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ECOGEOGRAPHICAL SURVEYING AND *IN SITU* CONSERVATION OF CROP RELATIVES

Report
of an IBPGR Task Force,
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The International Board for Plant Genetic Resources (IBPGR) is an autonomous international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The IBPGR was established by the CGIAR in 1974 and its Executive Secretariat is provided by the Food and Agriculture Organization of the United Nations. The basic function of the IBPGR is to promote and coordinate an international network of genetic resources centres to further the collection, conservation, documentation, evaluation and use of plant germplasm and thereby contribute to raising the standard of living and welfare of people throughout the world. The Consultative Group mobilizes financial support from its members to meet the budgetary requirements of the Board.

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EXECUTIVE SUMMARY

- These recommendations by an IBPGR Task Force are aimed at helping the IBPGR to develop a policy for the use of ecological and geographical data in exploration, and employment of in situ methods for conservation of germplasm.

- "Ecogeographical surveying" is an essential prerequisite to better collection of genetic resources of wild plants and to in situ conservation planning. Such surveys will require greatly expanded programmes of field work and monitoring as well as germplasm sampling and subsequent experimental evaluation. Similarly, it will be necessary to expand information systems to process the data which are produced.

- Protected natural areas as methods of in situ conservation can be major components within broader programmes to preserve and utilize genetic resources of wild relatives of crops. However, these efforts must have scientific merit and be well considered if they are to be capable of both sustaining genetic variability over the long term and making genetic resources available for crop improvement. A substantial portion of the world's protected natural areas containing wild relatives of crops will need to be reworked in terms of design and management if they are to adequately conserve these genetic resources. New protected natural areas will be necessary for numerous species, particularly in the tropics. Implementation of proposals will be the responsibility of respective national and local governments.

Summary and major recommendations:

- The Task Force recommended ecogeographical surveying for all or portions of the genepools of 28 of its priority crops (Table 2, page 20). The genepools of another 15 crops were recommended for preliminary studies which would determine if there are needs for surveys. A number of forage species were also recommended for comprehensive surveys (Appendix II, page 25).

- Portions of the genepools of 20 of the IBPGR's priority crops were recommended for in situ conservation (Table 2).

Another 17 genepools were recommended for study which could lead to proposals for *in situ* conservation. A number of forage species were also recommended for *in situ* conservation (Appendix II, page 25).

- Portions of the genepools of 11 of the IBPGR's priority crops were recommended for complementary types of conservation (Table 3, page 22).

Specific recommendations are made in relation to the development of special data bases on wild species (paras 19, 30), training (para 33) and funding (para 34).

INTRODUCTION

1. Wild relatives of crops are becoming increasingly important as genetic resources. The IBPGR, in its first ten years, focussed its major attention on cultivated forms and their ex situ conservation. However, recently there has been a shift towards increased conservation and utilization of genetic resources of wild relatives. As a result, there are clear needs for more comprehensive and precise field surveys and better sampling. This is especially true to provide data on infra specific variability.

2. Following decisions by the IBPGR to reduce its emphasis on generalized germplasm collecting and to target more localized and specific work, there is recognition that projects should be based on better information. In particular, use of more systematic ecological and geographical data is stressed as a background to germplasm collection and conservation. In parallel with these changes in emphasis was a request from the donors to IBPGR that the samples of crops conserved in genebanks should be widened so that they are more fully representative of the wider genepool.

3. A number of Committees and Working Groups of IBPGR have stated, in the past, the need for in situ conservation methods for some species. By 1983, it was apparent to the Board that existing, protected natural areas were not adequate for survival of numerous, valuable species and respective infra specific diversity. There has been a vacuum, both in scientific leadership and technical expertise, which has impeded development of an international network of "genetic reserves". Accordingly, the Board, at its twelfth meeting in February, 1984 agreed upon an initial policy statement on in situ methods for wild relatives of crops within broader conservation strategies.

4. The Board requested Dr. Q. Jones, member, to convene a task force to provide guidelines on ecogeographical surveying, to advise on priorities for action, to provide principles and to set priorities for in situ conservation. The reason for linking the two topics -- ecogeographical surveying and in situ conservation -- is that knowledge of variability within

genepools, and the factors which sustain it, is a prerequisite to any *in situ* conservation which is secure, efficient and practical for purposes of germplasm utilization.

5. The Task Force met in the World Bank, Washington, D.C., USA, 30 July - 1 August, 1984. The participants represented a range of expertise in population genetics, taxonomy, plant ecology, remote sensing and environmental planning (Appendix I).

