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PRACTICAL APPROACHES FOR CAPACITY BUILDING FOR TAXONOMY

Note by the Secretariat

1. INTRODUCTION

1. At no time has there been a greater need for taxonomists than now, as the crises facing biodiversity escalate. Effective habitat conservation, bioprospecting and the sustainable use of biodiversity on a global basis all require taxonomic decisions and expertise on a scale not presently available. In fact, in many countries th number of taxonomists is declining for a variety of reasons.

2. Decision II/8 of the Second Meeting of the Conference of the Parties to the Convention on Biological Diversity identified the lack of taxonomists as a significant impediment to the implementation of the Convention at the national level.

3. The decision recognised that a sound taxonomic (sometimes called biosystematic) knowledge base is a prerequisite for environmental assessment, ecological research, the conservation of biological diversity, and managing biological resources within a framework of sustainable development and fair and equitable sharing of those resources. It called for taxonomy to be directed towards practical ends, including bioprospecting and ecological research on the conservation and sustainable use of biological diversity and its components.

4. Taxonomy is the practice of naming life forms and arranging them in classifications that reflect patterns of relationships. Taxonomy forms part of the science of systematics, which deals with the organisation, history and evolution of life, its diversification and distribution in space and time (Novacek 1992). It is the tool by which the components of biological diversity at the species level are identified and enumerated, and it therefor provides the basic knowledge underpinning efforts to conserve biological diversity, optimise the use of biological resources in a sustainable way, and enhance the quality of life in diverse human societies.

5. Classical examples of the practical value of taxonomy include the exhaustive taxonomic research on African freshwater snails and mosquitoes that provided the foundation for biological and medical research into bilharzia and malaria, and the development of high-yield, hardy strains of wheat based on the detailed exploration and study of the taxonomy and properties of wild wheat forms from around the glob . More examples, perhaps less well known but equally important, are presented in Annex 1.

6. Decision II/5 specifically requested that the SBSTTA, at its second meeting, address the issue of th lack of taxonomists needed for the national implementation of the Convention and to advise the Conference of the Parties at its third meeting on ways and means to overcome this problem, taking into account existing studies and ongoing initiatives while adopting a more practical direction of taxonomy which is linked to bio-prospecting and ecological research or conservation and sustainable use of biological diversity and its components. In order to assist the SBSTTA in its consideration of this issue, the Secretariat has prepared this document which reviews the current status of taxonomic capacity, particularly in developing countries, considers how taxonomic capacity might be developed and contains a number of options to address the needs of the Convention and its Parties.

2. BACKGROUND TO THE PROBLEM

2.1 The Discipline of Taxonomy

7. Taxonomists are trained biological scientists who specialise in the identification, formal description, classification, and naming of plants, animals and microorganisms.

8. Taxonomy underlies our understanding of biodiversity because it addresses fundamental questions such as the kinds of organisms that exist, their number, how they are related to each other, where they occur, and then allocates names to them in a systematic manner. Without this basic knowledge of the facts of biodiversity, its conservation cannot proceed in an informed, and therefore sustainable, manner. In particular, by allocating universally recognised names to organisms, taxonomy provides a common language for communication about biodiversity.

9. The discipline of taxonomy is based on universal principles developed over the 270 years that hav passed since the pioneering work of Carolus Linnaeus, the Swedish naturalist. The basis of these taxonomic principles is a recognition of structural resemblances among organisms, so that if organisms have similar structures, they may be regarded as members of the same classification group, that is, they are closely related to each other, and therefore their naming should reflect this close relationship.

10. Intrinsic to the discipline of taxonomy is the recognition that related organisms may occur in widely disparate parts of the earth. This means that it is often not possible to carry out taxonomic studies of the biota of a

particular region or country in isolation; these studies must be placed in their global context by comparative analysis.

11. The work of taxonomists is based on the study of the characteristics of the particular group of organisms that define the group (or taxon) and differentiate it from other taxa. In order to do this, it is necessary to have adequate samples of the plants or animals being described, and likewise specimens of the related taxa to which they are being compared. Samples are collected from living specimens occurring in their natural habitat, preserved as specimens in accordance with standardised procedures, and kept in herbaria (in the case of plant specimens) and museums or fauna collections (in the case of animal specimens). Detailed records of each specimen are essential.

12. When a taxon (e.g., a species or genus) is defined and described, the description is related to a particular specimen, known as the type specimen, whose location in a particular herbarium or museum is clearly identified. It is essential for the continuing and orderly application of taxonomic principles that type specimens, together with suites of specimens of related organisms, are preserved in perpetuity, to provide comparative information that can be used to classify and name new species as they are discovered.

13. The discipline of taxonomy has developed standardised rules and procedures that are embodied in various internationally accepted codes, such as the International Code of Botanical Nomenclature and th International Code of Zoological Nomenclature. International bodies of scientists develop and maintain thes codes, which ensures that taxonomic research maintains internal consistency and can be applied with confidenc to any group of organisms wherever it is found on earth. The codes are not quite identical, and thus there ar some differences in approach between botanical, zoological and microbial codes.

14. The results of taxonomic research, like other scientific research, are published in internationally accepted journals through established procedures, including peer review. Subsequently, the results are brought together in publications (including electronic media) such as handbooks, catalogues and floras, usually on a regional or national basis.

15. Taxonomists generally gain their qualifications by undertaking studies in biology at a university and then undertaking postgraduate or specialist research in taxonomy. In gaining their taxonomic qualifications they learn the skills of collecting, identifying, describing and naming, classifying, and elucidating th distribution of the groups of plants, animals or microorganisms in which they intend to specialise, all within the formal framework of the Codes and within the accepted scientific culture of precedence, peer review, and publication.

