of greater significance for plant breeding than single genes. Bennett argued that "... experience indicates that not single gene characters but whole groups of characters affecting the phenotype at many levels and in many ways are responsible for adaptive fitness" (Bennett 1970a:116).[49]

In this respect, Bennett shared the opinion of scientists such as VanderPlanck, Zhukovsky and Simmonds, in arguing that exposure of populations to pathogens could best be countered by polygenic resistance. Consequently, genecological information could

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[47] The ideas of Gregor promoted the genecological school in the UK a great deal. Genecological ideas, however, had older roots in Scandinavia (Turesson 1922, 1925, 1930) and California (the Carnegie Group: Clausen, Keck, and Heisey) in the 1940s (Clausen and Hiesey 1958).

[48] Adaptation is usually considered as a characteristic of the population rather than an individual plant.

[49] Similarly, Dobzhansky argued that manipulation of single genes is unlikely to replace co-adapted gene complexes of fundamental importance to the adaptation of populations to their environment (Dobzhansky 1959).

be instrumental in tracing adaptive disease resistance, also referred to as 'field resistance', depending on polygenic variation.

So genotypes, not single genes, had to be the focus of future conservation strategies. Another important realization was that, in order to maintain the dynamic interaction between gene complexes and the environment, the isolation of genetic material in seed storage *ex situ* would stop this process, and would, therefore, from a genecological point of view, be undesirable.

Bennett, in one of her contributions during the 1967 Conference, stressed the importance of more genecological knowledge of crop and related wild species to provide the basis for further conservation and exploration. Frankel said that the approach, although scientifically interesting, was virtually impossible to take.

One objection was that, although it was acknowledged that variation within populations could be useful for further breeding purposes, there was almost no practical experience in making selections of plants that contained the required polygenic variation. In other words: no one really knew how to sample when not only the separate characteristics of a plant, but also the relation of these characteristics to different environments, had to be reflected in future collections. How could selection criteria during sampling be set?

Bennett suggested a method in which random sampling was accompanied by a more biased form of collecting. The latter would be useful only when "necessary on the basis of visual evidence or rare types of low frequency in the crop" (Bennett 1970b:166). Still, Bennett emphasized that sampling should not only consist of collecting samples, but rather should be accompanied by an extended survey of climate and its local variations, soil types, topography, distribution of crops, detailed knowledge of local crop varieties, etc. She therefore emphasized the need for more knowledge on agricultural structure and practices, social structure, customs and history. In her opinion, regions of less-advanced agriculture crop varieties were especially interesting because of the close adaption of the varieties to local environments. Tabulated cards and colour photographs of the material *in situ* and *ex situ* would be useful (Bennett 1968:29).

Although this method was hardly a compromise with respect to the amount of work needed, in Bennett's eyes it remained clear that only detailed local knowledge of habitat variations within regions could provide a reliable basis for planning exploration. From her experience in Afghanistan and Turkey (where she had collected wheat varieties) and on her work at the Scottish Plant Breeding Station, Bennett indirectly criticized traditional sampling strategies.

During the Conference, it was Frankel especially who raised questions about the feasibility of Bennett's approach. He emphasized the practical difficulties attached to field exploration during which so much extra data had to be collected:

> ... where there is no particular incentive either in the material or in the ecological situation, heaven forbid that we should encourage people to think that detailed studies are necessary. As in all scientific endeavour, she has to have a good idea, and test an intelligent hypothesis, but genecological studies should not be regarded as necessarily a routine thing (Frankel in Bennett 1968:30).

Frankel regarded the use of collections which had been integrated in various environments as a hindrance to use by the breeder since it would be very difficult to discern different characteristics (such as disease resistance) in a plant deriving its character from polygenic inheritance.

In his contribution to the handbook that resulted from the Conference, Frankel explained his comments in more detail: "What is the purpose of keeping landraces in a 'dynamic state' in their original site, if the site itself is changing beyond recognition?", he asked (*ibid*).

It is on this point that Frankel's and Bennett's views were most divided. Bennett regretted the fact that crop adaptation was shifting from the farmer's field to the breeder's plot (Bennett 1994, personal interview); to Frankel this was an inevitable, and even positive development (Frankel 1970:476, 77). In Frankel's opinion, to make genetic material useful for breeding purposes, it had to be preserved under controllable conditions and should not be left in the field exposed to continuously changing agricultural practices. In addition, he felt that the field might not be the ever-reliable 'breeding' ground for resistance: it could well be possible that continued evolution under farmer guidance is constrained by limited, local genetic variation or by changing farming methods. In practice, this meant that *ex situ* was the best preferable option in establishing a safe niche amid a "hurricane of change" (Frankel 1970).

Furthermore, Frankel doubted if collections based on locally adapted variability would be of any other than local use (Frankel 1970:478). This point revealed another difference in opinion. Bennett would not consider a limited use of genetic material to be a great problem, as long as it would support the maintenance of diversity in the field and feed the local population. Frankel was inclined to regard the practical use of the material on a global scale "to feed the millions". Their attitudes towards the Green Revolution which, at the time of the debate was in full swing, were completely different. Frankel was inclined to continue on the track chosen by the major international agricultural research institutes including FAO, i.e. the production of high-yielding varieties. Bennett, on the other hand, was (and is) not convinced of the success of the Green Revolution, and rejected breeding for high-yielding varieties without adaptation to local environmental circumstances: "If the millions were being fed, then the most critical among us would be fully prepared to accept many compromises not only with the seed corporations, but also with breeding techniques. But the millions were not fed, and are not being fed" (Bennett 1996, pers. comm.). This debate of the 1967 Conference is still the subject of discussions on the usefulness of small-scale, locally adapted agriculture using local varieties, versus large-scale modernized agriculture based on standard high-yielding varieties. Did conservation strategies have to support both, or was a choice necessary for practical purposes?

From the point of view of the users of genetic material (most often breeders), *ex situ* conservation is the easiest way to find the easiest genes to work with. Plant breeding in the Mendelian tradition prefers already selected material and a safe niche of extractable genes over a jumble of "undesirable" linkages occurring in the field. Ideally, it should be possible to extract genetically simple traits from storage and transfer them to elite lines with little disturbance caused to other desirable features. In doing so, agronomy by definition seeks to tame the environment and, through breeding, to tailor the crop to this environment. Consequently, the adaptive complexes of crop populations, built up over centuries, may sometimes be interpreted merely as weediness or other constraints on yield improvement (Dempsey 1990:84).

The support for the *in situ* option in the genecological tradition was mainly derived from the idea that resistance did not necessarily have to be built up from (single) extractable genes, but was rather a matter of polygenic inheritance.

This line of reasoning did not exclude the option of *ex situ* conservation. However, *in situ* conservation, because of the practical difficulties associated with it, was considered more useful as a 'safety valve' against continuing genetic erosion than in terms of its direct usefulness in crop improvement. As *ex situ* conservation came out of the conference as preferable, we shall now look at the discussions which led to this conclusion.

In Situ Versus *ex Situ* Conservation

During the 1967 Conference, the most severe criticism of *ex situ* conservation came from Erna Bennett:

> I see no special advantage in conservation in the form of seed apart from the very eminent one of convenience, and I think that attempts to find other merits in the 'steady state' which seed storage represents, seem to come dangerously near to adopting museum concepts. The purpose of conservation is not to capture the present moment of evolutionary time, in which there is no special virtue, but to conserve material so that it will continue to evolve. Such 'continued evolution' could only be possible in *in situ* collections (Bennett 1968:63).

As mentioned before, Bennett supported the genecological approach favouring a dynamic interaction between environmental changes and genetic material.[50] Also Allard, in his contribution to the handbook that came out of the Conference, noted that *ex situ* preservation had considerable drawbacks. The primary drawback was related to differential survival or genetic erosion in storage:

Although it is commonly assumed that ... 'static' preservation will capture and preserve the variability as it exists at the time the collection is made, both population [genetic] theory and practical experience indicate that this is in general not the case[51] (Allard 1970:491).

However, Allard also acknowledged the disadvantages of having to sort out material for breeding purposes which is in continuous interaction with its environment. He therefore proposed a combination of procedures. In short, this method would rely on a highly refined system of "opportunistic manipulation" on the basis of collection and evaluation of different populations "as more and more is learnt about them" while promising populations would be separated and grown in different environments" (Allard 1970:493, 494).[52]

In 1967, however, the single example where populations had been explored systematically *in situ* was the Izmir International Crop Research Centre. The Centre was established to carry out the exploration, cataloguing and evaluation of the valuable genetic resources of the Mediterranean and Near East gene centres. An early FAO discussion document on the functioning of the Centre reflects the genecological dogma, emphasizing that "the old technique of collecting material in large amounts and in a haphazard way must be replaced by one based on a full appreciation of the ecological requirements and distribution of the individual genus or species being collected" (FAO/UNDP 1970).

Following principles related to the genecological approach, the Centre was to gather as much knowledge as possible of the natural vegetation and primitive crops of the region,

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50 In 1962, Simmonds had referred to the 'wasting asset' of museum collections (Simmonds 1962).

51 The normal solution to this defect is to periodically regenerate accessions and harvest new seeds, a process which according to Allard carries further risks of genetic change. Changes incurred while growing out stored seed may be the result of natural selection, chance out-crossing with other entries and 'genetic drift'. (Genetic drift: the bottleneck effect resulting from a small sample and the subsequent 'fixing' of beneficial or deleterious genes) (Dempsey 1990:45).

52 For a genetic theory of sampling see: Marshall and Brown (1975), "Optimum Sampling Strategies in Genetic Conservation," Pp. 53-80 *in* Crop Genetic Resources for Today and Tomorrow (Frankel & Hawkes, eds.). IBP, United Kingdom.

and of the flora and the ecological habitats of the important genera and species. Exploration of genetic material within the Mediterranean gene centre *in situ* had to be based on local knowledge in order to assess and maintain basic collections of crops and local races and wild relatives. This involved setting up areas of genetic conservation to be managed in such a way as to preserve the evolutionary potential of local population-environmental complexes (Bennett 1965:90, 95).

However, the Izmir Centre encountered many difficulties. An important reason for the problems may have been that it was set up with a double aim: not only did it function as a regional exploration centre, but it was also to serve as a plant research centre with a purely national character. Zagaja (the representative of the Izmir Centre at the 1967 Conference) commented: "This compromise has been elaborated as the project has developed and, as one can easily understand, it took quite a while before some problems were resolved" (Zagaja in Bennett 1968:103). In practice, the compromise meant that local varieties of specific ecotypes were collected for their potentials regarding "adaptive, quantitative, genetic variation and the selective forces of their environments" (Bennett 1965:91). Successful breeding work derived from the selection of ecotypes spearheaded in Europe and Australia, but had not been applied to other (food) crops. The research section, by contrast, was to focus on plant introduction for crop improvement, and consequently added to the destruction of specific ecotypes. Evaluation and study of material collected within Turkey hardly took place, owing to lack of staff. Zagaja complained that the Centre even had difficulty in establishing a representative collection of ecotypes in Turkey, since the country covers so many different climatic areas. And because of financial problems, the Centre did not have storage facilities.

The reaction of the conservation movement to the Izmir 'experiment' set the scene for the debate on the *in situ* versus *ex situ* issue. However, other participants argued against the idea of conserving landraces *in situ* because they thought that this would be impractical and more expensive. Later Frankel, looking back on the Conference, stated that: "I regarded *in situ* conservation of primitive cultivars impracticable in view of the large numbers [of accessions] involved and the technical and social problems to be met" (Frankel 1985:31). Although Frankel had the most outspoken ideas about the matter of how to conserve genetic material, he did not reject *in situ* conservation outright, but had practical reservations:

> ... freezing of the material as seed has its distinct advantages. From the point of view of preservation for current utilization during the next 20 years or so, an adaptive system of conservation may have advantages. It seems to emerge from the discussions of the Preparatory Meeting that both methods are justified and that in fact both should be advocated, depending partly on economics, and whether both are possible (Frankel in Bennett 1968:111).

In spite of this, the issue of economics and feasibility indeed became one of the main arguments in favour of *ex situ* conservation. As Frankel put it:

> Seed banks, wherever applied and to whatever material they are applied, are inexpensive and, technically relatively well explored, and so must be taken seriously ... Preservation in seed banks, probably the most secure way of preservation where it can be used, has been discussed extensively and opinions have been expressed on this and other methods, but it is generally agreed that on economic grounds – quite an important proviso – seed banks have the advantage (Frankel in Bennett 1968:111).

Frankel's other criticism referred to a more fundamental level of dispute, partly also to the genecological approach:

> ... material maintained other than as seed, it must be remembered, is subjected to adaptive changes [in] environments as they change under the influence very largely of man, and less of major climatic changes ... biological freezing of material has its distinct advantages (*ibid.*).

Frankel's conclusions were further supported by the contribution of J.F. Harrington on seed storage that supplied the scientific and technological rationale for preservation *ex situ*:

> Probably the easiest and least expensive way of preserving plant gene resources is seed storage. Under proper conditions the seed of many species remain viable for up to hundreds of years, but proper conditions include both optimum techniques of seed preparation and optimum storage environment (Harrington 1970:501).

Although *ex situ* preservation in seed genebanks was accepted as the predominant conservation technique (albeit only suitable for orthodox seed), it was far from clear how and under what conditions this had to take place. The biggest difficulty was the unavailability of *ex situ* storage facilities which would be able to perform as international clearing houses for worldwide exchange of genetic resources. Were existing national conservation centres able and willing to collaborate to form an international network? This raised the question of the conditions under which national institutions were willing to accept a degree of international responsibility.

Naturally the participants looked at the rich countries first. The Japanese delegate was in principle willing to exchange material, but spoke of "careful taxonomic and genetic investigations necessary ... before meeting ... demands", as well as the poor facilities that Kyoto University as a centre for maintenance of wheat had to rely on. The comment of John Creech (USDA) on this question was more outspoken:

> ... our concept of a national seed storage laboratory is of a laboratory for long-term preservation, and that as long as materials exist in working collections elsewhere we would not expect to move seed stocks out of the laboratory (Creech in Bennett 1968:112).

In addition to these legal and financial difficulties, the problem of access was acknowledged as a problem as well. Delhove (in Bennett 1968:92) comments:

> Most research workers prefer independence... There is a kind of hostility on the part of the research worker to the idea of having to obtain the plant material they need, through a national centre. There is a feeling that national centres tend to be badly equipped ...
>
> Delhove also mentioned that the exchange of material was hindered by the lack of quarantine facilities, a problem which was especially relevant in developing countries.

A third problem, mentioned by Steppler (the delegate from Canada), referred to the increased use of Plant Breeders' Rights:

> This is bound to become increasingly important in the movement of cultivars in the future because more and more of these are the property of private companies, and are protected by breeders' rights or by the companies themselves (Steppler in Bennett 1968:94).

Looking at these difficulties, Frankel must soon have realized that an international exchange system based on the cooperation of national conservation centres *per se*, although desirable, would be very difficult to achieve. Frankel (in Bennett 1968:112):

> One fact which seems to emerge already from this discussion is that whatever national storage is used it will be restricted in some way or another. This seems to be inevitable, and this is the very reason why in all the discussion we have had here in FAO, we have come more and more to the conclusion that an international storage in a true sense is probably inevitable if in fact it is regarded as desirable, which I personally advocate that it should be.

Consequently, the most practical solution as stated in the recommendations, was that FAO would assume greater responsibility for the coordination of national and international efforts concerned with the exploration, conservation and utilization of plant genetic resources in the fields of agriculture and forestry, including those of existing institutes of germplasm storage and conservation. This became the principle recommendation of the 1967 Conference.

Although an *ex situ* conservation strategy under the coordination of FAO was concluded to be the best option for preservation of landraces, this still did not solve at once the question of how to select criteria in order to prevent the accumulation of uncoordinated, unstructured and oversized collections. This was not an easy matter since the Conference aimed at a double goal: (a) to collect as much as possible to counter further genetic erosion, and (b) to collect systematically in order to optimize the use of the material for agricultural purposes. Perhaps this dilemma can best be illustrated by using the artificial distinction which Frankel made between two approaches to collection strategies: (a) the 'generalist' and (b) the 'mission oriented' approach.

The Generalist versus the Mission-Oriented Approach

Perhaps the most feasible way to establish an international genebank was to quickly establish clear exploration targets in areas and crops. In the past, the choice of targets had reflected the needs of institutions or individual collectors. This was a mission-oriented approach. However, Frankel felt that this attitude was increasingly difficult to maintain, as genetic erosion was mounting. Mission-oriented collecting is by definition highly selective and hence contributes relatively little towards countering the threat to the genetic resources of a crop as a whole.

On the one hand, to salvage genetic diversity, less specific objectives were needed. The best example of such a strategy was the collecting work under Vavilov, whose aim it was to assemble the greatest possible diversity of a great variety of crop species in all the centres of diversity to which they had access. Frankel called this the "generalist" strategy (Frankel 1975:126, 131; 1985:27).

On the other hand, collections had to have a broader scope than those maintained by the USDA, for example, which were chosen strictly for the purpose of solving specific economic problems such as resistance to a parasite or even a specific biotype of a parasite, or for some other ecological, agronomic or biological characteristic. The problem which the Panel of Experts at the time of the 1967 Conference faced was that these 'breeders' collections' very often operated as single entities servicing specific users. From this perspective a truly international exchange network would only result in complications. As Creech (USDA) (in Bennett 1968:27) formulated the matter in his speech to the 1967 Conference:

> Breeders require sources of genetic traits that are readily incorporated into existing varieties ... Plant breeders prefer it this way, and we [the New Crops Research Branch of the USDA] operate by servicing the needs of specific groups of plant breeders.

Creech was in favour of restricting plant exploration to examining the agricultural purposes of plant genetic material or their use in plant breeding programmes for agriculture and industry. Indeed, most breeders appear confident about the contents of their collections, and there are many more examples of collections that were successful in yielding resistance than those that were not: "In the vast majority of cases where resistance has been sought in collections it has been found" (Harlan *op. cit.* Dempsey 1990:75). In this approach, target areas were selected on the basis of previous collections. The viewpoint presented by Creech was particularly dominant in the United States, where (apart from sunflowers) "no indigenous sources of variation for major crops were available" (Creech 1970:221).[53]

The mission-oriented approach, biased towards the economic importance of crops, tended to exclude or give lesser prominence to species which had limited importance, or which are not seen to be of primary economic or nutritional significance. Yet it had played a significant role in countless breeding programmes, and resulted in one of the most sophisticated exchange networks of plant material then existing.

Another strong argument in favour of a mission-oriented approach was the notion that the variability of existing collections had not been adequately classified. C.F. Krull and N.E. Borlaug stated during the Conference that "the problem at present is less a lack of genetic variation but rather of efficiency in identifying and incorporating it". In a later publication they support their statement by arguing:

> Progress in varietal improvement in the past has seldom, if ever, been restricted because of the lack of available variability in wild and primitive populations, as well as in the world's cultivars. Progress has been slow rather because of the lack of imagination, vision and efficiency in identifying and incorporating the existing variability into improved varieties (Krull and Borlaug 1970:434).

In their opinion, exploration targets had to be as specific as possible because of the difficulties in recognizing valuable new traits and in screening new material for its usefulness. Krull and Borlaug illustrated their case by referring to the worldwide success of the Japanese Norin dwarf wheats which were found in a collection of cultivars at an experiment station, and appeared to have a large number of seeds per head. Crosses between Norin and Brevor later would form the basis of a revolution in the yield of Mexican spring wheats. Later derivatives were to be widely grown in Pakistan, India, Turkey and Afghanistan.

However, Frankel (in Bennett 1968:53), in a reaction to Borlaug and Krull, clearly stated:

> In some instances, it is possible to identify material immediately that a collector wants. In many instances ... there is just no chance of identification. I, for one, favour the collection which really tries to get as much as possible ...

Favouring the generalist approach, Frankel would not deny the importance and effectiveness of the mission-oriented approach, but noted that the latter "by definition is

[53] Hawkes (pers. comm., 1996) adds: "Many breeders do not maintain large collections but use material from the large national or international genebanks. If they find something close to what they want, they may sometimes go out and make more collections from the source of the original material."

highly selective and hence contributes relatively little towards countering the threat to the genetic resources of a crop as a whole" (Frankel and Hawkes 1975:128). This limited contribution was not only caused by the collecting strategy taken by the curator of a genebank. As was remarked during the Conference, (private) genebanks with specialized collections may not accept the sort of responsibility for maintaining records that would be acceptable to national or international public sector units.

Another problem with the mission-oriented approach was the lack of practical experience. At the time, collecting efforts on the Vavilov model were rare, and mainly focused on potatoes.[54] Although the mission-oriented approach generated considerable support during the Conference, the final recommendation supported a combination of the mission-oriented and the generalist approaches. This recommendation reflected the dual priority of the Conference. Exactly how were the collecting priorities to be established? This question lingered throughout the debate, and reflected the double-edged problem of the need to combine conservation and use in one conservation strategy. On the one hand, the Conference stressed the need for a long-term increase in the quantity of food production in developing countries. Collections of germplasm of specific cereals, millet, grain legumes, edible tuber crops and fodder crops therefore received high priority (Swaminathan in Bennett 1968:96). In this sense, the use of the material by plant breeders formed the basis of the priority. *Ex situ* conservation consequently received strong support. The other priority was related to the rapid erosion in gene centres, because of which as much material as possible had to be collected. Hence the need for a generalist approach to conservation.

Thus the members of the Conference concluded that the best approach was to conserve a generalist collection *ex situ*. To maintain the rather ambitious aim of conserving as much genetic material as possible, seed storage facilities *ex situ* were considered to be the only way to achieve a broad representation except for materials such as fruits which could not be considered as seeds to regenerate from the original clones. Besides, and perhaps this is more important, it fitted well into the Mendelian breeding tradition in which crop improvement on the basis of single genes had become standard. The genecological approach in this sense was not considered as a serious option because it would need extensive exploration *in situ* with additional vagueness in the use of the material for breeding. Undoubtedly, the latter option would have become a less secure and probably also a more expensive investment. This choice was confirmed by the existing experience in conservation. On the one hand, the problems with the Izmir Centre had provoked many doubts, while on the other, the USDA, by the late 1960s, had already successfully explored *ex situ* seed collections.

Conclusions and Summary

The Panel of Experts was able to capitalize successfully on a combination of (a) the rising concern about possible 'genetic erosion' of landraces and wild relatives for modern agriculture, and (b) the more general, increasing need of the agro-industry for a steady flow of new germplasm. The message of the 1967 Conference reflected this double concern. The members tended towards a generalist approach. This approach differed from the mission-driven (goal-oriented) approach which, in collecting strategies, would discriminate more on economic grounds. The generalist approach was considered to be

[54] Examples were the potato collections made by Vavilov and his colleagues Juzepczuk and Bukasov, and the collections of the Commonwealth Agricultural Bureau by J.G. Hawkes. At that time, the IR-1 potato collection in Wisconsin (see Chapter 1) was in full swing too.

the best method to counter genetic erosion. An additional advantage of this broad conservation strategy was that it could be carried out practically and economically in centralized and large *ex situ* genebanks[55]. New cold-storage techniques, as developed in the 1960s, made such long-term *ex situ* storage possible.

However, the report of discussions during the 1967 Technical Conference reveals that, although the need for quick and effective action through *ex situ* facilities was generally recognized among the participants, the alternative of *in situ* conservation was brought forward as well. This, however, met considerable opposition, particularly from the scientists who emphasized the direct use of genetic resources in mainstream breeding programmes, for example, Otto Frankel, Jack Hawkes and John Creech. It should be noted that Frankel is by training a wheat breeder, Hawkes was a Professor of Botany in the University of Birmingham and is an expert in potato collecting and breeding. John Creech was a horticulturist representing the Plant Science Research Division of the Agricultural Research Service in Beltsville, USA (Williams 1985, personal interview). Their deep involvement in the 1967 Conference explains why "conservation for use" became the established creed. The three experts, and Erna Bennett, would become part of the core group of the FAO Panel of Experts which formulated guidelines for a global network of plant genetic resources in the early 1970s (see Chapter 4).

The scientific arguments for *in situ* conservation, not only as a complementary conservation strategy, but also as an **alternative** to *ex situ* conservation, were mostly based on genecological premises. The *in situ* alternative, however, did not materialize as practical conservation strategies. After the 1967 Conference, *in situ* conservation as an alternative to *ex situ* conservation remained merely a subject of theoretical dispute among breeders and geneticists.

During the 1967 Conference, the arguments against *in situ* conservation were mostly practical/economic and to some extent social. Frankel regarded the use of collections which had been integrated in various environments (*in situ*) as a hindrance to effective use. To make genetic material useful for breeding purposes, in the opinion of most Conference participants, it had to be preserved under controllable conditions, and not left behind in the field, exposed to continuously changing agricultural practices and continued erosion.

The *in situ* versus *ex situ* debate of the 1967 Conference continues today. No agreement has been reached on which is the more useful: a breeding strategy based on *in situ* collections taken from small-scale, locally adapted agriculture using local crop varieties, a breeding strategy closely associated with *ex situ* conservation, or a combination of the two? While during the 1967 Conference mostly practical arguments were put forward, the scientific background to breeding strategies of the *in situ* versus *ex situ* debate was seldom considered. To understand the persistence of the debate, Chapter 3 will focus on the link between breeding and conservation strategies.

[55] Hawkes recalls: "At that time it was felt, on the one hand, that *in situ* methods would need at least another ten years to complete, and by then there would be very little material left in the centres of diversity and other regions. Thus *ex situ* methods, however imperfect, were at least able to conserve what remained of crop genetic diversity in the field, and were also immediately available to evaluators and breeders (Hawkes 1996, pers. comm.).

3 Breeding strategies and conservation strategies: some connections

Debates on conservation strategies of crop species are closely connected to those on breeding strategies. Because breeding strategies determine to a large extent the use of and need for genetic resources, they are an important issue underlying the discussions on conservation strategies, like those that took place in the 1960s (see Chapters 1 and 2).

These discussions started during the 1961 FAO Technical Conference and were dealt with more extensively during the first 1967 FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources. These conferences focused both on designing a worldwide conservation strategy and on integrating conservation strategies with existing breeding strategies.

The report of the FAO/IBP 1967 Conference and the handbook that came out of it, Genetic Resources in Plants: Their Exploration and Conservation, confirm that a formal consensus was reached on the need for more facilities and efforts for both *in situ* and *ex situ* conservation of landraces and wild relatives. Nevertheless, in the following decade, *ex situ* conservation became the dominant conservation strategy. Only in the late 1980s and early 1990s did *in situ* conservation again attract attention as a necessary and additional means of storing genetic resources (see also Chapter 6).[56]

Even though the *in situ* versus *ex situ* debate continues to this day, the underlying mainstream breeding methods are seldom questioned. This chapter will examine to what extent the prevailing breeding practices have influenced the current worldwide emphasis on *ex situ* conservation. Hence, the focus lies on breeding strategies for crop resistance employed by pathologists and/or geneticists.

The sidelining of arguments for *in situ* conservation during the implementation phase of the 1967 Conference may have been, in part, a result of the domination of resistance-breeding, which was geared toward exploiting single-gene resistance. This, and other breeding objectives, benefit from relatively easy access to genetic resources that could be conveniently stored in *ex situ* storage,[57] except in the case of those seeds which could not be stored as, for example, many tropical perennials, where *ex situ* field collections were established.

In situ conservation in the 1970s and 1980s remained more or less disconnected from agricultural research practices, particularly with regard to conservation of landraces in farmers' fields and orchards (where they originated). Although *in situ* conservation is generally preferred in the case of wild relatives of crops, it is frequently regarded to be the responsibility of conservationists/environmentalists to conserve them. This 'division of labour' was further supported by a crisis atmosphere to conserve the world's genetic resources as soon as possible by using already reasonably well understood *ex situ* technology.

At various conferences in the early 1990s, it appeared difficult to move to a more integrated approach in which both agricultural and environmental/ecological interests

[56] See for example the proceedings of the International Symposium on Plant Genetic Resources in Europe under the title: Integration of Conservation Strategies of Plant Genetic Resources in Europe (Gatersleben, December 1993) (ref. Hammer 1994; Hardon 1994).

[57] Dempsey (1990) examined these links between breeding and conservation strategy, "but found it hard to disentangle the impact of conceptual biases favouring *ex situ* collections from more practical justifications (e.g. urgency, convenience, limited resources etc.)." Brush in several studies, has questioned the validity of some of these practical assumptions, e.g. the universality of genetic erosion (see Brush 1989).

were served. During the 1967 Conference these interests conflicted for the first time: those who focused on conservation for agricultural/genetic use were in favour of *ex situ* conservation, while those with ecological concerns preferred *in situ* conservation.

In this chapter we will focus on the impact of both genetics and ecology on conservation strategies. In a third section, 'genecology' – a branch of science which incorporates ecological as well as genetic theories – will be dealt with.

The International Biological Programme (IBP)

The establishment of the International Biological Programme (IBP) was a response of the international ecological scientific community to the "growing pressure of human activities on agriculture and on biological resources" (Worthington 1975:10). It was established by the International Council of Scientific Unions in 1964 as a counterpart of the International Geophysical Year. Its subject was defined as "The Biological Basis of Productivity and Human Welfare". IBP received donations from over 50 industrialized and developing countries, being the first, probably the best and perhaps the only opportunity ever for ecologists to turn their ideas into practical conservation practices.

The seven major programmes[58] carried out by IBP between 1964 and 1974 had in common that they formed a compromise between agricultural and biological/ecological demands. This was especially true for the programme on the Use and Management of Resources – otherwise known as the 'UM programme'. The IBP-UM programme, established in 1966, was largely dedicated to the conservation and use of plant genetic resources, and was divided into two sections: (a) exploration, assembly and conservation of genetic stocks, and (b) evaluation of plant genetic resources: biology of adaptation.

Section (a) concentrated on landraces and wild relatives of cultivated plants:

> Such material is of great scientific interest; it is a reservoir of genes and gene combinations of potential value in plant breeding; it has not been widely and systematically surveyed and collected on a world scale; and some of the wild relatives of cultivated species are regarded as weeds and so are threatened by the advance of civilization (Worthington 1975:46).

This quotation reflects early but general worries on genetic erosion as they were formulated for example during the 1961 FAO Technical Meeting on Plant Exploration and Introduction, and again during the 1967 Technical Conference, and the growing awareness of the need for 'rescue-missions' to save as much material as possible.

Section (b) on "evaluation of plant genetic resources" with special attention to the "biology of adaptation" takes the conservation issue a step further. It implied that not only had many genetic resources to be collected and conserved as soon as possible, but also that the conservation of landraces and wild relatives could be instrumental in reaching a better understanding of co-evolutionary and adaptational mechanisms between plants and their environments. The proposal suggested that this idea could be the starting point for research on crop resistance different from conventional agricultural research programmes (in which a dynamic co-evolution in habitats is not primarily dealt with). In theory, this

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[58] These were: Productivity Terrestrial (on biological productivity of wild and man-modified ecosystems); Production Processes (on photosynthesis and nitrogen fixation in plants); Conservation Terrestrial (protection of ecosystems on land); Productivity Freshwater (use and cleaning of sweet water resources); Production Marine (on ecological mechanisms which control marine organisms); Human Adaptability (relation between humans and their environment); Use and Management of Resources (conservation of genetic material and the development of biological control mechanism) (Worthington 1975:17-50).

research, when carried out by ecologists and/or biologists, would offer an opportunity to test the practical usefulness of the stability-diversity hypothesis. This might explain why in a first outline, the IBP-UM programme emphasized the need for *in situ* study, but did not mention *ex situ* conservation (Worthington 1975:45).

When confronted with practical organizational requirements, the ideas as formulated in the first IBP-UM programme on the use and conservation of plant genetic resources were absorbed by the preparations of the joint 1967 FAO/IBP Conference. However, only the first section of the programme was reflected in the 1967 Conference. Perhaps section (b) was not used because ecologists were not able to design alternative strategies on the basis of the 'stability-diversity hypothesis' supporting *in situ* conservation.[59]

However, to accuse ecologists, or even IBP, of not further developing *in situ* conservation would be wrong. What did transpire was that a flow of ideas from ecology to agronomy did not take place in the late 1960s. This could have increased the understanding of species diversity of a benevolent kind (e.g. against insect predators), offering more scientific arguments for the value of *in situ* conservation for crop species.

Genetics and Conservation Strategies

As mentioned above, the dominance of the *ex situ* approach in discussions on conservation strategies in the late 1960s and early 1970s was related to the inability of ecologists to design alternative strategies on the basis of a practical interpretation of the stability-diversity hypothesis. But to claim that it was so only because of this inability, another, even more extensive, debate among breeders and geneticists would start. This debate would also focus on co-evolutionary processes (in which dynamic co-evolution in habitats is sometime neglected in the quest for gains in yield and resistance). This debate was based on the proposition that to some extent is similar to the stability-diversity hypothesis.[60] The discussion among geneticists took this hypothesis a step further by assuming that when the genetic mechanisms behind co-evolutionary processes (supporting stability) were better understood, they could be instrumental in crop improvement, particularly where they could add to durable resistance.

Jack R. Harlan (the son of Harry V. Harlan) was one proponent of an approach in which *in situ* conservation could also be integrated.[61] Harlan tried to benefit from what he called "adaptation syndromes resulting from automatic selection" which can be translated as 'adaptation through natural selection' (Harlan 1975). The assumption is that landraces, often in contrast to advanced cultivars in high-input cultivations, are more adapted to the

[59] The general weaknesses of ecology with regard to practical action perhaps facilitated the involvement of figureheads from other disciplines such as Sir Otto Frankel. Frankel had been invited to translate the plans of IBP-UM programme into practical conservation targets. A special group on plant genepools was arranged and led by Frankel. His work resulted in the involvement of IBP in the FAO 1967 Conference. The conference report of the 1967 Conference reveals that Frankel considered impractical a plan in which the dynamic interaction between host plant and pathogen would become an integrated part of *in situ* conservation.

[60] Namely that ecosystems are dynamic systems in which each organism maintains adaptational characteristics to (re)establish a balance with other parts of the ecosystem, and that 'unbalanced' ecosystems would lead to the decrease of diversity.

[61] It should be noted here that Jack Harlan can certainly not be regarded as an outspoken supporter of *in situ* conservation. However, unlike other members of the 'genetic resources movement', he did not dismiss the option outright.

specific local environments in which they evolve, resulting in a wide diversity between them.