PRINCIPLES FOR ECOGEOGRAPHICAL SURVEYING

6. By ecogeographical survey is meant the determination of:

(i) distributions of particular species in particular regions and ecosystems;

(ii) patterns of infra specific diversity; and

(iii) relationships between survival and frequency of variants and associated ecological conditions.

Because it is often impossible to distinguish genotypic from phenotypic variability in the field it is usually necessary to grow out sampled populations under controlled conditions. Hence the initial field work will nearly always require follow up in experimental conditions. While this can sometimes be completed in as short a time as one growing season for annuals, it may involve considerable periods for perennials.

7. As part of the large germplasm exploration and utilization programmes, ecogeographical surveys can have a number of general functions. Field data provide a basis for determining how to maximize the sampling of genetic diversity. Ecogeographical information can be used to locate significant genetic material and representative populations can then be monitored. Such data, in turn, could guide the selection of samples for more efficient utilization of germplasm.

8. The Task Force considered that a number of scientific principles need to be itemized for the development of ecogeographical surveys. More comprehensive approaches to obtaining and using ecogeographical data could improve

exploration and conservation efforts by allowing for more intelligent collecting strategies and determining when sampling of genetic diversity in a given area has been effectively completed. The resulting information is essential in order to design *in situ* preservation areas and for use in future monitoring of crop evolution. Ecological and geographical data, along with knowledge of species biology are necessary to determine minimum and optimum requirements for *in situ* reserves. In particular, information related to determining needs for number of populations, area, sites, associated species and communities, and successional factors needs to be collected. Such data, in turn, are essential for evaluating the effectiveness of already-established, protected natural areas for perpetuation of certain portions of targeted genepools.

9. As mentioned above (para 6) it is necessary to consider action to carry out field activities on the one hand and laboratory and experimental plot activities on the other. The two aspects must be closely linked through data handling and through training. One of the most important, and perhaps most difficult, tasks in conceptualizing, planning, and implementing ecogeographic studies is that of defining the level of investigation that will provide a reliable information base. Such studies are often easily bogged down with time-and-budget consuming details.

10. In the initial, assessment phase, distributions of target species are correlated with environmental and ecological conditions as well as with phenotypic variability. However, there are time and personnel constraints in field research. It could sometimes be possible to combine initial exploration of plant genetic resources with broader, environmental assessments. However, the necessary training, and interest in this, has been lacking.

11. The range of natural and social factors which must be considered in ecogeographical surveys is very wide. Abiotic factors include aspects of climate, weather, geology and soils. The biotic factors which may be significant for understanding the variability of target populations vary with species and ecosystems. Similarly, the social influences which combine to shape the landscapes in which targeted populations

survive, usually involve a wide spectrum from archaeological and ethnobotanic to economic and legal. The environmental assessment phase of a survey must collect relevant information from all of these fields.

12. The sampling phase would normally be carried out simultaneously with the more advanced portions of environmental assessments. Germplasm is obtained from points of distribution of the target species and will serve to test hypotheses about the correlations referred to previously. It is important to stress that sampling methods (and population size) must be adequate for the purposes envisioned, particularly if later estimates of gene frequencies are involved.

13. The third, "evaluation" phase involves growing out of samples to differentiate genotypic from phenotypic variation and thus tests the correlations which were suspected from the environmental assessment. In more sophisticated trials, samples are not only compared under identical conditions but in numerous environments.

14. It is pertinent to stress that genetic resources cannot be intelligently preserved if the taxonomic status of the plant and its gross patterns of variation are not well understood. The origin of the crop plant both geographically and biologically, needs to be well ascertained.

15. The Task Force recognized that for both planning of surveys and in situ conservation, use of new and sophisticated technologies may be necessary. The applicability of advances in two fields, remote sensing and information systems, was discussed. In both areas it was agreed that significant opportunities exist and that the IBPGR should utilize these technologies. At the same time, it was noted that because of the small scope, limited time scale and modest budget of most IBPGR projects, the present costs of employing methods such as remote sensing could be prohibitive.

16. Potential use of remote sensing: While remote sensing techniques include both satellite and aerial-based imagery, the Task Force's discussions centred on the former. Two US systems were discussed: NOAA's AVHRR weather satellite and the older, Landsat multispectral scanner (MSS). Both Landsat and AVHRR

data can be used to answer specific questions which can aid in locating promising sites for field research and collecting. Usefulness for particular surveys depends on the scope of the survey, the vegetation types which are associated with target species and the amount of annual cloud cover in particular target areas. The most promising use of such sophisticated but large scale types of remote sensing include identification of:

(i) areas with particular types of agriculture and other land uses;

(ii) natural vegetation types and particular sub-categories;

(iii) seasonal responses of vegetation to weather;

(iv) remaining natural or less disturbed vegetation; and

(v) changes in vegetation in sites for collecting and research as well as in formally protected, natural areas.