16. Taxonomists are predominantly employed in herbaria, museums, government agencies such as departments of conservation and agriculture, and in universities. Thus, in most countries the employment of taxonomists is heavily dependent on the government funding that supports such institutions.

2.2 The Lack of Taxonomic Capacity

17. The task confronting taxonomists as they attempt to provide an inventory of global biodiversity is enormous. Recent estimates of the total number of species on Earth range between 5 million and 100 million. Of these, little more than 1.5 million have been formally described and named in a taxonomic sense. Moreover, th geographic and ecological coverage of this taxonomic knowledge is very uneven globally.

18. At this very time when the need for a taxonomic stocktaking of the Earth's biodiversity is becoming increasingly urgent, the community of taxonomic experts is aging and declining in number, and the resources committed to the management of taxonomic collections is diminishing (Cotterill 1995). This lack of taxonomists is a critical problem that needs to be addressed on a global scale.

19. In the last century and the first half of this century public interest in and national capacity for taxonomic work were high in Europe and North America, but the advent of new subdisciplines of biology in the latter half of the 20th century has tended to siphon off researchers who might otherwise have become taxonomists. This has led to a decline in the training and recruitment of young researchers in this field in industrialised countries.

20. In developing countries, formal knowledge about biodiversity tended in the past to be generated by taxonomists from industrialised countries. Their work was usually funded from the researcher's home country or by international bodies, and the studies were not necessarily aligned with th □ost” country□ needs. Specimens collected were, as a rule, deposited in major European or North American collections, often with no attempt to establish collections in the countries of origin, or to lodge voucher specimens there for identification purposes. This is true also for countries such as Australia, which in its colonial era, lost many important type specimens to European collections.

21. Because of this historical background, many of these □ost” countries have not developed the requisit level of expertise, infrastructure and employment opportunities required to address urgent taxonomic issues locally, although there was, of course, a degree of skills transfer, particularly in field-work methods and basic identification.

22. Even where museums and herbaria have been established to provide for the safe storage of specimens and the infrastructure for research and information retrieval, many of these institutions now have inadequat resources even to maintain their collections in an active, accessible form, let alone to expand and develop their great potential to contribute to the aims of the Convention and to national, regional and local objectives.

23. Concurrent with this decline in taxonomic capacity, technological advances have aided access to remot habitats (for example, deep oceans), thereby revealing previously unknown biological resources and creating an even greater need for taxonomic effort.

24. In addition, the Convention has focused attention on the urgent need for inventories of biological resources, including generalised surveys to assess conservation status, targeted surveys to explor pharmaceutical resources or new genetic resources for primary industry, and the rapid assessment and monitoring of habitats. This has created a demand for taxonomic capacity to be directed towards functional aims, often with an emphasis on quick results. However, the results of such surveys need to be presented within the framework of the accept d nomenclature developed by traditional taxonomic methods.

25. These various approaches to the acquisition of knowledge about biodiversity require a range of taxonomic skills to be available in each country or region. This in turn creates a demand for increasing numbers of taxonomists, both fully qualified experts and lesser qualified parataxonomists. The optimum blend of skills required in any particular regional or national setting also needs to be addressed.

26. Public awareness of the immediate and future values to human welfare of biodiversity conservation and land management, and the role of taxonomy in their achievement, is critical to their success. Educational programs are needed to achieve this awareness.

27. In the industrialised world, public awareness of the need to conserve and manage threatened and vulnerable aspects of biota and generally to reverse environmental degradation and misuse has increased dramatically over the past two or three decades. There has been a failure, however, to develop any political, corporate or general public understanding and appreciation of the role of taxonomy as part of this new awareness.

28. In some developing countries political awareness of biodiversity conservation and management may b largely centred on natur -based tourism and the economic potential of genetic resources, which are as yet largely unknown. General awareness amongst the public of the need to conserve and manage local and regional ecosystems may be low, although local knowledge among indigenous peoples about plants and animals is high, and often more detailed than formal taxonomy.

3. STATUS AND TRENDS

3.1 The Existing Knowledge Base

29. The expansion of taxonomic capacity in developed countries must build on existing knowledg accumulated over decades and centuries. Most if not all developed countries hold, or are currently building, national collections within their governmental structure. Many also have significant collections established outside the official framework. Such collections, oft en private and brought together over many years and even generations, may be limited in taxonomic scope but highly valuable from both a historical point of view and as a part of the existing national knowledge base (Cotterill 1995). It is important to locate, recognise, and ensure th long-term safety of important collections of this kind.

30. For many developing countries, lacking such institutions within their own boundaries, the primary sources of information about their own biodiversity are the long -established collections in the developed countries and the widely scattered scientific literature. They need to be able to access these sources, but ar inhibited from doing so by the variety of formats and institutions and by the fact that electronic access is inadequately developed.

31. There is therefore an urgent need for the dissemination of existing taxonomic knowledge back to th countries of origin, in a consolidated form targeted to immediate, nationally determined needs.

32. The existing taxonomic kn owledge base differs significantly between continents, regions and nations, and between groups of organisms. Charismatic groups like birds and mammals, and, to a somewhat lesser degree, groups such as flowering plants and trees, snakes, butterflies and dragonflies, are quite well known globally, but tools for identification in the field (locally or regionally) are often not available.