> Landraces have a certain 'genetic integrity'. They are recognizable morphologically; farmers have names for them and different landraces are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse. [They are] balanced populations – variable, in **equilibrium with both environment and pathogens**, and genetically dynamic ... (*ibid.*; emphasis added).

This view, in which landraces in balance with both environment and pathogens would provide resistance, has been subject to considerable debate. Frankel and Soulé (1981:182), for example, simply state that "we lack experimental or observational evidence" to prove that this assumption will work in the field, adding that since "epidemics occurred throughout history" no particular resistance properties could be attributed to landraces as such. Bennett (1996, pers. comm.) still disagrees with Frankel and Soulé, arguing that they "adduce no evidence to support their statement. They also fail to note the connection between intensive monocultures – not a characteristic form of agriculture until recent times – and epidemics. And mere survival of whatever epidemics may have occurred over the centuries will have contributed to the resistance of surviving populations of landraces".

Harlan's research, however, can be considered as a guide for a larger group of breeders and geneticists who argued against the rapidly increasing reliance on 'pure-line' and often susceptible high-yielding varieties. In the words of Harlan:

> We are risking our food supply on the experience, skill, and judgement of a comparative handful of people. It would appear that the ecological imbalance is about as extreme as it can get. There are not many important crops left to be abandoned. The challenge is to look to our defences and see if we are doing the right things. Would it be possible, in time, to generate some sort of endemic balance for the few major crops that have become absolutely essential for human survival? Probably not: **the situation is too artificial to stabilize completely, but we could do more to move in that direction** (Harlan 1976:43; emphasis added).[62]

The "imbalance" between crop and environment evolved into one of the most fundamental criticism of the Green Revolution. It focused on the idea that crops in modern agriculture have been developed in spite of, rather than in harmony with, their natural environment and that, as a consequence, the crop's ability to counter pathogen races has been disrupted. More specifically, the criticism focused on crop breeding programmes in which modern pure line varieties only contained short-term resistance against changing pathogen races. This criticism had already been offered in the 1950s when Suneson, for example, stated:

> Modern plant breeders and plant pathologists may have over-extended the logical application of the pure-line theory and become enslaved by the uniformity and conformity conventions their over-indulgence produced. The 'boom and bust'[63] cycles of popularity for certain pure-line varieties

[62] For additional information on the discussion on adaptation and co-adapted gene complexes, see Bennett 1964 and 1965.

[63] Modern cultivars are subject to what is called 'resistance breakdown' implying that pests and pathogens are able to adapt themselves so quickly to new pure line high yielding cultivars that resistance is 'broken down,' usually between four to seven years after sowing or planting. Hence the four to seven years' requirement to build up new resistance, which is referred to as the

resulting from **changing race populations of fungus and insect parasites** spotlight the problem (Suneson 1960:319; emphasis added).[64]

Duvick (1984) calculated that the average time of wide-scale use of a successful variety is about seven years, committing breeders and farmers to a 'treadmill' of varietal replacement (Dempsey 1990:180). To design resistance that could overcome the "changing race populations" and subsequently the 'boom and bust' cycles of pure line varieties, required research efforts involving the disentangling of co-evolutionary host-pathogen relationships.[65]

Harlan, among others, argued that an improved balance between crops and their environment could be restored when co-evolutionary host-pathogen relationships could be traced back into history[66] (Harlan 1976:31, 51). With this knowledge, a better understanding of a plant's defence mechanisms (triggered through 'adaptation syndromes') under natural selection pressure could be achieved. Translating this defence mechanism into crop improvement programmes would involve breeding strategies which would essentially provide a short-cut to co-evolutionary processes by imposing artificial selection regimes on crop plants. Such a breeding strategy is in a way an accelerated and more controlled version of the traditional low-input cultivation practices where farmers make use of a plant's natural defence to survive different pathogen races.

The lack of successful breeding strategies in which adaptational co-evolutionary mechanisms of plants could be used in plant improvement might well have had a negative effect on the overall support for *in situ* conservation strategies for agricultural purposes. On the other hand, one can suggest that if co-evolutionary mechanisms in host-pathogen relations had been integrated more in breeding strategies, *in situ* conservation (and probably also decentralized breeding) of locally adapted varieties would have become a more integrated element in modern crop improvement.

The debate on single-gene resistance versus polygenic resistance

Resistance based on polygenes tends to be more difficult for the pathogen to overcome. Polygenic resistance, which is not based on a gene-for-gene relationship between host and pathogen, remains after all single-gene resistance has been matched by a pathogen, placing several 'genetic blocks' in the path of pathogen evolution. As polygenic resistance is pathotype non-specific, it is considered to be more 'durable'.[67,68] This means that once it is selected and stabilized it tends to be long-lasting because it is usually effective against all parasite strains (NAS 1972:58; Gould 1988:28-29).

Single-gene resistance is pathotype specific. Each gene confers a specific resistance in a host, while there is a specific and 'matching' gene in the pathogen. When present, this

"**boom and bust**" problem (Suneson 1960).

64 Already in 1956 Suneson had suggested a breeding method with broadly diversified germplasm, "and a prolonged subjection to the mass of the progeny to competitive natural selection in the area of ... use" (Suneson 1956:190).

65 It should be noted, however, that there were exceptions such as breeding methods termed "convergence-divergence selection" or "shuttle breeding".

66 See, e.g. Robinson 1996.

67 The term 'durable resistance' refers to cultivars widely grown in an environment where a certain disease was effective. The term was introduced in the 1970s (Johnson 1983:5).

68 Case studies have found microbial pathogens and insect pests to overcome defences of some resistant crops sometimes within two years of their use on a commercial scale (Johnson 1983; Sosa 1981 *op. cit.*; Gould 1988:27).

matching gene can overcome the host's resistance – often within a very few years – which is essentially the motor of the much-criticized 'boom and bust' cycles in plant breeding.

Single-gene resistance as a dominant concept

If single-gene resistance could have offered durable resistance comparable to that of polygenic resistance, the debate would no longer be relevant. However, since the use of polygenic resistance is still widely considered to have potential, and 'boom and bust' cycles have continuously been criticized, one might ask why single-gene resistance has become dominant.

The **first** reason for the dominant use of single-gene resistance relates to the fact that the first type of resistance ever found (by Biffen in 1905) was single genic (Loegering 1985:189). This evoked further research, which led H. Flor in the early 1950s to what Raoul Robinson later referred to as a 'lock and key' relationship between host and pathogen. A parasite (the 'key') which is able to match all of the host's resistance genes makes the host (the 'lock') susceptible. Flor's findings on the relationship between host and pathogen were translated into what became known as a 'gene-for-gene' relationship in which matching host-parasites determines susceptibility of the host.[69] Flor's findings can, therefore, be considered to be an important contribution to the single-gene resistance concept.

By comparison, resistance based on polygenes simply lacks the gene-for-gene relationship (it is 'non-specific') and therefore does not succumb after host and parasite have matched.[70]

The **second** reason is the scientific 'inertia' in searches for alternatives for the negative consequences of 'boom and bust' cycles. Dominant characters based on single-gene resistance make progeny testing easier. A breeder will be very likely to continue to select individuals from backcross progeny with the best expression of resistance in order not to make the job more difficult than it already is. In the classical backcross system (often referred to as 'pyramiding') plants are determined either as resistant or susceptible, while resistance to pathogen races which are not apparent in the environment at the moment of breeding is not built up (Barrett 1984:221).[71] Hence, resistance with more complex, polygenic inheritance will be discarded unless there is no other variation available. It should be noted here that breeding procedures for single genes may break up polygenic complexes.

A **third** reason for the dominant use of single-gene resistance has to do with practical problems related to the use of polygenic resistance in monoculture farming practices. In contrast to single-gene resistance, polygenic resistance allows the pathogen to survive and grow, but only slowly.[72] Therefore even the most dedicated proponents admit that when polygenic resistance is used, limited yield losses will occur.[73] Breeders working on

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[69] Flor's important conclusion was that "for each gene conditioning rust reaction in the host there is a specific gene conditioning pathogenicity in the parasite" (Flor 1956:29-54).

[70] "In terms of gene-for-gene relationship, an infection is described as matching when the gene(s) of the parasite match the resistance gene(s) of the host (i.e. the biochemical key of the parasite fits the biochemical key of the host)" (Robinson 1996:430).

[71] Pyramiding is backcrosses of several genes into a certain background.

[72] The idea is that this partial resistance puts less selection pressure on a pathogen population to adapt to a host plant. A plant doing this is less helpless then one which is totally resistant to pathogen, since once the pathogen overcomes the resistance, the host plant will become infected immediately and totally.

[73] It should be noted here that although the disease might be visible, this does not necessarily incur losses. It is very hard to prove and estimate moderate disease losses.

polygenic resistance examine the rate of growth of the pathogen to identify this type of resistance, instead of trying to completely 'block' it, as happens with single-gene resistance. Some breeders, therefore, suggest redefining polygenic resistance as 'resistance which reduces the rate of infection'.

Socioeconomic implications of single-gene resistance

When looking at worldwide farming practices, only farmers in temperate climates, who largely depend on monocropping, have opted for disease-free crops. This is especially true for intensive agriculture in industrialized countries. Farmers in developing countries who rely on locally selected landraces, which may contain polygenic resistance, incorporate losses in their production targets. This is why Raoul Robinson, for example, although he is one of the most dedicated supporters of polygenic resistance, admits that this type of resistance has commercial limits with regard to intensive agricultural crops (e.g. potatoes) in industrialized countries and some horticultural crops that are easy to breed (e.g. onions, tomatoes) (Robinson 1976:112). How does this relate to the single-gene versus polygenic resistance debate?

The preference of single-gene over polygenic resistance was based most of all on the criteria of agricultural practices of farmers working in temperate climates; there, pathogens are less active than in warmer climates and more capital is available to buy new varieties. But the question remains whether the use of polygenic resistance, in spite of fixed losses due to direct host-pathogen reactions, would ultimately be more beneficial for farmers in developing countries than the use of high-yielding varieties with less durable single-gene resistance.

The application of single-gene resistance in short-term 'boom and bust' cycles on less-intensive (and less uniform) local farming in tropical areas has created serious socioeconomic problems (see, for example, Dempsey 1990). Using breeding techniques developed for temperate climates and based on single-gene resistances may not be appropriate for many tropical farmers, who do not have reliable access to agrochemicals to control losses when single-gene resistances break down. An unplanned spillover of high-yielding varieties to marginal environments could damage farmers' interest, as such varieties are not bred for such environments.

However, there is evidence that, following careful experimentation by farmers, high-yielding varieties can become part of low-input systems, and can soon become accepted as traditional varieties by farmers. Even in developed countries, there are problems with high-yielding varieties grown under marginal conditions, or within appropriate levels of inputs.

David Wood (1995, pers. comm.) comments: "Compared with the good yield stability of Green Revolution varieties in Asia, the very poor stability of US cereal yields is a result of both a periodic expansion of production to more marginal conditions, and a very high application of fertilizer (which is known to increase yield instability)."

Breeding for higher yields through polygenic resistance is still generally considered a remote ideal. However, VanderPlank (1984:88) has already warned against overoptimistic expectations, saying that "... high yields of grain or tubers are inimical to high horizontal resistance". The question, however, remains as to what extent better resistance (leading to stable yields) should be counterweighted against constant high yields. To understand the scientific-political context of this question we should also focus on a field in crop improvement almost forgotten: 'genecology'.

Genecological Ideas on Conservation Strategies

Simply put, genecology is the field of science which uses theories from both ecology and genetics. The field of genecology has been subject to criticism from the beginning of its existence, both with regard to its theories on crop improvement and with regard to the conservation strategies it has devised. By using the dichotomy between genetics and ecology, and the debate on poly- versus single-gene resistance, we will attempt to explain why it is criticized.

As early as 1953, Otto Frankel illustrated the ability of contemporary agriculture to modify the environment versus the ability of breeders to adapt new releases. In Figure 1, the strong connection between agriculture and plant breeding versus the weak connection between natural selection and agriculture shows that mainstream crop improvement, at least until the 1950s, involved very little natural selection mechanisms.

Frankel drew Figure 1 on the basis of data on the relation between the level of modification of the environment versus the adaptation of the crop (in the figure, referred to as "heredity") in the early 1950s, so it was before the Green Revolution had its impact. The same figure projected on the new relation in the 1960s and 1970s, with the Green Revolution in full swing, would have shown a tremendous increase in the ability of agriculture to modify the environment.

If designed on the basis of genecological principles, the same figure would look very different. The links between the different crop categories with natural selection would be much more pronounced, while those between different crops and plants and "modification of the environment" (far left in the figure) much less.

Genecological premises

For genecologists, landraces and wild relatives of cultivated plants – being the products of generations of conscious and unconscious selection by farmers and co-adaption to their own habitats – represented a tremendous genetic reserve. Hence landraces were not valued so much for their specific genetic content, as for their ability to adapt to their environment while simultaneously developing resistance. As such, landraces were starting points (parents) for breeding practices (as, for example, in potatoes) as much as genetic 'donors'.

As the desired characteristics of a plant could best be generated by 'learning' from the co-evolutionary responses, natural selection processes are of primary importance for understanding the genetic mechanisms of resistance. Relying on this and other ecological insights, genecology required that taxonomic research on plant variation was closely connected to ecological observations in the field.

Selection for resistance in genecological breeding programmes could be done with greatest reliability only in the habitat itself and therefore had to be de-centralized. Continuous selection under continuous exposure of the pathogen where the crop would later be grown was to lead to the accumulation of polygenic and more durable resistance.

A field station's staff would consist of a mixture of plant breeders (genecologists), taxonomists and ecologists. Only through a close-knit structure of these research stations[74] could sufficient knowledge be gathered to develop crops that were closely adapted to their environment. As the preferred breeding strategy focused on the desire to benefit from landraces (and to some extent also wild relatives) and their dynamic interaction with their environment, a **decentralized** ***in situ*** conservation strategy was also required. In this context, Bennett's argument should be considered:

[74] During the 1961 Meeting, these stations were referred to as Exploration Centres, which also were to include developmental programmes for agriculture (Rudorf 1961:2).

> To provide the necessary crop genecological services at every regional and local centre ... is a more realistic means ... than vast, centralized, and improvident international collections which appear to be the aims of present-day administrators (Bennett 1964:93).

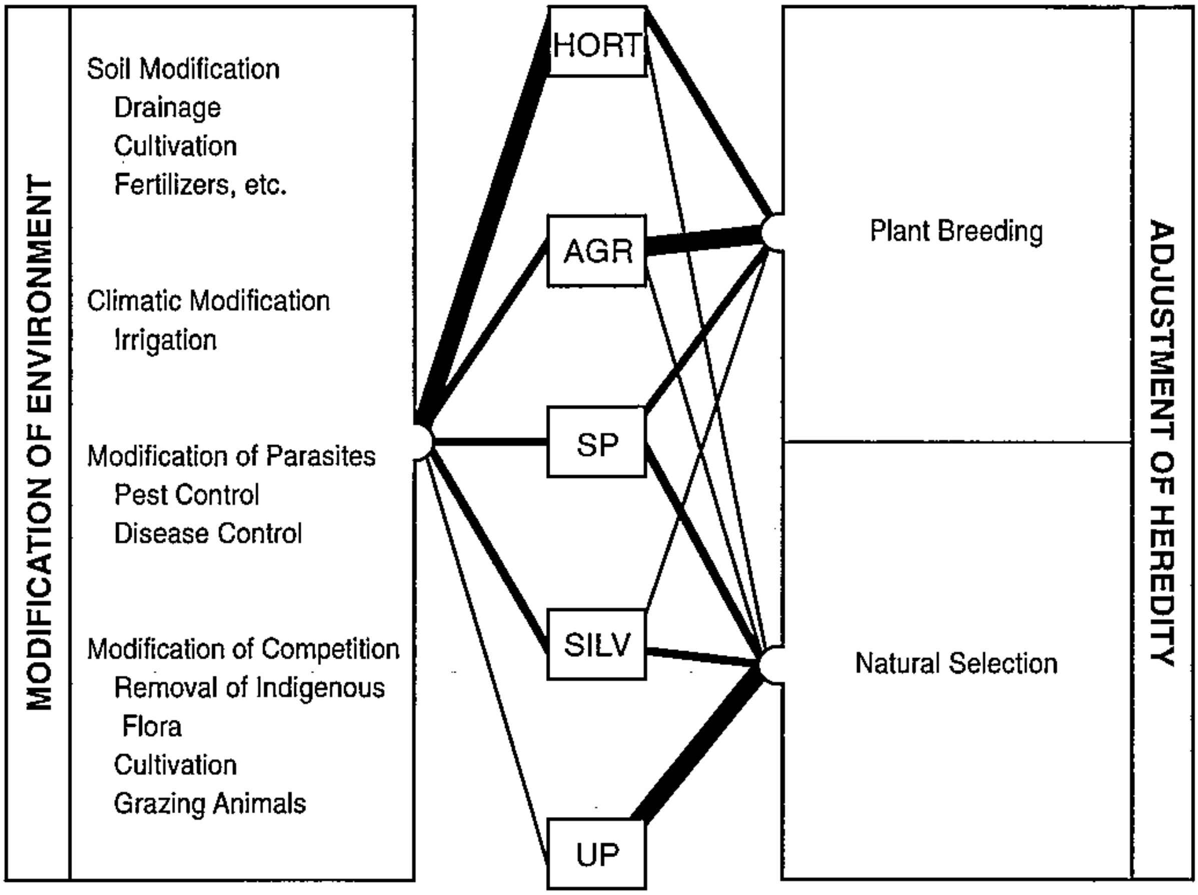

Fig. 1. Fitting of crop plants into new environments: the parts played by modification of environment and adaptation of heredity in the main groups of crop plants. The relative intensities of adaptive influences are indicated by the thickness of connecting lines [75,76] (Frankel 1954 in Whyte 1958:55; reproduced with permission): HORT = horticultural crops; AGR = agricultural crops; SP = pasture plants in sown pastures; UP = pasture plants invading unimproved (indigenous) pastures; SILV = silvicultural crops.

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[75] In Figure 1, the thickness of each line gives a rough impression of the extent to which different crops and plants (central part in the figure) either require a modification of the environment (far left) or a modification of their own heredity (far right). Horticulturists, for example, equipped with glasshouses can best manipulate the environmental conditions in favour of production. Open air agriculture is less able to do so, and in general relies much more on plant breeding.

[76] Note that the introduction (by man or nature) of pasture plants in Figure 1 is more subject to natural selection. A good example in this respect is the introduction of Mediterranean grasses to South-East Australia after World War II. No wonder most genecological research concentrated on pasture plants, especially grasses. See, for example, Gregor (1956).

However, genecological experiments were judged on the basis of the fact that they could not 'outyield' the successes of high-yielding varieties, which, considering the strong population-pressure argument during the Green Revolution, was indisputably within dominant agricultural circles.

Genecology received wider attention during the late 1960s when genetics increasingly offered inroads for further analysis of the genetic system behind co-evolution and adaptation. But the main problem remained that the results of these analyses primarily focused on the survival characteristics of a plant, rather than on those conditioning production.

Nevertheless, some encouraging positive results were reported by Suneson (1956), Harlan (1956), Whyte (1960) and Bennett (1964). Data came, for example, from Soviet scientists (among others, Tikhomirov 1960) who reported that the northward advance of the limit of agricultural cultivation in the USSR in the 1920s and 1930s had been made possible by genecological studies on the natural flora of the tundra with regard to plant-permafrost relationships. Successful genecological experiments also include work of Olmsted (1944, on range grass genus *Bouteloua*); Sinskaya (1958, on the composition of the ecotypical and varietal populations of *Onobrychis, Dromus* and *Secale,* among others); McMillan and the work of the Carnegie Institution of Washington, stationed at Stanford in California, on the phenotypic expression of genotypes in contrasting environments (Clausen and Hiesey 1958).

Although the genecological approach gained further support in the 1960s (especially by geneticists such as K. Mather, E. Mayr and G.L. Stebbins)[77] the lack of success in the release of ready-made, commercial crops contributed to the lack of support from the agricultural research establishment because, as Bennett later remarked "it was less profitable, even though it pointed the way to a better solution of breeding problems" (Bennett 1995, personal interview). In this context, the following remark by Otto Frankel during the 1967 Conference might be better understood:

> ... Now I think genecology, being a part of ecology and a part of genetics, is a very interesting field, but it is just not possible nor even necessary to repeat parallel studies in very many places on very many organisms (Frankel *op. cit.*, Bennett 1967:30).

And a lack of evidence of the applicability of genecology to crop breeding automatically led to distrust.

> As in all scientific endeavour [one] has to have a good idea, and test an intelligent hypothesis, but genecological studies should not be regarded as necessarily a routine thing (*ibid.*).

A more fundamental criticism is that in the genecological literature it remained unclear to what extent resistance genes imported from outside the susceptible population were considered as a tool for crop improvement. Genecological theories almost exclusively focus on wild populations and their ecological differentiation. Hence the argument of imported (resistance) genes to improve crop production is not common to the genecological argument. Applying genecological arguments to crop improvement therefore met (and meets) strong resistance from breeders and agronomists.[78]

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[77] See Bennett (1964:68, 81-97) and Bennett (1965:42, 49-54, 80).

[78] Evidence against specific local adaptation in crop varieties is provided by the extensive interchange of traditional varieties of all crops (Wood 1988a). Specific information on wheat is given, e.g. by Smale and McBride (1996) and by Brush (1994). The latter argues that farmer management

Another possible criticism refers to the difference between ecological **differentiation** of populations with **adaptation.**

> Farmers massively differentiate populations – this is easy, and can be very strongly selected for (at some expense of narrowing the total genepool of the variety). Awns versus awnless in wheat, rice, millet, etc. are examples, as are almost all seed colour traits. However, this, as in nature is not all, or even mainly, adaptive change, merely differentiation ... The assumption that local varieties are locally adapted leads directly to the enormous dogma that evolutionary change on-farm is progressive, and therefore that we must maintain farming systems to maintain this 'process'. This (mis)guides the thinking of many scientists and sociologists alike! (Wood 1995, pers. comm.).

Wood further argues that even if there is local adaptation, it may not keep pace with environmental changes – notably in disease pressure: in a 'one step forward and two steps back' situation the variety may become "dys-adapted". Co-evolved host-pathogen systems illustrate this situation.

> The importance of "dys-adaptation" – particularly host-pathogen co-evolution – is that the farmer may be better off abandoning the older variety and bringing in something new, i.e. not co-evolved, but not therefore "dys-adapted". This is the probable reason for the prevalence of introduced crops, and farmers' wide searches for new variation (Wood 1995, pers. comm.).

Market forces and durability: some connections

Modern plant breeding is geared towards the demand of industrialized farming systems for yield increase and, to a lesser extent, cost reduction of inputs such as pesticides, insecticides and fertilizers. The agro-industry that applies modern breeding for profit, however, has not managed to combine yield increase with a decrease of input costs for fertilizer, pesticides and insecticides. Private breeding companies are often the supplies of those inputs. Research costs, particularly those in the private sector, have to be recovered before a new release of a high-yielding variety is replaced by another (possibly from a competing company). Therefore, in most plant breeding, resistance with a more complex inheritance (polygenic resistance) will be discarded unless nothing else is available. In common agricultural research, the resistance is backcrossed to agronomically superior lines which are susceptible to a disease. In backcrossing programmes, resistance that is easily expressed (preferably at a single locus) is preferred to facilitate classification. Because the characteristics and the workings of single genes are better known, and therefore easier and cheaper, commercial (mainstream) breeding processes tend to favour resistance which relies on single-gene resistance (Barrett 1985:221). When research costs increased, for example, due to long-term research on polygenic resistance, an extra net return through royalties would be necessary, increasing the price for the new release.

In addition, since most high-yielding varieties of crops with single-gene resistance (especially hybrids) are sold in 'packages' (a variety plus fertilizers, weed control, pesticides and insecticides 'tuned' to the characteristics of the seed), varieties with polygenic resistance might reduce additional sales. Consequently, a new variety of a crop with polygenic resistance containing more durable resistance would only become

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would seem to minimize specific adaptive fit to highly local field conditions (Brush 1994; Wood and Lenné 1996). Jennings and Cock (1977) further note that varieties of introduced crops cannot be specifically locally adapted at the time of introduction, yet appear to perform better than local crops and varieties.

successful if the short-term cost-benefit cycle were replaced by a long-term one.[79] The cost-benefit cycle will remain short as long as short-term single-gene resistance remains the primary tool in mainstream breeding practices. It is to be expected that long-term breeding targets can first and foremost be achieved through non-commercial public breeding projects – now generally under severe pressure of budget cuts.

Implications of Breeding Strategies for Conservation Strategies

More attention to polygenic resistance in breeding for resistance could have offered an inroad to better understanding of the relationship between crops and their environments, in particular host-pathogen relationships. However, considering the commercial interests in common breeding practices and the limited knowledge and experience of polygenic resistance, single-gene resistance has been most commonly applied.

Breeders using single-gene resistances require *ex situ* genetic stocks which are quickly accessible and surveyable. Access and clarity of arrangement are more easily obtained in *ex situ* genebanks than in *in situ* conditions.

The second link between breeding and conservation strategies is established through the fact that polygenic characters in plants are not easily or not at all observable. Hence curators of the *ex situ* collections evaluate their collections on the basis of observable characters, which more often than not are monogenic (Frankel and Brown 1984:250-51).

The main reason, however, why *ex situ* conservation rather than *in situ* conservation was developed parallel to mainstream breeding programmes is that the former is of much more practical use for breeders than looking for material with known characteristics first (often elite material). The same breeders, both in the private and public sectors, dealing with the increasing demand for high-yielding varieties, are forced to deal with short 'product cycles'. Pragmatism and opportunism do not support arguments for *in situ* conservation.

How pragmatism and opportunism can dominate has been illustrated by Duvick (1984) who questioned over a hundred breeders. The results even put a question mark behind the use of *ex situ* genebanks, showing that breeders rely most of all on elite material containing characteristics generally known by colleagues or curators. The material is most often obtained through personal informal contacts outside the network of genebanks. This is especially true for material in which breeding improvement is well established and has been underway for a long time (Wilkes 1992:38). For example, most maize breeding has been carried out on the basis of private maize collections with narrow genetic bases.

The preference for *ex situ* conservation over *in situ* conservation cannot be attributed to the 'defeat' of ecological and/or genecological ideas on breeding and related conservation strategies. But their premises (particularly with regard to dynamic host-pathogen relationships) reflect ideas which nowadays can be found in publications of those emphasizing the value of traditional or 'grassroots' local farming practices. It is from this side that the demand for *in situ* conservation strategies has started to grow.

[79] This may explain why preliminary research on polygenic resistance has only been carried out in the public sector, which is under less pressure for relatively quick returns on investment. In the private sectors, income not only relies on royalties, but also on extra income from unusually high returns on early seeds sales while a new variety still has a novelty value. In the public sector, income returns are generated through royalties and, at a later stage, taxation on consumers of the product (Simmonds 1979:346/7).

However, an updated call for *in situ* conservation as "evolutionary gardens" (Wilkes 1992:25), without more attention to co-evolutionary relationships and their effect on durable resistance does not seem, as history shows, to be very promising.

Even so, however, disconnecting the use of genetic resources from its ecological context has had a number of negative consequences and it might be questioned if an alternative focus on *in situ* conservation is still possible.

In *ex situ* collections, information on origin and biological status of the material is very often unavailable, so that information on the origin of the evolution of crop parasites is only limited or not available at all (Leppik 1970). Only the varieties whose characteristics are best known are valued more than those which are not. This is because, as Frankel and Soulé (1981) state, sampling procedures during collecting and maintenance are varied and poorly documented. They may range from a random sample to a biased sample, often without a record of actual procedures. As breeders are more interested in performance than information about sources, not many collections have precise information on the geographical origin of all their accessions (Frankel and Soulé 1981:186).

Conclusions and Summary

Agriculture, biology and ecology are all, or should be, concerned with conservation. While within the agricultural realm the conservation of plant genetic resources emerged in the 1960s and 1970s, ecological and biological initiatives remained limited, at least at the institutional level. The rise and fall of IBP illustrates the difficulties in organizing biologists (and to a lesser extent ecologists) on an international scale. This was particularly true for the IBP initiative to set up a 'gene pool' conservation strategy within the framework of its 'Use and Management of Resources' programme. The fact that IBP initiatives in this field were guided by a well-known breeder, Otto Frankel, gives some indication of this weakness. Frankel established a formal link between IBP and FAO, out of which came the joint 1967 Technical Conference. But what might have become an interdisciplinary effort merging ecological, biological and agricultural ideas on the conservation and use of genetic resources, turned out to be an expert meeting predominantly of plant breeders and geneticists. The IBP was only formally involved: it contributed to the expenses of the Conference and the book that came out of it.

The demise of IBP in 1974 was also a the result of more general problems that ecologists and biologists had in organizing themselves internationally and setting up institutions and programmes that would protect and serve their interests. In this respect, FAO in the 1960s and 1970s, for agricultural scientists, had a much clearer role.

On a scientific level, things were much more complicated. In the 1960s, ecologists and biologists had started a discussion on the 'stability-diversity hypothesis', which in agricultural terms focused on adaptational responses of host plant populations to pest and pathogen populations. One might ask what effect a more wider spillover of the stability-diversity debate within ecology into the debates on co-evolutionary processes among agriculturists might have had for conservation strategies in the 1980s and 1990s. The answer to this cannot be given here, but a merging of ecological and agricultural ideas on the genetic interaction between plant populations and their habitat did occur within genecology.

However, some scientists (Wood and Lenné 1993, among others) are convinced that local adaptation (as developed in genecological literature for wild species) may not lead to optimal adaptation in crops. There may be two reasons for this difference: farmers' access to a restricted local genepool of a widely distributed crop;and farmers' high ability to select for morphological characters that could rapidly restrict the on-farm genepool and counter much slower natural selection. This argument is ignored by NGOs in developing and developed countries (e.g. RAFI) who instead argue that although breeders have access to a more extensive genepool than farmers, breeders are incapable of selecting for adaptation to the great range of environments encountered by farmers. However, both arguments may be true (Wood 1995, pers. comm.).[80]

These theoretical discussion are important, because they may indicate whether current research proposals for alternative breeding in developing countries, the increase of diversity "as in nature" are a waste of time or not, and indirectly give an idea of to what extent *in situ* conservation should or could be linked with farming practices. The present discussion indicates that *in situ* should serve farmers' needs for on-farm diversity to produce diverse products and maintain labour phasing, and not be considered as an ecological need for more diversity *per se*.

[80] To argue that diversity brings stability is to imply that stable systems must be diverse. This is not so in nature. There are some very uniform and quite stable systems - for example, water hyacinth is **absolutely** genetically uniform for thousands of km^2 (clonally propagated, and even then, often existing in only one of the three possible style forms), and exists in pure stands with very high productivity throughout the tropical world. ... Also the genetic variation (measured biochemically) is no measure whatever of the evolutionary success of a species (Wood 1995, pers. comm.).

4 Establishing a global *ex situ* conservation network

The 1967 FAO/IBP Technical Conference generated some important guidelines for the establishment of a global network for long-term conservation *ex situ*. In retrospect, the conversion of these guidelines into practical action took place surprisingly quickly. This chapter contains a short analysis of the possible reasons for this. The first is the effective collaboration of a small group of leading geneticists and breeders representing key institutions, which became known as the Panel of Experts on Plant Exploration and Introduction. Their ideas led to a plan of action presented during the 1973 FAO/IBP Technical Conference on Plant Genetic Resources, held 12 to 16 March in Rome, and published under the title "Crop Genetic Resources for Today and Tomorrow" (1975) edited by Frankel and Hawkes. The second reason was increased public and institutional attention to the dangers of genetic erosion both within the agricultural realm (for example, the 1972 report of the US National Academy of Sciences, NAS, on genetic vulnerability; NAS 1972), and the environmental realm as emerged in the 1972 United Nations Conference on Human Environment (UNCHE) in Stockholm. A third stimulating factor was the support from the Consultative Group on International Agricultural Research (CGIAR) and its donors for establishing a world network of collections coordinated by the International Board for Plant Genetic Resources (IBPGR). In order to galvanize the contributions from some CGIAR institutes to the development of food crops (particularly maize and rice), many scientists had started to think of an international network that could secure a constant supply of genetic material to breed new varieties. These developments had considerable consequences for the position of FAO in international genetic resources conservation work.

The Panel of Experts and the 1973 Technical Conference

The Panel of Experts on Plant Exploration and Introduction that gathered at the 1967 Technical Conference probably realized that if they did not take advantage of the momentum offered at that time, worldwide political action to manage the conservation of plant genetic resources would probably not reappear on the UN agenda for a long time. The most important members of the Panel of Experts were, both in terms of expertise and active involvement, Erna Bennett of the FAO[81], Jack R. Harlan of the Crop Evolution Laboratory of the University of Illinois, Jack G. Hawkes of the University of Birmingham, John L. Creech of the United States Department of Agriculture (USDA) and Sir Otto Frankel of the Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia.

The Panel of Experts was officially established in 1965.[82] It was to advise FAO on new lines of action and also to assist in expanding the exchange of plant materials between

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[81] Frankel later notes that Erna Bennett was kept on a consultancy contract and was appointed to the staff only after prolonged delay. As a consequence of the 1967 Conference, Bennett single-handedly ran a newly established FAO secretariat, the Crop Ecology and Genetic Resources Branch (see also Chapter 5).

[82] Under Article VI-4 of the FAO Constitution following a suggestion of the 1953 FAO Conference. This suggestion was repeated in one of the recommendations of the 1961 FAO Technical Meeting.

countries and scientific institutions. The Panel had two restricted meetings in 1966 and 1967. At that time, participants included six members from the Genepool Committee[83] of the International Biological Programme (IBP), one from the FAO Panel, two members from the FAO Forestry Division and five from the Plant Division of FAO (Frankel 1985:29).

Undoubtedly the most important achievement of the Panel was that it formulated basic arguments for the conservation and use of genetic material. These were: (a) that plant material was to be made available immediately and without restriction to all breeders whose work required it, and (b) that genetic variability had to be maintained for future generations in long-term storage under conditions of maximum physical and genetic security (FAO Panel of Experts 1969:16).

The Panel also identified priority targets for exploration, proposed a survey of threatened resources, drafted proposals for an international network of genetic resources centres and urged FAO to initiate international cooperation in seed conservation, including the development and adoption of appropriate documentation systems (Anishetty and Esquinas-Alcázar 1991:53). After the two meetings in 1966 and 1967, there were four formal meetings of the Panel, in 1969, 1970, 1973 and 1975. All of these meetings were chaired by Otto Frankel.