17. Landsat multispectral scanner (MSS) data have been available worldwide for the past 12 years. These data have been used extensively to examine and map vegetation cover for surveys of districts and regions. Vegetation types are readily mapped from MSS data and are ideally suited for merging with soil data and digital terrain information in detailed landscape analysis. Thematic mapper (TM) data has substantially improved spectral and spatial resolution and is suitable for reproduction at 1 : 100,000 scale. The TM false colour composite images are suitable for manual interpretation and pre-survey site selection activities. It would work well in conjunction with broad scale maps derived from AVHRR or MSS data and serve as a permanent document for the sites which are selected.

18. Information systems: The task group recognized that acquisition of ecogeographical information will require expanded and new data bases. In particular, data on populations of wild species (especially those which have geographically-related variability) will require new data base formats and types of organization. Many of the micro-computers

which are currently in use for germplasm collections can be easily adapted to these expanded functions. Wherever possible, data bases with ecogeographical information should be designed to interact with data bases for both relevant germplasm collections and environmental monitoring and land use planning. Such data bases do not exist or are only in their initial stages.

19. Entry of data into a system requires one basic format for ecogeographical factors. Raw ecological information can be then organized into intra specific inventories and status reports on populations and distributions of wild species. Taxon Status Reports should be developed by the IBPGR for each priority species or taxon, they would be similar to the Red Data Book sheets of IUCN and the Element Abstracts of the Nature Conservancy (US) but must be more comprehensive. These computerized abstracts could be backed up by extensive manual files of information and linked to other major data sources. Each Taxon Status Report would include preliminary recommendations for conservation action, both in situ and ex situ. For instance, if in situ conservation is not yet appropriate because of information gaps then these can be identified. Filling these information gaps would become a priority for research and conservation for that taxon.

20. The advantages of data bases with geographic and mapping capabilities were noted. It is necessary to organize data not only by taxa but by particular districts and sites. This information can be used to assess the extent and condition of genetic resources of target species as well as for computation and modelling for planning, management and research. It was noted that the many of the moderately priced, micro-computers which are currently available are not capable of mapping. Fortunately, many of those of the "next generation" will be sufficiently powerful.

PRINCIPLES FOR IN SITU CONSERVATION

21. In situ conservation methods are those which seek to maintain self-perpetuating populations in natural ecosystems. For crop germplasm, in situ methods will therefore be employed largely for wild species. This is because the interventions

which are required for the survival of landraces in agricultural landscapes would be too extensive to be considered, although model "evolution gardens" could be considered in special cases as and when necessary.

22. As the Board expands its work with conservation of perennials, ex situ plantations (field genebanks) will become more important. These must not be confused with in situ conservation. The Task Force agreed that diverse conservation methods should be complementary. It felt that for a number of species evolution gardens would be advantageous. Such gardens range from the planting together of diverse parts of the genepool of the particular crop, therefore allowing emergence of new patterns of recombination, to the continued maintenance of diverse material in semi-natural environments. The former example would relate more to perennials e.g. oil palm. In addition, the Task Force recognized the almost impossible task of adequately maintaining in conservation collections, samples of outbreeding species. In this case there are advantages to be gained from the careful bulking of samples (on a ecogeographic basis) to form panmictic populations or the formation and maintenance of composite cross populations which are maintained as such rather than as individual original samples.

23. The Task Force recognized that in situ conservation through genetic reserves can produce a range of social benefits, only some of which are relevant to use of germplasm in breeding programmes. Whilst maintenance of some populations of wild species within their natural ecosystems is desirable for purposes of research and more generally for preservation of biological diversity, its importance to germplasm conservation strategies will vary greatly between genepools. The chairman reminded the group that the mandate of the IBPGR necessitated not only biological conservation, but also access to the genetic materials for practical benefits through crop improvement. The Task Force noted that few of the existing protected natural areas (which might contain crop genetic resources) have been established with this in mind.