33. Knowledge about the diversity of most invertebrates, lower plants, fungi and microorganisms in terrestrial, freshwater and marine habitats range from good in some groups in developed countries to poor and often minimal in most parts of the world. On a conservative estimate of global biodiversity (e.g., 10 million species) about 15 percent of species (1.5 million) are known, approximately two-thirds of which are insects.

34. Developing countries generally do not have large reference collections of plants and animals for help in identification and to provide the basis for research relevant to their national needs. While most countries no require representative material from field collecting to be deposited as types or voucher specimens in designated national repositories, reference material from taxonomic studies carried out over the past two centuries is mostly deposited in overseas collections.

35. The repatriation of such physical collections, as opposed to supplying database information, is unlikely to be adopted as a means of boosting taxonomic capacity in developing countries. Development of nationally or regionally relevant reference collections should be undertaken as a combination of local field work and specific ackages" of authoritative voucher specimens collaboratively compiled from large, established collections in th industrialised world. The critical issue for such reference collections is the correct (authoritative) identification of species.

36. The trend in developed countries is increasingly to prioritise funding for taxonomic research on groups that are believed to be either of significance in the maintenance of ecosystem health, or that are of particular interest to sustainable primary industry production or pharmaceutical surveying. Nevertheless, they also maintain, to a greater or lesser degree, support for continued taxonomic studies across the entire range of living organisms in order to provide the broad knowledge base essential to organise and underpin research in all fields of biology.

3.2 Existing Taxonomic Capacity

37. Taxonomic capacity building should be based on a nationally or regionally ass ssed balance between skills, expertise, the collection and research infrastructure necessary for identifying and documenting targeted groups of plants, animals and microorganisms, as well as mediu - to long-term requirements for accelerating broader based inventories and understanding of biological diversity. The experiences of the developed countries provide lessons, both positive and negative, for other countries.

3.2.1 Human resources

38. Human resources currently available for taxonomy are summarised i n the *Global Biodiversity Assessment*. There may be 20,000 to 30,000 biological taxonomists (biosystematists) worldwide. Very few of these are believed to be engaged full-time in systematic research. Around 7000 are actively publishing new descriptions of species in journals. The great majority of systematists work in North America and Europe, although not necessarily on species or groups of species from those regions. Fewer than 10% of taxonomists ar resident in the moist tropics, which hold far more than 50% of global non-marine biodiversity. Moreover, effort is very unequally distributed amongst different taxonomic groups, with a large percentage of taxonomists engaged in studying groups that are among the best documented. For example, in Australia it is estimated that there are 17 species of higher vertebrate for each taxonomist concerned with this group, but 840 insects and spiders for each taxonomist concerned with these groups. Globally, and taking into account estimated rather than described species, the discrepancy varies from 370 or so plants per plant taxonomist to perhaps 5000 viruses per virus taxonomist.

39. The lack of jobs and lack of training have interacted over recent decades to produce a downward spiral in the numbers of taxonomists and in the volume of taxonomic work being undertaken in the developed world. This trend reduces the ability of the international taxonomic community to support capacity building in developing countries. A way of cutting this nexus needs to be found.

40. To achieve this, the importance of taxonomic work, not only from the point of view of conservation, but

from an economic perspective as well, must be emphasised. Such emphasis is particularly important in the emerging fields of bioprospecting and sustainable use of natural resources. The vast majority of taxonomists ar currently employed directly or indirectly by governments, generally in museums, herbaria, government departments or in tertiary education institutions. Future job growth, if it is to occur, will largely be in national or provincial governments, although corporate sponsorships for taxonomists under the umbrella of environmentally sustainable development, and employment or funding of taxonomists by primary and pharmaceutical industries provide potential opportunities. International funding activities, such as, *inter alia*, the UK Darwin initiativ could play a key role here.

41. Many developed countries with a long tradition of tenured positions in taxonomy -oriented institutions are now tending to offer shorter term contracts of 3 to 5 years when filling vacancies, and are increasingly expecting their taxonomic staff to attract funds for research through consultancy projects with external bodies, often with a less-than-rigorous taxonomic focus. To acquire high-level taxonomic expertise takes many years, and involves research projects with time-frames much greater than those typically supported by external consultancies. The new trend towards shorter-term engagements will inevitably aggravate the problems faced by taxonomy in general, not the least by eroding the recruitment base by undervaluing the nature and importance of taxonomy and diminishing the possibility of creating a long-term career in the field.

42. Whilst developed nations will need to reassess this approach before a critical loss of high-level expertise becomes apparent, it is urgently important that taxonomic capacity in developing countries be built on a solid foundation of tenured positions coupled with attractive academic as well as techni cal career structures that encourage staff to stay in front-line research. With such a core of tenured taxonomists and technical staff, taxonomic training, job opportunities, taxonomic work and collection development can be enhanced by providing short- to medium-term jobs from external funding (research grants, project-based funds).

3.2.2. Taxonomic infrastructure

Collections and research

43. Taxonomic work requires it own infrastructure, the most important parts of which are well -maintained, secure, representative collections, adequate library facilities, and laboratory/office space equipped with standard research tools such as microscopes and personal computers. The funding outlook for the collections in particular must be permanent, as taxonomy is heavily dependent on historical precedents and the ability to consult previously reported and unreported material. Biological collections are a significant part of the national and international heritage. Whatever the administrative arrangements for their operation, they must be covered by statutory protection against mismanagement or uncontrolled disposals or dispersal. At the operational level, taxonomy cannot function on a stop -start basis; expertise cannot be developed or maintained and it becomes unattractive to enter this field of research.