Until the late 1960s, immediate availability of genetic material was normally only ensured by the maintenance of working collections of (international) plant breeding and research institutes. Consequently, most of these collections were confined to the same or closely related taxonomic groups with which the institute was working, and were rarely retained beyond the duration of the project for which they had been assembled. This problem became more immediate during the 1960s as the number of International Agricultural Research Centres (IARCs) started to grow due to financial support from the Ford and Rockefeller Foundations. These were the International Rice Research Institute (IRRI, 1960), the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, 1966) (on the basis of the earlier Rockefeller Foundation Mexican Programme which had started already in 1943), the Centro Internacional de Agricultura Tropical (CIAT, 1967) and the International Institute of Tropical Agriculture (IITA, 1968). This development, as well as the increased awareness of genetic erosion, became one of the primary motivations of the Panel to organize international action.

The Panel pointed out a few regions in the world and the corresponding native crops that needed immediate attention. During the Third Session of the Panel of Experts in Rome, 1969 (FAO 1969:5-6), these were:

- **the Near East** (Anatolia, the Mediterranean Basin, Pakistan, Iran, Iraq); wheat, cucurbits, peas, other pulses, tree fruits, nuts, barley);
- **the Sudanian zone of Africa:** *Oryza glaberrima, Voandzeia,* cowpea, sorghum, yam, millet;
- **southern and eastern Africa:** forage grasses;
- **Ethiopia**: various local varieties;
- **South and Central America:** cotton, tropical fruits, cucurbits;
- **Southeast Asia:** tropical fruits, tropical soybean, yam;
- **Oceania**: yam.

This priority list, however, was very broad and impractical. In its last formal meeting (March 1975) the Panel made a modified ranking. It recommended that the FAO first had to look for cooperation with the "Germplasm Laboratory at Bari" to coordinate further exploration in the west and central Mediterranean regions. Ethiopia was given the second

[83] The Panel of Experts held its first two meetings (in 1966 and 1967) in conjunction with the IBP genepool committee. FAO partly financed the meetings.

priority "because it is still rich in genetic resources of a number of important crops and genetic erosion is accelerating". The third target embraced a more specified number of tropical crops.[84]

These modified criteria illustrate a shift from a crop-oriented to a region-oriented approach, for which two reasons can be mentioned. The first was that for infrastructural and funding reasons the collection of genetic resources could best be organized via a limited number of genebanks in each centre of genetic diversity. In this respect, the Mediterranean and Ethiopian centres were feasible starting points. The other, more political reason, is that by 1973, the Panel in its planning had to take into account the network of the CGIAR centres, the creation of which had just begun (see below). By opting for two genebanks in two specific centres of genetic diversity, and for which no CGIAR centres were planned yet, the Panel apparently had decided to adjust its preferred collecting strategy to those of the emerging CGIAR network.

The criteria for exploration went beyond that of the impending danger of genetic erosion. They also included the extent to which genetic variation was already available in collections, the economic value of the crop in question, its nutritional value, its potential in terms of production expansion, future technical exploitation and the demand for the material by breeders.

A third important result of the Panel meetings was a categorization of *ex situ* genebanks. *Ex situ* genebanks would be divided into 'base collections' and 'active collections'. Base collections (modelled after the collection at Fort Collins in the USA) would conserve reserve stocks on a long-term basis (Frankel and Soulé 1981:246). They would be combined with 'active collections', which would offer medium-term storage, activate the 'utilization stream' of genetic material and offer facilities for regeneration, characterization, documentation, multiplication and distribution (Frankel 1975:474; Frankel and Soulé 1981:246). A third type of collection facility, 'working collections', were the plant breeding institutions in which evaluation of genetic resources would take place.

The information gathered through the various Panel meetings led to a plan for another joint FAO/IBP Technical Conference on Crop Genetic Resources within FAO in 1973. The 1973 Conference differed from its predecessor in 1967 in that it did not formulate scientific parameters for the conservation and use of plant genetic resources. Instead, the contributors to the book that came out of the conference, "Crop Genetic Resources for Today and Tomorrow" (Frankel and Hawkes 1975), formulated practical action plans that were intended to help FAO set up a global network of conservation activities. However, the book perhaps raised more questions than it could answer.

A contribution of Don Marshall and Anthony Brown in Part I of the book, "Optimum Sampling Strategies in Genetic Conservation", determined criteria for sampling techniques for *ex situ* collections. Their rationalization of sampling strategies gave rise to a good deal of controversy at the conference[85] as only a clear picture of the need for specific material in

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[84] In tropical America: cacao, beans, cassava, potato, sweet potato, peanuts,cucurbits, capsicum, avocado, tomato, papaya, pineapple, forage legumes; in Southeast Asia: rice sugarcane, tropical tree fruits, aroids; in tropical Africa: rice, coffee, sorghum, millets, cowpea, yams, forage grasses (FAO 1973a:8).

[85] Marshall and Brown concluded that (a) there are definite limits to the numbers of samples which can be handled effectively in programmes for the conservation and utilization of crop genetic resources; (b) the number of alleles per locus is the simplest measure of genetic diversity for the purpose of exploration and conservation; and (c) while there is little or no information available on the variation in nature, the optimal strategy is to collect very selective samples (50 to 100 per site) on as many sites as possible and in a very broad range of environments (Frankel and

breeding practices could offer good sampling criteria. But, as it was impossible to look into future needs for breeding, definitions for limited or 'core' collections remained uncertain.

Another contribution was C. Qualset's "Sampling Germplasm in a Center of Diversity: An Example of Disease Resistance in Ethiopian Barley". This was a critical evaluation of the coverage of genebank collections in terms of variability in a certain region, taking resistance for yellow dwarf virus disease in Ethiopian barley as an example.

Part 2 of the book dealt with methods of exploration in seed crops, vegetatively propagated crops and tree species, and summarized what had been accomplished in these fields. An introductory contribution of Frankel to this section, "Genetic Resources Survey as a Basis for Exploration", contained the nucleus of a survey of genetic resources in their centres of diversity conducted in 1971/72 and jointly planned and financed by FAO and IBP, with FAO as the executing agency. The survey was a compilation of existing published and, most of all, unpublished data assembled in the minds or notebooks of plant breeders and collectors and concentrated on major food crops. The survey and the message of urgency connected to it by Frankel were intended to form a matrix for further collecting work by FAO. This, however, did not materialize as he envisaged during the conference.

Part 4, and particularly the contributions of Roberts on "Problems of Long-Term Storage of Seed and Pollen for Genetic Resources Conservation", offered a state-of-the-art report on concurrent conservation strategies. *Ex situ* conservation was analyzed as the most simple and inexpensive operation in terms of technology, facilities, staff and operation expenses. On the basis of Roberts' contribution Frankel and Hawkes concluded that:

> "[...M]ost crop plants can be stored over long periods with a minimal risk of genetic damage, and regeneration should be a rare event. It remains to be spelt out the organizational and administrative consequences – the size of the stocks, access and organization of distribution, and no doubt a great deal more" (Frankel and Hawkes 1975:7/8).

Lack of institutional backing

Although the ideas of the Panel were formulated before and during the 1973 Technical Conference, they lacked serious institutional and financial backing. The genebanks the Panel was looking at were those under the aegis of USDA, the Australian collection facilities (mostly of Mediterranean, tropical and subtropical forage species), the Japanese Hiratsuka genebank under the auspices of the Japan Science Council, and a new genebank planned in Braunschweig, Germany. In the Third World, notable candidates were not national genebanks but IARCs, such as CIMMYT and IRRI (FAO 1969) which had developed into motors of the spread of the Green Revolution crops.

IRRI especially, with its very extensive long-term storage facilities served as a model. In the 1970s, IRRI had been able to assemble a collection representative of most of the tropical rice-growing areas in the world and was one of the most complete genetic resource centres in the world. This quality, however, also meant that the possibility of being integrated into another centralized international network under the responsibility of FAO (the Panel's employer) would be limited. The 1967 Technical Conference had made it clear that, although in principle there was a willingness to cooperate, the existing genebanks were directed towards either national or crop-specific interests (see Chapter 2).

The overall contribution of the FAO Panel of Experts to the establishment of an international system for the conservation of genetic resources, can perhaps be summarized

Hawkes 1975:78/79).

as a bridge between the general, rather scientific, recommendations formulated during the 1967 Conference, and the establishment of a practical plan for an *ex situ* conservation network. This also meant that the genetic resources issue had shifted from a scientific to a more practical focus. But who was to pay for a new world network?

Financially, in the 1970s FAO had little room to manoeuvre, since shifts in the FAO budgets in favour of genetic resources conservation were not likely to be supported by developing countries. Most of the developing countries suffered from acute food problems and considered genetic resources conservation on a world scale a matter for extra-budgetary funds (Esquinas-Alcázar 1995, personal interview). It should be noted that this stance was taken at a time in which genetic resources conservation and use had not yet gained much attention in developing countries, and that most conservation of genetic resources was carried out by IARCs. At FAO, the only facilities that did function, although as an intermediate and not physically as a storage facility, were the Crop Ecology Unit and the Crop Genetic Information Centre[86]. An institutional network for the conservation and use of genetic resources would be established in the early 1970s, but not under the aegis of FAO.

'Genetic erosion': An unexpected spark

Although the Panel of Experts had been very concerned about the negative consequences of 'genetic erosion', the issue received little public attention in the 1960s. The early 1970s, however, saw an unexpected recognition of the issue as the world witnessed two serious consequences of genetic erosion. In 1970, a serious outbreak of Southern corn-leaf blight in the USA reminded the scientific world that genetic variability was not always enough if the cytoplasm is entirely of one kind. In the same year, a catastrophic outbreak of coffee rust caused great losses in Brazil with higher coffee world-market prices as a consequence. In contrast to many other agricultural disasters of the same kind, this case provoked publicity on a global scale, generating a flow of information on other ongoing cases of genetic erosion.[87] The Panel, of course, was eager to present facts and figures.

Within the agricultural community in the USA, the publication of a report in 1972 under the responsibility of a special study committee on the Genetic Vulnerability of Major Crops consisting of the Agricultural Board, the Division of Biology and Agriculture, and the National Research Council, attracted much attention, both within scientific and circles

[86] The Centre, established in 1968, as an outcome of the 1967 Conference mainly concentrated on information services and some exploration activities. Special attention would be given to the further development of the Plant Introduction Newsletter, a computer-based register of genetic resources, and the expansion of publication activities in the field of plant genetic resources conservation (FAO 1969:15; NAS 1972).

[87] Other classic examples referred to by the Panel related, among others, to the diffusion of Mexican wheats and their derivatives from an estimated 10 hectares in India and Pakistan in 1964-65, to around 10 million hectares in 1971. In Turkey, by the late 1960s, 80-95 per cent of the wheat acreage had been replaced by modern varieties replacing mixed, adapted landrace populations. Monocropping occurred even at the cost of acreage in other crops such as barley, oats, rye and grain legumes. In Sri Lanka, landraces were rapidly being replaced by new dwarf rice varieties. In crop year 1971-2, it was estimated that the new dwarf rice varieties were established on 60 per cent of the land suitable for them and that 90 per cent of the remaining acreage (the bulk of the total rice area) was planted to locally released improved cultivars. In South-East Asia, the traditional mixed plantings and wild forms of tropical fruits were rapidly being replaced by a rapid increase in plantings of oil palm and rubber and by the expansion of mechanical logging and strip-mining (Panel of Experts 1969).

of agricultural non-governmental organizations (NGOs).[88] This report discussed the vulnerability of 11 important crops: corn, wheat, sorghum, pearl millet, rice, potato, sugar beet, sweet potato, soybeans (and other edible legumes), vegetable crops and cotton. It concluded that the Southern corn blight disaster of the 1970s was a typical case of what could go wrong with genetic uniformity, which is inherent in modern crop improvement.

> The key lesson of 1970 is that genetic uniformity is the basis of vulnerability to epidemics ... [M]ost major crops are impressively uniform genetically and impressively vulnerable ... This uniformity derives from powerful economic and legislative forces ... The situation poses substantial challenges to scientists and to the nation (NAS 1972).

Genetic Vulnerability of Major Crops stands out as one of the first accounts written by scientists organized within established agricultural research organizations on the problem of market forces calling for produce uniformity. The report contains a plea to crop scientists to resist the powerful forces of consumer and crop processor demands for uniformity.

> Clearly the market wants uniformity. If one breeder or one farmer does not want to provide it, the market will turn to another that will. The irony is that if the uniformity encourages an epidemic, the scientist, not the market, tends to receive the blame (NAS 1972:289).

The language of the report[89] shows bitter frustration towards consumer demands and subsequently also towards the policies of private and public investors in crop research. The general assumption that it is easier for public research institutes to concentrate on commercially less attractive, and hence less uniform crops, is put aside: "... the market system in the USA also forces the public sector to research and produce almost the same varieties – often in cooperation" (*ibid.*:288). And:

> Whether working for a public or a private institute ... the breeder seldom wins. If he appeals his case to the public, he is labelled a public relations man who should spend more time in the laboratory; if genetic vulnerability results directly from this research efforts, he is labelled shortsighted with respect to the limitations of new germplasm or insensitive to his public responsibility (*ibid.*).

The report, however, did not call for a complete revision of the agricultural marketing and research system, but for an enlarged role of the US government in offering facilities for scientists to prevent future disasters due to crop vulnerability. The committee advised the US government to:

- provide a complete "early warning" system, including: overseas laboratories to monitor exotic pests and to test American varieties against them there; a quarantine service at the borders; a talent pool of scientists as the basis for its efforts; a national monitoring committee;
- provide the facilities for continuously maintaining genepools, and
- provide a guaranteed insurance against catastrophic losses. (*ibid*:1-2).

Perhaps the most important message of the 1972 NAS report was that for the first time breeders publicly stated a direct correlation between genetic vulnerability and genetic variability. To prevent further disasters, four strategies for reducing genetic vulnerability

[88] Published by the USA National Academy of Sciences in 1972.

[89] Especially Chapter 10.

had to be built into common research strategies: (a) diversity through time (varietal turnover), (b) diversity through anticipation (mainly through early warnings), (c) diversity in reserves (numerous advanced lines), and (d) rapid deployment of genetic diversity (the ability of the US seed industry to bring in materials from anywhere in the world) (Committee 1993:72). Although the correlation between vulnerability and variability had long been known among breeders and collectors (see Chapter 3), the 1972 report was to receive widespread public attention.[90]

Another impulse: Stockholm 1972

One of the statements of the Panel of Experts had been that genetic variability had to be maintained for future generations in long-term storage under conditions of maximum physical and genetic security and stability (FAO Panel of Experts 1969:16). It was this message that Frankel wanted to spread in Stockholm. However, in spite of the fact that his presentation during the United Nations Conference on Human Environment in Stockholm received considerable attention, Frankel's personal account of his stay in the first half of June 1972 in Stockholm is one of a lack of communication with the rest of the Conference machinery: "They gave me a huge office, just for myself, but no one was really aware of the problem I was going to present" (Frankel 1994, personal interview). Nevertheless, his efforts resulted in six articles (Articles 39-45) on the conservation of genetic resources in the UN Declaration on the Human Environment (United Nations 1972). Many years later, however, Frankel revealed his doubts about the effect of the lack of the "conservationist" attention to the preservation of genetic resources during the early 1970s and thereafter:

> Conservationists who became so concerned in the eighties when the battle was essentially over, were notably uninterested when their publicity might have been invaluable, and the struggle for recognition was left to a handful of people (Frankel 1986:31).

Various recommendations in the final report show the strong influence of Frankel as the primary expert and chairman of the FAO Panel of Experts. Article 43-4 even directly offers a special role to the Panel:

> It is recommended that Governments, in co-operation with the Secretariat-General and FAO where indicated [to] fully implement the programmes initiated by the FAO panels of experts on forest gene resources in 1968 and on plant exploration and introduction in 1970 (United Nations 1972:6).

The influence of the ideas of the FAO Panel of Experts becomes significant in the clear division of labour between *in situ* and *ex situ* conservation. Article 39-c states that both are needed, but in Article 43 it becomes clear that genetic resources with an agricultural value had to be conserved in "national or regional genetic conservation centres" *ex situ*, such as the National Seed Storage Laboratory (NSSL, USA) or the N.I. Vavilov Institute of Plant

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[90] The effect of the 1972 report on maize breeding practices goes beyond the subject of this chapter. However, a short evaluation occurred on what might be considered as the follow-up of the 1972, a book under the title: Managing Global Genetic Resources: Agricultural Crop Issues and Policies. The contributors, assembled in the Committee on Managing Global Genetic Resources reassessed the past two decades with some disappointment. "Only after 1975, did large changes in the frequency of use of major inbred lines begin, but two germplasm sources (Iowa Stiff Stalk Synthetic and Lancaster Sure Crop) continued to dominate. ... Many of the new maize hybrids sold under different names, however, continue to depend on a few closely related inbred lines" (Committee 1993:73).

Industry (VIR, USSR). Also, in accordance with the ideas of the Panel, a distinction was made between 'working collections' and 'base collections'. These facilities had to be designed to "assure the use of the materials and information by breeders" (Article 45-1a).

Wild relatives of crop species, on the other hand, would be maintained in their 'national communities' (original environment) – *in situ* – for which the UNESCO Man and the Biosphere Programme was recommended to fulfil an important role (see Chapter 6). To establish an *ex situ* genetic resources network, UNCHE recommended "that the appropriate UN agency establish an international liaison unit for plant genetic resources" (Article 45-2a) and "to provide the secretariat for periodic meetings of international panels and seminars on the subject; a conference on germplasm might be convened to follow up the successful [FAO/IBP] conference of 1967" (Article 45-2v).

The overall impression given by the six articles on genetic resources is that *in situ* conservation was formally recognized as important and necessary (for example, in Article 39-c and Article 43-2) but only a few methods were identified for carrying out the task. With regard to *ex situ* conservation, plans were worked out in relatively great detail: different types of *ex situ* facilities were mentioned, specific categories of genetic resource crops were made, existing storage facilities and potential international coordinating organizations were mentioned. It was clear that during UNCHE in 1972, Frankel, through the Panel, tried to give FAO a suitable role in the conservation of genetic resources. This plan, however, did not materialize, which explains Frankel's frustration 15 years later.

'Beltsville' and the Construction of a Global Network of Genebanks

Although the 1972 Conference in Stockholm had brought the genetic resources issue onto the agenda of the global environment, and the 1973 Technical Conference had generated wider support in the agricultural realm, neither event had any direct impact in terms of more collection and storage activities. What was available was a rapidly growing network of IARCs, part of which had become the CGIAR network in 1971.

Some members of the Panel of Experts (through FAO) realized that the assemblage of the CGIAR collections could just as well embrace a global network of genebanks, and therefore submitted a proposal to the CGIAR Technical Advisory Committee (TAC) in October 1971 "to establish a mechanism to encourage, coordinate and support action to conserve genetic resources and make them available for use" (FAO 1989:2). In March 1972, the Panel presented its plans to TAC in Beltsville, Maryland, USA. Although it was perhaps not realized at that time, this move of the Panel would have tremendous consequences for the position of FAO in the conservation of genetic resources. Before continuing, a short review of the institutional background of TAC and its role in the CGIAR is required.

The role of TAC

The idea for establishing the CGIAR came in 1965 from Robert McNamara who was then President of the World Bank. During the first preparatory founding meeting of the CGIAR, in April 1969, a number of international institutes were represented: FAO, the United Nations Development Programme (UNDP), the World Bank and the Ford and Rockefeller Foundations. The central question of the meeting was how to design an international research network to stimulate further and consolidate the scientific advance of the Green Revolution.

During the succeeding preparatory meetings between April 1969 and January 1971, the Rockefeller Foundation, the Ford Foundation and the World Bank gradually overruled the two UN organizations – leaving the role of the UN cosponsors at the time of the first the

CGIAR meeting in May 1971 "undefined"[91] (Baum 1986:63). From 1971 on, the CGIAR was housed at the World Bank headquarters in Washington, DC. The active involvement of the two Foundations and the World Bank and 16 mostly developed country donor governments (by 1976, 26)[92] could guarantee the establishment of a strong network of international agricultural research organizations.

The function of TAC is to advise the CGIAR on the main gaps and priorities in research on agricultural problems, both technical and socioeconomic, of developing countries.[93] TAC members were nominated by the donors and appointed by the CGIAR. A representative, J.G. Harrar, of the Rockefeller Foundation, one of the CGIAR's most important contributors at that time, was the first chairman. There were 12 TAC members in total: six members from developing countries and six from industrialized countries. The representation of six members of developing countries was regarded as the solution to the 'problem' of developing countries that wanted to become members of the CGIAR without being able to contribute financially. Warren Baum, vice president of the World Bank and chairman of the CGIAR for ten years comments: "If all developing countries interested in the Group's activities were to become members, the Group would become unwieldy and ineffective" (Baum 1986:61). The fact that developing countries could not participate freely in TAC, although most decisions taken directly affected them, later became the nucleus of the political criticism of CGIAR policies in the 1980s (see Chapter 5).

TAC's plans for a global network

With regard to the issue of genetic resources, TAC did not have special expertise among its members. Because of this, TAC invited some external experts, some of them from the FAO Panel of Experts, to come to Beltsville. Bennett was specifically excluded. Otto Frankel and Jorge León represented the FAO Panel. Other important guests from the Panel were John Creech, Jack Harlan of the University of Illinois and Jack Hawkes of the University of Birmingham. The group was completed by T.T. Chang of IRRI, M. Gutierrez of CIMMYT and Dieter Bommer of the German genebank at Braunschweig.

On the agenda was an ambitious project: the establishment of a World Network of Genetic Resources Centres. The plan embraced four elements (TAC 1972:

(a) **A Coordinating Centre:** later to become the International Board for Plant Genetic Resources.

(b) **To stimulate the establishment of genebanks in international centres already existing in developing countries.** These were: IRRI (established in 1960), CIMMYT (1966), CIAT (1967) and IITA (1968).

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[91] In addition to the cosponsors, the members of the CGIAR were 16 donor governments, three regional development banks, the European Economic Community, the US Kellogg Foundation, the International Development Research Centre (Ottawa), and two representatives from each of five major developing regions.

[92] In the period 1972-76, the total of grants had risen from US$ 20.8 million to US$ 62.9 million and the number of staff of the IARCs from 133 to 324.

[93] TAC was given five tasks: (1) to advise the CGIAR on the main gaps and priorities in research on agricultural problems, both technical and socioeconomic, of developing countries, (2) to recommend to the Group feasibility studies on how best to organize and conduct agricultural research on urgent problems, (3) to present its views and recommendations to the Group on these and other feasibility studies, (4) to advise the Group on the effectiveness of existing international research studies, and (5) to encourage in other ways the creation of an international network of agricultural research institutions (Baum 1986:60).

(c) **To establish genebanks in new international centres:** the West African Rice Development Association (WARDA, 1971), the International Potato Centre (CIP, 1971) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 1972). These organizations were already in existence and could immediately become part of the new network. Soon after 1972, the International Livestock Centre for Africa (ILCA, 1974) and the International Centre for Agricultural Research in the Dry Areas (ICARDA, 1976) were included.

(d) **The establishment of new 'regional' centres** in the Vavilovian centres of crop diversity. Following an 'ecogeographical approach' (see Chapters 3 and 6) the Vavilovian centres would serve as a matrix to determine a global division of labour in collection efforts (van Sloten 1995, pers. comm.).

With regard to plans on the conservation and use of plant genetic resources, the TAC proposal reveals a combination of a scientific focus on the basis of regional centres which had been pursued by the FAO Panel members, and a practical orientation (on the basis of existing and planned CGIAR institutes). The scientific orientation which came from the FAO Panel embraced rather general incentives to conserve genetic resources. The institutional orientation, on the other hand, reveals the interest of the CGIAR to extend its mandate. The CGIAR considered genetic erosion to be a threat as well, but mainly a threat to the further development of the Green Revolution.

The following will illustrate how the establishment of IBPGR accelerated the formation of a world network of genebanks corresponding to the specific interests of the CGIAR, supporting to a certain extent the more general aims of the FAO Panel. In this context, it should be noted that IBPGR had a very precise but immense task: "to promote and assist in the worldwide effort to collect and conserve the plant germplasm needed for future research and production" (TAC 1972). This meant that IBPGR was not primarily established to help collect and conserve genetic resources to prevent genetic erosion. The practical implications of this divergence will be illustrated in the remainder of this chapter which will concentrate on two items, the first technical, and the second institutional in character:

1. IBPGR's move from a more or less regional approach to an approach more coordinated with the CGIAR's demands, and
2. the difficult relationship between IBPGR and FAO.

IBPGR's Years of Growth

Within ten years (from 1974 to 1984), IBPGR managed to develop a cooperative network of research centres and agricultural scientists in about 100 countries. In this sense, the TAC Policy Plan No. 1, the promotion of cooperation of **all interested institutions** through a coordinating centre, was a major success. Apart from networking, the following achievements should be noted:

1. the organization of **collecting missions**, partly by using consultants and making contracts with existing genebanks. By 1988, IBPGR had organized and (co)financed more than 300 collecting missions in about 90 countries, yielding 120 000 new seed accessions, covering 120 species;
2. assistance in 28 **national programmes** (mostly in developing countries) in establishing national conservation facilities and documentation systems, and the financial support in 12 for establishing collections of crops propagated by vegetative means;

3. the establishment of an **international network** of base collections in 31 countries for long-term storage for 35 crops or groups of crops stored as seeds. Of the centres, 25 are located in developing countries (see also Chapter 6);
4. the support for an international M.Sc. **Course in Conservation and Utilization of Plant Genetic Resources at the University of Birmingham** (UK) and the arrangement of training fellowships;
5. promoting of and assisting in **technical meetings**;
6. establishing an **information system** with standard procedures in documentation, recording, storage and retrieval of computer data;
7. sponsorship of more than 165 **publications** on topics related to plant genetic resources (FAO 1989:2; IBPGR 1984:12, 15; IBPGR 1988; TAC 1986:87; Williams 1984a).

The strength of IBPGR in the 1980s lay essentially in (a) its ability to create effective cooperative efforts with governments which had shown an interest in setting up new genebanks, (b) the mobilization of the scientific community in support of IBPGR's collaborative efforts with governments, and (c) the networking of existing initiatives through an effective strategy of limited funding of ongoing or new activities within or outside the rapidly growing CGIAR network. In the period 1974-1985, IBPGR had also organized consultative intergovernmental meetings on plant genetic resources in more than 80 countries (TAC 1986:88). By not working as an initiator or as a technical assistance organization *per se*, but rather as a catalyst, stimulating research and collecting programmes and mobilizing other funding, IBPGR successfully explored its institutional niche in the CGIAR structure.

However, with regard to its significance in the international world network of genebanks outside the CGIAR, some have questioned how much IBPGR, separately from the CGIAR, has added to existing (most often informal) networks among breeders and curators. In the context of the great volume of publications (most often from IBPGR itself and not seldom praising IBPGR's achievements in research, conservation and documentation), as well as the many publications on the long-term achievements of IBPGR[94], some doubt arose about what the global IBPGR network really looks like. This question calls for a closer look at IBPGR's mandate.

Building collections through networking

IBPGR's strength lay in providing targeted financial support for a selected group of national and international genebanks. By integrating these genebanks in an (information) exchange network of institutions which also received support, IBPGR managed to create and maintain standard criteria for the maintenance of collections. The institutions in the network that preserve genetic material on a long-term basis, the base collections, form the core of IBPGR's international network. However, the base collection network (by 1984 consisting of 40 collections in about 30 countries) was not physically established by IBPGR. So, although in 1985 it was stated that: "IBPGR has placed most of its effort in the past to building up a network of base collections so that material is secure for the future" (FAO 1985:2) one should interpret this achievement mainly in terms of **advice and support**, which often remained limited to financing refrigeration of accessions and other equipment while the host government or institution is expected to provide the land and buildings (IBPGR 1984:16). Also with regard to financial donations from IBPGR, it warned against high expectations:

[94] See for example Arora *et al.* 1991; Baum 1986; Holden 1984; Plucknett *et al.* 1987; Williams 1984a,b.

"IBPGR was never established as a grant-awarding body. Therefore, countries and programmes requiring finance, have to look to the normal channels for funding. The Board's funds which are limited in size, are to be used for stimulating urgent work and helping to articulate activities to form a viable network" (FAO 1985:2).

The network approach combined with standardization and regulation of conservation criteria of IBPGR is fully understandable when considering its relatively small budget[95]. With regard to developing countries, this pragmatic approach worked well. As most genebanks in developing countries (and even some in industrialized countries) were structurally underfunded, every dollar was welcomed. Curators of national genebanks in these countries are often confronted with the fact that funding for genebanks is usually only used to balance the national agricultural research budgets. The networking, low-budget approach, however, remained vulnerable in terms of its dependence of the policies of national genebanks. Large genebanks in rich countries could simply neglect IBPGR's demands for free exchange. For example, when the USA was approached by IBPGR to participate in the network of base collections, it agreed to do so. Nevertheless, the USDA indicated that the genetic resources would become the property of the US government. While for many years the USA has generally had a policy of freely exchanging germplasm with most countries, it has allowed political considerations to dictate the exclusion of some countries, for example, Afghanistan, Albania, Cuba, Iran and Libya (Witt 1985; Lacy 1995:338).

The regional approach of IBPGR

In terms of conservation strategies, the direct link with the CGIAR implied that conservation strategies were most of all defined as direct requirements for international agricultural research, instead of those for the local population in developing countries. The 1972 TAC report, for example, stated that "No country can today support an advanced and competitive agriculture based on indigenous plants alone" (TAC 1972:3). In this sense, the report follows the mainstream Green Revolution view of the 1970s, pursuing the idea that landraces could not compete with and therefore inevitably would be replaced by more nutritious or higher-yielding strains. Landraces had to be conserved, but not to become the only basis for further crop improvement. The main function of the genebanks would be to serve international agricultural research stations in their need for landraces and wild relatives which were under threat of replacement by major crops. This 'supply function' scenario also implied that conservation tended to focus on the world's major crops (most of all rice, maize, potato, wheat and sorghum) and constituted a clear break with the FAO Panel of Expert's initial view regarding threat as the first, and the economic importance of a crop as the second, criterion for attention.

How limited the space was for IBPGR to manoeuvre within the the CGIAR network is illustrated by its attempt to establish an alternative networking approach, following the so-called **'regional approach'**. In this approach, the Vavilovian centres of diversity served as a matrix to determine a global division of labour in collecting efforts. In terms of their contribution to the overall achievements of IBPGR, the regional approach historically does not have a prominent place. The question here, however, is (a) why the regional approach in the mid-1970s was recognized as one of the main conservation strategies of IBPGR, and (b) why it disappeared from its agenda in the 1980s.

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[95] IBPGR's budget in 1975 was US$ 730 000, in 1976 US$ 1.3 million and in 1980 around US$ 5 million.

The regional network versus the CGIAR network

In spite of the bad experiences surrounding FAO's plan to organize conservation efforts on the basis of the matrix offered by the Vavilovian centre of crop diversity (see Chapter 1) IBPGR, in 1974, planned to establish several regional centres. Like FAO regions, they would serve regional needs for genetic resources on the one hand (and as such collaborate with national centres), while acting as a distribution point for a worldwide network on the other. Like, for example, the Izmir genebank (supported by FAO), the IBPGR regional genebanks were not to become "simple depositories of seeds or living collections, but active agents in the interchange, evaluation, distribution and eventual utilization in plant breeding programmes of genetic resources, as well as in the promotion of research in fields allied to these activities" (TAC 1972). In this context, it should be noted that the original idea for the regional approach came from a member of the FAO Panel of Experts, Jorge León, who, in the early 1970s, had joined forces with Erna Bennett at the FAO Crop Ecology Unit. Bennett's ideas on the active use of landraces were in line with the original ideas behind the FAO regional approach.

An important difference between IBPGR's regional approach and that of FAO was that it did not focus on the conservation of the total regional diversity. The IBPGR regional centres would follow a much more targeted, mission-oriented approach. The difficulties with the Izmir regional genebank experienced by FAO had left their mark. This might be the reason why plans for the creation of an IBPGR Genetic Resources Support Unit (GRSU) in Turkey were presented with great care. The minutes of IBPGR's third meeting in 1976, for example, explicitly state that "This proposed Unit should be separate and independent from a Turkish national genetic resources programme" (IBPGR 1976:4, 7).

The careful treatment of the regional approach is also reflected in the slow acceptance of the idea by TAC. The first proposal for a regional network was not acceptable to all members of TAC, and therefore had to be redrafted by Frankel, Hawkes and Chang. But the second version also met with criticism from TAC. The final proposal (as redrafted by Swaminathan) showed a much greater overlap between the proposed new regional centres and the existing CGIAR centres than the Panel's version had done, while IBPGR was put in the middle as the "coordinating centre". In this context, it is important to note that at the Beltsville meeting, representatives from CIMMYT (M. Gutierrez) and IRRI (T.T. Chang) were present. Although TAC was of the opinion that CIMMYT and IRRI as well as other CGIAR centres "could not entirely substitute for regional centres since in certain respects they lay outside the main centres of genetic diversity, e.g. CIMMYT for wheat" (TAC 1972), it opted for a plan in which as many regional centres as possible would be covered by existing and new CGIAR centres. TAC concluded that a new regional network had to be set up in "close liaison" with the new CGIAR network (TAC 1972). Therefore, although in initial proposals in the Beltsville meeting the functioning of the planned regional genebanks was not necessarily linked to the CGIAR network, the final outcome was closely in line with its interests.

Political boundaries of the regional approach

Setting up regional networks of genebanks would seem to be a difficult task for an organization that was eager to maintain a politically neutral and scientific status. From the mid-1970s until the early 1980s, several regional centres were set up: in the Mediterranean basin, in southwest Asia (particularly for cereals and pulses), in the Sahelian zone of Africa (particularly for sorghum and millets), in other countries of western Africa (for rice, root and tuber crops and legumes), in the Andean highlands (for quinoa, lupins and the indigenous tuberous crops) and in the countries of southeast Asia (especially for fruits and legumes) (IBPGR 1984:7).