24. Two factors were recognized which will determine the short-term importance of in situ methods to the IBPGR's broader, germplasm conservation efforts. The first factor

relates to limitations of conventional seed storage. For some species, particularly those which are tropical and perennial, seed storage behaviour (recalcitrance) prohibits conventional ex situ seed conservation. Also the environmental and ecological conditions which are necessary to multiply and regenerate some species (to reproductive maturity) are often not easily available and if arrangements are made these are costly and time consuming. The group also noted that advances are being made in the storage of difficult genetic material using in vitro culture methods. Nonetheless, it was concluded that for many wild species of IBPGR's priority crop genepools, populations conserved in situ will become essential adjuncts to base collections whether the latter are seed or in vitro collections.

25. It was emphasized throughout discussions on in situ conservation that these methods involve more than simply establishing protected natural areas which contain random or fragmentary populations of species which are wild relatives of crops. There are a number of component activities, which are essential if efforts are to be efficient, secure and sustainable as well as useful in crop improvement. All of these operations must be based on ecogeographical information. The general categories of activities which are required for in situ activities for crop germplasm conservation, are as follows.

(1) Initial surveying:

(a) taxonomic clarification

(b) determination of distribution of species

(c) correlation of ecological and geographical factors

(d) determination of genotypic variability by growing out of samples or other experimental methods.

(2) Formulation of conservation objectives:

(a) determination of short- and long-term needs for the germplasm of the wild species of the targeted genepool

(b) determination of the extent of conservation of alleles which is necessary e.g. all alleles (including the most rare), all alleles with greater than a 5% frequency etc.

(c) determination of a satisfactory level of security for maintenance of alleles

(d) determination of minimum level of access to target germplasm as related to convenience, dependability and costs for procurement.

(3) Determination of minimum requirements for conservation of targeted species (based on conservation objectives) such as:

(a) number of populations

(b) size of each population

(c) ecological and environmental conditions

(d) size of habitat units

(4) Assessment and choice of sites in terms of minimum requirements for conservation including:

(a) existing, protected natural areas

(b) non-allocated wildlands

(c) lightly exploited sites which could be acquired or managed.

(5) Reserve design:

(a) integration of minimum requirements for preservation of targeted populations into larger conservation and development planning units

(b) design of reserve boundaries possibly in clusters or as multiple reserves

(c) zoning and related regulation for "mitigation" of potentially adverse impacts of land use activities in adjacent areas which could influence targeted populations within reserves.

(6) Reserve management:

(a) formulation of "prescriptions" to off-set any negative ecological impacts from fragmentation

(b) formulation of regulations and prescriptions to control human activities and to off-set negative impacts which are produced by them

(c) implementation of prescriptions along with on-going evaluation and revision of prescriptions.

(7) Monitoring:

(a) on-going research on targeted populations and genetic variability

(b) on-going assessment of the biological requirements of the targeted species and the conditions of respective populations

(c) on-going assessment of human activities and related impacts as they affect targeted species.

(8) Access to germplasm:

(a) regulation of procurement of genetic material

within reserves so as to maintain minimum levels of conservation

(b) documentation such as mapping, organization development and training guides.

26. All of the above activities necessitate the development of extensive new research programmes. Given the time constraint, the Task Force concentrated on guidelines for determining minimum requirements for conservation and concluded with the following points.

(i) The following factors should influence the pattern of "sampling" which is chosen for populations of a wild species within networks of reserves:

a) the reproductive biology of the relevant plants, breeding system, ploidy level, periodicity of flowering, growth form and habit;

b) the geographic distribution, including population sizes and density especially for species that are not continuously distributed throughout a region;

c) phenotypic variability for characters that may represent genetic differences;

d) "ecological age" of local populations that might be judged on the basis of recent colonization of disturbed sites; and

e) physical parameters within the environment.

(ii) For crop genepool conservation, in situ, the aim must be to save the array of alleles existent. Without being able to analyze the alleles themselves nor to predict their usefulness, the only recourse we have is to attempt to maintain sufficiently large populations so that enough alleles are present. Guidelines have to be provided for population sizes with respect to risks to population integrity and reproduction. Minimum population sizes for

saving low frequency alleles have been estimated from a few hundred to a few thousand individuals. These minima are derived from probabilities of not sampling any of several low frequency alleles at several loci. The more often that low frequency alleles exist, the larger the population size required but usually not more than a few thousand individuals are needed.

(iii) The estimates in (ii) are derived assuming completely random intermating among equally competent hermaphroditic adults. Since mating is never as ideally distributed as this, any inbreeding or population subdivision will increase the number of individuals which are required for minimum levels of conservation. Also, inequalities of distribution of sexuality and fecundity would increase the total number of individuals over the effective breeding number. Therefore 10,000 is not too large to consider for the effective population size given some uncertainty as to mating system.