44. Compared with most other branches of natural science, the capital costs of taxonomic infrastructur facilities are modest, as are the costs of day -to-day maintenance and research projects. Despite this, many national governments in developed countries have increasingly, over the past few decades, starved taxonomic institutions of capital and operational funds (Idema 1993), to the point where many national collections ar barely surviving,

research areas are being reduced or closed down, and major parts of internationally significant collections ar rendered inaccessible by being "othballed".

45. Nationally and regionally, developing countries have the opportunity to lead the way in a revival of biological collections and the biosystematic research that depends on them by recognising their fundamental importance and placing taxonomic capacity building as a high national priority in the pursuit of sustainabl development and conservation.

Field work

46. The development of biological collections as major national facilities for public inquiry and for current and future taxonomic research relies almost exclusively on field collecting and biosystematic field studies, primarily by the institution's own staff, but importantly also through the acquisition of material collected by others for related purposes.

47. Field work requires its own infrastructure in the form of transportation means, specialised collecting equipment and, often, camping facilities adequate for keeping samples and equipment (and people) safe under adverse conditions. Effective and efficient field collecting requires training and experience, not only in operating and maintaining specialised equipment, but also in general biological knowledge (natural histo ry, habitats, ecology) in order to optimise field time.

48. Properly targeted and supervised, the field collecting of specimens and associated biological and environmental data is an area particularly well suited to the enhancement of the responsibilities and expertise of collection managers and parataxonomists. It is a fertile training ground for the development of taxonomic expertise and recruitment to a taxonomic research career.

49. While developed countries now possess highly sophisticated equipment to undertake biological collecting in the most inaccessible and inhospitable environments on the globe, the general trend is to significantly reduce operational funds for the basic field work necessary for standard collection-based taxonomic research, which is relatively low in cost and often locally based. Consequently, the acquisition of specimens becomes reliant on participating in external consultancies that are frequently broad-based surveys with limited time-frames and that are not targeted to meet th researcher's requirements.

Dissemination

50. Traditionally, new taxonomic knowledge has been disseminated in scientific journals for th consumption of fellow taxonomists. This knowledge base was, and still is, largely inaccessible to the many users who now require identification of and correct names for plants and animals, as well as access to spatial data. Efforts to collate taxonomic knowledge for distribution on a global scale either in hard copy or electronically ar in train for many groups of plants, animals and microorganisms.

51. Such publications and databases are unlikely to be of significant help to developing countries in th short to medium term because of the long term nature of most projects, and because they do not target th diverse needs of individual countries or local requirements. In the longer term, they will have a major impact on all taxonomic work, and developing nations will have a significant role in contributing to the global databases as one result of their taxonomic efforts.

52. New taxonomic knowledge must continue to be reported in international scientific journals to ensure th appropriate recognition of national efforts. It is important, however, that taxonomic output also focus on other activities, including the preparation of fauna and flora catalogues, databasing of and user access to biodiversity information, and identification tools for targeted groups of plants and animals in order to further facilitate local or regional ecological studies, conservation efforts and responsible bioprospecting. It should be recognised also that identification tools for the more conspicuous groups of plants and animals in a well circumscribed area hav great appeal for nature tourists and amateur naturalists, who can contribute significantly to local economies by visiting those areas.

Public education

53. Probably the main reason for the decline in resources for taxonomic research and the maintenance and development of biological collections in the industrialised world over the past several decades is the failure of taxonomists to communicate the relevance and importance of their science to the public in terms of community concerns about local and global environmental issues. Similarly, many taxonomists and their institutions hav been reluctant to adjust research and outputs to user needs and expectations. Even the non-government conservation organisations and their large numbers of supporters appear to be unaware of the crucial role of taxonomy.

54. Taxonomy as a discipline has relied for too long on the public image it developed last century, without taking up the competitive challenge for recognition and access to limited resources from technologically new disciplines in the natural sciences. There is a clear movement among biosystematists in the developed countries to try and reverse this trend, but the community impact, and hence political impact, so far is very limited.

55. In building taxonomic capacity, developing countries should embrace these lessons in order to ensure a high degr of public acceptance of the role and benefits of biological collections and biosystematic research, and to promote a sense of community pride in and responsibility for biological diversity as a source for improved human welfare and as a national heritage. Two issues are of particular importance in publicising this message: education targeted to relevant local problems and conditions, and the strength of supportive messages sent out by the highest levels of government.

56. It is important that community education focus on the less charismatic components of biodiversity -- invertebrates, lower plants and microorganisms -- that comprise the vast majority of biological species, and thus genetic resources, responsible for developing and maintaining ecosystem integrity with its attendant socio-economic benefits. Only with such a focus may the so-called egafaunal bias" (Platnick 1991) be avoided, which sees vast resources spent on a few large species without adding to the broad knowledge base required for conservation and sustainable development. Pragmatically, a iggy-back" approach may be effective in letting the few pull the many along, and in explaining the complex links between the few, the many and the ecosystems in which they interact.

57. In building up taxonomic capacity in developing countries, it is critical that governments recognise and support: the links between national, regional and local needs; well-targeted field collecting; establishing and maintaining biological collections; taxonomic research; the timely and appropriate dissemination of research results to users; and public education about the role and benefits of taxonomy as a national effort.

3.3 Training new taxonomists

58. Universities and other tertiary institutions are not teaching taxonomy (or other whol -organism studies such as morphology) to the same extent as in past years. New utting edge" disciplines such as molecular biology have displaced them in crowded curricula. Increasingly, students are being graduated as narro specialists in the infrastructure of plants and animals, but with little understanding of the whole organism or of the phylogenetic and taxonomic relations of the taxa on a broad scale.