The initial idea was to support the establishment of one large crop-specific genebank per region that would serve as a centre for other, smaller, genebanks. This 'regional centre' would then supply scientific and supporting staff and maintain the central genebank, partly with the support of IBPGR. The boundaries of the region were ecogeographical (mostly overlapping the Vavilovian centres) and could only function when political constraints in collecting and exchange were not involved. This stance was taken in the agreements IBPGR established with governments of specific countries. These governments were to adjure genebanks to "guarantee complete freedom for the collection of materials and their exchange according to specific quarantine regulations" (IBPGR 1984:7).

IBPGR's regional approach was under political pressure almost from its inception in the early 1970s. Most countries did not have national genebanks and were often unfamiliar with the very idea of exchange of genetic resources. This added support to the opinion that, although IBPGR's regional approach was scientifically justifiable, it was not backed by political reality. The political vulnerability of the regional approach, which was mainly based on voluntary agreements between the institutes involved, was soon apparent. In cases in which material could be easily duplicated (like fruit species exchanged among the southeast Asian countries), the enthusiasm for cooperation of countries with conflicting commercial interest declined and distrust started to gain ground.

In the cases where a central regional genebank was available, supplying countries suspected the recipient of not following a transparent exchange policy (van Sloten 1995, personal interview). Trevor Williams (1984b:6) comments that: "Not all regional programmes were fully successful ... That in southwest Asia was fraught with political difficulties". IBPGR soon concluded that the agreed strategy "was not practicable" (IBPGR 1984:25), at least not in comparison with the CGIAR network:

> The idea of a regional centre in one country serving several other countries in the same region is often not acceptable to the latter countries, at least [not] until each has sufficient national strength to assure that it does not become dependent on an institution outside its borders. Nor is it easy, even where national strength exists, to reach agreement on the location or the financing of a regional centre (IBPGR 1984:25).

L. Kåhre who, after Richard Demuth,[96] was the second Chairman of IBPGR in the early 1980s, comments:

> [W]hen the IBPGR was established it was thought that a limited number of regional genebanks would be sufficient to serve the world. We soon had to revise our ideas. Regional genebanks do not always function because of national sensitivities and the ultimate participants are individual countries. Each country, may, of course, hold material of interest to several other countries, but the formal regional concept does not always work (Kåhre 1983:4).

In consequence, IBPGR "necessarily accepted" (IBPGR 1984:25) that it had to look first to existing, functional programmes, rather than set up regionally centralized operational units without a precedent. So, although a region's richness in genetic resources was initially considered as a primary criterion for a new network of collections, the creation of new cooperative structures on the basis of existing infrastructures of national and international (CGIAR) genebanks ultimately determined the organization of the new global network of IBPGR.

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[96] For a review of and comments on the role of Demuth in the establishment of IBPGR, see Baum 1986, and Fowler and Mooney 1990.

However, the problematic experiences in regional cooperation in the second half of the 1970s should not be regarded as the only factor that strengthened IBPGR's ties with the other CGIAR Centres. CGIAR's strong financial backing (at least compared with most national programmes) contributed to a pragmatic approach due to a "lack of any major international finance other than that mobilized through the CGIAR" (Williams 1984b:7). However, as mentioned above, funds for IBPGR from the CGIAR were not very large either. Thus, IBPGR received just enough donor finance to fulfil a networking function within the CGIAR system (in the late 1970s less than US$ 5 million per year), but not enough to create a new network of its own. The establishment of new genebanks (sometimes with a regional function) was left to the initiative of individual donors, for example, the initiative of the German Agency for Technical Cooperation (GTZ) to build the Ethiopian and Costa Rican Plant Genetic Resources Centres and, later, the genebank in Kenya.

Difficult years: FAO and IBPGR under one roof

Throughout the 1960s and early 1970s, the handling and collecting of genetic resources at FAO had been organized by the Crop Ecology Unit. In 1974, the FAO Unit was transformed into the FAO Crop Ecology and Genetic Resources Unit. In 1982, again another name was used: the FAO Crop Genetic Resources Centre. These changes not only reflect the involvement of IBPGR as an institute concentrated on 'genetic resources' but more the general shift in agricultural research towards various forms of advanced breeding and biotechnology. Thus, genetic resources, rather than seed introduction and distribution, became the new focus. However, the difference between the units of IBPGR and FAO was not only of a technical nature. The FAO unit in Rome which distributed seeds within its own network of national research centres was a different world from the rapidly expanding network of international centres of the CGIAR for the exchange of genetic resources.

The relationship between FAO and IBPGR has received much attention in terms of a rather simplistic 'IBPGR versus FAO' dichotomy. The scientific and institutional background of this conflict, however, has seldom been treated, and reveals a more complex picture in which not only controversies but also mutual interests appear.

It should be remembered that it was the FAO Panel of Experts which submitted a proposal to TAC in October 1971 (FAO 1989:2). Since the Panel operated within the FAO bureaucracy between 1967 and 1974, it was considered a logical fact that a new world network would be placed under the FAO umbrella. Beltsville was especially important because it prevented this from happening.

Staff of the FAO Crop Ecology Unit (and the later Crop Ecology and Genetic Resources Unit) were eager to preserve the status of FAO as a multilateral organization independent of the influence of selected donors. An overlap of interests of FAO and the CGIAR was unacceptable. Erna Bennett was one of the most outspoken opponents:

> As for the corporate pressures within FAO, they were both diffuse and powerful. The major so-called 'donor' states, that is, the states contributing most to the UN/FAO system, which I prefer to call investor states ... and their interest in the internal activity of the FAO Plant Division [part of which was the Crop Ecology Unit] was intense ... Beltsville took away the carpet from under our feet (Bennett 1994, personal interview).

Erna Bennett was convinced that the public character of FAO as a UN organization had to be defended against the influence of the CGIAR which received its funds from organizations with corporate interests in agriculture (for example, the Rockefeller and Ford Foundation, the Kellogg Foundation and the World Bank). For Bennett, the debate on the conservation of plant genetic resources had to remain "free from corporate influences" and within the realm of the United Nations. To Bennett, close contacts with the CGIAR were a sign that FAO had started to lose control over the exchange and use of genetic resources (Bennett 1994, personal interview). Bennett doubted if the FAO Panel of Experts would be inclined or able to keep the initiative for a world network under FAO. But since the efforts of Frankel and other Panel members to stimulate FAO to set up a world network had not been very successful, Frankel was highly motivated to get any form of finance and organizational backing, within or outside FAO. TAC's report of the 1972 Beltsville meeting clearly evokes the Panel's frustration, and was used by TAC to motivate their financial support for an initiative independent of FAO:

> The FAO Unit has been assisted by an international advisory Panel of Experts. This Panel has repeatedly stressed the inadequacy of resources to enable the Unit to fulfil its mandate effectively, and this was one of the main reasons for submitting a proposal to TAC for independent support to complement its activities (TAC 1972:10).

As became apparent during the Beltsville meeting, the CGIAR, on the basis of the advice of TAC, was prepared to cover the "probable costs of such a programme" (US$ 5.4 million for the first five years) without much hesitation. For some Panel members, the CGIAR offer was 'unrepeatable'. In economic terms the offer, considering the general lack of funds within the United Nations, was generous and FAO would receive an in-house world networking institution almost free. But the political price was higher: IBPGR would be created as an independent entity within FAO headquarters, while FAO would provide a small secretariat. Funds from the CGIAR to IBPGR would be channelled through a Trust Fund. Although the Trust Fund was administered by FAO without charge, its disposition was to be put entirely under the control of IBPGR. Besides, FAO would be represented by only one non-voting member on the IBPGR Board (FAO 1989:2).

Why did FAO not fund a world network of its own, in spite of the pressure from the Panel of Experts in the late 1960s? Ex-Panel members, particularly Otto Frankel, speak of a complete lack of interest within FAO circles. Indeed, the state of urgency with regard to genetic erosion, and the inability of the Panel to set up a network on the short term in cooperation with FAO and through the 1972 Stockholm Conference, must have added much to the willingness of the Panel to cooperate with a strong international agricultural network with more financial resources than FAO. As Harlan stated: "It must be admitted that for all the organizational development, and despite repeated and urgent pleas by the Panel of Experts, remarkably little collecting [by FAO] has been done to date" (Harlan 1975). Frankel even attributed the establishment of IBPGR to the lack of action from the side of FAO: "IBPGR would not have been established had FAO shown strong determination for concerted action to establish a genetic resources programme. IBPGR originated not in competition, but out of frustration with FAO" (Frankel 1985).[97] In the words of Bommer (1990:6):

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[97] Another even more articulated version is given by Hawkes (an active member in the Beltsville Meeting and one of the world's most renowned potato gene experts): "None of [the Panel of Experts'] recommendations, however good, were implemented because for some reason or another, FAO never seemed to find the funds. In fact, by 1971, FAO itself realized it couldn't fund this kind of activity, so it looked to the newly established Consultative Group to see what it could do" (Juma 1989:86-90).

> Having been member of all the bodies involved, the Beltsville group, TAC, and the subcommittees of TAC and the CGIAR, I remember the challenges involved, the various interests and pressures before the IBPGR came into being. There was a strong move to ensure self-governance and independence from FAO including the Panel.

Why others within FAO did not start to form a network also has to do with other, more structural, financial reasons. José Esquinas-Alcázar (Secretary of the FAO Commission on Plant Genetic Resources)[98] explains the situation in the early 1970s as follows:

> "In the 1950s and 1960s, genetic resources were largely discussed in technical terms. But as soon as the main technical issues began to be addressed, financial problems emerged (especially for FAO). Delegates from some developing countries felt they simply could not give financial priority from the regular core budget of the organization to an issue such as genetic resources, of main interest for future generations (as the industrialized countries could), when people in their home countries were often under immediate threat of starvation. Shifts in the FAO budget were therefore not favoured, and extra resources had to be sought as extra-budgetary funds" (Esquinas-Alcázar 1995, personal interview).

The financial argument, however, should also be connected to the institutional interests of the CGIAR and the donors. The Rockefeller and Ford Foundations, the prime financial sources of the CGIAR at that time and generators of the Green Revolution, and later also the World Bank were eager to allocate the necessary funds to secure the supply of genetic resources for agricultural research in the future. The financial argument is closely related to one of sheer political interests. As Esquinas-Alcázar comments: "The demand for extrabudgetary funds meant that the initiative tended to be pushed towards a few rich countries, and the donors then naturally sought more control over funds for genetic resource conservation" (Esquinas-Alcázar 1995, personal interview). Conservation of genetic resources by FAO would have implied a centralized coordination of the work.

Management problems

Organizational difficulties as described above would be unlikely to form an ideal basis for collaboration at the FAO headquarters where, between 1974 and 1987, both IBPGR and the FAO Plant Genetic Resources Centre (formerly the FAO Crop Ecology and Genetic Resources Unit) were located. In the beginning of the collaboration, only a few staff members could be paid directly by FAO Regular Programme funds. These were R.J. Pichel, T. Sykes, Erna Bennett (who resigned from FAO in 1981), José Esquinas-Alcázar (employed by FAO from 1979) and Dick van Sloten (employed by FAO from 1980). Owing to the formal cooperation between FAO and IBPGR, Pichel was both Chief of the FAO Plant Genetic Resources Centre, as well as the Executive Secretary of IBPGR. Pichel's supervision was not a success, and in 1979 he was replaced by Trevor Williams. Under Williams' directorship the tensions between FAO and IBPGR rose even more. While Pichel was an FAO employee to whom genetic resources conservation and use were 'business as usual', Williams took the creation of a world network seriously, had good contacts with important donors of IBPGR, notably the USA and the UK, and had worked with students from developing countries whilst in Birmingham.

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[98] José Esquinas-Alcázar was employed in 1979 by FAO and was closely involved in the FAO/IBPGR relationship. Later in 1983, he was appointed Secretary of the FAO Commission on Plant Genetic Resources.

The change of directorship influenced day-to-day collaboration between the FAO Centre and IBPGR, especially in the growth period of IBPGR in the 1980s. Although FAO initially provided the Secretariat of IBPGR, CGIAR support to IBPGR in 1982/83 was already ten times greater than FAO could provide to both IBPGR and its Plant Genetic Resources Centre: US$ 7.9 million came from the CGIAR and US$ 714 000 from FAO. In the early 1980s, IBPGR staff grew much faster than the regular staff FAO affiliated to the Genetic Resources Centre. New IBPGR employees, although working at the FAO headquarters, did not feel strongly affiliated with the Organization. IBPGR started to create its own agenda.

The gap between FAO and IBPGR increased when Williams was accused of strengthening bilateral ties with the most important donors, less through usual FAO channels than directly through their embassies (notably that of the USA).[99] From FAO's viewpoint, Williams' actions posed a direct threat to its relationship with IBPGR. Williams (1996, pers. comm.) contests that he at that time "... was not able to enter [into] independent bilateral ties ..." and "... had to work through the embassies to FAO to maintain good donor links especially to maintain funding ..." while "All the links to FAO embassies were through the FAO representatives". Formally, the fact that the FAO Unit and IBPGR were housed together at the FAO headquarters had to symbolize the joint interest in creating a world network. This joint interest was further underlined by the dual position of Williams, who was both Executive Secretary of IBPGR and Chief of the FAO Plant Genetic Resources Centre. As Chief of the FAO Centre, Williams had to report through the FAO administrative structure. Meanwhile (as executive officer of IBPGR) he reported to the Board of Trustees of IBPGR on matters affecting IBPGR activities. A TAC report of 1986 reports the following about this situation:

> This dual reporting is usually a serious disadvantage in an organization, but, occasionally, it can work satisfactorily if there is a great deal of understanding, tolerance and goodwill on the part of both organizations. In the case of IBPGR, the Board [of Trustees] is uncomfortable with the arrangement, the Executive Secretary is stressed by it and FAO indicates dissatisfaction with some aspects of the interface activity (TAC 1986).[100]

By pursuing direct relationships with donors, Williams, in the opinion of FAO officials, had shown his hand. In a later personal comment Williams states that many other IBPGR employees suffered from FAO bureaucracy as well (Williams 1995, personal interview). Although an organizational separation had been in the air almost from the beginning of the 1980s, the above statement by TAC, in 1986, was the first official sign that this was indeed going to happen soon.[101] In the first half of the 1980s, the informal communication between

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[99] Williams, in a letter to George White of the USDA, stated: "As far as the IBPGR is concerned, all genetic resources samples entering the USA enter the USA germplasm system." (Williams *op cit.* Fowler 1994:186). In a later comment Williams (1996, pers. Comm.) adds that "This is only part of the facts. This statement was made, not so that the material would become US property pure and simple, but because the USDA system needed to regard it as such for national insurance purposes. Also, it was to enter the national system to avoid it being dumped in a seed store as a black box, which is what happened previously".

[100] The TAC, in an additional comment, stated that the "Executive Secretary is working far beyond reasonable limits," and that "the corporate memory is too dependent on one individual [Williams], introducing unnecessary risk for the organization" (TAC 1986:24).

[101] Another previous sign was aired in the minutes of the Twelfth IBPGR Board Meeting (February 1985).

FAO and IBPGR on their relationship had already been intense. On 9 and 10 February 1984, the IBPGR Executive Committee met with the IBPGR External Programme and Management Review Panel[102] at the FAO headquarters in Rome. Part of the agenda was the relationship with FAO. During the meeting the Panel emphasized the:

> ... necessity for the IBPGR Secretariat to have a higher degree of autonomy within FAO and its dual accountability to the Board and to FAO, the unavoidability of increased space and FAO procedures which constrain IBPGR's operational effectiveness. As these problems cannot be resolved by FAO/IBPGR action, the Panel examined new structures for IBPGR and suggests that the CGIAR sets up a special task force to solve uncertainties and make final recommendations (IBPGR 1985a:2).

The pressure from the IBPGR Board, and the formal support of TAC for IBPGR in its quest for autonomy had several important implications (FAO 1989:3-4):

(a) A different staffing structure for IBPGR was adopted, in particular to strengthen its new focus on research.
(b) Trevor Williams became Director of IBPGR (instead of Executive Secretary), emphasizing IBPGR's autonomy.
(c) A Memorandum of Understanding between FAO and IBPGR was signed in February 1987. According to the Memorandum, IBPGR would take over the funding of the few staff members (hitherto paid directly by the FAO Regular Programme).
(d) The IBPGR Board of Trustees would become the only institution to which the IBPGR Director had to report.

The final step to complete its formal autonomy was made by IBPGR in 1988 when it made an offer to FAO to pay for all its own costs, including the allotted space for its headquarters, "due to the financial situation of FAO and increasing autonomy requested by IBPGR" (FAO 1989:4). This point emphasizes another reason for the separation, namely the financial and political power of IBPGR's donors. However, in spite of the new regulations and the Memorandum of Understanding, IBPGR personnel officially remained FAO staff members (and would remain so until early 1994).

The formal separation between IBPGR and FAO in the period 1987-89, systematized by the Memorandum, cleared the way for yet another IBPGR step: the physical separation between IBPGR and FAO headquarters. It was announced that IBPGR had made enquiries in Denmark, Switzerland and Italy to become its host country. Italy and Switzerland did not react, but the Government of Denmark "reacted favourably" (FAO 1989:4) and suggested that IBPGR should come to Copenhagen. In February 1989, the Board of Trustees, under the Chairmanship of W.J. Peacock, decided to follow this suggestion. However, the plan to move to Copenhagen soon became one of the most hotly debated issues in the history of IBPGR. The issue was raised again at the third meeting in April 1989 of the FAO Commission on Plant Genetic Resources (CPGR, see Chapter 5). The CPGR expressed its surprise at IBPGR's intention. IBPGR's new Chairman, W.E. Tossell, from Canada, justified the move by referring to the need: (a) to develop IBPGR's research capacities, and (b) to increase IBPGR's financial strength. Delegates from most countries (including important donors such as Germany and Italy) understood the limited relevance of these arguments and realized that a move of IBPGR to Copenhagen would create a

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[102] Consisting of Messrs. M.F. Day (Chairman), J.H. Barton, J.J. Hardon, W. Tossell, A. von der Pahlen and D.L. Plucknett and S. Ozgediz from the CGIAR Secretariat and Mr L.H.J. Ochtman from the TAC Secretariat (IBPGR 1985a:1).

political disaster. Ultimately, a compromise was found: IBPGR would leave the FAO headquarters but would remain in Rome.

Conclusions and Summary

The early 1970s is marked by a plethora of developments all pointing in the direction of a world network of genebanks. One can summarize it in terms of a race between the FAO and the CGIAR network. Indeed, although there was already some awareness of the problems related to the involvement of donor-oriented CGIAR policies in the early 1970s, their impact would reach the surface only a decade later, when FAO's modest institutional network had been set aside by the CGIAR network, leaving FAO no other option but to focus on the international regulation of gene exchange (see also Chapter 5).

The other important development was that, although the idea of the core group of scientists who had been involved in the 1967 Conference gained ground, they themselves did not participate in the exploration of their ideas in spite of the guidelines that came out of the 1973 Technical Conference (and summarized in Frankel and Hawkes 1975)

The first sign of this development was the replacement of the activities of the Panel of Experts by IBPGR. This outcome was an unexpected side-effect of the Beltsville meeting of 1972 which had quite suddenly offered what the Panel had wanted for so long: financial backing and an infrastructure to develop a worldwide *ex situ* network.[103] The arrangements made during the Beltsville meeting in 1972, organized by CGIAR-TAC, led to the establishment of IBPGR as a formally integrated but in practice independent institution within FAO. But after a decade of successful networking, IBPGR started to realize that it could function just as well without the legal and institutional umbrella of FAO. This realization, in combination with the initiatives of Trevor Williams as IBPGR's Executive Secretary, disturbed the weak balance between FAO and IBPGR. But until the mid-1980s, FAO could offer IBPGR three valuable things:

1. an organizational context to operate as an international agency to set up a large collecting and networking effort (it should be remembered that IBPGR was a non-governmental organization);
2. almost 30 years of collecting experience (see Chapter 1): FAO country programmes provided the much needed administrative support for IBPGR field projects, and
3. international status in the Third World.

Also, as Hawkes (1996, pers. comm.) recalls:

> "IBPGR might probably never have existed, or at least not in its present form, if FAO had not seen the need for conserving the genetic resources of crops and had not set up a Panel of Experts to provide the necessary scientific basis for this to be undertaken".

IBPGR, on the other hand, offered FAO the financial support and manpower to build up and coordinate a new world network of genebanks. However, the successful growth of IBPGR contributed to its desire to act as an independent institution. If there had been a pragmatic reason for collaborating with FAO (formal access to genetic resources in FAO member countries), IBPGR's own network had reduced the value of such a connection, thus contributing to IBPGR's separation from FAO. But apart from a 'push-factor', there

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[103] It should be noted that another FAO Panel of Experts had been established in 1968: The FAO Panel of Experts on Forest Gene Resources. Owing to its more limited mandate, this group of experts played a politically less important role than the Panel of Experts on Plant Exploration and Introduction. At that time, the CGIAR had no programme on forestry.

also was a 'pull-factor': the institutional backing provided by the CGIAR. IBPGR, in spite of its position as one of the CGIAR institutes, remained financially tied to its donors represented in TAC. The various TAC reports (especially that of 1986) decisively influenced IBPGR's institutional and conservation policies.

The separation of IBPGR's and FAO's conservation programmes in 1987 would never have received so much attention within and outside circles of NGOs if IBPGR had not been able to become the world's primary intermediary between existing national and international genebanks. However, neither would there have been a clash between IBPGR and FAO if FAO had not successfully taken up the task of setting international legal parameters for the use and conservation of genetic resources in an earlier phase. The next chapter will focus on FAO's more recent achievement, the formulation of the legal and institutional parameters for the regulation and exchange of genetic resources.

5 Conservation and use of genetic resources in two political arenas

Chapters 1, 2 and 4 dealt with institutional aspects of the history of the conservation and use of genetic resources: the FAO 1961 Technical Meeting, the 1967 and 1973 FAO/IBP Technical Conferences and the 1972 Beltsville meeting. While, during the 1961, 1967 and 1973 Conferences, scientific principles were developed for the conservation of genetic resources, the 1972 Beltsville meeting linked financial and institutional support to these principles. The Beltsville meeting was mainly motivated by the growing awareness among scientists of the dangers of genetic erosion and the potential consequences for agriculture. Wide recognition of the ecological dimension of the problem of genetic erosion was still to come. Stockholm 1972 in this respect did not alter the situation much. But the care for genetic resources was not only motivated by fear of erosion. There was also a direct interest in conservation for agricultural research because agricultural research in the IARC/CGIAR network demanded a constant flow of genetic resources for crop improvement. In the 1980s, this demand increased as a result of rapid developments in the biotechnology industry.

While during the late 1960s and 1970s concern for the conservation of genetic resources was mainly treated within the realm of agriculture, a rise of 'environmentalism' came only during the mid-1980s. Thus, at the end of the 1980s, during the preparation period for the UN Conference on Environment and Development (UNCED) in Rio de Janeiro (1992), genetic resources were dealt with in **two** arenas, instead of only **one**. These were:

1. the agricultural arena, as represented by FAO and IBPGR, and
2. the environmental arena, as represented by the United Nations Environment Programme (UNEP), the International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wide Fund for Nature (WWF).

The relationship between these two arenas and, particularly, their relative political strengths will be the subject of this chapter.

The 'Genetic Resources Issue' Versus the 'Biodiversity Issue'

While the success of the 1972 Beltsville meeting put genetic resources on the international political map, it brought the **genetic resources issue** outside the scientific realm into the field of 'donor' politics which made it more susceptible to criticism by pressure groups. Assessing the agricultural-economic value of genetic resources had an important side effect. Public attention for the crucial importance of genetic resources for agricultural development and food security generated considerable discussion among social scientists and NGOs on **control over** genetic resources. These discussions not only questioned the scientific merit of the **use** of genetic resources, but also the institutes that stored seeds that could contain useful genes. In this chapter, the political discussions will be treated as part of the genetic resources issue. These discussions had a strong North versus South dimension: the fact that plant genetic resources of agricultural interest are mostly concentrated in the tropical and subtropical developing countries (South), while the users and conserving institutions were mainly Northern, contributed to this conflict. The most important forum for this discussion was FAO although IBPGR often became the focus of discussion.

Although the genetic resources issue dominated public discussion on genetic resources from the beginning of the 1980s, the conservationist/environmental context gradually became part of the public concern as well. This concern focused mainly on the maintenance of genetic resources as a necessity for preserving the earth's biological diversity for future generations. The **biodiversity issue** differed from the genetic resources issue in the sense that (at least initially) biodiversity issues did not primarily focus on the agricultural-economic value and use of genetic resources. Hence biodiversity issues tended to be treated in a less contentious political context. Only much later, in the 1990s with the rise of initiatives such as 'biodiversity prospecting', did biodiversity issues become part of the North-South dicotomy.

The construction of the genetic resources issue

The genetic resources issue is primarily about power relationships between countries and institutions with different abilities in respect of having access to and use of genetic resources. The issue, as it appeared in 1979, remained anchored in the institutional setting created by FAO and IBPGR, although a few prior external conditions can be held responsible for the persistence of the genetic resources issue within FAO.

Historically, the genetic resources issue fits well into the existing premises that were brought to bear against international agricultural research institutes. These premises are related to the long-standing social justice-oriented view of Third World poverty and underdevelopment, in which mass poverty is considered to be the result of oppressive social structures and social policies invoked in the interests of dominant groups (Buttel 1992). These discussions generated significant institutional political impact when the Group of 77 developing countries proclaimed a New International Economic Order (NIEO) in several UN fora, among them FAO, in the late 1960s and 1970s. But although the genetic resources issue was an important one on the NIEO agenda, it also was one of the last.

One of the driving forces behind the political awareness of control over genetic resources among the members of the Group of 77 was a selected group of NGOs, with the Rural Advancement Foundation International (RAFI, registered in Canada and the USA) particularly conspicuous. Its constant lobbying within FAO against the North's dominance in the exchange and use of genetic resources and against the neglect of the rights and needs of small farmers, helped to shape the genetic resources issue as it stood throughout the 1980s. In the early 1980s, RAFI's Director, Pat Mooney, started to supply representatives of developing countries with information on their position in the global exchange and use of genetic resources.

Mooney was the first to identify the political power of the users of genetic resources: rich industrial countries, their multinational corporations, privileged social classes, and the government and quasi-government (for example, the CGIAR) officials that comfortably supported them. It became equally clear that the victims were Third World countries and smallholder farmers. The effect of Mooney's criticism within UN circles partly relied on his ability to oppose his antagonists with exactly the same weapons as those with which they usually fought back: facts and figures. Data assembled by RAFI staff members were widely distributed among NGOs, scientists and decision-makers. Mooney gave weight to the argument that genetic resources are a strategic commodity instead of a freely exchangeable public good, by making (rough) calculations of their value for the Northern agro-industry, particularly the biotechnological sector. Pointing out the value of a formerly unassessed good cleared the way for more research on the 'commoditization of genetic resources'. Mooney, in Seeds of the Earth: A Private or Public Resource? (1979), offered the first ingredients for the conceptualization of the economic value of genetic resources for the Northern agro-industry by defending the views that:

- genetic resources are instrumental in capital accumulation;

- corporate actors had an interest in protecting genetic resources through the industrial patent system;
- the control over genetic resources both in the public and private sector, and in terms of conservation and use, is not transparent and hence is detrimental to developing countries.

Seeds of the Earth still stands out as one of the most thought-provoking publications in the field of agricultural politics, and provided many NGOs with fresh ammunition in the battle against seed multinationals and agricultural bureaucrats. In Mooney's second publication, The Law of the Seed (1983), the debate on genetic resources was further transformed into one on the loss of and access to plant genetic resources – again with a strong emphasis on the socioeconomic impact of breeding and new biotechnologies.

In the 1980s, RAFI under Mooney had not only developed into a major critic of genetic resources issues, but had also become actively involved in international arguments on the conservation, use and access to genetic resources. Mooney, and later also Cary Fowler, carried out campaigns and speaking tours in many countries; encouraged FAO to establish the Commission on Plant Genetic Resources (CPGR) (see below); lobbied for the adoption of Farmers' Rights by the CPGR; supported the call for the FAO International Fund for Plant Genetic Resources, and participated in the Keystone International Dialogue on Plant Genetic Resources (an off-the-record negotiation between governments, NGOs and industry). They also played a role in encouraging the US government to join the CPGR and the Undertaking on Plant Genetic Resources.[104] In 1990, Fowler and Mooney put their experiences together in the publication Shattering: Food Politics, and the Loss of Genetic Diversity (1990).

Another important source of information for NGOs came in 1988 when Henk Hobbelink (of Genetic Resources Action International, GRAIN) published New Hope or False Promise: Biotechnology and Third World Agriculture[105] (1987). Hobbelink, in 1984, started working at the International Coalition for Development Action (ICDA) after Mooney had left to coordinate RAFI's activities. ICDA has been particularly successful in networking among many NGOs and individuals in campaigns supporting the free exchange and decentralized (*in situ*) conservation of genetic resources. ICDA (renamed Genetic Resources Action International in 1990),[106] like RAFI, concentrated on influencing public opinion and mobilizing critical (NGO) representatives from developing countries both within and outside the UN. Today's widespread awareness among NGOs on genetic resources issues can be mainly attributed to the pioneering work of ICDA/GRAIN and RAFI.

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104 In 1986, RAFI launched the RAFI Communique, an irregular series exploring the impact of biotechnology on specific Third World commodities.

105 New Hope or False Promise, Biotechnology and Third World Agriculture in 1990 appeared in a fully updated version under a new title: Biotechnology and the Future of World Agriculture, also by Henk Hobbelink.

106 The objectives of GRAIN (ICDA) are: (a) to stimulate public awareness and concern about the vanishing resource base of agriculture; (b) to increase understanding of the structural causes behind genetic erosion, and its implications for the poor; (c) to stimulate activities and policies that lead to a better conservation of genetic diversity with special focus on the interests of developing countries and small farmers; and (d) to support the activities of public interest groups that are working on these issues and to facilitate communication and co-operation between them (Hobbelink 1990). GRAIN publishes its findings on these issues in Seedling, a bimonthly newsletter.

Scientists hit back

An often neglected factor contributing to the genetic resources issue was that breeders, geneticists and representatives of the agro-industry and genebanks gradually started to participate in the debates. Their arguments were often based on the conviction that, because genetic resources were highly important in safeguarding international food production, the treatment of such resources as strategic economic resources would hinder scientific progress in both public and private research institutes. The use of genetic resources 'to save the millions' therefore had to be treated as a scientific, politically neutral and freely exchangeable good, from which developing countries could or would benefit even more than industrialized countries.

In 1986, IBPGR stated: "[IBPGR] has always been at great pains to adopt an apolitical stance in the setting up of its network and emphasized its continued adherence to this principle. The IBPGR is a scientific and technical body" (TAC 1986:xxxiii). This argument was used in particular to counter critical remarks on CGIAR's policies on conservation and use since these arguments would strengthen the North-South gap in the control over genetic resources.

Scientists within the CGIAR network tried to convince their critics that the results from the research in the CGIAR Centres mostly benefited developing countries and that the access to the genetic resources in their genebanks was excellent. RAFI and GRAIN, however, reacted to these arguments by saying that the CGIAR Centres were the main driving forces behind the Green Revolution, the creators of monocrops and, implicitly, the main contributors to genetic erosion. The argument of free exchange was countered by publications about embargoes on the export of genetic resources by industrialized countries (particularly the USA) that had affected the free exchange of genetic resources (see, for example, Fowler and Mooney 1990:193, 197). Some of the most severe criticism of the CGIAR system was targeted on IBPGR. David Wood, then of CIAT, wrote an open letter in 1987 to genebank directors in the system claiming that "There is a relation between the amount a country donates to IBPGR, and the number of collections designated to that country by IBPGR" (Wood *op. cit.*, Fowler 1994:185). In a later comment Wood adds: "The situation at the time was a 'turf battle' between the CGIAR genebanks and IBPGR for influence and funding, and I was trying to show that the genebanks were a more responsible mechanism than was IBPGR." (Wood 1995, pers. comm.).

However, there were a few occasions on which scientists publicly took issue. In 1988, in a contribution to Kloppenburg's Seeds and Sovereignty, Otto Frankel specified his protest with regard to the genetic resources issue as follows: (a) rich countries do not "rob" poor countries of their genetic resources, these countries take only small samples and, since IBPGR, these samples are shared with the host country; (b) indigenous landraces have been replaced by Green Revolution cultivars without which "Asia and Latin America would still be starving as they did", and (c) it is "palpably untrue" that IBPGR supports rich countries at the expense of developing countries (Frankel 1988:40, 41).

Another issue concentrated on the extent to which there were embargoes on the export of genetic resources. Cases in which developing countries (such as Ethiopia with coffee) had violated the international codes of free exchange were used to illustrate that it was not only the US that had mixed political with scientific interests.

Wood argues that RAFI's campaigns were wrongly targeted. The US seed companies (a major source of technology transfer to developing countries) should not have been the focus of the RAFI campaigns, but rather the US agricultural exporters that (with extensive governmental subsidies) flooded developing countries with cheap grain, depriving farmers in those countries of opportunities to generate their own income.

Interdisciplinary involvement in the genetic resources issue

The genetic resources issue, especially in the late 1980s, started to receive considerable attention from historians and social scientists, who were later accompanied by anthropologists, biologists and economists. In 1979, Lucile Brockway, a British historian, published Science and Colonial Expansion: The Role of the British Botanic Gardens (Brockway 1979; 1988:49, 66). Brockway's book offers a description of the connection between British colonial interests and the global botanical garden network controlled through the Royal Botanic Gardens, Kew. Her analysis showed how the network of 19th century British botanical gardens took over much of the work of exploring and collecting from individual 'plant hunters' and how it acquired the technical ability to improve and adapt plants for commercial production. The network system was referred to as the "botanical chess game" through which the exchange of plant material between the two hemispheres was coordinated. The result was a global division of labour in agriculture dominated by the North (Brockway 1988:49, 52).

Another, and equally important, analysis on the basis of the centre-periphery model came eight years later, in 1988, when Jack Kloppenburg published First the Seed: The Political Economy of Plant Biotechnology, and Seeds of Sovereignty: The Use and Control of Plant Genetic Resources (Kloppenburg 1988a, 1988b). First the Seed elaborated on Brockway's and Mooney's pioneering work on the historical and new interests of the agro-industry and the public research sector (mainly the US public research institutes and CGIAR) in the control over genetic resources. Kloppenburg also showed the interrelatedness of the use of intellectual property rights issues and the development of advanced breeding and biotechnology, calling it the 'commoditization' of the use of genetic resources. Both issues were analyzed in terms of the conflicting interests between the dominant (public and private) actors in the centre versus the weaker ones (mainly farmers) on the periphery.