(iv) Natural subdivisions of populations might be expected to be reflected through alleles in linkage groups. For species which are uniformly dispersed and completely panmictic, the location of the population and its subdivisions are irrelevant. Any sufficiently large population will do. If alleles occur at generally low frequency but are locally frequent in some areas, then the probability of saving such alleles is enhanced by conserving dispersed populations. For highly dispersed species, with many possible allelic variants in different subpopulations, dispersal of the sites to be conserved becomes more urgent. Within subpopulations, minimum viable population sizes will generally be in the order of 20-40 individuals if all are mature and equally contributing to the genetic pool. Deviations from this due to age, sex and fecundity variations, however, elevate these numbers as does any uncertainty of mortality. Thus, the total number of individuals should exceed 100 mature individuals per subpopulation.

(v) In order to ensure the existence of appropriately distributed conserved populations, it is recommended that for each target crop species (and each of its wild

relatives) its population structure and locational distributions be determined and cross-checked with existing reserves and conservation areas. Thereafter, a coordinated plan for supplementary conservation areas can be drawn up. More information on the centres of diversity or dispersal patterns would allow efficient design of reserves. Dispersed and isolated areas might be needed in addition to large reserve areas.

27. Altered landscapes: Although in situ conservation might be particularly relevant to wild species in natural ecosystems, there is a range of types of altered landscapes that can maintain significant genotypes and provide convenient sources of germplasm. In some cases, scientifically determined planting of cultivars can enrich the natural genepool and permit additional future recombinations. Such special evolutionary gardens (as condensations of genetic diversity within natural distributions of respective species) are deemed useful for more assured and/or increased source of germplasm. Strategies can be developed, e.g. for temperate tree fruits.

28. For a number of crops, some ex situ stands (field genebanks) are already maintained as "evolutionary genebanks" such as for rubber and oil palm. It is necessary to devise better strategies so that such ex situ field genebanks become more effective. It was noted that such strategies will usually be the responsibility of institutes often far removed from areas of natural diversity.

PROPOSALS FOR ACTION AND POLICY RECOMMENDATIONS

29. In all new exploration activities supported by the IBPGR, field research to obtain more comprehensive, ecological and geographical data and laboratory research (to determine related genotypic variability of samples) should be undertaken as part of the agreed project. The Task Force identified crops (see para 35 and Table 1) where needs for ecogeographical survey are particularly obvious. The species and regions within these genepools should be determined by the appropriate IBPGR working groups or committees.

30. For both attaining minimum levels of conservation and

Table 1. Priorities for ecogeographical surveying

Highest priority	
Wheat:	wild species
Sorghum:	wild species
Barley:	entire genepool
Pearl millet:	wild species
Maize:	wild relatives and limited work on some cultivars in a limited area
Phaseolus beans:	wild species
Groundnut:	wild species
Soyabean:	wild perennial species
Cowpea:	forage forms both wild and cultivated
Cassava:	entire genepool
Coconut:	entire genepool
Banana:	wild species in South East Asia
Rubber:	entire genepool
Oil palm:	wild species in both Africa and South America
Coffee:	*Coffea canephora*, *C. arabica*
Cocoa:	entire genepool
Grape:	wild species in Asia
Prunus:	wild species
Apple:	wild species
Pear and quince:	wild species
Mango:	wild species
Citrus:	wild species
Avocado:	wild species
Forages:	See Appendix II
Lower priority	
Rice:	wild African perennial species
Winged bean (*Psophocarpus* spp):	wild species in Africa
Sweet potato:	wild species
Beet:	entire genepool of wild and primitive cultivated forms
Sugarcane:	entire genepool
Grape:	wild species in the New World

Table 1. Priorities for ecogeographical surveying (cont'd.)

Further study	
Lupin:	Andean genepool
Cotton:	portions of genepool (expert advice needed)
Potato:	portions of genepool (expert advice needed from CIP)
Other priority tropical fruits:	genepools of cashew, fig, papaya, pine apple, peach palm, *Lansium*, durian, rambutan, *Annona* and *Passiflora*
Yam:	portions of genepool (advice from an expert group is needed)
Onion (*Allium*):	portions of genepool (advice from an expert group is needed)

access for breeding programmes for numerous genepools, it will be necessary for the IBPGR to support the use of *in situ* methods, often involving protected, natural areas, as part of broader germplasm conservation efforts. To ensure that efforts for *in situ* conservation are effective and economical, the Task Force has proposed a number of points:

(i) Except where there is need for immediate intervention to save particularly well known, endangered and valuable populations, *in situ* conservation should be preceded by ecogeographical surveying. Early stages of planning of *in situ* conservation measures (such as determining interim conservation objectives and assessing already known sites) can be conducted as part of survey activities.