59. The result is that the world's pool of trained taxonomists is shrinking, and aging, while there is insufficient recruitment of young scientists to replace the existing workers. This problem is strongly linked to a second problem: the lack of jobs for taxonomists. There is a perception that taxonomy is ld-fashioned science" and that there are few jobs available for taxonomists. This reinforces the trend towards diminution of training.

60. Concurrently, the increasing concern with threats to biodiversity worldwide has highlighted th enormous gaps in taxonomic knowledge of the world's flora and fauna. While there is a well-founded perception that organisms are under threat, the size of the threat and the numbers of taxa involved can only be guessed at so long as the cataloguing of taxa and their distribution remains incomplete, or i n some cases, barely begun. Attempts at management and survey that are not backed by sound taxonomy will inevitably be flawed.

61. This aspect of the problem can only be addressed by educating the educators, and by demonstrating that taxonomy has a central role to play in natural science. The generation of jobs for taxonomists will automatically drive a demand for training. At the same time the role of taxonomists as the driving force behind large, important and prestigious projects needs more publicity.

3.4 Monographic Treatment versus Inventory versus Rapid Assessment

62. Over the last fifty years, public and political environmental imperatives have changed dramatically at the local as well as global levels (deforestation, soil degradation, pollution of fresh water sources, utilisation of genetic resources, global biodiversity crisis, and the greenhouse effect are just some of the major contemporary concerns). Apart from their direct impact on human welfare, all these environmental problem areas have serious implications for the survival of local and regional species diversity, which is essential in maintaining healthy ecosystems and providing sustainable bases for agriculture and for the utilisation of biological resources.

63. All conservation planning and management, and efforts to remedy past mismanagement and restor economically and environmentally significant habitats, require input from, and underpinning by, biosystematic studies. The demands for taxonomic knowledge and the ability to confidently identify organisms is steadily increasing, a situation that is in stark contrast to the decline in numbers of trained taxonomists.

64. In order to accelerate environmental research without having to wait for results from traditional taxonomy, which is perceived to be slow to deliver because it is based on monographic treatments, new methodologies have been developed for assessing biodiversity. These include inventories, surveys, rapid biodiversity assessment, monitoring, and the use of indicator species. Whi le these techniques are designed to provide specific answers to specific questions within a short time -frame, they nevertheless rely on a taxonomic underpinning and using identification skills obtained through taxonomic training. Thus, traditional taxonomy cannot be bypassed. Rather, in seeking to understand the particular nature of the biodiversity of a nation or a region and the associated management problems and socio-economic potential, all these methods will have to b employed.

65. Inventories and surveys are crucial first steps in making a census of poorly known habitats (Cotterill 1995). They rely heavily on field work and mediu -level identification skills, the realm of parataxonomists. They produce important specimen materials and associated distributional and biological data that flow back into

biological collections as voucher collections for subsequent verification of identification and that can contribut to the data base for expert taxonomic research.

66. Rapid-assessment methods and sampling for indicator species are designed to monitor selected biotopes of critical value; for example, river health. Base-line studies of pristine or near pristine biotopes are require against which rouble spots" are monitored. Mediu -levels identification skills are necessary. Collaboration between staff with parataxonomic skills, hydrologists and statisticians is necessary. Monitoring sites would normally be selected on the basis of inventories or surveys of relevant ecosystems.

67. Monographic taxonomic res earch deals with all species in a particular taxonomic group within a specified region. Such studies are crucial in bringing results from inventories and surveys forward to a new level of taxonomic knowledge and in developing identification tools. This is particularly important for ecological research, managing genetic resources, determining agricultural and forestry pests, and assessing potential biological-control agents.

68. In building taxonomic capacity in developing countries, nations or consortia n d to assess and prioritis job requirements, training needs and infrastructure against the mix of methods that will be employed. This is a dynamic process where increased knowledge derived from one method will fuel demands for increased input from other taxonomic fields. For example, the need to progressively refine the level of identification in inventories will place increasing demands on specialist taxonomists for the monographic research and production of inclusive identification tools.

3.5 Existing Models for Developing Taxonomic Capacity and Knowledge

69. Programs for taxonomic capacity building, enhancing the taxonomic knowledge base and developing electronically accessible databases containing consolidated information are initiated at many levels, ranging fro local counties and individual institutions through provincial, national, and broader regional efforts, to global initiatives. They reflect a range of different objectives and time-frames. There is an unrealised major potential for enhancing th flow of knowledge between and among these various programs, and for reducing th duplication of effort.

70. Examples of national and international mechanisms and program initiatives in support of taxonomy ar presented below. International programs provide regional or global structures that link national efforts to wider networks. National models reflect specific needs, priorities and capacities. They may provide a model for adoption, either directly or with modification, by developing countries that ar setting out to build up their taxonomic capacity.

3.5.1 National models

Government appropriation

71. General government funding for taxonomic research and collections: Capital, salary and basic infrastructure costs for taxonomic research and training normally are funded by governments through budget appropriation (museums, herbaria, tertiary institutions, other government agencies). The issue of concern with this model is that in many cases financial support is stagnating or declining, which impacts adv ersely on collection maintenance and development (e.g., security, accessibility, transfer of specimen data to electronic format), the renewal of equipment and research tools, training and recruitment, and the capacity to undertak field-based studies.

72. Increasingly, the trend is for governments to expect researchers and their institutions to obtain operational funds for research projects, including equipment and technical assistance, from external sources.