However, with regard to a third discussion point, the global exchange of genetic resources, Kloppenburg did not follow the centre-periphery model. By using FAO data on crop production and linking these figures to a modified version of the Vavilov centres of diversity, he emphasized a **global interdependence** of all these centres for future food and industrial crop germplasm requirements instead of a North-South gene drain. The outcome revealed that even the genetically most self-sufficient centres, such as west and central Asia, look to other centres for almost a third of their basic food germplasm.

Fowler and Mooney (1990), however, assert that Kloppenburg's figures were easy picking for the defenders of the dominant international (CGIAR) genebank structure,[107] but also false. Fowler and Mooney attributed a much higher level of self-sufficiency to African and Asian countries in terms of utilization of directly available genetic material than Kloppenburg had done, because (a) poor farmers in these countries were surrounded by much greater variability, and (b) they generally look to a wider range of crops (for example teff in Ethiopia, African rice in Senegal) (Fowler and Mooney 1990:199).

Defining the genetic resources issue

It is not possible to give a single definition of the 'genetic resources issue' as it consists of many different aspects and can be presented in many different types of analysis, with

[107] (..) the North has used Kloppenburg's figures in a "divide and rule" strategy to insist that some Third World regions would be disadvantaged by a "centres of origin" approach to assigning benefits to those who "donate" genetic resources. They claim that even the less well-endowed Third World regions benefit from the current system. But that interpretation of the Kloppenburg table does not reflect either political or practical realities"(Fowler and Mooney 1990:199).

many different historical connotations. However, the main points can be roughly summarized as follows ("a" is a criticism, "b" a counter-criticism):

1a. The Northern countries are 'gene poor' while those in the South are 'gene rich'. The North is 'technology rich' while the South is 'technology poor'. The Green Revolution and current (biotechnology) research has widened this gap.
versus
1b. To limit the negative consequences of this dichotomy, the North has created the global network of IARCs, including those of CGIAR. The Green Revolution crops which came out of the research of these networks have saved millions of people.

2a. The importation of advanced breeding lines from the North into the South replaces traditional landraces and contributes to a greater yield in the short run, if supplied with enough inputs, but causes unstable and/or lower yields in the long run.
versus
2b. The importation of advanced breeding lines from the North into the South did replace traditional landraces but substantially contributed to long-term higher yields. Agricultural development has to result in the replacement of diverse ancestral crop varieties by improved varieties.

3a. The value of genetic resources in agricultural improvement in developing countries is misunderstood and underrated. Farmers have identified and classified valuable genetic material in landraces (often according to indigenous taxonomic systems), selected them, bred them and named them.
versus
3b. Genetic resources that are used in the agro-industry in the North are derived from specific agricultural systems that are underdeveloped, agriculturally marginal and poorly controlled by farmers. The landraces have no direct value for crop improvement in agro-industry and, in most cases, are not consciously selected, bred or named.

4a. Farmers in developing countries are not rewarded for their contribution to the North's agricultural production since landraces are considered to be freely available. The patent system in the North leaves no room for reward for landraces.
versus
4b. Research on crop improvement will be seriously hindered when the principle of free availability of genetic resources worldwide is abandoned. It is almost impossible to trace what the specific contribution of landraces or related wild species has been to an advanced breeding line.

5a. The North controls not only the use of genetic resources but also the collection and exchange of genetic resources. The North favours centralized genebank systems which limits the South's access to them.
versus
5b. Genetic resources in the IARC, CGIAR Centres and most Western genebanks are freely available, while the South benefits from the know-how and technical assistance offered for free through these institutions. When genetic resources are collected, duplicates are always left behind in the country of origin.

6a. The agro-industry, mostly dominated by the North, protects its products through property rights even though the basic material for these products often originates from the South.
versus
6b. The North's investments in research on genetic resources can only continue when intellectual property is recognized worldwide. 'Unimproved material' from the South has no real value for agro-industry, but is freely available to the South.

In spite of these controversies, discussions among authors of various disciplines on genetic resources issues contributed to a limited set of core assumptions: (a) genetic resources are indispensable to the improvement of generally all agricultural systems, (b) genetic resources must be secured so that they can be tested to assess their usefulness. These two core assumptions which largely helped to build up the international exchange network of genetic resources in the 1960s and 1970s, in the 1980s gradually became subject to the question: "How can the North help the South when it not only conserves its resources for global conservation purposes, but simultaneously uses them for its own commercial purposes?"

While on the one hand a public institutional **cooperation** (and hence free accessibility) was proclaimed within CGIAR and other international organizations with regard to the conservation and collecting of genetic resources, the use of these resources (at least in the private sector) was subject to commercial **competition**. The answer to this paradox was to be sought in an analysis of the strategic alliance between three core actors: the CGIAR Centres, the financial donor states and their agro-industries.

Linking the Intellectual Property Rights Issue with the Genetic Resources Issue

The publication of Seeds of the Earth (1979) and the sudden request among FAO delegates from the Third World at the 20th FAO Conference[108] in 1979 for information on the legal control over genetic resources issues, was no coincidence. In the late 1970s, Mooney and Fowler were actively involved in lobbying NGOs, researchers, scientists and government officials on genetic resources issues.[109]

But before the issue of the legal control over genetic resources became part of the 'seed wars' at FAO,[110] similar issues regarding the privatization of genetic materials had already gained an audience in the USA. The Diamond versus Chakrabarty case, which was pending in various courts in the USA through the later 1970s, had been won by the filing company, General Electric (under the name of Chakrabarty) in 1980. The Chakrabarty application was for a cell fusion-created bacterium which metabolized oil. Although it had no commercial value in itself, it served as a test case to see how far patent coverage over living material could reach. The court held that the discovery was patentable because the bacteria were "not nature's handiwork, but his own" (Fowler 1994:149, 150).

Since the famous Chakrabarty case, hundreds of patents have been issued for plant varieties.[111] However, in the USA, patents on plants had been possible for many years. The

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108 The 'FAO Conference' is the major decision-making body of the Organization in which all members are represented. A Conference is held every two years.

109 For a detailed account of Fowler's experiences in this period see his dissertation, published under the title: "Unnatural Selection: Technology, Politics, and Plant Evolution" (1994).

110 See later section in this chapter: "Agenda setting at FAO in the early 1980s on genetic resources issues".

111 It should be noted here that breeders have other, more informal ways of protecting their

Plant Patent Act (PPA) of 1930 was the first legal protection for plant breeders and largely the work of an industry committee led by Paul Stark of the Missouri nursery family. The Chakrabarty case formed an extension to the PPA as it deals with living organisms developed by genetic engineering and covers newly developed plant varieties. The seed industry, the private breeders and the growing agricultural biotechnology industry under the leadership of the American Seed Traders Organization (ASTA) were the prime motivators of this form of more extensive Plant Intellectual Property Rights (PIPR). Other organizations with similar objectives were the Industrial Biotechnology Organization (IBA) and the Association of Biotechnology Companies (ABC).

PIPR (usually applied to asexually reproducing plants) in terms of legal and economic protection go further than the more common plant breeders' rights (usually applied to cross- and self-pollinating varieties under the Plant Variety Protection Act: PVPA) in two respects:

- Breeders' rights were subject to what is known as a "research exemption", which allows other plant breeders to use protected varieties as parents, the products of which may be protected under the PVPA.
- Breeders' rights under PVPA are subject to a "farmer exemption" allowing farmers to save seed to plant future crops, also known as a "plant back" or "crop exemption". The PVPA allows farmers to sell protected seed to other farmers (which is still a controversial issue to private seed breeders) (Hamilton 1993:8-10).

In the early 1980s, Jeremy Rifkin (then leader of the US-based People's Business Commission), supported by Fowler's and Mooney's information, successfully drew attention to the negative effect that utility patent laws covering plants could have on developing countries in the future, and on the loss of genetic diversity in these countries.

Another event that attracted the attention of US-based activists was the decision of the US government to become an active member of the International Union for the Protection of New Varieties of Plants (UPOV) in November 1981. UPOV had been created by several European countries in 1961 to develop and refine a system to recognize and protect the legal rights of plant breeders and plays a major role in promoting a standardized level of intellectual plant variety property rights in industrialized countries. Whether this protection also would involve patents became a political issue in the early 1980s and focused on Article 2 of the 1978 UPOV convention stating:

> Each member State of the Union may recognize the right of the breeder provided for in this Convention by the grant either of a special title of protection or of a patent. Nevertheless, a member State of the Union whose national laws admits protection under both of these forms may provide only one of them for one and the same botanical genus or species (*ibid.*).

The USA had previously been exempted from the ban on such 'double protection'. However, the removal of this ban created the opportunity for the rapid expansion of both forms of protection in other countries, especially in Europe (*ibid.*).

How Plant Breeders' Rights issues affected policies

Doubts about the appropriation of seeds by companies and the rights of the plant breeders began to spread in the late 1970s, first in the USA among non-governmental organizations

inventions, e.g. breeders of hybrid corn use the law of trade secrets to protect the identity of their parent lines. Also companies which market improved genetic lines may also provide seed to producers under contractual arrangements which commit the producer not to save or sell any of the harvested crop as seed (Hamilton 1993:7).

(often church organizations), social scientists and activists. These public protests had also drawn the attention of Erna Bennett, then in the last and most frustrating years of her appointment at the FAO Crop Ecology and Plant Genetic Resources Unit (see Chapter 4). Bennett was convinced that FAO, as a UN organization, had to do everything to obstruct Plant Breeders Rights' legislation for fear of it hindering the use of genetic resources by farmers and/or small breeders (the Chakrabarty patent question of 1980 was not yet an issue). From the early 1970s onwards, Bennett and Mooney had started to exchange views and experiences.[112] In March 1979, Bennett was invited to Regina (Saskatchewan, Canada) to contribute to a conference on: "Plant Breeders' Rights": Implications for the Prairies. In her contribution, "Plant Breeders' Rights and their Effect on Plant Breeding Material", Bennett for the first time showed her concern publicly:

> ... I cannot see any public benefit likely from legislation conferring proprietal rights on plant varieties. Such varieties are frequently the result of considerable inputs by public sector breeding programmes. This is not to deny that private sector breeding programmes exist or are useful, but in resolving the problems of agricultural development of Third World countries, private sector dominated operations have a number of identifiable defects[113] (Bennett, unpublished correspondence, 1980).

In Rome, Bennett started a personal campaign to raise awareness inside and outside FAO headquarters. Copies of these letters were distributed among her colleagues at the FAO Crop Ecology Unit. Bennett expected that, at some moment, FAO could form a buffer against the establishment of property rights benefitting private breeding. Her concern was especially understandable because the Executive Vice President of ASTA, H.D. Loden, in 1980 pressured FAO to take issue on Plant Breeders' Rights legislation. What was FAO's stance on the UPOV convention with regard to its effect on small-scale breeding efforts in developing countries? Much to the frustration of Bennett, FAO did not reject the UPOV legislation. An FAO Office Memorandum of May 1980 concluded that:

1. UPOV is a double-edged tool – it can have positive as well as negative impacts on developing countries, and
2. no hard and fast rule can be decided upon regarding our relations to UPOV (FAO 1980a).

This statement, however, did not fully reflect the opinion among Bennett's supervisors at FAO. A few months later their ideas were translated into a new FAO Memorandum on the UPOV issue, by FAO's Legal Council. The Legal Council concluded that FAO had:

> ... noted that [Plant Breeders' Rights] do not provide any basis for restrictions on the access by developing countries to the sources or results of plant breeding activities ... [and that FAO had] noted that plant breeders' legislation encourages the development of new plant varieties by the private sector, which can have beneficial effects for the world as a whole (FAO 1980b:4).

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[112] Bennett, for example, was involved in reviewing Mooney's 1979 publication, Seeds of the Earth (Bennett, unpublished correspondence 1980).

[113] The defects mentioned were: (a) seed marketing is driven by the criteria of profit only, and not the concern of the poor people, (b) royalty payments will only lead to increases in seed prices, (c) public and private breeding must remain separate, and (d) legislation conferring property rights introduces an element of secrecy in breeding operations that affects the free distribution of material and the free exchange of breeding germplasm (Bennett, unpublished correspondence of 1980).

The argument that Plant Breeders' Rights served commercial interests was precisely Bennett's concern. Meanwhile she became involved in the establishment of a European Cooperative Programme for the Conservation and Exchange of Genetic Resources for Plant Breeding. This joint UNDP/FAO project, which had been initiated in 1975, had reached a critical phase as most participating countries started to place some restrictions on the full exchange of inbred lines and hybrids. Other 'difficult categories' embraced plant material which was part of a contemporary breeding programme, not yet fixed parental stocks, and selections at the subvarietal level (FAO 1979).

Bennett's departure

Another matter of frustration was the difficult cooperation between IBPGR and FAO at FAO headquarters in Rome. As described in Chapter 4, FAO Regular Budget staff (including Bennett) were gradually outnumbered by the IBPGR staff. Bennett disagreed entirely with Trevor Williams, which contributed to her belief that FAO was frittering away its Crop Ecology and Genetic Resources Unit (and Crop Genetic Resources Centre) by using it for corporate interests.

During a Consultation meeting at FAO on the UNDP/FAO European Cooperative Programme in Rome on 8 and 9 March 1979 (at which the IBPGR Secretariat was present as observers), Bennett clearly expressed her feelings with regard to the lack of guidance from the side of FAO in the protection of the free exchange of genetic resources, as well as about the detrimental role of IBPGR in this question. This incident contributed to the awareness outside headquarters in Rome that the relationship between IBPGR and FAO was seriously worsening.

In this context, it should be remembered that a large portion of Bennett's opinions and actions were simply labelled as too idealistic (also among her FAO colleagues). Out of frustration, Bennett resigned from FAO in 1983 and decided to continue her work as a journalist. After her lengthy fight for alternative conservation strategies within the FAO in the 1960s (see Chapters 2 and 3) and 1970s, Bennett's departure was a bitter end to her career.

Although Bennett left FAO, her critical ideas had inspired activists such as Mooney and Fowler. Partly benefiting from the rise of anti-IPR pressure groups in the USA, and partly due to their own (post-Rome) intense lobby work, they were able to connect the property rights issue with the global issue of conservation, exchange and use of genetic resources. This connection was first picked up by delegates from Mexico and Spain in the late 1970s. In the 1980s, several issues developed into many fragmented controversies (as outlined above) which together formed the genetic resources issue. The many points of controversy, however, did not appear as such in the political arena. The following is a short outline of the process at the level of intergovernmental decision-making at FAO in the 1980s.

Agenda-Setting at FAO in the early 1980s on Genetic Resources Issues

During the 20th FAO Conference in 1979, a number of developing countries started to ask for information about the following issues (Esquinas-Alcázar 1989:4):

(a) Who owns the genetic resources collected with international money and stored in countries other than those in which they were collected? Who will guarantee their long-term security?
(b) What guarantee is there for the continued free exchange of material in *ex situ* collections? Will *bona fide* statements of intention be enough, at present, and for the future?
(c) How can countries benefit from the plant genetic resources that their farmers have produced, improved and conserved over millennia, as they currently lack the technical and financial capacity to use these resources for their own benefit?

Questions "a" and "b" connected the institutional IBPGR/CGIAR versus FAO question to a more concrete one on the ownership of genetic resources. As IBPGR and FAO were making collections together (or at least were housed under one roof), the question of the ownership of the collections had started to become a matter of concern for source countries. Question "c" illustrated the structural problem behind the genetic resources issue. Developing countries lacked the technical and financial capacity to use the resources in their territories for their own benefit, hence the merits of long-term *ex situ* conservation.

At the 20th FAO Conference, some delegates from developing countries had personal and sometimes negative experiences with IBPGR (Fowler 1994:186). Even more were they agitated by the American stance over ownership of genetic resources, both with regard to Plant Breeders' Rights, and with regard to the rule that genetic resources that were subject to the principle of common heritage, once obtained, became property of the USA. Questions were posed such as: what is the overlap between the CGIAR and FAO collections?; what does the CGIAR's 'trusteeship' over genetic resources precisely mean?; what does IBPGR's statement that it supplies its collections only to *bona fide* users mean?, and why are most of the world's *ex situ* collections located in the North or financed by institutes from the North?

Throughout the 1980s, FAO remained the principle forum in which developing countries tried to pursue their interests, which comprised: attempts to support the establishment within FAO of an international legal framework to set global standards and rules for the conservation and exchange of genetic resources; and, second, to establish an alternative network of genebanks under the auspices of FAO as a form of assurance that genetic resources would remain available in the public domain.

However, it was mainly the legal framework that took shape in the 1980s. An alternative FAO genebank network did not materialize, partly also because it lacked the resources to 'compete' or complement the existing CGIAR network. Financial donors, often industrialized countries, were unwilling to pay 'extra' to an FAO network. An additional reason was that, since FAO was an international organization accountable to governments and in the 1980s (with the Cold War in full swing) was thought to be "susceptible to red tape" (Juma 1989:89), industrialized countries had a greater political interest in supporting the CGIAR network instead of an alternative FAO genebank network (see Chapter 4).

During the 1979 Conference, the Spanish delegation, headed by the Minister of Agriculture, proposed the establishment of: (a) an internationally coordinated network of base collections, and (b) the signing of an international agreement on the conservation and exchange of genetic resources "as a means of strengthening existing structures" (Esquinas-Alcázar 1987:43). According to the normal procedure, the FAO Conference asked for a feasibility study regarding this subject.

To create a precedent, the Spanish delegation proposed to offer germplasm stored in a Spanish genebank under international jurisdiction through a letter from the Spanish Minister to the Director General of FAO, which was accepted. This gesture was not only important in terms of the possible formation of an alternative *ex situ* network. It also was a strong signal that such an alternative FAO genebank network could also be formed outside the structure of the CGIAR network. As of 1995, however, only Morocco signed up to join the network.

The 21st FAO Conference

After Spain had given a clear sign to other countries that the FAO plans were not to remain as mere paperwork, Mexico took the lead in pushing for the approval of a resolution which encompassed both the establishment of an international FAO-coordinated network of genebanks and the signing of a legal convention. During the 21st FAO Conference, these points were translated into FAO Resolution 6/81 on Plant Genetic Resources, adopted on 25 November 1981 (see next page).

Resolution 6/81 became one of the most hotly debated resolutions in the history of FAO. The genetic resources issue, having been mainly a matter of expert discussion during most of the 1970s, suddenly in 1981 received worldwide press coverage. NGOs[114] were actively involved in informing and mobilizing delegates from developing countries. Industrialized countries heavily opposed the resolutions, particularly the USA, UK and Australia. However, Mexico, with José Ramon López-Portillo (the son of the former Mexican President and ambassador to FAO) worked actively together with Mooney to get the Resolution accepted by the Conference.

Resolution 6/81 also widened the gap between IBPGR and FAO. Statements "a" and "b" of the Resolution recalled FAO's and IBPGR's respective roles in the conservation of genetic resources and indirectly emphasized a gap of almost three decades of experience in collecting efforts. Although statements "c" and "d" emphasized the joint effort of FAO and IBPGR in the collection maintenance, evaluation, exchange and distribution of genetic resources, the reference to their joint work for an "international collaboration of national, regional and international plant genetic resources centres" (in statement "d") in practice basically embraced IBPGR/CGIAR activities.

It is in this context that the final statement "e" should be read. Emphasizing the lack of an "international agreement for ensuring the conservation, maintenance and free exchange of genetic resources of agricultural interest contained in existing germplasm banks" it offered a window of opportunity for FAO to get legal control over the exchange and distribution of genetic resources in the CGIAR network. The Resolution offered two means of achieving this goal: an international convention (see point "1") and an international genebank (see point "2").

The importance of the 6/81 Resolution was that it opened formal procedures for the exchange and distribution of genetic resources worldwide. The results of this procedure would be presented to the FAO Committee on Agriculture (FAO-COAG) at its Seventh Session in 1983 (point "3") and subsequently at the 22nd FAO Conference of 1983. So, between 1981 and 1983, all the actors (CGIAR, IBPGR and FAO staff, representatives of the seed industry, NGOs and governments) became involved in a heavy dispute over the interpretation and consequences of Resolution 6/81.

[114] Much lobbying work within FAO was done by Renée Vellvé and Henk Hobbelink of ICDA, and Pat Mooney and Cary Fowler of RAFI.

Resolution 6/81

THE CONFERENCE,

[a] Recognizing that plant genetic resources are indispensable for the genetic improvement of cultivated plants, and that they are in danger of erosion and loss,

[b] Recalling that work on plant genetic resources was begun in FAO as the result of a recommendation made by the First Session of the Advisory Committee on Agriculture in 1946,

[c] Recalling further that in 1974 with the support of the Consultative Group on International Agricultural Research [CGIAR], the International Board for Plant Genetic Resources (IBPGR) was set up for which FAO provides the Secretariat,

[d] Noting that a joint FAO/IBPGR programme is promoting the international collaboration of national, regional and international plant genetic resources centres in which plant genetic resources are collected, maintained, evaluated, exchanged and distributed,

[e] Considering that there is no international agreement for ensuring the conservation, maintenance and free exchange of genetic resources of agricultural interest contained in existing germplasm banks,

Convinced of the need of such an agreement,

Recalling the proposal made by some members during the Seventy-Ninth Session of the Council in June 1981 that consideration be given to the establishment of an international bank of plant genetic resources under the auspices of FAO to ensure the free exchange of plant genetic resources between countries.

1. Requests the Director-General to examine and prepare the elements of a draft international convention, including legal provisions designed to ensure that global plant genetic resources of agricultural interest will be conserved and used for the benefit of all human beings, of this and future generations, without restrictive practices that limit their availability of exchange, whatever the source of such practices.

2. Requests the Director-General to prepare a study on the establishment of an international bank of plant genetic resources of agricultural interest under the auspices of FAO, taking into account the provisions of the proposed international convention as well as on-going national, regional and international efforts in this field in particular those of the IBPGR.

3. Requests the Director-General to present proposals based on the studies mentioned to the Committee on Agriculture for consideration at its Seventh Session in 1983, which shall report thereon to the Council with a view to consideration by the Twenty-second Session of the FAO Conference.

The atmosphere in Rome and among the NGOs that were involved in the discussions can perhaps best be described by a quote from an open letter[115] of Clarence Dias and Ward Morehouse (of the US Council on International and Public Affairs) of December 1983:

> As matters involved are of a global nature and they have implications to millions of people we must politicize the issue on a mass scale. I suggest that we should get in touch with peasant movements and farmers associations in some Third World countries and internationalize the issue from below. If I may think aloud without being misunderstood why do we not consider the following courses of action?:
>
> 1. Mass meetings including peaceful marches to UN offices and some embassies to hand over petitions and appeals.
> 2. A massive signature campaign among farmers and concerned people against genetic erosion and the dominance of North in the control of genetic resources.
> 3. Some joint meetings and campaigns with third worldist groups in Europe and America including "gene resources protection marches."
> 4. At another level we need to update and sharpen our critique of international research organizations based in Third World countries and elsewhere related to seeds (Unpublished correspondence).

Although these ideas were never carried out, the letter offers an idea of the very deep concern among activists. The conflictual atmosphere was further aggravated by a countermovement from the agricultural and genetic resources community. Alarmed by the potential impact on intellectual property issues of public awareness in the USA, the USDA in 1983, and later also ASTA in 1985, started to take issue. The USDA, in a briefing paper to FAO, stated when the pending proposals for an FAO Undertaking would be implemented this "would politicize germplasm policies" and would offer FAO control over the CGIAR network, driving primary financial donors out of the system. Also, the authors assured FAO that the USA would "never grant FAO control to National Seed Storage Laboratory" (Fowler 1994:188).

The discussions during the 22nd FAO Conference in 1983 were fuelled by a letter from the USDA that proved what many developing countries feared, namely that germplasm received by the USA from the international community would become US property, and that the exchange of this material would also be subject to considerations of US foreign politics. Also, during the Conference, the term 'germplasm embargo' was coined,[116] referring to several developing countries which, for political reasons, had been subject to restricted access to genetic material maintained in genebanks in the North.

Nevertheless, the 22nd FAO Conference of 1983 approved the Director-General's proposal for an International Undertaking which included 11 articles, as well as the establishment of the FAO Commission on Plant Genetic Resources (CPGR). The CPGR is an intergovernmental forum through which financial donor countries and users of genetic resources, information, technology and funds can sit together to discuss issues with regard to the conservation and use of those resources, and monitor the implementation of/adherence to the Undertaking.

In spite of the round-table character which the CPGR was supposed to have, there was strong hesitation from the USA and other industrialized countries such as Canada, France,

[115] "An appeal for action on the problem of genetic resources", written shortly after the November 1983 FAO Biennial Conference.

[116] For an exciting account of the implementation of the Undertaking and the politicization of the genetic resources issue, see Fowler and Mooney 1990.

Germany, the Netherlands, Sweden and the UK. These stemmed from the fact that the Undertaking embraced the categories of genetic resources referred to as "special genetic stocks including elite and current breeders' lines and mutants" (FAO 1983a:50). These countries argued that the special genetic stocks could not be freely exchanged as national legislation in these countries provided for private property rights on crop varieties in the form of PVPAs. Many developing countries on the other hand argued that special genetic stocks as they are derived from germplasm originating from within their boundaries should be available freely (Pistorius 1991:4). Also, the proposal for a Commission was considered by some donors as an attack on IBPGR, an attempt to set up a parallel body with the political and legitimacy of the United Nations (Fowler 1994:189).

In spite of the limited support from industrialized countries to the Undertaking (it being a non-binding agreement), the 22nd FAO Conference was considered a major victory for developing countries. Perhaps equally important, FAO itself had now gained some institutional ground in the genetic resources issue as most of the countries hostile to the Undertaking did become members of the CPGR. The large subscription to CPGR did not harm the interests of the financial donor countries, rather, it offered them some formal control over the new political developments in Rome. The first session of CPGR took place in March 1985 and since then it has met every two years.

An alternative international FAO genebank?

The discussion on the alternative FAO genebank network (point "2" of Resolution 6/81) developed from one concentrated on its feasibility and necessity, to one on the functioning of the CGIAR network and its benefits to developing countries. Both FAO and IBPGR asked consultants to carry out studies on this matter.

A FAO survey on genebanks and assorted research institutes attempted to gauge the degree to which the use of germplasm was being restricted (Fowler 1994). To form a counterargument, IBPGR asked Donald Marshall (Head of the Department of Crop Sciences of the University of Sydney) to write a report on constraints affecting the full and free availability of genetic resources and to come up with "practical methods to overcome constraints **that are not of a political level**" (emphasis added).

Marshall travelled to genebanks and (national) research institutes in seven developing countries[117] to get an impression of genebank policies. In 1983, his findings were presented in a report under the title: Practical Constraints Limiting the Full and Free Availability of Genetic Resources (Marshall 1983).

The report concluded with the remark that the "political constraint appears to be a major and, unfortunately growing, impediment to germplasm exchange." As far as Marshall touched upon political items, he presented the genetic resources issue both as a North-South and a South-South problem. The latter category referred to a lack of diplomatic relations between countries due to previous conflicts arising from territorial, religious or political differences. The following quote shows Marshall's concern to put the North-South controversy in a broader perspective:

> ... Genetic resources ... come to be seen as weapons in the struggle between rich and poor countries desirous of obtaining access to endemic resources in another country ... However, it is still possible for germ plasm exchange between countries in the absence of direct relations via the international research centres or international agencies such as the IBPGR or FAO ... For example, there has undoubtedly been little direct exchange between USA and Cuba, Israel and some Arab States, China and the USSR, to list a few, in recent years (Marshall 1983:3, 4).

[117] The Philippines, Thailand, India, Argentina, Peru, Costa Rica and Mexico.

According to Marshall, a practical way to overcome these constraints was that IBPGR would pursue its special role in guaranteeing "access to all scientists regardless of their state of origin ..." and that IBPGR, by funding national collecting missions, would ensure that samples of all material collected would be sent to internationally designated base collections. Marshall further emphasized that, in spite of these political problems, the most severe problems he witnessed during his travels were economic and technical in kind[118] forming another argument for more IBPGR funding and assistance (*ibid.*).

Marshall's report is an attempt by IBPGR to mitigate political problems which, according to Marshall, were "associated with strong nationalistic attitudes towards endemic genetic resources". More funding and technical assistance, more distribution via and to the CGIAR network, and new base collections for large-scale duplication, were the best solution to circumvent the disturbances in the exchange of genetic resources. In December 1983, Marshall's report was used directly to mitigate the atmosphere of conflict at FAO with regard to the role of IBPGR in the international exchange of genetic resources. To the FAO-COAG, L. Kåhre, Chairman of IBPGR stated:

> You will be interested to know that ... [Marshall's] consultation did **not** highlight any political constraints, but it did show that most constraints are the result of a lack of understanding and budget provisions in developing countries (Kåhre 1983:4).

To many members of the CGIAR, an international FAO genebank system would impinge on the role and work of IBPGR and those IARCs that maintained collections, and "institutionalize a master system of collections of plant genetic resources" (Baum 1986:168).[119] Developing countries now could start thinking seriously of opting for an alternative 'trustee' for their genetic resources. Also, an alternative genebank network would directly harm IBPGR's mandate. Again, technical/financial arguments, as well as IBPGR's mandate were used to question FAO's initiatives. In the words of Kåhre at an FAO-COAG meeting in 1983:

> In relation to any convention we question whether it would be a wise use of restricted financial resources to establish an Intergovernmental Committee to duplicate the work of IBPGR ... For an international genebank to function properly there would have to be on-going cooperative agreements for multiplication of seeds in many parts of the world. The costs for this would be high and would increase year by year. How many national governments at this stage of their technical development could make a commitment for such a service function and quickly resolve concomitant problems of quarantine? (Kåhre 1983:4, 5).

The discussions on an alternative FAO genebank lost some of their sharpness as, in the course of 1983, FAO left the idea that this had to be in the form of one physical entity (some

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118 Economic problems encountered were: seed multiplication, sample preparation, packaging and distribution. The technical constraints were a lack of information on collecting missions and the paucity of follow-up studies, the lack of documentation and description of collections, the lack of evaluation of collections, definitions of the responsibilities of curators, lack of specificity in requests for material from genebanks, and constraints imposed by plant quarantine (Marshall 1983:6-12).

119 During the 83rd Session of the FAO Council: "Some Members felt that the existing system developed by the FAO/IBPGR would meet in principle the requirements for international cooperation and plant genetic resources exchange, and considered the two proposals [for an International Genebank and an International Undertaking] were unnecessary" (FAO 1983:27).

even thought at the FAO headquarters). During the 83rd Session of the FAO Council, it was decided that it could also be formed as an international network of storage facilities instead of one centralized facility. Also the argument of the excessive costs of a full duplication of the existing CGIAR collections started to gain ground. Some Council members started to think in terms of proceeding on the road already taken: by using the building blocks of the existing "FAO/IBPGR" network (FAO 1983b:28).

The matter of the International FAO Genebank, however, revived after the adoption of the FAO Undertaking on Plant Genetic Resources of 1983. Article 7 of the FAO Undertaking asked for a coordinated action of all the institutions involved in the conservation of genetic resources to develop a Global System on Plant Genetic Resources for food and agriculture (Figure 2). The objective of the FAO Global System is to:

> ... ensure the safe conservation, and promote the availability and sustainable utilization of plant genetic resources for present and future generations, by providing a flexible framework for sharing the benefits and burdens (FAO 1995b:5).

The Global System has been established to form an institutional means to effectuate the articles of the Undertaking and the decisions of CPGR, but would also consist of *in situ* conservation areas and an *ex situ* network of active and base collections, and, as such, form a real institutional core to strengthen FAO's political position in the collecting, conservation, evaluation and documentation, as well as the use of genetic resources.[120]

The CPGR itself and the Undertaking are the main supports of the Global System. The Global System falls into three elements. The first is regulatory in kind, consisting of a Code of Conduct for Plant Germplasm Collecting and Transfer and a Code of Conduct on Biotechnology. The second consists of three network systems: (a) the World Information and Early Warning System on Plant Genetic Resources, (b) a network of *ex situ* genebanks[121] (since December 1994 also including the 12 CGIAR collections – see later in this Chapter), and (c) a network of *in situ* and on-farm conservation areas. The third element is a Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources For Food and Agriculture (GPA) (FAO 1996b).[122]

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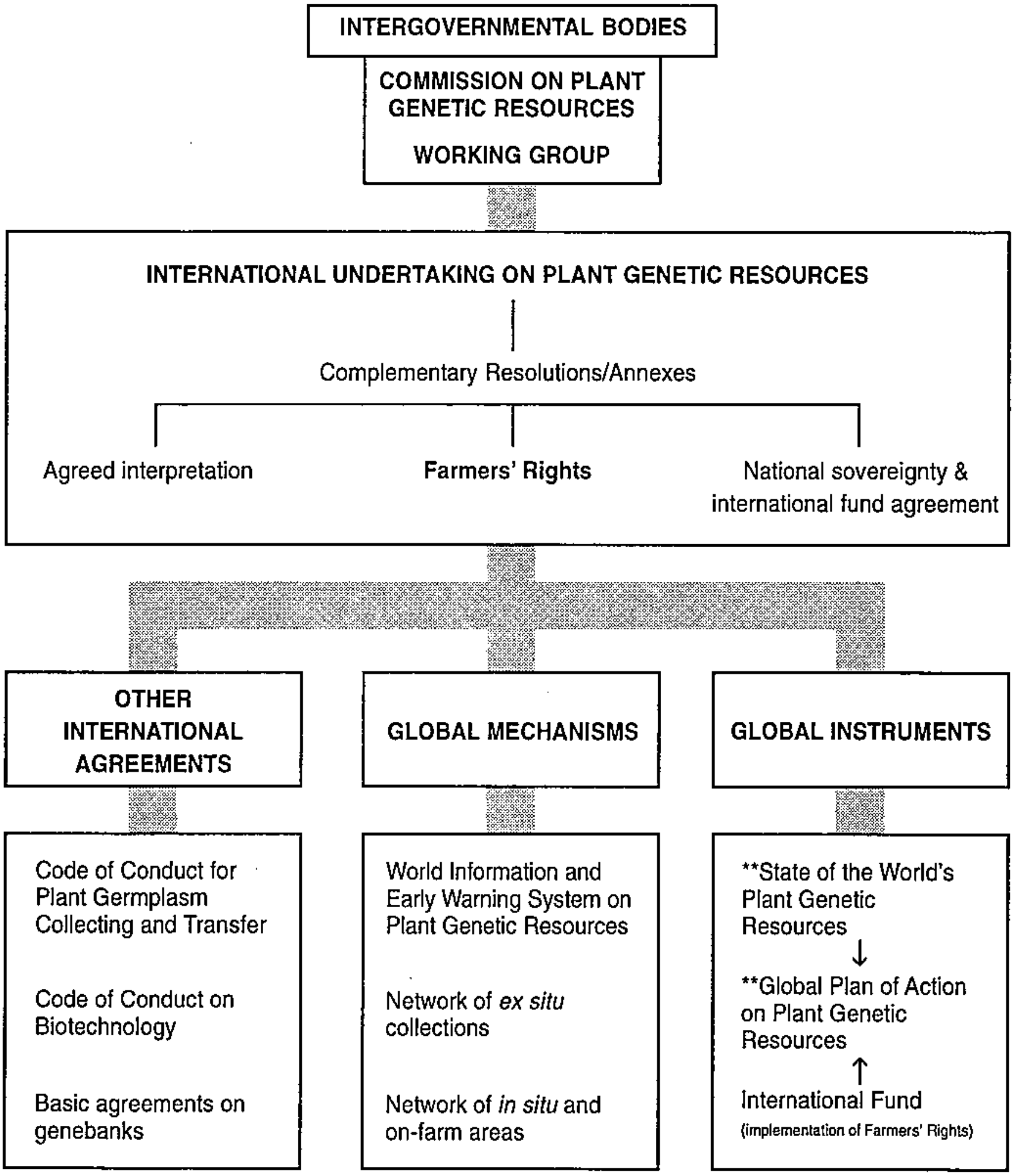
[120] As of May 1996, 171 countries are actively in the development of major components of the Global System; 142 countries and the European Community are members of the Commission on Plant Genetic Resources (FAO 1996c).