(ii) The IBPGR should, in principle, support *in situ* conservation efforts by other agencies. There is an opportunity to work cooperatively with a growing number of national and international programmes. However, the Task Force has to note with regret and concern, a number of *severe deficiencies* in many of the current *in situ* conservation efforts.

- Most protected natural areas that are purported to be conserving genetic resources have not been adequately inventoried for species or genotypes.

- Many populations of wild relatives of crops which exist within currently allocated protected natural areas are insufficient for both long term species survival and maintenance of allelic diversity. This is due to the planning and design of these parks and reserves which in most cases did not consider requirements for plant conservation nor sustained intra specific variability.

- The concept of conservation of genetic resources is often mistakenly equated with species and biome conservation and desired intra specific diversity is not defined. Consequently, monitoring does not always obtain key data nor are minimum conservation requirements considered in on going management. Given that there is a tremendous amount of work to be done to create a network of in situ conservation sites for wild relatives of crops, the IBPGR will have to carefully choose projects to which it will lend its support. In the main, such IBPGR support will be through scientific surveys, organization of survey information into data bases and forging of linkages to associated research.

- The pioneering work of UNESCO's Man and the Biosphere Programme (MAB) in initiating an international network of genetic resources conservation and research was recognized. Nonetheless the task group noted that in situ conservation of complete pools of variability for its priority species must invariably extend beyond the boundaries of the relatively small number of internationally recognized conservation sites such as biosphere reserves. Consequently, in situ conservation of many species may require employment of several formal and informal categories of protected natural areas. In some cases, this may require that IBPGR work directly with national and local Governments as they devise in situ conservation programmes compatible with local development.

(iv) As a major input to in situ conservation activities, the IBPGR could make available for environmental assessment, land use planning, resource managers and conservation organizations, information on wild species of its priority genetic resources and important populations and sites (see also para 19). This would serve to better inform land use decision making and thus avert emergency situations caused by uninformed development planning. For many situations, this tentative, informal protection would be adequate until more comprehensive germplasm conservation strategies are formulated in the future. Information exchange in regard to these species could be established with national and international development agencies, such as the Environmental Review Section of the World Bank, and international conservation organizations such as IUCN, The Nature Conservancy US (International Programs) and the United Nations Environment Programme.

31. The requirement for carrying out the surveys of wild and weedy species and for their in situ conservation will need to involve a number of new developments.

(i) The IBPGR will need to work more closely with the scientific/academic community than hitherto on compiling ecogeographic data for its priority crops and their wild relatives. This will involve not only IBPGR agronomic and crop genetics networks but in many cases extensive cooperative relationships with institutes involved in research on taxonomy, field botany, plant ecology and conservation biology. Additionally, conservation organizations such as IUCN and WWF with their affiliates within national governments, may prove to be the key partners in projects which will produce benefits both to ecosystem and wildland conservation and to crop improvement.

(ii) Germplasm conserved, in situ, will always be under the control of national (and sometimes local) governments and the responsibilities of stewardship of these resources are likewise under these jurisdictions. While the Board should continue to reaffirm the importance of free availability and exchange of germplasm within the international community, it is realistic to recognize that the terms of

access to germplasm conserved, in situ, even when there is assistance from the international community, is a matter of national policy for individual governments. Therefore, the IBPGR should be prepared to assist in making various arrangements as such governments desire.

32. Current information systems will need to be expanded to handle the additional data which is required for both surveys and in situ conservation with on going monitoring. While it will be necessary to acquire new hardware and software for these purposes, it is imperative that new systems be compatible with and enhance those which already exist for crop genetic resources, wild plants and protected areas. Centres such as the IBPGR and IUCN's Conservation Monitoring Centre might have to be expanded along with the addition of smaller, linked systems in research institutes.

33. To carry out ecogeographic surveys and in situ conservation at the scale that is necessary will require involvements of the fields of botany, taxonomy, plant ecology, conservation biology and environmental planning as well as crop genetics. The IBPGR could support a number of training programmes which instruct crop genetics professionals in wild plant conservation and which inform ecologists and environmental advocates of crop genetic resources. Similarly, the IBPGR is in a position to support research and training which involves both of these scientific networks and to advocate greater funding for this work.