National research agencies

73. Government fund ing for autonomous or semi -autonomous research agencies is the most commonly applied model for competitive research support. National research agencies are frequently subdivided into autonomous branches (e.g., medicine, natural sciences, arts). Research agencies set broad priorities and funding policies.

74. In many countries, research agencies are the main or only source of external funding for taxonomic research. The advantage of the research-agency model is that agencies have the financial capacity to pr ovide th more expensive taxonomic research tools (e.g., electron microscopes, large collaborative projects with heavy field logistic requirements). The disadvantage of this model is that taxonomic research is in direct competition with projects from a wide range of other research fields. This is particularly detrimental in an intellectual environment where taxonomy is not seen as front-line research. In addition, the direction of taxonomic research funded through the research-agency model, notwithstanding the quality of individual projects, can becomes unfocussed due to the generally very broad priorities.

75. If the research -agency model is used to drive capacity building in taxonomy within its broader charter, funding for 3- to 5-year periods should be earmarked and perhaps placed under a separate advisory subcommittee with responsibilities for setting priorities and vetting funding proposals.

Primary industry corporations and agencies

76. Primary industry bodies concerned with, for example, agriculture, horticulture, livestock and forestry, frequently dispense funds for research and development (R&D). Funds for R&D will often derive from a combination of a levy on the constituency supplemented by government appropriation. Major funding issues include the exploration of new sustainable resources, the development of new genetic strains, and pest control. These areas require a solid taxonomic foundation for setting funding priorities.

77. In general, primary industry relies on other organisations and funding sources to provide the taxonomic foundation they require as end users. The end users are thus not in control of priority setting. There is, however, an increasing understanding of the need for primary industry to set its own priorities and allocate funding for taxonomic research (normally on contract to specialist organisations) to underpin their required R&D.

78. This trend should be strongly encouraged in industrialised as well as developing countries, as it has significant potential for increasing and focusing taxonomic capacity in areas of immediate economic importance.

Targeted funding

79. Funding bodies targeted more or less specifically towards taxonomic research and inventories are not common, but several models have emerged in recent decades. Representative examples are outlined below.

The Government-program approach

ABRS

80. The Australian Biological Resources Study (ABRS) was established by the Australian Federal Government in 1973 in recognition of the inadequate knowledge about Australia's plants and animals and wher they occur. The aim of the program is o provide the underlying taxonomic knowledge necessary for th conservation and sustainable use of Australia's biodiversity". The ABRS is part of the Australian Natur Conservation Agency and the program is guided by an Advisory Committee comprising leading taxonomists, who are appointed to the committee by the Minister for the Environment. The ABRS employs three key strategies:

(a) A Participatory Program of competitive grants for taxonomic and biogeographical research, which includes a strong focus on attracting and training young taxonomists. Th Advisory Committee publicises annual priorities for funding.

(b) A publishing program for a major book series on Australia's plants, animals and microorganisms on a continental scale (Flora of Australia, Algae of Australia, Fungi of Australia, Fauna of Australia, Zoological Catalogue of Australia). There is strong feed back to the publishing program from the research grant program.

(c) Liaison with and coordination between Australian and overseas taxonomists and their institutions, primarily museums, herbaria, other large biological collections and biological departments in universities. ABRS also establishes links with regional and global initiatives in taxonomy.

81. Since museums and herbaria in Australia are funded primarily by individual state governments, ABRS has provided an essential focus for coordination and for setting priorities for taxonomic research at a national level. The result has been a significantly increased collaboration in the field of taxonomy, and an avenue for bringing concerns about collection maintenance, development, and electronic access on a national scale to th attention of the federal government in a consolidated way. In addition, a substantial amount of skills transfer has been achieved through the involvement on research grants of overseas experts.

82. ABRS employs 20 staff, mainly professional taxonomists working as scientific editors, and including a small secretariat for grant administration. The annual research-grant budget is currently just under A$2 million, which supports 68 research projects. Although a federal agency, ABRS works closely with state agencies to deliver a nationally focused program.

83. The strength of the ABRS Program is its constantly maintained focus on taxonomy, on distribution in monographic form rather than on local inventory type lists of names, its direct access to Government, and its strong links with and recognition by th taxonomic community.

CONABIO

84. Comision Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) was established as a ministerial commission in 1992 by the Mexican government and started operations late in 1993. The priority area is to support the development of taxonomic checklists and databases on Mexico's biodiversity, but CONABIO's charter is broad and includes issues such as charting indigenous use and knowledge of biodiversity, databasing information about Mexican biodiversity stored in co llections outside Mexico, and continually educating the population through the media (Nature 368).

85. Government funding is placed in a trust administered by the national development bank. This uniqu mechanism provides a buffer against political vagaries and allows considerable accounting flexibility, including the acceptance of donations.

86. The high-level government support (CONABIO's president is the president of Mexico) sends a very strong message to the entire population about the government's commi tment to exploring, conserving and sustainably using Mexico's biodiversity.

The private, non-profit approach

INBio

87. The Costa Rican Instituto Nacional de Biodiversidad (INBio) was established in 1989 (Gamez et al. 1993). INBio is an autonomous, non-profit private institution with strong links to organisations involved with its creation (government ministries, the National Museum, universities, the National Scientific Research Council, non-government organisations).

88. INBio's key objectives are: to carry out a total inventory of Costa Rica's biodiversity by the year 2003; enhance the collection infrastructure through integrating diverse collections; centralise (including epatriation" of data and information) and distribute information on Costa Rica's biodiversity; and increase local awareness of the importance of biodiversity conservation and sustainabl -use issues.