[121] When proposed in 1983, the political connotation of an international network of FAO *ex situ* genebanks was well understood by FAO itself: "A special significance of an internationally supported genebank, as compared with some existing genebanks would not necessarily be such attributes as better management and greater safety, but the fact that the genebank would be established within a constitutional framework and become an activity within an existing intergovernmental organization. The implicit assumption in the concept of an international genebank under the auspices of FAO is that the Organization, by virtue of its status, would be able to overcome difficulties between Member States in obtaining plant genetic resources" (FAO 1983: 10).

[122] In 1993 the FAO Commission on Plant Genetic Resources decided that an International Technical Conference was needed to transform the relevant parts of the UNCED process, including Agenda 21 and the Convention on Biological Diversity, into a costed global plan.



** The first State of the World and Global Plan of Action on Plant Genetic Resources is being produced during the preparatory process for the **Fourth International Technical Conference**

Fig. 2. The Global System for the conservation and utilization of plant genetic resources for food and agriculture (for illustrative purposes only) (source: FAO 1995b:2).

A draft of the GPA was discussed during the International Technical Conference in Leipzig, Germany, 17-23 June 1996.[123] The GPA contains 346 recommendations derived from data assembled in the Report on the State of the World's Plant Genetic Resources (FAO 1996b), which is the main background document for the GPA. To assemble data for the report, 154 countries, divided into 11 subregions worldwide, held preparatory meetings.

In cooperation with FAO these countries also formulated policy standpoints to be expressed in the GPA. While the report can be considered as the most recent expression of the state-of-the-art on ideas from various disciplines regarding optimal conservation and use of plant genetic resources, the GPA formulates guidelines for future funding, conservation and use.

In the GPA, the most preferable conservation strategy is a combination of *in situ* and *ex situ* storage. Local and indigenous knowledge should be recognized as important components of surveying and inventorying activities. Participatory, on-farm management of plant genetic resources is recommended, although no consensus was reached on the question as to whether this should be supported by (financial revenues from) farmers' rights. Regarding *in situ* conservation, the GPA explicitly demands more attention for wild relatives which could be used for the improvement of food crops. Many of the world's nature parks, it states, contain wild relatives, but receive little concern. Regarding *ex situ* conservation, the GPA intends to give high priority to safeguarding as much diversity as possible in *ex situ* collections while countries have national sovereignty over, and responsibility for, their own plant genetic resources. More funds are requested to support *ex situ* 'core' collections (containing a selected and characterized number of entries already available in *ex situ* collections).

Regarding the use of plant genetic resources, the GPA supports a sustainable agriculture through diversification of crop production and a broader diversity in crops. Various strategies are opted for, starting with further support for seed production and distribution in the public sector. A relatively new strategy to increase the demand for diverse plant genetic resources was to develop new (niche) markets for local varieties and 'diversity rich' products. The issue of the use of plant genetic resources subject to property rights "in accordance with applicable international agreements and national legislation" was not resolved. Neither was the exchange of plant genetic resources for technology. The final section of the GPA on Ensuring a Fair and Equitable Sharing of Benefits which demanded an effective implementation of Farmers' Rights was not agreed upon (Pistorius 1996:4).

Ownership and Legal Status of *Ex Situ* Collections

The issue of the status of *ex situ* collections was first raised when FAO called for the implementation of Article 7.1(a) of the FAO Undertaking in relation to the development of an "international network of base collections in genebanks under the auspices and/or jurisdiction of the FAO". This implied that countries and institutions which voluntarily decided to place their collections in their genebanks within this network, agreed to ensure

[123] The first Report on the State of the World's Plant Genetic Resources (FAO 1996a) and Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources For Food and Agriculture (FAO 1996b) have been developed through a country-driven process that led to the FAO International Technical Conference on Plant Genetic Resources, that took place in Leipzig, Germany in June 1996 (for a discussion on the First Technical Conference see Chapters 1 and 2).

that the genetic material would not only be made available for plant breeding and research purposes but also respect "the rights of the providers of germ plasm" (FAO 1995d:8, 9). By 1995, 32 countries[124] (but not the USA) had offered to bring their collections into the network. Norway offered *ex situ* storage facilities for duplicating collections in a permafrost area in Svalbard (near the North Pole). However, the status of collections held in national genebanks *ex situ* while at the same time being part of an international network remained unclear, which emphasized the importance of regulation on the access to and use of *ex situ* CGIAR collections.

In 1987, FAO's Legal Office researched the ownership and legal status of the *ex situ* collections of IARCs. The study revealed that the ownership of genetic resources was usually vested in the countries in which the genebanks were located. However, for material held in the IARCs, the legal position was unclear. Available charters and legal documents of the CGIAR Centres "did not generally contain explicit provisions governing ownership of plant genetic resources". The concept usually applied by the CGIAR Centres to cover its *ex situ* collections is 'trusteeship'[125] which, to the CPGR, was "unsatisfactory" (FAO 1995b, Annex 3).

The legal status of CGIAR and other international *ex situ* collections was left unresolved until after the implementation of the UNCED Convention on Biological Diversity (CBD) in December 1993 (signed in Rio de Janeiro in June 1992). The CBD offers signing states international rights over their natural resources (Article 3). Articles 15.3, 16 and 19 of the CBD, however, determine that national legislation can only embrace genetic resources of states that can prove they are also "countries of origin",[126] or states that have acquired genetic resources "in accordance to" the CBD thus only **after** the entry into force of the CBD in December 1993 (UNEP 1992:28, 32-34). This, in turn, means that the CBD does not cover *ex situ* collections which were acquired prior to the implementation of the CBD, whether they be held in or outside the country of origin, e.g. the majority of the accessions in the CGIAR collections[127] (Pistorius 1995:21).

However, in 1992, Agenda 21 of UNCED had recommended strengthening and adjustment of the FAO Global System in five respects: (1) the development of the World Information and (2) Early Warning System; (3) the realization of Farmer's Rights and (4) the development of networks for the *in situ* and *ex situ* conservation of plant genetic resources; and (5) the preparation of reports on the State of the World's Plant Genetic Resources and rolling Global Plan of Action for Plant Genetic Resources (FAO 1995b:1). The importance of the issues of *ex situ* collections and Farmers' Rights was further emphasized during the Nairobi Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity in 1993. Shortly after the Nairobi Conference, the FAO

[124] These countries were: Argentina, Bangladesh, Chile, Costa Rica, Czech Republic, Denmark, Ethiopia, Finland, France, Germany, Indonesia, India, Italy, Japan, Iraq, Madagascar, Morocco, Netherlands, Norway, Pakistan, the Philippines, Russia, Senegal, Spain, Sweden, Switzerland, Syria, Togo, Tunisia, United Kingdom, Uruguay and Yemen.

[125] Meaning that the material is held 'in trust' for the international community.

[126] A "country of origin" is defined in the Convention as the "country which possesses those genetic resources in *in situ* conditions" (Article 2).

[127] Joint IBPGR/FAO counts revealed that about 50.4 per cent of the accessions of all existing *ex situ* collections (estimated at 4 415 700 accessions) were held in developed countries, 38% in developing countries, and about 11.6% in international centers. However, FAO CPGR also noted that the relatively low percentage of 11.6 (or 510 500 accessions) could not disguise the importance of the CGIAR collections "which probably comprise the world's most significant collections" (FAO 1995d:7).

Conference, at its 27th session, adopted Resolution 7/93 which called for intergovernmental negotiations on: "the issue of access on mutually agreed terms to plant genetic resources, including *ex situ* collections, not addressed by the Convention; [and] the issue of the realization of Farmers' Rights". These two issues fell inside a larger goal of FAO, namely "the adaptation of the International Undertaking on Plant Genetic Resources, in harmony with the Convention on Biological Diversity" (FAO 1995d:2/3).

The *ex situ* CGIAR collections quickly became the focal point of the discussions that followed the adoption of Resolution 7/93. Following the CBD, and Resolution 7/93, pressure grew on CGIAR to develop an agreement with FAO on their collections. During the second session of the FAO Intergovernmental Committee for a Convention on Biological Diversity (FAO-ICCBD) in which most of these discussions took place, many country representatives "strongly supported the efforts to bring these [CGIAR collections] under the auspices of the FAO". On 26 October 1994, all twelve of the CGIAR centres holding plant genetic resources collections placed them under the auspices of the FAO International Network of *Ex Situ* Collections, which are part of the FAO Global System (FAO 1995b:7; Pistorius 1995:20-22).

A short history of Farmers' and Plant Breeders' Rights

From the beginning, countries used the intergovernmental forum of the CPGR to negotiate compromises on genetic resources issues. This should be taken into account when looking at the package deal of March 1989 which extended the FAO Undertaking by two resolutions. The concept of Farmers' Rights which resulted from debates in FAO was in explicit recognition of the fact that a commercial variety is usually the product of applying breeders' technologies to farmers' germplasm. This recognition of the potential commercial value of landraces and wild relatives from developing countries, led to questions about the property protection over commercial varieties, on the one hand, and 'farmers' germplasm on the other. "While the former may generate returns through Plant Breeders' Rights, or other intellectual property rights legislation, no system of compensation for the providers of germplasm was operational" (FAO 1995d:11). These issues finally led to the simultaneous and parallel international recognition of Plant Breeders' and Farmers' Rights in Resolution 4/89[128] and Resolution 5/89, removing the reservations of the industrialized countries towards the first version of the FAO Undertaking (that did not discriminate enough between 'improved'[129] and 'unimproved' genetic resources), as well as those of developing countries that wanted recognition of the social and economic value of germplasm provided by farmers in the past and future.

These revisions regarding Plant Breeders' Rights and Farmers' Rights also implied that Article 5 of the Undertaking ("Availability of Plant Genetic Resources") dealing with the principle of "free access to genetic resources" had to be adapted in order to make explicit that "free access" did not imply that genetic resources were "free of charge". This led to FAO Resolution 3/91 stating that:

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[128] Resolution 4/89 recognizes the "enormous contribution that farmers of all regions have made to the conservation and development of plant genetic resources, which constitute the basis of plant production throughout the world, and which form the basis for the concept of Farmers' Rights" (FAO 1994c: 12).

[129] Improvement in this context is understood as improvement by the agro-industry in the North. Farmers in developing countries have improved landraces for centuries.

> The concept of mankind's heritage, as applied in the international Undertaking on Plant Genetic Resources, is subject to the sovereignty of the States over their plant genetic resources (FAO 1995c:7).

However, although the inclusion of Plant Breeders' Rights in the Undertaking was based on existing legal interests in industrialized countries, Farmers' Rights mainly referred to a moral acceptance of the social and economic value of genetic resources in landraces developed by farmers in past millennia.

Representatives from developing countries and NGOs felt that breeders in industrialized countries, putting only "finishing touches" to landraces developed by farmers, disposed of potent legal instruments in the form of property rights to protect their economic interests. As a counterbalance, it was suggested that Farmers' Rights could be institutionalized through an International Fund for Plant Genetic Resources, or "Gene Fund", to which industrialized countries, recognizing the rights of farmers, would contribute in terms of finance. Gene Fund money would be used to conserve and utilize genetic resources in the South, and, as such, add to the functioning of the FAO Global System.

Farmers' Rights: from an economic to a social dimension

The history of the international discussion on Farmers' Rights is a very short and recent one, and is certainly not yet finished. Nevertheless, one can discern a gradual evolution of the discussion on Farmers' Rights over the past six years, as in the early 1990s, the discussion on Farmers' Rights would gradually shift from the rather edgy discussion on economic compensation to socioeconomic rights.

The reasons for this shift are various. Not only had it become clear that industrialized countries would not accept Farmers' Rights in terms of intellectual property (thus as an alternative mechanism for Plant Breeders' Rights),[130] but also NGOs started to realize that a mechanism in which indigenous communities or individuals could obtain intellectual property rights would probably be "difficult to implement and could restrict access to genetic resources" (GRAIN 1991:5).

Apart from the questions of how to guarantee the income of the Fund, many other questions remained unanswered, for example, how to assure that the Fund would be filled, how to determine the distribution and the use of income received, how to determine which farmer contributed to an ultimate variety?[131]

The examples outlined by Mooney and others about the multi-million dollar value of landraces and wild relatives in the agro-industry, were based on assessments of properties of samples that usually had passed outside the control of farmers of the country of origin.

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130 In spite of their limited political and economic consequences for industrialized countries, the acceptance of Farmers' Rights continued to meet resistance from industrialized countries, particular the UK, Germany and Australia. They opposed the idea of mandatory contributions to the Gene Fund with a lengthy amendment.

131 Wood (1988b) comments that an important prerequisite for measuring such contribution would be the development of a clear methodology to determine the contribution of landraces to finished varieties of seed companies. This would imply access to very detailed data on landraces and finished varieties, embracing detailed passport data (including the precise origin of each sample), details of morphological and biochemical characterization (as an indication of the relationship of each sample to others in the collection), evaluation data emphasizing yield-related properties (such as pest and disease resistance and drought tolerance), and stock-keeping information (such as the location and size of samples in both working and base collections).

David Wood, among others, warned that one consequence of not finding a workable mechanism for valuing genetic resources could "lead to long and drawn-out bargaining over access to germplasm" which would mainly affect small countries with little or no native germplasm of their own and without strategic reserves of germplasm of nationally important crops in national collections (Wood 1988b:285). This issue was raised by, for example, Garrison Wilkes:

> It is true that landraces are the product of indigenous farmers and, in a sense, belong to a region. There is nothing to stop a nation or a group of farmers from registering a native landrace under varietal protection if it meets the criteria; currently most national governments that might lay claims to such landraces do not have the necessary characterization capacity (Wilkes 1987:216).

> Payment for plant genetic resources to the developing world is also unworkable. For most crops it will be difficult to determine which genes, and how many, were used and to know what country or countries to pay (Wilkes 1987:215).

It should be remembered that the primary beneficiary of any intellectual property system for plants and plant varieties (UPOV and patents) has been the owners of these rights, in developed countries, rather than farmers and farming communities which developed and continue to develop the landraces with which they work. Also, local (ethnic) populations in developing countries are not seldom in conflict with national governments. Moreover, in the context of "deluge" problem (as outlined in Chapter 4) in IARC collections, an economic valorization of genetic resources would not automatically lead to benefits for source countries. Regarding these difficulties, and in comparison with the heavy institutional and legal basis[132] of Plant Breeders' Rights, the 1989 Farmers' Rights Resolution, in the 1990s, gradually started to receive the status of a formal encouragement without any financial consequences.

GRAIN, in 1991, asserted that revindicating ownership over seeds is not so much the point if farmers are not in a position to develop them further (GRAIN 1991). GRAIN's reasoning was that Farmers' Rights could better be connected to capacity-building at the grassroots level, providing local communities with their own tools to improve stable, low-input production systems, rather than be connected to economic compensation mechanisms. GRAIN has opted for an emphasis on socioeconomic rights, among other options, through the recognition of the right to save, improve and use indigenous landrace and wild materials, as well as a recognition and acceptance from the side of the formal sector (mainly the national and international research community) of local farmer conservation and breeding.

The shift in the discussion on Farmers' Rights from its economic to its social dimension has also been stimulated by the realization of some NGOs that these rights, as an intellectual property concept, would imply an extension of the Western paradigm on intellectual property with its strict focus on ownership. Indigenous knowledge systems are similar to Western plant science in that they are part of public knowledge. However, the usual criteria for recognizing intellectual property rights, novelty, utility and nonobviousness, generally do not apply to the knowledge systems of traditional farmers. But although the emphasis on Farmers' Rights as socioeconomic rights rather than as the rights on intellectual property, meant that the battle for percentages from seed sales has

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[132] For an excellent history on the political and institutional background of the creation of plant breeders' rights see Cary Fowler (1994), Unnatural Selection: Technology, Politics and Plant Evolution.

become a secondary issue, a new revision of the 1978 UPOV convention[133] in 1991 has offered avenues for a new linkage.

Re-linking Farmers' and Plant Breeders' Rights in India?

Owing to a lack of consensus among UPOV members, the revised 1991 UPOV convention contains an "optional exception" which provides that it is up to a national government to decide whether to permit farmers to use the seed of a variety protected under Plant Breeders' Rights for propagation purposes on their own holdings (Article 15.2 of the 1991 UPOV convention). India has not signed the UPOV convention, but designed its own version by using provisions of the Plant Breeders' Rights acts of Australia and Canada[134] as models. The most important provisions are (a) that it retains breeders' exemption, (b) that it strengthens farmers' privilege and (c) provides for a mechanism for giving operational content to the concept of Farmers' Rights (Swaminathan 1995:200, 212-249).

The case of India reveals that although the importance of Farmers' Rights on an intergovernmental level has been recognized since 1989, the real action is taking place at the national level, or in the words of M.S. Swaminathan (1995:251): "Charity begins at home and hence we should first show the way to the world how to fulfil our obligations to farm and tribal women and men". Swaminathan is one of the scientists in India who is lobbying for the recognition of an integrated version of Plant Breeders' Rights and Farmers' Rights legislation.

The issue of Farmers' Rights in India has especially attracted attention following the agreement on Trade Related Intellectual Property Rights (TRIPs) in the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The TRIPs agreement obliges parties to it – that is nearly all countries, developing as well as developed – to protect the rights of commercial breeders and biotechnologists and their companies, and to ensure that they can claim and receive royalties on new seeds, through patents or Plant Breeders' Rights. Both patents and Plant Breeders' Rights can be transferred to country-specific *sui generis* systems[135] on IPR.

In October 1992, farmers' organizations in India resisted the government's acceptance of GATT-TRIPs, even though it would formally **allow** farmers to save and exchange seed non-commercially. For the farmers, the statement was regarded merely as a concession to

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[133] The revision can be considered in the light of growing privatization of plant breeding research on the one hand, and the increasing size of farm holdings on the other, in industrialized countries. Also the demand for eliminating the **breeders' exemption** and the farmers' privilege have grown. As a result, the UPOV 1991 Convention strengthened the position of plant breeders' rights' holders by narrowing down the concept of the breeders' exemption (the right to use protected varieties in a breeding programme) for an "essentially derived variety". This is defined as a variety predominantly derived from another (initial) variety which retains the expression of the essential characteristics from the genotype or combination of genotypes of the initial variety. One consequence of the change is that a breeder who inserts a single new disease-resistant gene into a variety protected by plant breeders' rights, will now have to obtain permission from the holder of the original rights before marketing the new variety.

[134] India, like Canada and Australia, has large government-financed plant breeding programmes.

[135] Article 27.3(b) of the GATT-TRIPs treaty states: Parties may exclude from patentability plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and micro-biological processes. However, parties shall provide for the protection of plant varieties either by patents or by an **effective** *sui generis* **system** or by any combination thereof. This provision shall be reviewed four years after the entry into force of the Agreement establishing the World Trade Organization (WTO).

a fundamental right the farmers already have on the use and distribution of seed. Through the call for Common Intellectual Property Rights, the demands of Indian farmers were translated into a protocol. On 15 August 1993 (India's Independence Day), farmers declared their knowledge and biodiversity as protected by their interpretation of Common Intellectual Property Rights. This implied that any corporation using their local knowledge or local resources without the permission of local communities is considered to be involved in intellectual piracy (such in the case of the use of patents on neem).

According to Vandana Shiva (a well known Indian activist), Common Intellectual Property Rights can create an opportunity to define *sui generis* systems centred on Farmers' Rights (GRAIN 1994). Contrary to the ideas of Swaminathan, Common Intellectual Property Rights are considered as a means to escape from the UPOV Plant Breeders' Rights model systems. One of the reasons for this, according to Shiva, is that although the USA has agreed to the possibility of countries developing their *sui generis* systems within TRIPS, there is the condition that it should be done in an "effective" way (see footnote 135). The inclusion of the word "effective" is generally interpreted to be a legal tool to oppose Plant Breeders' Rights systems which differ from the UPOV and/or TRIP's model designed by a few industrialized countries.

From the Genetic Resources Issue to the Biodiversity Issue

The growth of governmental interest in plant genetic resources for food and agriculture, as described above, has mainly taken place within FAO. Discussions within and outside the CPGR became particularly controversial when IPR issues were dealt with in connection with the formerly apolitical (more technical) issue of the conservation and use of genetic resources. The politicization of the genetic resources issue has mainly become apparent in the discussions on Farmers' Rights and Plant Breeders' Rights, as well as on the allocation of genetic resources in CGIAR genebanks.

Controversies within FAO on these issues, and the analytical context provided by a limited number of critical social scientists and historians, contributed to the construction of the genetic resources issue in its current form. This, however, is not to suggest that the genetic resources issue has only been dealt with in the context of a North-South controversy concentrated in Rome. Apart from FAO, other agricultural organizations have also witnessed conflicts between defenders of Western agricultural interests and those of developing countries (GATT for example), and discussions on the use and allocation of genetic resources have recently become integrated into a much wider debate on the maintenance of 'biological diversity' for future generations.

At this point a clear distinction between the genetic resources issue and the biodiversity issue must be made. While the term 'genetic resources' refers to the genetic information contained in the genes, the terms 'biological diversity'/'biodiversity' encompasses all species of plants, animals and microorganisms (and the ecosystems and ecological processes of which they are parts). And while the genetic resources issue deals with 'use' and 'valorization' aspects of the genetic resources, the biodiversity issue also covers non-use and non-value (such as ethical) aspects. It should be recalled here that the Panel of Experts, when it first formulated its plans in the late 1960s, virtually include both issues: conservation was motivated by the threat of 'genetic erosion' (or loss of genetic diversity) and the need for more access to genetic resources for crop improvement programmes. As described in Chapter 2, these plans were gradually replaced by a more pragmatic approach geared towards collection for potential future application in crop improvement programmes.

With the breakthrough of the environmental movement in the early 1980s (the UNCHE of 1972 did not lead to a breakthrough in the 1970s), publications on mass extinction started to receive the attention of a broad audience. Within a few years, 'biodiversity' became a 'coffee-table' subject.[136] The ethical code for the biodiversity issue was laid down by David Ehrenfeld in Arrogance of Humanism of 1978. Norman Myers documented the extent of the damage in The Sinking Ark: A New Look at the Problem of Disappearing Species (1979) and in A Wealth of Wild Species: Storehouse for Human Welfare (1983). Paul and Ann Ehrlich (1981) provided a treatise on extinction: Extinction: Causes and Consequences of the Disappearance of Species. In Biophilia, E.O. Wilson (1984) articulates the aesthetic losses of extinction in a highly personalized account. Conservationist views like these, in their extreme form, have resulted in ecosystem and biosphere preservationism which desires to protect all ecosystems, life forms and genetic materials, irrespective of their current or future usefulness to humanity. A failure to protect the world's biological diversity, in this view, could result in the collapse of regional or even global biospheric systems and, thus, in the annihilation of the life on Earth. This notion of the dangers of extinction was quickly picked up by the media. But as Henry Vogel (1994:8) remarks:

> From a strictly rhetorical viewpoint, mass extinction is easy pickings for the journalist. Not only are the references easily intelligible, but the story is also dynamic; each day another species bites the dust.

Public support for the conservation of biological diversity was channelled by the World Conservation Strategy, launched by the IUCN, UNEP and WWF in 1980. The World Conservation Strategy had a rather general objective, which was not only to conserve for potential scientific purposes. Also less utilitarian arguments were used:

> There are other reasons for preserving the species. Simple human compassion can be one. Not restricting the rights of other kinds of life to exist is another. The extraordinary beauty of natural forms is yet another. Perhaps most importantly, we are obliged to our descendants not to leave the earth less alive, less interesting and less wondrous because we have been there (IUCN, UNEP, WWF 1984:14).

In the 1980s, the attention for genetic resources not as economic sources but as cornerstones of the earth's ecosystem was picked up by many international and national governmental organizations and NGOs. A publication in 1989 of the World Resources Institute (WRI) reveals that in 1989 US$ 62.9 million (spread over 1093 projects) was invested by the USA in 127 developing countries for biodiversity protection. Compared with 1987, this meant an increase of 68% (US$ 37.5 million for 873 projects) (Abramovitz 1991:vii). Although there are very limited data available on global spending on genetic resources conservation, a rough calculation of Plucknett *et al.* in 1987 revealed that about US$ 55 million was spent on crop germplasm conservation worldwide. These data should be seen in the context of the decreased attention and financial support for agricultural (development) aid.

In this context three international developments should be highlighted:

1. In industrialized countries, the decrease in public funds for agricultural research coincided with decreases in funds for development aid purposes. For this reason,

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[136] See, for example, the reaction of Otto Frankel (in Chapter 4) regretting the involvement of the environmental groups in the 1980s "when the battle was essentially over" (Frankel 1986: 31).

the institutional system built around the Green Revolution started to receive less donor support. Ironically, NGOs formerly focusing on 'social-justice' aspects of the food policies had to reorient themselves at the end of the 1980s as well (see Buttel 1992).

2. International agricultural research was increasingly constrained by political decisions driven by concern over agricultural surpluses and farm crises in industrialized countries. The diffusion of improved varieties seemed to have slowed down while Green Revolution proponents had to recognize boundaries and disadvantages of high-input agriculture. Most problematic was that the early successes with dwarf wheat (CIMMYT) and rice (IRRI) could not easily be extended to other crops.
3. North-South issues which dominated international fora in the 1960s and 1970s (particularly those in the context of the New International Economic Order), such as debt crises, trade disparities and food security in the 1980s were gradually replaced by 'global change' issues, such as climate change, protection of freshwater resources and oceans, deforestation and biodiversity.

Sustainability: the missing link?

With the boundaries of the Green Revolution in sight, a reappraisal of the possibilities of establishing more sustainable links between the environment and agriculture started to receive wider public and institutional support. In the late 1980s, the phrase 'sustainable development' had become commonplace in reports of development planners, activists and bureaucrats. As such it became an accepted part of the rhetoric of Third World and First World politicians, providing a new potent slogan and campaigning theme of NGOs.

Sustainable development also influenced discussions on the conservation and use of genetic resources by forming a linkage between the biodiversity issue and the genetic resources issue, and became a tool for compromise between environmental interests on the one hand and agricultural (utilitarian) interests on the other. While the two views seemed impossible to merge in the early 1980s, the situation after the publication of the Brundtland Report Our Common Future (WCED 1987) seemed different.

Also a 'sustainable use of plant genetic resources' offered inroads into harmonizing poverty alleviation, economic development and environmental protection in a way that each could be advanced simultaneously. The focus on sustainable use also contributed to the much heralded success of the Keystone Meetings (in Keystone 1988; Madras 1990; Oslo 1991):

> If the loss of plant genetic resources continues unabated at the present rate, genetic options for needed changes in agricultural production in the future will be lost forever. The Dialogue participants firmly believe that the current situation calls for a Global Initiative for the Security and Sustainable Use of Plant Genetic Resources. ... Crops will have to be adapted to sustainable forms of agriculture while maintaining increased productivity to feed a still growing population (Keystone Center 1991:v).

Although the Keystone Dialogues on plant genetic resources contributed to a formal merger of the politicized genetic resources issue on the one hand, and the biodiversity issue on the other, the Dialogues are still merely considered as symbolic steps in the right direction. The US$ 300 million per annum additional funding for the conservation and use of genetic resources "on a sustainable basis" demanded by the participants is considered likewise (Keystone 1991:vi).

However, the Keystone Dialogues were not only important to the formulation of the problem. What is indirectly illustrated is the large gap between the political arena of agricultural development (represented by FAO and IBPGR) on the one hand, and that of environmental protection (represented by IUCN, UNEP and WWF) on the other. How these different fora relate to each other has become apparent during the preparation phase of the UNCED conference.

The genetic resources issue and the biodiversity issue at stake at UNCED

After the UN General Assembly had decided upon the necessity of an International Conference on Environment and Development (UNCED), the conservation and use of genetic resources was taken up as one of the primary subjects on the agenda. To prepare a Convention on Biological Diversity (CBD), there were various players in the international field that in principle could play a significant role in this drafting process: UNEP and FAO as intergovernmental organizations and IUCN and WWF as influential NGOs. The question of who was going to have the major impact on the earth's future conservation strategy can be considered in terms of the institutional interests concerned with the relative strength of the 'genetic resources' versus the biodiversity issue, FAO supported by critical NGOs such as GRAIN and RAFI historically representing the former, IUCN, WWF, UNEP (among others) the latter. This relative strength would decide to what extent the CBD would either treat genetic resources in terms of 'development' (use) or 'environment' (conservation). The negotiation process leading up to the final draft of the CBD showed how difficult it was to link biodiversity issues to harder political hurdles which historically had been dealt with within FAO.

Simultaneously with the popularization of the biodiversity issue during the 1980s, UNEP's mandate increasingly focused on the conservation of biodiversity, and as far as genetic resources are concerned, on wild relatives. In 1987, a UNEP Ad Hoc Working Group on Biodiversity prepared a UNEP Biodiversity Convention. The UNEP convention was designed to be used as a global legal instrument for the conservation and preservation of biological diversity, which was to become the basis for the CBD, to be signed during the UNCED.

FAO officials – aware of the fact that the UNEP convention, if accepted at UNCED, would overrule the Undertaking – initially received the UNEP initiative with certain misgivings (Rosendal 1991). They suspected that the convention would merely bind the developing countries into surrendering their plant genetic resources for free. This anxiety was connected to the notion that a UNEP treaty would merely aim at the preservation of genetic resources for environmental protection – regardless of their agricultural or economic value. Also, a shift of the discussions on plant genetic resources towards UNEP would easily offer industrialized countries an opportunity to deal with the transfer of plant genetic resources from developing countries to industrialized countries without having to deal with politicized issues, notably the use, access to and ownership of plant genetic resources as within the forum provided by FAO.

The mistrust of the FAO officials turned out to be justified. During its first meeting (Geneva, November 1989), the UNEP Working Group stated that "other relevant international programmes (for example, the FAO Undertaking) could not adequately meet the aim of conserving biological diversity on a global level" (Rosendal 1991).

However, UNEP could not give assurance that its treatment of biodiversity issues remained free from politicization. Whereas the first meeting of the UNEP Ad Hoc Working Group had been behind closed doors, the second meeting (February 1990) was open to NGOs which (almost inevitably) led to the politicization of the discussions on the content of the UNEP convention. An important consequence was that FAO successfully proposed to add elements of the FAO Undertaking to the UNEP convention. In accordance with the interpretation of the FAO Undertaking, the UNEP Working Group agreed that "access" in the UNEP convention would not imply access "free of charge". Another consequence was that the subjects of 'transfer of technical and financial resources' had to be examined in detail.

With regard to the technology transfer issue, the question of to what extent income could be generated through a North-South '(bio)technology' versus 'gene' exchange became subject to controversies. In the UNEP Working Group, the USA, UK and the Netherlands expressed their scepticism towards including biotechnology in the negotiations. This view was partly based on the fear that such an inclusion would disrupt the negotiations. The NORDIC countries, the Soviet Union and several Latin American countries with Brazil in the lead, were of a different opinion, stressing the economic value of landraces, the export of which would legitimize compensation. The representatives of several Latin American countries argued that if declarations stressing the joint development of biotechnology and systematic access to technology were not included, they would not join a convention on biodiversity (Rosendal 1991:41). The issue of technology transfer echoed the larger one of compensation as first expressed in the Farmers' Rights issue within FAO.

At this point, it is worthwhile mentioning in brief the role of IUCN in the preparations for the CBD which, like UNEP, tended to circumvent controversial genetic resources issues. A few months before the UNEP Working Group had gathered for the first time, the IUCN had designed a 'Draft Convention on the Conservation of Biological Diversity' (6 June 1989). This convention did not focus on issues related to technology transfer and biotechnology. The main emphasis was on conservation strategies, particularly *in situ* conservation of wild species. The CBD refers to *in situ* conditions as: "Conditions where plant genetic resources exist within ecosystems and natural habitats and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties" (Rosendal 1991:33). IUCN feared that linking the less politicized with the more politicized issues "would hamper negotiations in such a way that no conservation agreement can be reached either for wild or domesticated species" (*ibid.*). Within IUCN policies, conservation had traditionally been focused on tropical forests and wild species.

The issue of financial compensation initially remained a 'soft' issue, since most parties obviously agreed that additional financial resources were required. However, during the Working Group sessions, criticism raised because the UNEP convention included what some referred to as a "blank cheque" provision. Developed countries were required to provide money in an amount determined by the parties of the convention, most of them developing countries. A block of 19 developed countries addressed the issue by the provision that only the total amount of money was to be emphasized and not the contribution per individual country (Busch 1992:141).

After these events, industrialized countries like the USA, the UK and the Netherlands started to express their scepticism about the UNEP convention. Nevertheless, the UNEP convention was still more acceptable to the industrialized countries than the FAO Undertaking because issues such as Intellectual Property Rights were not (yet) discussed. NGOs speculate that the reason for the preference of UNEP may also be found in the strong role of the USA within UNEP. The USA, to date, has refused to pay its full yearly contribution to FAO for many years.