34. Any expansion of the international germplasm system to include in situ conservation efforts would require substantially greater levels of funding. The Task Force notes the ineffectiveness of the ad hoc approach which is based on individual projects of limited duration. Two possibilities exist to remedy this basic weakness.

(i) International conservation organizations with an interest in the genetic resources of wild plants can better coordinate their projects and thus be more comprehensive in their long-term programme development. There is substantial promise in projects involving funding from several organizations.

(ii) More funding must be located and the international conservation organizations can join together to present a case for greater expenditures. The Task Force recognized the catalytic role which the IBPGR can play in these efforts especially in regards to organizing support for research and in documenting the importance of conservation of wild relatives of crops.

35. The Task Force assessed the needs for in situ conservation on a crop by crop basis. Emphasis was placed on those gene pools of crops which are accorded high priority for action by the Board 1/. Ideally all species will require more ecogeographic research and better knowledge of patterns of variation. A priority list was drawn up (Table 2) that reflects the most obvious gaps in knowledge.

36. The priorities for IBPGR involvement in in situ conservation of plant germplasm are based on the following criteria.

(i) In situ conservation programs should be complementary, integral and essential parts of the international plant germplasm system. Because of selection factors inherent in regeneration from storage, genetic reserves can work as back ups to efforts to maintain full complements of allelic variability in ex situ collections.

(ii) Genetic reserves should be designed to contain sufficiently large and diverse populations and habitat units so as to sustain the levels of allelic variability that are thought to be of significance to crop improvement over the long term.

1/ Revised Priorities Among Crops and Regions. 1981. IBPGR, Rome.

Table 2. Preliminary priorities for *in situ* conservation

Highest priority

Groundnut:	perennial species
Oil palm:	entire genepool
Banana:	wild diploid species
Rubber:	entire genepool
Coffee:	*Coffea arabica*
Cocoa:	entire genepool
Onion:	some wild species
Citrus:	wild species
Mango:	wild species
Prunus:	wild species
Apple:	wild species
Pear:	wild species
Forages:	see Appendix II

Lower priority

Maize:	*Zea diploperennis* and other perennial species of *Zea*
Soyabean:	wild perennial species
Cassava:	wild species
Sweet potato:	wild species
Olive:	*Olea laperrinei*
Avocado:	wild species
Durian:	wild species
Rambutan:	wild species

Further study

Phaseolus:	advice needed from an expert group
Sorghum:	advice needed on the wider genepool
Rice:	wild perennials
Cowpea:	some forage forms of wild species

Information on the status of the following species is needed:

Coconut, strawberry, pomegranate, date, fig, cashew, papaya, pineapple, peach palm, *Lansium* spp., *Annona* spp., *Passiflora* spp. and cotton

(iii) In situ genebanks will be required to continually provide research samples to users.

(iv) Genetic reserves can provide facilities for training germplasm biologists and population geneticists and can provide unique opportunities for studying crop evolution.

37. The priorities in Table 2 for in situ conservation are largely based on a complex of inter-related factors and are preliminary. The factor which is more central in general, biological conservation, that of endangerment of species, sub-species and genotypes is not adequately considered. This is due to the poverty of data on the status of most wild relatives of crops. Also, none of the current data bases which are concerned with conservation of wild plants adequately assesses status of intra-specific variability. While there is fragmentary information, often of dubious accuracy, on the endangerment of some species of important, crop genepools, it is too early to have a complete list which could be worked with storage considerations for a more balanced set of in situ conservation priorities. Taxonomic clarifications, delineation of genepools, formulation of more consistent criteria for loss and impending loss of both allelic variability and species are all necessary before the taxa with the most pressing needs for conservation can be identified.

38. In addition to the priorities for ecogeographical survey and in situ conservation the following complementary conservation methods rate priority (Table 3). Recommendations on all these groups have already been made in the past but action should be accelerated.

39. Forages. Forages are a special case in that there are literally hundreds of species and our knowledge of most species is limited. In such a situation of limited information, genebanks can hope to conserve but a small proportion of the available genetic resources. Given the wild or semi-wild nature of many forage species, it could be more effective and economical to conserve these genetic resources in situ.