89. INBio employs around one hundred administrative and scientific -technical staff, partly at headquarters and partly at 29 Biodiversity Offices situated in and around national Conservation Areas.

90. Capital works, infrastructure, training and detailed planning required over the first years were funded by private foundations and donors from around the world, by the Costa Rican government, and by external government bodies concerned with aid programs in developing countries. Following this initial phase, INBio must become self -supporting. Funds required over the next decade to undertake the National Biodiversity Inventory and to ensure th permanent maintenance and development of the biodiversity collections are estimated at $50 million.

3.5.2 Global and Regional Initiatives in Taxonomy

91. Following Rio and the adoption of the Convention on Biological Diversity and Agenda 21, a number of international programs or national programs with international scope were initiated that implicitly or explicitly aim, in whole or in part, at strengthening global taxonomic capacity, restoring the role of and support for biological collections in the biodiversity equation, and developing comprehensive regional or global taxonomic publications and databases summarising current knowledge about the planet biological diversity. Examples ar given below.

Initiatives that include taxonomic capacity building in their goals

GEF

92. The Global Environmental Facility (GEF) was developed by the international community, concurrently with the completion of the Convention on Biological Diversity and Agenda 21, as a global fund for biodiversity conservation and other environmental priorities.

93. As a recent example of the GEF providing substantial support for taxonomic infrastructure capacity building, the Biodiversity Collections Project for Indonesia must be highlighted. The project aims, over the next five years, to build the institutional capacity of the national herbarium and the national zoological museum to inventory, monitor and study Indonesia's biodiversity. This joint Indonesian-GEF funded project has a strong focus on reviving, restoring to safe curatorial practice and developing the existing large and very valuabl biological collections in recognition of their crucial role in understanding the nation biodiversity. The project includes the building of a national biodiversity information system (Townsend 1995).

94. The GEF may apply such funding mechanisms as project trust funds. If the GEF were to get involved in national or regional taxonomic capacity building programs, such trusts would allow the orderly development and implementation of major capital infrastructure issues or operational aspects. They would also provide a hedg against currency devaluations and the vagaries of politics, and would provide the basis for long-term funding security.

WCCR

95. The World Council on Collections Resources (WCCR) was founded in 1992 as an outcome of the first World Congress on the Preservation and Conservation of Natural History Collections in Madrid in 1992. Its aims are to facilitate the development of research-quality natural history collections in developing countries, provide public education about the value of these collections, and promote access to collection-based information. The WCCR has already been asked to help secure funding for a new natural history museum in Vietnam.

BioNet

96. The Biological Network (BioNet) was established in 1994 by agreement between a large number of developed and developing countries. Funding has been negotiated with, among others, the World Bank and major international development banks. The aims of BioNet are to support ta xonomy, identification, training, collections and research infrastructure, primarily in developing countries, in regional frameworks. Currently th emphasis is on microorganisms and insects, but other high-priority biodiversity groups are given consideration. BioNet has a small international secretariat and locally organised networks of countries called oops". Loops in the following regions have been or are in the process of being established: the Caribbean, South Africa, South East Asia, South Pacific Island Countries.

Initiatives that aim at surveys, inventories and databasing

BS&I

97. The Biotic Surveys & Inventories Program (BS&I) of the United States National Science Foundation was established in 1991. The program supports research aimed at recording and documenting the diversity of life on Earth based on field collecting or inventories in broad bio-regions. It also supports inventories of existing collections, and the development and dissemination of taxonomic databases. The BS&I has funded projects on plants, animals, fungi and microorganisms worldwide: in North and South America, Asia, Pacific, and Madagascar , for example (Lane 1995).

Initiatives that aim at presenting a global overview of existing knowledge

ETI

98. The Expert Centre for Taxonomic Identification (ETI) was started in 1991. A non-profit organisation associated with the University of Amsterdam, it is funded by the Dutch government, the University of Amsterdam and UNESCO. ETI aims to concentrate, preserve and distribute taxonomic and biological knowledge worldwide by aid of modern computer technology, to support research, inventories, monitoring and conservation efforts. On-line access to ETI's databases and the distribution of tailored subsets on CD-ROM are the dissemination means. ETI envisages that data and information will be made available in a highly interactive, multimedia form. ETI has produced several CDs, including Birds of Europe, Holothurians of Northern Australia, and Marine Turbellarians of the World. A UNESCO-IOC egister of Marine Organisms" project is currently under way in collaboration with ETI. The Register project is associated with th pecies 2000: Indexing the World's Known Species" conceptual framework (IUBS-ICSU-IUMS).

99. Species 2000: Indexing the World known species is a new programme launched by the IUBS at its General Assembly in September 1994. The objective of the programme is to enumerat ll known species of plants, animals, fungi, and microbes on Earth". It hopes, ultimately, to establish a eta database of standards and working taxons for all groups of organisms which will be accessible electronically. Implementation of Species 2000 will involve the establishment of a global federation of existing taxonomic databases. Thes master species databases will provide the validated names. Financing for this programmes is yet to be secured but is being lead by UNEP.

Species Plantarum

100. Species Plantarum (or, Flora of the World) operates under the auspices of the International Organisation for Plant Information (a Commission of IUBS). Planning is well advanced, but implementation has been slowed by a lack of resources.