The intensification of the discussion on the more controversial elements of the plant genetic resources issue within UNEP helped FAO re-gain ground. At the third session of the UNEP Working Group (Geneva, July 1990), FAO presented its International Convention on the Conservation and Utilization of Biological Diversity. In this new convention, both the ecological interests (with regard to the conservation of plant genetic resources) and agricultural interests (with regard to the utilization of plant genetic resources) seemed to be treated in harmony by linking the two items by means of 'sustainable use'. The FAO Convention, however, still defined conservation in a much narrower sense focusing on landraces and wild relatives for potential agricultural use. Besides, it was not the intention of FAO to let the CBD replace the FAO Undertaking.

Within the UNEP Working Group the FAO International Convention was received with mixed feelings. The governmental representatives from Norway, Sweden and Denmark, together with the UK, France and Canada and many developing (especially Latin American countries), supported the proposal but Germany, the Netherlands and the USA refused to accept FAO's narrow focus on conservation.

In spite of the last-minute efforts of FAO, however, it became clear that the UNEP convention was to serve as a framework for the CBD. The CBD has not offered developing countries any definite answer to both the technology transfer issue, as well as the issue of financial compensation.

The financial mechanism that would ultimately support the implementation of UNCED would be in the hands of an organization that was only partly involved in UNCED, namely the World Bank. The World Bank, assisted by UNDP and UNEP, had established the Global Environment Facility with a clear ecological focus (see Wood and Pistorius 1993).

Technology transfer, according to the CBD, should be on "mutually agreed terms, including technology protected by patents and other intellectual property rights". The real treatment of the property rights issue would be dealt with outside the agricultural and environmental realm, namely as part of the TRIPs negotiations within GATT. So, although the patent issue showed its North-South dimensions when the Third World pushed the debate into FAO and onto the negotiations for the CBD, the industrialized countries, at the same time, managed to introduce the issue into the GATT negotiations.

Conclusions and Summary

The politicization of the conservation and exchange of genetic resources historically falls into the premises that during the 1970s Green Revolution debates were brought to bear against the international agricultural research establishment. These premises can be divided into three elements: (a) the view that genetic resources are instrumental in capital accumulation; (b) the view that corporate actors had an interest in protecting genetic resources through the industrial patent system, and (c) the view that the control over genetic resources both in the public and private sector, and both in terms of conservation and use, is not transparent and hence is detrimental to developing countries.

As the genetic resources issue is primarily about power relationships between countries with different abilities to have access to and use of genetic resources, the organization of conservation efforts (especially the location of genetic resources in genebanks) by industrialized countries became a primary element in the discussions. IBPGR was a special case in point since on the one hand it represented 'free access', while on the other hand developing countries and NGOs suspected that its strong ties with western donors could not guarantee this principle.

Although the genetic resources issue dominated the public discussion on genetic resources from the beginning of the 1980s, the conservationist/environmental context of the conservation of genetic resources gradually started to become part of public concern. In the late 1980s, the term 'biodiversity' conservation became a commonplace in many public fora and publications.

As indicated earlier, the genetic resources issue deals with 'use' and 'valorization' aspects, whereas the biodiversity issue also covers non-use and non-value (e.g. ethical) aspects. Thus, the biodiversity issue differed from the genetic resources issue in the sense that (at least initially) issues related to the commercial value and use did not dominate the political discussions. Hence it tended to be treated in a relatively less conflicting political context.

The rapidly spreading adherence to the biodiversity issue by various environmental organizations in the late 1980s should be considered in the context of (a) decreased attention and financial support for agricultural issues, and (b) a spectacular rise of institutional support for conservation efforts. Although the Keystone Dialogue meetings never resulted in practical political action, they offer an indication of the tendency to formulate a 'sustainable use' policy with regard to genetic resources which can be considered as an attempt to link institutional interests dealing with the biodiversity issue (emphasizing 'conservation') on the one hand, and the genetic resources issue (emphasizing 'conservation' for 'use') on the other. Such synthesis, however, has proved to be much more difficult than envisaged.

At this point, it must be acknowledged, however, that with the rise of the issue of Material Transfer Agreements (MTAs: contracts on the conditions of transfer and use of genetic resources) increasingly used by CGIAR genebanks, the political and economic questions related to the value of unimproved genetic material for agricultural purposes is gaining ground again.[137]

Another indication of a similar kind is the rapid spread of the phenomenon of "biodiversity prospecting" – the exploration of biodiversity for commercial and biochemical resources (Reid *et al.* 1993:1), often used for screening biological material in niche-rich biospheres for positive compounds that might lead to the development of new drugs. It is felt, however, that such values are very large because of the high returns individual drugs can give. However, agricultural values, for genes used in breeding programmes, although potentially enormous (in terms of production) and vital for future development, cannot be so easily appropriated, or treated as intellectual property. "Because of the easier appropriability of returns from pharmaceutical prospecting, the drug tail often wags the agricultural dog" (Clive Stannard 1995, private communication; Pistorius 1993).

This chapter has shown that a reason for the difficulties in formulating a sustainable use policy on genetic resources can be found in the institutional divergences between fora that deal with the biodiversity issue on the one hand, and the genetic resources issue on the other. The next chapter will attempt to show to what extent this schism is also reflected in conservation strategies.

[137] See, for example, Pistorius 1995.

6 *In situ* or *ex situ*? Conservation strategies in the 1980s and early 1990s

In the history of conservation strategies, the most recent but perhaps also most important discussion refers to *in situ* and *ex situ* conservation. Treated as a purely scientific matter, the discussion rarely leads to a fundamental and decisive choice between the two. It is widely held among scientists that *in situ* and *ex situ* conservation should be treated as complementary strategies. One of the reasons is that *ex situ* conservation can never take over the function of *in situ* conservation as a means of storing the world's genetic diversity of crop plants or their wild relatives with a potential use, if only for budgetary reasons, and *vice versa*. However, in spite of the general agreement in scientific circles, the issue looks different in relation to institutional policies. In this context questions are raised such as: to what extent should one conserve wild relatives and landraces of important plants *ex situ* rather than *in situ*? To what extent should farmers' efforts be supported to maintain landraces *in situ*? To what extent should nature parks or reserves conserve both landraces and wild relatives?

The history of the conservation of genetic resources illustrates that the *ex situ* approach has become the primary tool for the conservation of crop plants. It is said there exist over 4 million accessions in 400 to 500 *ex situ* collections throughout the world (see, for example, Plucknett *et al.* 1987; FAO 1996b). In retrospect, Otto Frankel together with many other scientists feels justified about the predominance of *ex situ* conservation for preservable seeds:

> Two decades were to show that *ex situ* preservation, using low temperature storage, was to become the standard practice, and that, with sound management, the predicted pitfalls could be avoided. I regarded *in situ* conservation of primitive cultivars impracticable in view of the large numbers involved and the technical and social problems to be met ... For short-lived plants, *ex situ* germplasm collections were the only practicable solution for the long-term preservation of large numbers of accessions ... although full consensus was not reached at this stage (Frankel 1985:31-32).

Frankel defended his pragmatic approach in his contribution to the 1967 FAO/IBP Technical Conference and in the book that came out of it: "Genetic Resources in Plants – Their Exploration and Conservation" (see Chapter 2). In this approach, he argued that *ex situ* genebanks offered opportunities for attaining increased efficiency in terms of more accessibility for use in breeding programmes. Centralized collections can be relatively easily observed, studied, used and safely stored (Frankel 1970:488-482).

Indeed, breeding for high-yielding crops would have been a much more difficult job had *ex situ* genebanks not existed, although the extent to which genebanks are actively used is still an open question (see, for example, Duvick 1984). During the creation of an *ex situ* network, genebanks were considered the most appropriate way of preventing the rapid rate of genetic erosion. However, in the 1980s (see Chapter 5) not only did the centralization of *ex situ* conservation strategy start to be questioned on political grounds, but so did the general claim that it was the best option for conserving genetic resources. Decentralization versus centralization of collections is an issue with both scientific and political aspects. Decentralization of responsibility and control over *ex situ* collections is, in principle, generally considered to be a laudable goal but difficult to achieve. Bureaucrats tend to emphasize the constraint of excessive costs, scientists the issue of decreased security of accessions. Less heard are those that emphasize the political 'risks' involved:

decentralization means a greater involvement of local farmers' organizations in conservation.

These pragmatic, scientific and political arguments are the main ingredients of the question as to what extent *ex situ* conservation can be replaced by *in situ* conservation. In the 1970s and 1980s, this question was raised not only by critical NGOs and social scientists, but also by concerned scientists with long experience of the *ex situ* system, for example Melaku Worede of the Plant Genetic Resources Centre in Ethiopia, Karl Hammer of the Institute of Plant Genetic and Crop Plant Research in Gatersleben (Germany) and Stig Blixt of the Nordic Genebank. One might ask: Why didn't the new criteria, which came up in the 1980s, on the accessibility and usefulness of genebanks result in a second Panel of Experts generating a world wide *in situ* conservation network?

Arguments For and Against *In Situ* and *Ex Situ* Conservation

Ex situ *conservation*

In the literature on conservation strategies, the arguments in favour of *ex situ* conservation of storable, non-recalcitrant seeds tend to be formulated in terms of the shortcomings of *in situ* conservation. In summary, they refer to the following:

(a) *ex situ* conservation is most suitable for long-term conservation;
(b) *ex situ* storage facilities can store more diversity and quantity of accessions of seeds;
(c) evaluation is easier than in *in situ* circumstances, and
(d) *ex situ* offers wider availability to breeders than do *in situ* collections.

Arguments related to the shortcomings of *ex situ* conservation have been heard from the late 1960s on. Following the 1967 FAO/IBP Conference, Allard (1970:491-494), for example, made a short summary of the potential drawbacks, on scientific grounds, of long-term *ex situ* conservation:

(a) **differential survival of genotypes in storage**: long-term storage causes a loss in germination rate (which varies with genotype);
(b) **selection during rejuvenation**: after several cycles of rejuvenation, entries bear little resemblance to the original parent(s) collected in nature;
(c) **outcrossing with other species**: it appeared very difficult to provide adequate isolation to prevent outcrossing between different entries during regeneration;
(d) **genetic drift**: during storage, allelic frequencies can be subject to considerable changes compared with the parent populations.[138]

Allard's list can be complemented by a more recent one of Hawkes (1991):

(e) it is impossible to store recalcitrant seeds *ex situ*;
(f) *ex situ* conservation "freezes evolution" (or leads to evolutionary stasis), and
(g) *in vitro*[139] storage *ex situ* may cause loss of diversity.[140]

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[138] Hawkes (1996, pers. comm.) comments on these points as follows: (with reference to points a, b and c respectively) (a) there is not a differential survival of genotypes if regeneration takes place once the germination rate drops below 85-90%; (b) the regeneration cycles are so far apart that this change is only to be considered possible after several centuries, and (c) regeneration takes place under controlled conditions which prevent outcrossing (see also Frankel and Hawkes 1975). He considers (d) doubtful as there is no evidence for it.

[139] *In vitro* refers to storing some plants in tissue culture in glass containers to save space and reduce costs.

[140] If the storage and other conditions are not suitable for the species or genotypes conserved; careful control is always advisable for this method of conservation (Hawkes, pers. comm. 1996).

The reservations of Allard and Hawkes have been strengthened by later, less scientific reservations. A short summary of the main arguments in the existing critical literature on the conservation and use of genetic resources is given below. It should be noted that the arguments postulated in the early 1970s were used equally often in the decades thereafter.

1. Finance

Genebanks are dependent on the financial possibilities and the willingness of the state to establish and run them (Hammer 1994:158; Shands 1991). Political and economic changes can have serious implications for genebank systems as was for example observed in Eastern Europe and in the former Soviet Union.

But financial constraints also can lead to an overemphasis on long-term conservation strategies (cold storage) through which other forms of *ex situ* conservation have been neglected, as, for example, the proper handling of cross-pollinated and vegetatively propagated crops (Hammer 1994:158-9). A third constraint is that *ex situ* conservation depends on the input of skilled and well-educated curators and technicians, who need (expensive) training or experience in an already established *ex situ* conservation institute. An additional factor is that genebanks are often service- rather than research-oriented, which tends to limit career possibilities.

2. Representativeness

There are more than 5000 crop species globally, but only a limited number (Hammer refers to only a few hundred) are present in genebanks. Additionally, the number of species with a more or less sufficient variation to be worth maintaining in genebanks is rather limited (Hammer 1994:159). A related argument is that, in the past, once samples were stored *ex situ*, the incentives to ensure the survival of remaining *in situ* populations seemed to disappear. "The wild equivalent would be putting a few tigers in a zoo and then making no effort whatever to ensure survival in the wild" (Wood and Lenné 1993:12).

The argument is related to the one which criticizes *ex situ* conservation because of its narrow focus on use by breeders. As Frankel still argues: "There is no point in collecting crop species that are unlikely to be bred" (Frankel 1989). But current debates on the use of genetic material increasingly emphasize the possibility of using material from the secondary and tertiary genepools. On this view it is considered that only a global concept of *in situ* including on-farm conservation complementary to genebank collections can meet the growing demands for material.

3. Overflowing collections

Too many accessions in one collection can result in losses because accessions that are badly registered or are not regularly evaluated, can be considered as non-existent. This fear of collections being 'swamped' contributed to what has become known as the 'deluge problem' (see, for example, Holden 1984) which also affected IBPGR's collecting strategy in the mid-1980s. The IBPGR 1983 annual report states that "Specifically, widespread collection of cultivars will be slowed down except for documented emergency situations" (IBPGR 1983). The same year, L. Kåhre, Chairman of IBPGR's Board of Trustees, presented a paper to the FAO Commission on Agriculture (COAG) stating that: "We already foresee the end of the collecting work for maize, tomato, sorghum, millets, potato and rice and others will be predicted in a few years. There are other pressing needs such as training, implementation of good documentation systems ..." (Kåhre 1983:3) Impressive, though possibly exaggerated, figures of existing collections were used to underline the problem. Base collections world-wide would contain 75 000 root and tuber accessions; 275 000 vegetable accessions; 1 200 000 cereal accessions; 185 000 grain legume accessions; and 212 000 accessions of forage grasses and legumes (Holden 1984:278).

In the mid-1980s, proposals were made to reduce IBPGR's emphasis on cereal crops from 56% in the first decade to 25% of the total collections, while food legumes would decline from 20% to 15% (Fowler and Mooney 1990:159). What criteria were used for this observation remains unclear, although J.H.W. Holden (senior advisor to IBPGR) in his review of the second five years of IBPGR (1984) concluded that:

> It is clear that the amount of germplasm now in store constitutes a serious problem to those responsible for it and that with present resources - and this is an intuitive judgement, but one with which many would agree - it simply is not possible to characterize, evaluate and multiply it all. Nor is it necessary to do so. ...

From knowledge of conditions in some genebanks in the more prosperous developed countries, one can confidently guess that on a world scale the conservation of material is sometimes good but frequently inadequate and occasionally disastrous (*ibid.* 279).

The deluge problem was also used as an argument against *ex situ* conservation during the politicization of the genetic resources issue. Mooney, for example, used genebank reports to draw attention to the problematic history of the NSSL, Fort Collins (Colorado, USA), one of the world's largest genebanks (Mooney 1983:75). Other genebanks and collections with good reputations also appeared to be more vulnerable than expected: the pre-1948 USDA wheat stocks, the VIR collections in St. Petersburg, the maize collection of the Rockefeller and National Research Council (NAS 1972:129; Leppik 1970:325; Goodman 1984:365; Dempsey 1990:43).

4. Use of collections

The discussion of use of *ex situ* genebank materials is perhaps one of the most precarious discussions since it relates directly to the primary goal of their existence. The criticism falls into two arguments. One is the limited use of *ex situ* genebanks (see Chapter 3) by breeders who for day-to-day use rely largely on elite lines in their own circuit. Research on this issue has been carried out by Duvick (1984), Peeters and Galwey (1988), and Peeters and Williams (1984). The research of Peeters and Williams (1984:24) reveals that there has been a low level of interest by breeders in larger genebanks, and very little interest in the newer, small, multicrop collections. The bulk of requests were for improved germplasm: "rarely do they relate to landraces and almost never to wild species". There is, however, a slowly growing recognition of the need for a more intensive use of landraces and even whole new populations to broaden genetic bases (Duvick 1996, pers. comm.). Also, it should be noted that breeders involved in pre-breeding tend to go back to genebank stocks, including those of the CGIAR (see, for example, Hawkes 1985)

Yet another criticism on *ex situ* collections refers to a too heavy breeder-centred approach, implying that little emphasis has been given to details of local use – including requirements for taste, cultivation ecology, history of a variety in the farm community, use in intercropping, prevalent pests and diseases, and traditional storage technology (Wood and Lenné 1993). In this respect some authors emphasize the great disparity between the formal and the informal seed sector (see, for example, Hardon and Van Hintum 1994; Friis-Hansen 1992).

5. Evolutionary stasis

The argument of Hawkes (1991) on evolutionary stasis refers to the cessation of evolution between the plants and their natural environments. The argument is that, once collected, *ex situ* storage becomes evolutionarily inert. More specifically, the argument holds that germplasm conserved *ex situ* cannot continue to adapt to the often complex and changing biotic and physical environment found in traditional farming – particularly in marginal areas. Ecologists, such as Myers, have described genebanks as "genetic ghettos" (Myers 1983:123) but much earlier criticism has also come from within the scientific community. Thus Simmonds (1962) referred to *ex situ* collections as potentially a 'wasting asset' of 'museum collections' which could be better used. Erna Bennett during the 1967 FAO/IBP Technical Conference claimed that there was:

> ... no advantage in the steady state [conservation, since] the purpose of conservation is not to capture the present moment of evolutionary time, in which there is no special virtue, but to conserve material so that it will continue to evolve (Bennett 1968:63).

Bennett considered *ex situ* conservation as a "wasting asset" for all but the major-gene variation. In her opinion, some other systems had to be provided for conservation of continuously varying, adaptive and physiological characters, such as disease, drought, frost or mineral resistance (Dempsey 1990:83 *op. cit.*, Bennett, pers. comm.). Frankel (1970:476) on the other hand argued that:

> Although it is commonly assumed that ... 'static' preservation will capture and preserve the variability as it exists at the time the collection is made, both population genetic theory and practical experience indicate that this is generally not the case.

Frankel's response to Bennett's argument during the 1967 Conference was to stress the complex and uncontrollable "components of change" that would lead to "massive erosion" of material maintained in the field (*ibid.*). This discussion refers back to breeding and conservation strategies (Chapter 3), in particular to the discussion on host-pathogen relationships. While for some, evolutionary interaction in host-pathogen relationships could work as a safety-valve against diseases, for others (most often in the commercial plant breeding establishment) this evolution was a disturbing factor in crop improvement which, by definition, had to take place *ex situ*.

In situ *conservation*

Motivations to support *in situ* conservation have partly come from bad experience with *ex situ* conservation, but also, and more recently, because of the new attention on conservation of biodiversity from nature conservationists. Although arguments in favour of *in situ* conservation of landraces have been recognized in the past 30 years or so, approaches in which both agricultural use and *in situ* conservation are combined are either very rare or non existent.

In her "Plant Introduction and Genetic Conservation: Genecological Aspects of an Urgent World Problem" Bennett (1964:91) concludes with some supportive notes on the creation of areas of natural conservation within the centres of genetic diversity, where plant communities might be maintained entire and *in situ*. Bennett's support mainly focused on the Izmir Regional Genebank in Turkey (see Chapter 1):

> Institutes of this type represent an essential stage in the development of a co-ordinated world genetic conservation programme based upon the genecological concept stressed by Vavilov and

> later workers that the potentialities of species are determined by the potentialities of the local populations of which the species are composed ... (Bennett 1964:91).

Another practical proposal came from Kuckuck who, relying on his long experience in Iran and Turkey, proposed the establishment of 'crop reserves', i.e. areas of 0.5 to 1 ha in size, where local crop varieties would be maintained under the supervision of a local agricultural officer (Frankel and Soulé 1981:227). During the 1967 Conference, Kuckuck formulated his idea as follows:

> My proposal is that the local varieties, landraces, should be grown under the improved environmental conditions in regions where agricultural conditions are being improved. Natural selection will act on these local varieties; the frequency of genotypes will be changed by the new environmental conditions ... (Kuckuck in Bennett 1968:61).

Although the idea to install agricultural officers is certainly not supported by more recent ideas on the knowledge and technical skill of 'traditional' farmers, ideas to combine conservation of landraces for specific 'use' purposes *in situ* were not frequently heard in the 1970s and thereafter. The proposal of Kuckuck, although not taken seriously at the 1967 Conference, stands out as one of the very few ideas to maintain diversity for strictly agricultural purposes *in situ*. A similar proposal a few years later came from Wilkes and Wilkes (1972:39) who suggested "carefully chosen strips of 5 by 20 kilometres at as few as 100 sites around the world where native agriculture would continue", somewhat more than the hectare of Kuckuck.

Frankel, in a reaction to Kuckuck's suggestion, stated that no "steady state" in the population of local varieties or landraces is possible in the population of primitive cultivars because of technological change in the farming systems that once produced them (Frankel and Soulé 1981:228-229).

Frankel and Soulé in "Genetic Resources in Plants" questioned the maintenance of such "small isolates, with all the inherent tactical difficulties, let alone the inevitable loss of identity" (1981:228-229). Their concern for the maintenance of genetic identity, however, might not have been the main concern of Kuckuck and others (such as Bennett) who also have suggested *in situ* conservation strategies for strictly agricultural goals. Considering especially the genecological ideas of Bennett among others, the problem of "loss of identity" might not have been a matter of concern at all. Or, as Kuckuck during the 1967 Conference emphasized:

> The gene pools of local varieties should be considered from the dynamic rather than the static point of view. They are permanently evolving. The influence of wild and weed relatives, and of mixed genotypes in a population should be seen as continually producing new forms (Kuckuck in Bennett 1968:32).

Frankel's observations have been countered by Brush (1994: 346), remarking that (a) it assumes that some type of steady state existed before the advent of fertilizers, (b) it assumes that landraces are mutually exclusive with new cultivars and fertilizers, and (c) it does not express conclusions "drawn from careful observation of the actual farming systems and crop populations undergoing technological change". ... "Frankel's conclusion that "farms cannot simply be conserved" (Frankel 1970) laid the foundation for the dismissal of *in situ* conservation (see for example Ford-Lloyd and Jackson 1986; Holden, Peacock and Williams 1993).

Much later in 1981, Frankel and Soulé in a critical (and until then unique) appraisal of the role of *in situ* conservation in agriculture, suggested reserving *in situ* conservation for wild relatives (and not for landraces) as it:

> ... provides the relative stability of multi-species diversity within a co-adapted community [and] tends to preserve genetic polymorphism and to provide opportunities for recombination. However, where ... the conservation of particular species for economic purposes is demanded ... more often than not *ex situ* preservation may be more economical (Frankel and Soulé 1981:227-229).

Frankel's argument is against the idea of maintaining landraces in *in situ* conditions, since this would hinder effective 'use' in the short and medium terms. Where conservation for an unknown or infinite period of time is demanded (more than a century or a few centuries) Frankel argues that *in situ* rather than *ex situ* conservation is most appropriate (*ibid.*).

Frankel and Soulé (1981:227-9) hold that *in situ* conservation should be reserved for wild relatives while for "species of economic significance ... more often that not *ex situ* conservation may be more economical". It is with a similar argument that Frankel also opposes the idea of Simmonds (1962) to use 'mass reservoirs'. These reservoirs would allow for composite crosses of large numbers of diverse parental types. Simmonds emphasized the use of reservoirs as adjuncts to breeding. This idea was dismissed by Frankel mainly on the basis of a comparison of the effectiveness of preserving material in *ex situ* conditions: "The question is whether genetic variation is maintained more effectively than in collections of individual accessions" (Frankel and Soulé 1981:230). Or as Marshall and Brown (1975) suggest: "[Mass reservoirs] are of little value in preserving variation, potential or expressed". Marshall and Brown also refer to the questionable potential of mass reservoirs as sources of new and effective resistance genes especially because of the limited number and size of the populations that could be grown in them.

A third option for conservation of wild species *in situ* was put forward by A. Dinoor (Dinoor *op. cit.* Frankel and Hawkes 1975:201). In this concept a continued evolution in host-pathogen relations in centres of diversity within 'nature reserves' was suggested. Also Jain (1975) proposed the creation of a network of clusters of "genetic reserves" with various designs, management activities and legal status that would reflect procurement and maintenance needs on a primarily 'for-use' to a primarily 'for-conservation' spectrum. Frankel's comment on these concepts again referred to its limited use potential "for no other reason than that the number of strands that could be included would of necessity be small" (Frankel *op. cit.*, Hawkes 1978:101-106).

The early suggestions of Bennett, Simmonds and Dinoor have gradually been translated into more recent proposals for combining existing local farming practices with *in situ* conservation strategies (notably by Stephen Brush in the late 1980s in various publications; Cromwell 1993; Cooper *et al.* 1992). Although organizations such as IBPGR (now IPGRI) have developed plans to support such efforts, resistance from the established conservation community (directors of genebanks, agricultural bureaucrats, etc.) remains. For example, IBPGR's director between 1976 and 1989, Trevor Williams, W.J. Peacock (Chief, Division of Plant Industry, CSIRO) and J.H.W. Holden in a joint publication (Holden *et al.* 1993:90) still consider *in situ* on-farm conservation as a step back compared with *ex situ* conservation in terms of its possibilities to maintain evolutionary change:

> It has been suggested that 'museum farms' or 'folk farms' are a way of overcoming this arrest of evolutionary change and are a preferable alternative to *ex situ* conservation. On these farms, the traditional old varieties or landraces would be maintained under traditional systems of husbandry –

> the farm system would be held in a state of arrested development ... [However] under these conditions, if they could be attained, the selection pressures from the environment would supposedly be constant, except for the normal variations in the climate, and therefore adaptive or evolutionary change would not be expected to occur. It seems, therefore, that the proposed 'folk farm' could not fulfil its stated purpose of ensuring the continuation of evolution; on the contrary, its function, if any, would be to prevent it (Holden *et al.* 1993:90).

The above practical proposals to set up *in situ* conservation have been countered not only with scientific arguments as suggested here. In past discussions on the viability of *in situ* conservation, most counter-arguments have been much more practical in kind. The more important ones are summarized:

1. practical problems and cost of administrating subsidies and monitoring the relevant areas (Plucknett *et al.* 1987:92-5);
2. lack of staff to supervise field sites (*ibid.*);
3. ready availability of the material to breeders is unclear (*ibid.*);
4. *in situ* preservation can only conserve a tiny fraction of crop germplasm (Dempsey 1990);
5. scientific, economic and social problems involved (Holden, Peacock and Williams 1993:96);[141]
6. obsolescence of *in situ* conservation methods especially where better, non-traditional methods are available (Frankel and Soulé 1981:227-229);
7. the right reserve size is unknown (Hawkes 1991:530);[142]
8. only a limited amount of diversity can be stored in established reserves, and
9. there are no generally accepted methods of storing landraces.

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141 The authors put the argument as follows: "We can see ... that the attractive simplicity of conservation in the wild is deceptive. It is rather more than just erecting a fence around an areas of interest. Many scientific, economic and social problems have to be solved before *in situ* conservation can be used with confidence for safeguarding genetic diversity (Holden *et al.* 1993:96/7).

142 Frankel and Soulé (1981) try to take up the problem of what they call "minimum viable population", which is considered to vary a great deal, from "a few hundred to a few thousand." Hawkes (1991:530) comments that "some 1000 individuals might be a better figure for the actual population size, taking into account that not all individuals may contribute genes to the next generation." Bennett (1996 pers. comm.), however, states that the normal population of most crops, except large plants or tree crops can register a density of one million per single hectare. One of the pending questions is, for example, whether inbreeders need more space than outbreeders. Hawkes concludes his article with ten "suggested basic requirements for establishing *in situ* reserves of crop-plant relatives" (Hawkes 1991:535). Hawkes' article further contains useful results of an experiment (The Ammiad Project) on the diversity and degree of adaptation of populations of wild crop relatives in their natural habitat.

Implications for Conservation Strategies

Chapter 2 shows that guidelines formulated during the 1967 and 1973 FAO/IBP Conferences have been translated into conservation strategies adapted to quick and efficient conservation of landraces and elite material *ex situ*. The 1972 Stockholm Conference generated some wider attention for genetic erosion, but had no practical follow up in terms of activities in the field of *in situ* conservation.

In contrast to practical institutional initiatives, scientific literature did pay attention to both *in situ* and *ex situ* conservation, although on the basis of a strict division of labour. Frankel's and Soulé's Conservation and Evolution of 1981 was relevant but did not lead to alternative conservation strategies in areas where *ex situ* conservation was already dominant. Rather, they thought *in situ* conservation was part of the responsibility of nature conservation organizations such as the UNEP, IUCN and WWF.

At the end of the 1980s, especially after the publication of the Brundtland Report Our Common Future (WCED 1987), the notion of 'sustainable use' offered some room for manoeuvre within the debate on *in situ* conservation. This was partly worked out during the Keystone Dialogue (see Chapter 5). In the early 1990s, UNCED again generated some serious interest in *situ* conservation. However, this new interest was not carried on by dominant agricultural institutes (FAO, CGIAR) but tended to be guided by sheer economic and political interest of governments and NGOs in regions of genetic diversity.[143] As Stephen Brush (1994:353) notes: "although *in situ* conservation might be acknowledged as possible and perhaps necessary ... there are few efforts to plan or implement *in situ* conservation". How and why the formal attention of international organizations to *in situ* work developed during the past two decades is treated below.

Formal attention to in situ *conservation policies in FAO and IBPGR*

Technical/scientific discussions in the 1980s had very limited direct impact on decision making within the institutes dealing with conservation strategies such as FAO, IBPGR, UNEP and IUCN. Where *in situ* conservation was proposed, it was not usually considered as a viable alternative to *ex situ* conservation, but rather as a complementary method in which agricultural/economic use aspects would not prevail. In this respect, there has hardly been any change in dominant conservation strategies since the late 1960s.

In Rome, a first formal acknowledgement of the need for *in situ* conservation, albeit with reservations, was given during the 1973 FAO Technical Conference on Genetic Resources – the follow up of the 1967 FAO/IBP Technical Conference. The 1973 Conference (see Chapter 4) recommended the establishment and maintenance of genetic resources in the form of living (*in situ*) collections "in view of the fact that methods of conserving genetic resources other than as seed have not been fully investigated, and may present advantages in certain areas" (FAO 1973:9).

Promising sounds were again heard in the early 1980s at the FAO/UNEP/IBPGR International Conference on Crop Genetic Resources (April 1981) where Robert Prescott-Allen presented a research report on *in situ* conservation (Prescott-Allen and Prescott-Allen 1981) stating:

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[143] The British Bureau for Science and Technology remarks: "The preservation of diversity, particularly of endangered plants, landraces and historic varieties, is no longer the domain of large national and international programmes. In fact, community seed banks, NGOs and seed saver exchanges are becoming more and more visible in the global conservation of diversity" (Bureau for Science and Technology 1990:61/62).

> Several conferences and experts on crop genetic resources have called for *in situ* conservation of crop gene pools, yet very little has been done. This Conference should re-emphasize the need for such conservation and propose a set of actions to achieve it.

Subsequently, the 1981 Conference approved five recommendations concerning *in situ* conservation of wild relatives of crops. These recommendations summarized the main institutional recommendations in the report prepared by the Prescott-Allens (affiliated to IUCN) who had produced their report at the request of IBPGR. IBPGR accepted the paper's main conclusion that "in many cases, *in situ* conservation is the best method of conserving the variability in valuable wild species" (IBPGR 1984:5). The report for IBPGR further endorsed: (a) national protected area agencies to improve the usefulness of protected areas for conservation of crop genetic resources, (b) IBPGR to support preparation of an inventory of wild genetic resources, and (c) IBPGR to participate with FAO, UNEP, UNESCO and IUCN in the formation of a committee to coordinate *in situ* conservation activities. The 1981 Conference also recommended UNEP and IUCN to take action with regard to *in situ* forestry projects (FAO/IBPGR/UNEP 1981:61). Further action with regard to *in situ* conservation was assigned to an *ad hoc* group representing all agencies to discuss the matter further.

IBPGR/IPGRI's in situ *policies*

Although, within IBPGR, *in situ* conservation seems to have gained some attention only after the conclusion of the UNCED Convention on Biological Diversity, there were some earlier but limited initiatives in the mid-1980s. Following its statement that it considered "*in situ* conservation as the most viable means to conserve wild relatives of food crops" (IBPGR 1984:25-26) IBPGR, in 1985, organized a Special Task Force. The Task Force recommended (a) *in situ* conservation for 28 of its priority crops, (b) ecogeographic surveying for genepools of 20 IBPGR mandate crops and (c) study of *in situ* conservation for another 17 genepools which could lead to proposals. The reason for linking ecogeographic surveying and *in situ* conservation was that knowledge of variability in genepools, and the factors that sustain it, were considered a prerequisite for *in situ* conservation:

> Ecological and geographical data, along with knowledge of species biology, are necessary to determine minimum and optimum requirements to determine needs for the number of populations, area, sites, assessment of species and communities, and successional factors .. (IBPGR 1985b:3).

The IBPGR Special Task Force developed a provisional list of species for ecogeographic surveying and *in situ* conservation for fruit trees, forages and a number of other crops, and pointed out the need for "sufficiently large and diverse" populations so as to sustain the levels of allelic frequencies in conserved populations. Compared with the day-to-day *ex situ* conservation strategy pursued by IBPGR, the Task Force's suggestions seem revolutionary and (almost) recall the earlier suggestions of Bennett[144] (see Chapter 3):

> The range of natural and social factors which may be considered in ecogeographical surveys is very wide. A number of factors include aspects of climate, weather, geology of soils. The biotic factors which may be significant for understanding the variability of target populations vary per

[144] Where Bennett in 1970 had recommended aerial photography to map specific sites (an idea which was dismissed), the IBPGR Task Force in 1985 suggested the use of remote sensing systems through the Landsat Multispectral Scanner (MSS) which results would be stored in new computerized databases (IBPGR 1985b:4-5).

species and ecosystems. Similarly, the social influences that combine to shape the landscapes in which targeted populations survive, usually involve a wide spectrum [of factors] from archaeological and from ethnobotanic to economic to legal (IBPGR 1985b:3).