40. It is important to consider the relative potential of ex situ and in situ conservation in terms of actual numbers of populations. A 1984 IBPGR Working Group on Tropical and

Table 3. Priorities for ex situ conservation involving maintenance of plants in panmictic populations or as composites and as true seed or evolutionary gardens

Production and conservation of panmictic populations/ composite crosses representative of geographical areas	maize, beet, pearl millet
Production and storage of heterogenous seeds	sweet potato, apple, pear, sugarcane, potato
Evolutionary gardens	rubber, oil palm, cocoa

Subtropical forages estimated a requirement of 3000-4000 population samples per genus to adequately represent samples of its genetic resources, with an estimated total of 100,000 samples for all tropical forages. This number can be achieved by ex situ seed collection, but it would appear that in situ conservation sites could probably only require a few hundred sites.

41. The establishment of in situ reserves has a special relevance to forages in semi-arid and arid areas of the world where the existing vegetation is being overgrazed to the point of extinction. There may be other habitats which would benefit from in situ conservation but those in charge of the land and its management must be fully conversant with the long-term commitments which must be entered into in order to achieve the desired goal.

42. A list of genera/species known to have a potential use is shown in Appendix II. Further studies are required to determine: (i) species for which in situ conservation is most necessary and; (ii) the occurrence of these genera/species in existing protected natural areas.

Appendix I

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Appendix II

Priorities for ecogeographical surveying and *in situ* conservation for forages

The following list includes genera which have shown the greatest potential and species widely used.

1. Mediterranean:

(a) forage legumes

Medicago	annual: *M. truncatula*, *M. littoralis*, *M. rugosa*; perennial: *M. sativa*
Trifolium	annual: *T. subterraneum*, *T. hirtum*, *T. cherleri*; perennial: *T. fragiferum*
Vicia	*V. sativa*
Onobrychis	*O. viciifolia*
Astragalus	*A. hamosus*
Hedysarum	*H. coronarium*
Ornithopus	*O. sativus*

(b) grasses

Lolium	*L. multiflorum*, *L. rigidum*
Dactylis	*D. glomerata* spp. *hispanica*
Festuca	*F. arundinacea*
Phalaris	*P. aquatica*
Agropyron	*A. desertorum*, *A. intermedium*
Bromus	*B. tomentellus*
Arrhenatherum	*A. elatius*

2. Tropical and subtropical species:

(a) forage legumes

Centrosema	*C. pubescens*, *C. brasilianum*, *C. macrocarpum*
Desmodium	*D. uncinatum*, *D. intortum*, *D. ovalifolium*
Stylosanthes	*S. guianensis*, *S. humilis*, *S. hamata*, *S. capitata*
Macroptilium	*M. atropurpureum*
Aeschynomene	*A. falcata*
Vigna	*V. radiata*

Alysicarpus	
Puereria	P. phaseoloides
Dolichos	Lablab purpureus
Calopogonium	
Crotalaria	
Desmanthus	
Leucaena	L. leucocephala
Glycine	
Phaseolus	P. adenanthus
Zornia	Z. latifolia, Z. brasiliensis, Z. myriadena

(b) grasses

Brachiaria	B. decumbens, B. humidicola, B. dictoneura
Botriochloa	B. insculpta
Cenchrus	C. ciliaris
Chloris	C. gayana
Andropogon	A. gayanus
Paspalum	P. plicatulum, P. scrobiculatum, P. dilatatum
Panicum	P. maximum, P. virgatum
Pennisetum	P. purpureum, P. glaucum, P. clandestinum
Haemarthria	
Axonopus	A. compressus
Urochloa	U. mosambicensis, U. pullulans
Sorghum	S. almum, S. bicolor
Setaria	S. sphacelata

3. Temperate areas:

(a) forage legumes

Medicago	M. sativa
Trifolium	T. Pratense, T. repens
Lotus	L. corniculatus, L. uliginosus
Onobrychis	O. viciifolia
Vicia	V. sativa

(b) grasses

Lolium	L. perenne, L. multiflorum
Dactylis	D. glomerata
Phleum	P. pratense
Festuca	F. arundinacea. F. pratensis, F. rubra
Bromus	B. inermis
Asropyron	A. cristatum, A. desertorum, A. intermedium

Appendix III

Acronyms used in this report

AVHRR	Advanced very high resolution radiometer
CGIAR	Consultative Group on International Agricultural Research
CIP	Centro Internacional de la Papa
IBPGR	International Board for Plant Genetic Resources
IUCN	International Union for Conservation of Nature and Natural Resources
MAB	Man and the Biosphere Programme (UNESCO)
MSS	multispectral scanner
NOAA	National Association and Atmospheric Administration (USA)
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture
WWF	World Wildlife Fund