An important aspect of the work of the Task Force was its emphasis on *in situ* conservation strategies for crop species. Until the 1990s, references in IBPGR literature to *in situ* conservation had focused on its significance for nature conservation (usually forestry conservation). The Task Force, however, emphasized that *in situ* conservation methods "involve more than simply establishing protected natural areas which contain random or fragmentary populations of species which are wild relatives of crops" (IBPGR 1985:8).

At a workshop on Agro-Ecological Characterization, Classification and Mapping[145] in Rome (April 1986) IBPGR offered a review of its plans. In cooperation with the WWF, IBPGR had decided to support three small ecogeographic surveys. The first was for species of mango (*Mangifera*) in protected areas of Malaysian and Indonesian Borneo. The second was for wild species related to pearl millet and forage *Pennisetum* species in the sub-Saharan Sahel.[146] The third was for wild wheat grasses in part of the area of origin and domestication of wheat in southeast Turkey. IBPGR assigned priority for ecogeographic surveying to 29 crops and to species of 45 genera of forage grasses and legumes (Esquinas-Alcázar 1986:65).

However, the project was soon terminated. The reason seems to have been both political and scientific. The 1986 TAC report refers to the political vulnerability of the *in situ* conservation projects, stressing that: "The basic problem for IBPGR, insofar as *in situ* conservation is concerned is that the whole process of designation of the areas, their maintenance and their management, requires action by national governments" (TAC 1986:83).

The reservations of TAC recall the problems IBPGR has had with designing a geographic 'regional approach' for *ex situ* conservation (see Chapter 4). As with the *ex situ* regional approach, the ecogeographic concept transcended national and thus also political boundaries. Even with its purely 'scientific mandate' IBPGR, in trying to set up a regional approach, had not been able to neutralize political sensitivities among nations in one region. By some governments, national interests (perceived or real) in specific crop relatives were considered to be in conflict with the international free exchange doctrine. This problem was also recognized by IBPGR. In a report on ecogeographical surveying and *in situ* conservation the following comment is made:

Germplasm conserved *in situ*, will always be under control of national (and sometimes local) governments. The responsibilities of stewardship of these resources are likewise under these jurisdictions. While the Board will continue to reaffirm the importance of free availability and exchange of germplasm within the international community, it is realistic to recognize that the access to germplasm conserved *in situ*, even when there is assistance from the international community, is a matter of national policy for individual governments (IBPGR 1985b:17-18).

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145 The results of the workshop were published in: Bunting A.H. (ed.) Agricultural Environments: Characterization, Classification and Mapping. Proceedings of the Rome workshop on Agro-Ecological Characterization, Classification and Mapping 14-18 April 1986 (FAO, IBPGR, CAB), Rome.

146 These plants were likely to include descendants of the progenitors of pearl millet which may be useful in increasing the adaptation of that crop to dry conditions.

TAC, apparently not willing to become involved in political problems, decided to advise IBPGR to "keep a watching brief on *in situ* conservation", and urged leaving the initiative to IUCN and WWF. TAC also noted that "... an unrealistic promise of IBPGR action might create false expectations on the part of other institutions" (TAC 1986:83-84).

Another explanation for the abrupt termination of the *in situ*/ecogeographical programme is that it was merely embraced as a *formal* matter which could potentially extend the mandate of IBPGR keeping pace with international trends in conservation strategies. In this context, it should be noted that one of the primary members of the IBPGR Task Force was Trevor Williams, who, throughout the 1980s, was Director of IBPGR (see Chapter 4). The great sympathy in the Task Force report for *in situ* conservation and ecogeographic surveys, contrasts heavily with the general policy line of IBPGR which (also during the 1980s) concentrated on *ex situ* conservation. Apart from this, Williams had reservations on *in situ* conservation for seed-propagated staple food crops. *In situ* conservation for staple foods would mean:

> ... a return to or a preservation of microcosms of primitive agricultural systems, which is of course unacceptable and impracticable. In any case, the majority of such landraces have long since been lost (Ingram and Williams 1984:164).

> Landraces cannot be conserved by growing them in primitive agricultural conditions; it is neither practical nor can it be justified morally (Williams 1988:246).

> If you have a situation where the material is in more or less natural vegetation there is a very strong argument for some *in situ* conservation i.e. some of the genepools of barley and wheat, but not on a farm (*ibid.*).

> *In situ* conservation is preferable most of all where *ex situ* conservation is too costly.... The idea of mass reservoirs as developed by Simmonds [see Chapter 3] would certainly make sense in the case of maize and pearl-millet, but is not a method you can apply to every crop (Williams 1995, personal interview).

The reason why *in situ* conservation did receive attention by the Task Force, as Williams himself argues is that: "At that time there was the enormous euphoria about nature conservation, and millions of dollars were made available" (Williams 1995, personal interview). Williams, however, also recognizes that, at that time, IBPGR simply did not have the expertise available to start seriously with *in situ* conservation: "In the early 1980s there was a great lack of concepts on how to conserve a genepool within an ecosystem [and] there were no concepts of appropriate management to maintain genetic resources or concepts of monitoring wild relatives over time" (*ibid.*). In one of IBPGR's first *in situ* studies (of tree fruits and vegetables in Europe), the results were far from encouraging. Less than 10% of the reserves appeared to have lists of plant species, and of these only five wild crop relatives had been recorded in six reserves, with no information as to genetic diversity (Dempsey 1990:152).

IBPGR's attention to *in situ* conservation was never implemented practically but neither was it forgotten. Since UNCED in 1992, increasing funds became available for *in situ* conservation (such as through the Global Environment Facility, GEF), and it seems that IPGRI decided to join the trend towards a more integrated approach of *in situ* and *ex situ* conservation strategies as the 1994-1995 appointment of Stephen Brush, an expert in *in situ* conservation of the University of California, may suggest.

IPGRI budget proposals for the 1994-1998 period includes a scenario which would include an additional senior staff member at IPGRI headquarters and in each of four regional offices (excluding Europe) for work on forest genetic resources, biodiversity, *in situ* conservation and ethnobotany, plus additional programme implementation funds (IPGRI 1993:15). IPGRI's "Strategy for *In Situ* Conservation of Agricultural Biodiversity" contains the following message:

> *Ex situ* conservation makes resources available to a wide variety of users concerned with agricultural improvement (particularly crop and forestry breeders). *In situ* conservation of plant genetic resources can make a much more direct contribution to the well being of farmers and communities by ensuring that adapted plant types remain directly available to them for their own continuing use. It provides an essential part of development strategies based on sustainable use and equitable sharing of benefits. ... IPGRI can play an essential part in the international collaborative effort required by supporting the scientific research, training, planning and implementation of *in situ* conservation, by collaborating with national programmes to build the capacity to support *in situ* conservation and by helping to tackle some major constraints (IPGRI 1995:1-2).

FAO's initiatives for in situ *conservation policies*

In FAO, *in situ* conservation since 1975 was dominated by the activities of the Forest Genetic Resources Project of the Forestry Department, with financial assistance from UNEP. The Project provided expertise and funding for conservation in forest and wildland areas in the major fields of protected areas and national park management and also included *ex situ* conservation. A few notable steps were made: FAO and UNEP produced a Methodology of Conservation of Forest Genetic Resources, which, among other things, proposed guidelines for *in situ* conservation and described Canadian efforts to conserve *in situ* genepools of jack pine (*Pinus banksiana*). In 1974, the FAO Panel of Experts on Forest Gene Resources drew up list of priority species for *in situ* conservation. A revised list was published which comprised 134 species. Funding was provided for two botanical reserves in Zambia to conserve one of these species, the Zambesi redwood or Zambian teak. At the Fifth Session of the FAO Panel of Experts on Forest Gene Resources in 1981, an updated comprehensive list of forest genetic resources priorities, by geographical region, species, and use and gene conservation operations phases, was compiled.

The lack of action on *in situ* conservation led FAO in the early 1980s to seek information from individuals and institutions in several countries on the existence of protected areas managed primarily for the conservation of genetic diversity or in which genepool conservation was explicitly stated as one of the management objectives. The response, however, indicated that there was "little or no experience in the actual management of areas for intra-specific genetic conservation which could provide a ready-made model for action in other countries" (FAO 1984:7). Throughout the 1980s, few initiatives were developed to extend *in situ* conservation programmes under FAO, although they were recognized as: "... the main responsibility of FAO in *in situ* conservation of wild relatives of cultivated plants, as well as promoting 'on farm' conservation and utilization of landraces while recognizing the importance of cooperation with other relevant organizations" (FAO 1991:5).

In 1985, some plans were developed within FAO-CPGR to develop interest in a combination of *in situ* and *ex situ* conservation while collaboration with IBPGR was envisaged. Formal agreements between FAO and Indonesia and Iran were signed to establish pilot-scale activities on *in situ* conservation. Primary emphasis would be laid on intraspecific diversity of plant genetic resources of socioeconomic value for food and agriculture. Also CPGR states that: ".... the network of *in situ* and on-farm areas" is part of the FAO Global System (see Chapter 5) (*ibid.*). However, the gap between planning and implementation is still rather large.

Until today, most of FAO's activities on *in situ* conservation are generated through its Forestry Department. Recent CPGR reports reveal that, with regard to *in situ* conservation projects in Indonesia and Iran, little concrete progress has been made due to the "lack of resources and work pressure" (FAO 1995b:8).

Initiatives of UNEP/IUCN and WWF in in situ *conservation*

Some attempt to coordinate work on *in situ* conservation came from the Ecosystem Conservation Group (IUCN, FAO, UNESCO and UNEP) in the early 1980s although not much came out of this initiative. The 1984-85 IUCN/WWF Plants Conservation Programme included numerous individual projects on the establishment of protected areas but not for wild relatives and landraces of crop species. IUCN does have a Captive Breeding Specialist Group which is part of the Species Survival Commission and other specialist groups. Also in the 1980s, an Inter-Agency Ecosystem Conservation Working Group concentrating on *in situ* conservation was set up by FAO, UNEP, and IUCN, but failed to promote clear action although "informal discussions" (FAO 1984:5) among the four organizations in 1980s led to A Global Programme for the Protection of Genetic Resource Areas which was included in the World Conservation Strategy (under Section 17). However, only a few years later, the project was terminated. A mixture of institutional interests and differences in 'corporate philosophy' played a role in this matter (Williams 1995, personal interview).

It may be concluded here that, in spite of various international initiatives, successful conservation efforts of wild relatives and/or landraces *in situ* are very rare indeed. Perhaps the Biosphere Reserves in the former Soviet Union are still the best documented effort to conserve genetic resources of wild relatives of crops through an international programme (i.e the UNESCO/MAB programme, see below).[147] Also, India is active in preserving so-called 'sanctuaries' for several crops[148] (FAO 1984:6).

Furthermore, initiatives in which conservation and use of landraces are combined are very uncommon. In projects where the use aspect of conserving genetic resources *in situ* is emphasized, this only covers wild relatives (see, for example, Ingram and Williams 1984). An example is the Man and the Biosphere programme (MAB, started in 1971 by UNESCO). MAB is considered a "symbol of voluntary cooperation to conserve and use resources for the well-being of people everywhere" (Ingram 1984:34). However, practical experience shows that the use aspect mainly involves forestry activities or fishery and that there was lack of monitoring activities which could reveal the genetic resources available in the parks supported by MAB. Roughly 80% of the biosphere programmes in the 1980s were originally national parks (*ibid.*). It should be noted that the MAB programme emerged as a central concern early on in the development of the environmental movement (Batisse 1982).

IUCN and WWF should not be regarded as conservation agencies in the strict sense. Hamann of IUCN stated that the main tactic was to "persuade other organizations to conserve plants, and to help provide them with resources to do the job, rather than for IUCN and WWF to attempt to do everything themselves" (Hamann 1987:38). With regard to initiatives in the area of *in situ* conservation of crop plants most action of IUCN and WWF relates to formal cooperation agreements with other organizations, particularly FAO

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[147] The former Soviet Union established 127 reserves (FAO 1984:6).

[148] *Musa, Citrus, Oryza, Saccharum, Erianthus, Mangifera* and their wild relatives.

and IBPGR. Other *in situ* projects of IUCN and WWF focus on the protection of pristine forest areas such as in Indonesia and Sri Lanka, Mauritius, Nepal, the Canaries, Tanzania, and Madagascar, but these projects focus on wild relatives of plants which do not necessary have economic value. To the extent that economic motives for conservation are involved, the focus is on medicinal plants (Hamann 1987:37-43).

Some Questions Behind the *In Situ* versus *Ex situ* Conservation Debate

Scientific and formal political discussions of *in situ* and *ex situ* conservation strategies tend to acknowledge that they are not mutually exclusive and should be implemented side by side. These statements implicitly suggest that existing institutions which are concerned with *ex situ* conservation can switch, if they wished and had the resources, to *in situ* conservation. But although scientific and popular-scientific literature in the late 1980s and 1990s has heralded *in situ* conservation as an important conservation strategy, the institutional context in which this should take place is hardly discussed.

Discussions on institutional action with regard to *in situ* conservation tend to be limited to **planned** actions (or non-actions) of existing international organizations while, in most programmes, *in situ* conservation focuses on wild relatives. The reason for the formal inclusion but practical exclusion of landraces in *in situ* conservation by international organizations may be related to its political context. *In situ* conservation of landraces implies decentralized conservation facilities and conservation strategies. Also, *in situ* conservation raises the difficult question of how to integrate conservation practices with development questions. The leading question is whether large centralized conservation organizations can be involved in conservation done by local farmers that maintain landraces *in situ* as a daily practice in their own interest.

The very informative book of Cromwell, Wiggins and Wentzel – Sowing Beyond the State: NGOs and Seed Supply in Developing Countries (1993) – may serve as an example of how to stimulate a decentralized conservation approach. The book demands new, multi-institutional approaches to local seed supply, in which NGOs are to strengthen existing community-managed seed networks throughout the developing world. Another strong proponent of this strategy is GRAIN in Barcelona (see Chapter 5).

This part of the *in situ* versus *ex situ* debate shows how science, conservation and institutional policies can become entangled. The decision on what kind of conservation can not be decided on the basis of a comparison between the two has been suggested in the beginning of the chapter. The *ex situ* versus *in situ* argument tends to become mystified by scientific reasoning in pro- and contra-arguments evading the institutional political problems which are equally important. This distracts from institutional action both in agricultural and conservation circles.

Are the traditional agricultural research policy institutions, such as FAO and IBPGR/IPGRI, and other CGIAR institutes, even when prepared to do so, really able and willing to finance, organize or administer *in situ* conservation efforts other than those focussed on nature preservation? It seems that contact with the farmer has been lost. There are very few field studies which could provide technical, sociological, ethnobotanical and anthropological knowledge to support *in situ* conservation which focus on on-farm conservation (and use) of landraces and farmers' varieties.

The lack of experience in *in situ* conservation, is expressed by the very broad goals both IBPGR/IPGRI and FAO pursue when presenting their plans: *in situ* conservation, meaning both on-farm conservation and nature preservation, is focused on both landraces and wild relatives, and sometimes mentions the farmer as a participant, sometimes not. Decisions on how to proceed appear very hard to tackle for international organizations with such broad mandates. The question remains: can *in situ* conservation serve crop improvement (either by farmers or breeders in research institutes) while simultaneously meeting the current wish to maintain diversity? Cromwell *et al.* (1993:113) note that the "potential tensions and synergies between genetic conservation on the one hand, and agricultural development on the other, are not well worked out".

The current funding system, particularly in the CGIAR system, traditionally focuses on *ex situ* conservation. Therefore it can be expected that donors, if they are prepared to make shifts in their contributions, will tend to weight old against new policies. The debate on how to proceed then tends to become a short one: *in situ* conservation does not serve breeding efforts (the core activity of the CGIAR Centres) better than *ex situ* conservation. To be prepared to focus on *in situ*, a totally different question has to be asked and answered: "Are the CGIAR Centres or FAO able to de-centralize their research activities and set up an infrastructure for the maintenance of landraces both for use and for conservation?"[149]

The answer is not only relevant for future conservation policies. More knowledge about farmer management of crop diversity can also be linked to sustainable means of disease and pest management. As has been outlined in Chapter 3, various scientists hold that landrace populations contain diverse resistance genes as built-in safeguards against epidemics. However, there is still little information on the function of diversity for disease and pest resistance in traditional agricultural systems (Wood and Lenné 1993:5). More specifically, there is hardly any systematic research on the identification and description of adaptive gene complexes, or on the way in which diversity is maintained by farmers (IPGRI 1994:5; 1995:3).

If international organizations such as FAO and IBPGR desire to integrate *in situ* work into their policies, these should be subject to:

- re-evaluation of the role of *in situ* conservation in crop improvement;
- re-evaluation of the role of local farming (as far as using landraces) in crop improvement, and
- re-evaluation of the relationship between conservation and development and the impact these will have on the maintenance of diversity.

The experts who redefined IBPGR's mandate in the 1980s developed a clear mission statement: IBPGR was to be considered strictly as a scientific organization. Political questions (such as on development issues) were left to FAO. Because of this division of labour, development questions have not become one of IBPGR/IPGRI's strong points. *In situ* conservation demands a much broader approach than the traditional *ex situ* conservation strategy of landraces and wild relatives. IBPGR/IPGRI has reached its scientific goal: an almost full supply of breeding material. FAO has almost reached its political goal: a global legal framework on the conservation and use of genetic resources. However, an important question remains: How to connect conservation and development? The answer lies in the ability to reach the most important existing work force *in situ* – the millions of farmers in developing countries worldwide.

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149 As David Wood comments: "Why should the CGIAR (and FAO) abandon a very successful breeding strategy to chase moonbeams? Before even the suggestion of this can be made, many pilot projects must first see if there is anything in it for poor farmers (beyond maintaining supposedly evolving genepools for US plant breeders). In any case, for anything at all de-centralized, it is the ... NARS, and not the CGIAR or FAO, that should be doing everything connected with farmers. NARS, like everyone else ... are mainly concerned with increasing national crop production" (Wood 1995 pers. comm.).

The scientific dichotomy between *in situ* and *ex situ* conservation and the lack of expertise for linking conservation with development has resulted in a tendency that most political support for *in situ* projects over the past 20 years has been initiated by nature-conservation agencies. One reason for this postulated in this book is the victory of the 'biodiversity issue' over the 'genetic resources issue'. At this point, an additional argument should be mentioned, namely that nature-conservation initiatives tend to neglect the human factor. This has led to a development in which forest preservation projects (whether or not protecting wild relatives) often prevent sustainable use by small farmers and negate their historical role in maintaining wild relatives and landraces (for example through slash and burn practices).

Conclusions and Summary

The *in situ* versus *ex situ* controversy among scientists and politicians has been treated in terms of their relative strengths. Most arguments in favour of *in situ* conservation are born out of negative experiences with *ex situ* conservation. Those favouring *ex situ* conservation assess the technical/practical and hence financial constraints related to *in situ* work. The decline of funds for agricultural research (which in the early 1990s caused severe budget reductions in CGIAR) tends to strengthen arguments for *ex situ* conservation. By contrast, public pressure (from agricultural and environmental pressure groups) and increased financial support for nature conservation (especially through UNCED) tends to support a greater focus on the *in situ* conservation effort, for example in part allocated through the Global Environment Facility (GEF) and administered by the World Bank, UNDP and UNEP.

The increased attention to *in situ* conservation contrasts with the scientific-technical attention that could support adequate conservation strategies for useful species in economic plant genepools. Usually *in situ* conservation money moves into areas of highest species diversity, most important for biodiversity conservation. This focus on 'climax diversity' can partly be explained by the large public call to 'protect nature from man'. However, as Trevor Williams remarks, "none of the major food crops and their progenors are associated with climax vegetation"[150] and worries about the "widespread misconception" that *in situ* conservation in a few areas of crop diversity will adequately conserve enough wild genotypes for future crop enhancement when wild relatives in other (much less diverse) areas will also be valuable. As most *in situ* management practices have been directed toward habitat preservation and have focused on ecological rather than genetic considerations, technical expertise on conservation strategies and techniques focused on *in situ* conservation of useful species is still very limited.

> In fairness, the nature conservation community has moved in the direction of species conservation as well as ecosystem conservation, but the parameters relevant to economic plant genepools must depend on an understanding of the patterns of distribution and diversity of each target species, including breeding systems and viable population size (Williams 1993:34).

This development identified IPGRI as the leading actor in the formulation of conservation policies, in a unique but difficult position. While, on the one hand, IPGRI's historical expertise lies in acting as a coordinator in the global conservation and exchange

[150] However, such a link is found in some other crops such as rubber, tropical fruits [although not bananas and pineapple], and some roots and tubers [although not potatoes, sweet potatoes and cassava] (Williams 1994).

of genetic resources among 'breeder-demand- oriented' genebanks and supporting national and international genebanks, the currently increased support for conservation with less utilitarian premises from the side of conservationists has created some incentive to pay attention to *in situ* work. More attention to *in situ* conservation is not only a scientific decision, but most of all a political one as it also would involve local initiatives in conserving landraces and wild relatives demanding other less centralized and, very likely, also more expensive conservation efforts than experienced so far. Questions arise such as:

1. Farmers' Rights: How can farmers become actively involved in *in situ* conservation? What incentives for farmers exist to maintain landraces? Should farmers be rewarded financially, or should there be structural re-assessment of the value of landraces? Brush (1992) notes that implementing *in situ* conservation with funding from Farmers' Rights will require a new institutional and policy framework, an improved information base and support from farm groups (see also Chapter 5).
2. Sovereignty: Poor countries may adhere to international conventions, but in daily practice have to deal with the problem of scarcity in arable land as well. Does sovereignty over genetic resources stimulate or hamper *in situ* conservation?
3. International cooperation: As biological resources make a much greater contribution to local economies than they do to national and international economies, to what extent can and will international organizations be the primary force to stimulate *in situ* conservation? What new role do NGOs have in this?

Another political dimension of the *in situ* versus *ex situ* question is that support for *in situ* conservation may be hampered by the fact that this strategy does not directly make genetic resources available to breeders.

This and the other items discussed above illustrate the difficult task any international organization that is willing to focus on *in situ* conservation will be confronted with. To what extent IPGRI is really able to (or should) broaden its mandate to include *in situ* conservation does not, perhaps, depend on the appointment of *in situ* experts such as Stephen Brush, but on a redefinition of the role the Institute (and other international agricultural organizations) will play in reassessing the role between conservation and use. Success in this respect would require what best can be described as a paradigm shift involving a decentralized decision-making approach involving room for NGOs, local action groups (for example farmers), and even companies using genetic resources.

Practical approaches to conserving genetic resources (and not just diversity) *in situ* are seldom treated in the scientific literature. The work of Stephen Brush may serve as an exception. Brush's emphasis is not on the preservation of specific genotypes, but rather on the maintenance "of the conditions that create and maintain diversity" (Brush 1992:1627). This interpretation automatically shifts the attention away from genotypes in the first place to the role of indigenous knowledge in the evolution and cultivation of different genotypes. "Indigenous knowledge has served as a handmaiden in the evolution of agrosystems by conditioning selection and cultivation of different genotypes" Brush states (*ibid*). At this point, the reader will certainly remember similar remarks made by Erna Bennett in the early 1960s.

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Acronyms

ASTA	American Seed Traders Organization
ABC	Association of Biotechnology Companies
CBD	Convention on Biological Diversity
CSIRO	Australian Commonwealth Scientific and Industrial Research Organization
CIAT	Centro Internacional de Agricultura Tropical
CIP	Centro Internacional de la Papa
CGIAR	Consultative Group on International Agricultural Research
CPGR	FAO Commission on Plant Genetic Resources
ECP/GR	European Cooperative Programme for Crop Genetic Resources Networks
EUCARPIA	European Association for Research on Plant Breeding
FAL	Federal Agricultural Research Institute, Germany
FAO	Food and Agriculture Organization of the United Nations
FAO-COAG	FAO Committee on Agriculture
FAO-CPGR	Commission on Plant Genetic Resources
FAO-ICCBD	FAO Intergovernmental Committee for a Convention on Biological Diversity
GATT	General Agreement on Tariffs and Trade
GRAIN	Genetic Resources Action International
GEF	Global Environment Facility
IBA	Industrial Biotechnology Organization
IARCs	International Agricultural Research Centre
IBP	International Biological Programme
IBPGR	International Board for Plant Genetic Resources
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICDA	International Coalition for Development Action
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IUCN	World Conservation Union (formerly International Union for the Conservation of Nature and Natural Resources)
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
ISNAR	International Service for National Agricultural Research
IUCN	International Union for the Conservation of Nature and Natural Resources
CIMMYT	International Wheat and Maize Improvement Centre
IRRI	International Rice Research Institute
JIBP	Japanese International Biological Programme
MAB	Man and the Biosphere Programme (UNESCO)
NRC	National Research Council
NSSL	National Seed Storage Laboratory
NIEO	New International Economic Order
NGO	Non-governmental Organization
OECD	Organization for Economic Cooperation and Development

RAFI	Rural Advancement Foundation International
TAC	Technical Advisory Committee of the CGIAR
TRIPs	Trade Related Intellectual Property Rights
UNCED	United Nations Conference on Environment and Development
UNCHE	United Nations Conference on the Human Environment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPOV	International Union for the Protection of New Varieties of Plants
USDA	United States Department of Agriculture
VIR	N.I. Vavilov Research Institute of Plant Industry
WARDA	West African Rice Development Association
WRI	World Resources Institute
WWF	World Wide Fund for Nature

Glossary[151]

Accession — Plant or seed sample, strain or **population** held in a **genebank** or **breeding** programme for **conservation** and use.

Adaptation — 1. The process of change in an organism's structure(s) and/or function(s) that makes it better suited to survive in an **environment**. Adaptations refer to favourable combinations of **genes** which are tried, accumulated and preserved by natural selection.

Allele — An alternative form of a gene. Alleles are located on corresponding **loci** of homologous chromosomes.

Asexual reproduction — Any reproductive process which does not involve the union of gametes (or haploid germ cells).

Awn — A bristle-like projection from the tip or back of the lemma in grasses; also known as beard.

Backcross — The cross of a **hybrid** to either of its parents (or a genetically equivalent individual).

Backcross breeding — A plant **breeding** system in which recurrent **backcrosses** are made to one of the parents of a **hybrid**, accompanied by specific selection for a particular character or set of characters.

Biodiversity — The total **variability** with and among **species** of living organisms and their **habitats**.

Biotechnology — Any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses.

Breeder's collection — See: **working collection**.

Breeding — The propagation and genetic manipulation by **hybridization** or deliberate self-crossing of plants, for the purpose of selecting and improving offspring.

CGIAR — Consultative Group on International Agricultural Research: an association of private and public donor agencies which support the work of 16 international agricultural research centres. Twelve of these are directly involved in the **conservation** and use of **plant genetic resources**.

Centre of diversity — The geographic region in which the greatest **variability** of a crop occurs. A primary centre of diversity is the region of true origin (often referred to as the **Centre of origin**), and secondary centres of diversity are regions of subsequent spread of a crop.

Centre of origin — The area in which a **species** or **taxon** first arose. The concept of centre of origin was developed by N.I. Vavilov but has subsequently been modified.

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[151] Source: Elsevier's Dictionary of Plant Genetic Resources (IBPGR 1991); Geneflow (IBPGR, various issues).

Classification The arrangement of organisms into a hierarchical order or system to identify them and to express their interrelationships.

Co-adaptation The natural selection process whereby harmoniously collaborating **genes** accumulate, as complexes of linked genes, in the genepool of a **population**.

Collection (of plant genetic resources) 1. The gathering together of domesticates (**landraces**, old and modern **cultivars** and **breeding** lines) and related **wild** or weedy **species**. 2. The material gathered by the act of collecting is termed a collection.

Community A naturally occurring group of various organisms that inhabit a common **environment**, interact with each other and are independent of other groups.

Conservation (genetic) The **collection**, maintenance and preservation of intra- and inter genetic variation, e.g. a representative **sample** of the **genetic variation** of a particular **species**.

Crop evolution The **adaptation** of a crop over generations of association with man, to forms more advantageous to man and brought about by generally unconscious selection, provision of nutrients and protection from **pests** and **diseases**. It may occur to the extent that the domesticated form loses the ability to survive in nature.

Cross-pollination Transfer of pollen to the stigma of a different plant or clone.

Cultivar A **variety** of a plant produced by selective **breeding**. (also: cultivated variety)

Cytology The branch of biology dealing with the structure, function and life history of the cell.

Deforestation The removal of a forest tree or trees, usually by human action, but it can also be caused by **environmental** change.

Disease A deleterious alteration in the dynamic interaction between an individual and the **environment**, caused by a biotic or an abiotic factor.

Diversity The existence of alternate forms (genetic or otherwise). (also: **variability**)

Ecology The study of organisms consisting of one or more **ecotypes**, capable of inter**breeding** in relation to their environment.

Ecosystem The complex of an ecological community, together with the non-living components of the **environment**, which function together as a stable system and in which exchange of material follows a circular path.

Ecotype The product of a **genotypic** response of a **species** (or a part thereof) to a particular **habitat** or **environment**, as a result of natural selection.

Elite germplasm **Germplasm** that has been manipulated for use in a **breeding** programme.

Environment The sum of the non-genetic factors which surround and influence an organism.

Epidemic	A rapid increase in **disease** over time and in a defined space.
***Ex situ* conservation**	Literally 'out of place'; **conservation** outside the original or natural **habitat**, e.g. seed in a **genebank.**
Evolution	The transformation of the form and mode of existence of an organism in such a way that the descendants differ from their predecessors.
Evolutionary dynamics	The process, force and rate of change in a **population.**
Farmers' Rights	Rights arising from the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in the **centres of origin/diversity**.
Gene	The basic unit of active transmission of the genetic information that determines patterns of inheritance.
Genebank	Storage facility where germplasm is stored in the form of seeds, pollen or *in vitro* culture, or in the case of a field genebank, as plants growing in the field.
Genecology	The study of **population** genetics in relation to **habitats**.
Genepool	All the genetic information encoded in the total gene composition of a **population** of sexually reproducing organisms, at a given time.
Genetic code	The system whereby genetic information is used to form proteins with specific sequences of amino acids.
Genetic diversity	Total amount of **genetic variation** present in a **population** or **species**.
Genetic erosion	Gradual loss of genetic diversity between and within **populations** of the same **species** over time; or reduction of the genetic base of a **species** due to human intervention, **environmental** change, etc.
Genetic resource	**Germplasm** in plants, animals or other organisms, containing useful characters of actual or potential value.
Genetics	The science of **heredity**; the study of **genes**.
Genetic stock	A **variety** or **strain** known to carry (a) specific **gene**(s).
Genetic variation	An inheritable **variation** brought about by a change in (a) **gene**(s), as distinct from differences due to **environmental** factors.
Genome	The collective term for all **genes** carried by a single representative of each of all the chromosome pairs.
Genotype	1. The genetic constitution of an organism. 2. A group of organisms with similar genetic constitutions.
Germplasm	The genetic material which forms the physical basis of **heredity** and which is transmitted from one generation to the next by means of germ cells.
Germplasm collection	Collection of **genotypes**, gene libraries or **alleles** of one or more **species**.
Habitat	A specific place that is occupied by an organism or **community**, and where interactions with other organisms and the **environment** occur.
Heredity	The transmission of genetic characters from one generation of organisms to the next generation.

Host See **pathogen.**

Hybrid The progeny of genetically dissimilar parents.

***In situ* conservation** Definition of the UNCED Biodiversity Convention: Conditions where plant genetic resources exist within **ecosystems** and natural habitats and, in the case of domesticated or cultivated **species**, in the surroundings where they have developed their distinctive properties.

In vitro "In glass". The term is generally applied to biological processes made to occur in isolation form the whole organism. Or collections of parts or whole organisms in the laboratory. (The opposite is *in vivo.*)

Intellectual Property Protection (IPP) Protection of an invention through use of legal instruments, e.g. **patents**, copyrights, **plant breeders' rights.**

Landrace Farmer-developed **cultivars** of crop plants which are adapted to local **environmental** conditions.

Locus "Place(s)". The term generally refers to the position of a gene on a chromosome.

Monoculture The growing of a single plant **species** in one area, usually the same type of crop grown year after year.

Parasite An organism that lives in or on a living organism (host) of another **species** from which it derives all of its nutrients while conferring no benefit in return.

Passport data Information about a **sample** or specimen and the site of collection, the time, and any other data, recorded at the time of collection.

Patent A legal instrument granting an inventor the exclusive right, for a limited time, to exploit the invention in exchange for disclosure about it.

Pathogen An organism capable of causing a **disease** in another organism (a **host**).

Pest Any form of plant or animal life or any agent **pathogen** to plants or plant products.

Perennial A plant that lives for more than two years, often for a number of years; many flower annually.

Phenotype The observable characters of an organism. Used to designate a group of individuals with similar appearance but not necessarily identical **genotypes.**

Plant Breeders' Rights A legal instrument granting the developer of a plant **variety** the exclusive right to market it for a limited time. Varieties protected by such legislation may be used by others in the development of new varieties.

Plant breeding The application of genetic principles and practices to the development of individuals, **cultivars** or varieties, more suited to the needs of man.

Plant genetic resources Genetic material of plants, including modern **cultivars,** landraces and **wild relatives** of crop plants, of value as a resource for present and future generations of people.

Polygenes	The **genes** responsible for the genetic component of **variation** in a quantitative character, each individual **gene** exerting only a slight effect on the **phenotype**.
Population	In genetics: A group of individuals which share a common genepool and have the potential to interbreed.
Progeny	Offspring.
Pulse	The edible seeds of leguminous plants such as peas, beans and lentils.
Pyramiding	Backcrossing of several genes into a certain background.
Sample	A small number of observations or individuals taken from, and intended to represent, a larger **population**.
Species	A group of actually or potentially interbreeding natural **populations** which normally are reproductively isolated from other such groups and/or show common characteristics.
Strain	A group of individuals from a common origin; generally a more narrowly defined group than a **variety**.
Susceptibility	The inability of a host plant to suppress or retard invasion by a **pathogen** or **pest** or to withstand adverse **environmental** conditions.
Recalcitrant seed	Seed that cannot be dried and so cannot be stored at low temperatures without damage.
Variability	The state of being variable, i.e. being able to change characteristics, form or nature.
Variety	A subdivision of a species below subspecies.
Wild relative	Uncultivated relative of a crop species.