101. The project aims at producing worldwide accounts of flowering plants, including full synonymies, descriptions of taxa to species level or below, and identification keys on a uniform worldwide basis, within a very short time. Another goal is to stimulate job growth and taxonomic training and experience on a worldwid basis. The first treatments, and some subsequent ones, will almost certainly be donated. Funding will be required to commission other treatments, or parts of treatments, in order to ensure timely progress. Such funding would achieve two of the major objectives of the Global Taxonomy Initiative outlined below: the provision of identification materials for important groups on a uniform basis; and the direct generation of employment and experience for taxonomists on a worldwide, distributed basis.

4. OPTIONS FOR ACTION

102. As recommended by Courrier (1992), apacities for undertaking [taxonomic] research and disseminating data should be developed close to those who need the information -- at the national or sub-national level -- though the support of international networks is vital". Furthermore, actions should, to the extent possible, build on existing capacities. Thus, the development of national biological collections should be based on existing museums and herbaria, and within the framework of biological departments in universities with significant collections. Likewise, the training of professional and technical staff should take place in a formalised collaboration between such collecting institutions, tertiary institutions, and other agencies with the appropriat expertise.

103. Where no adequate collection facilities exist, the opportunity should be taken to plan development in close proximity to an appropriate tertiary institution.

104. National affiliation with regional or international networks with relevant aims should be sought in order to facilitate th sharing of experiences, establishing collaborative programs to avoid duplication of resources and create consortium approaches to international funding sources in areas of common interest. Where bilateral arrangements are in place between developing and developed countries these should be further pursued within the framework of national strategies for taxonomic capacity building.

105. With these points in mind, it is clear from the preceding sections, however, that each country must develop its own programs and priorities for developing taxonomic capacity to meet specific national needs and goals. On this basis it would seem counter-productive to propose here prescriptive actions and solutions.

106. It is possible, however, to outline a framework for a Global Taxonomy Initiative within which developing countries can address taxonomic capacity-building in partnership with neighbours and th international community, and bring proposals forward to international funding bodies individually or in consortia of countries with overlapping interests. This proposed framework is presented diagrammatically in Annex 2, and is discussed below.

107. Centres of Excellence (CEs) as operational focal points are proposed, not as mandatory components, but from the conceptual point of view that such centres would serve partly to provide the necessary critical taxonomic expert mass-effect for research planning, giving advice, and policy development, and partly to rais the national profile of taxonomy and underscore its fundamental role.

108. Provincial Centres (PCs), or equivalent, should preferably be administered as distributed elements of central taxonomic institutions (CEs or otherwise) with responsibilities attuned to national planning and priorities. Where established within existing provincial research or educational institutions, their relationship with the CE should be formalised. They would have a pivotal role in developing and disseminating educational material about biodiversity and the role of taxonomy in collaboration ith local communities, and in providing an invaluable training ground for future taxonomists through participation in inventories, surveys and ecological studies. With minimum expert taxonomic supervision, PCs could be operated by trained parataxonomists and educators, with local assistance for field work.

109. Within a broad framework, as outlined in Annex 2, individual nations would set in place their own administrative, planning and policy-development structures based on specific national circumstances, priorities, existing government mechanisms and local traditions. A high-level national advisory or coordinating council charged with overseeing the implementation of taxonomic capacity building and providing recommendations to government on priorities and broad directions for the national taxonomic effort would ensure coherence and focus. If established, such advisory bodies should preferably be chaired by, or at least report directly to, th responsible government minister.

110. The framework provides numerous options for adaptation and scoping. These range from an individual nation developing the desired capacity using national resources with support from bilateral partners or regional fora, to large-scale consortia requiring international funding support. Each nation or consortium could, within the global, regional or national framework, choose to adopt or adapt infrastructures and administrative and funding arrangements tested in other countries with the added benefit of lessons already learnt. The model allows all levels of national, regional and international expertise and experience to become involved in various aspects of structured capacity building, at various times and with varying contributions of resources.

5. THE ROLE OF THE CONVENTION IN DEVELOPING TAXONOMIC CAPACITY

111. Even though it is undeniable that at every level there is under -resourcing of taxonomy, and although it can be taken as axiomatic that the discovery and description of all the world's species is a sound and legitimat goal, the crucial question within the context of the Convention is: to what extent is the "taxonomic impediment" invariably a limiting step in fulfilling the aims of the Convention? Indeed, it needs to be recognised that th national taxonomic needs of the Parties do not necessarily coincide with the taxonomic capacity needed to implement the Convention.

112. The Parties therefore need to be mindful of the basic requirements of the Convention when considering what is the optimal level of taxonomic capacity. Similarly, the COP and the SBSTTA will wish to be mindful of these constraints and to focus their attention and support in the areas where they can be most effective and ar most critical in terms of meeting the objectives of the Convention.

113. Taxonomic knowledge is required to address at least four basic issues under the remit of th Convention, including: the identification of areas of high diversity; of taxa under threat,;of taxa that are or may be of value to humankind; and improving the understanding ofecosystem functioning.

114. To be of value in fulfilling these functions, taxonomic information needs to be supplemented with additional information, particularly concerning the distribution of the species identified. It is important to consider whether greater benefit at present would be gained from increasing the information on already described taxa or from increasing the number of described taxa. The two activities should not, of course, be regarded as mutually exclusive, but their relative importance should be carefully weighed. In this respect, the SBSTTA will

no doubt wish to be mindful of its consideration of items 3.1, 3.2 and 3.3 of the provisional agenda of this meeting of the SBSTTA.

115. It is taken as given that financial resources are limited, therefore, in the context of the Convention, attempts should be made to analyse the cost -benefit ratios of different research strategies. With limited resources, and with the urgency of action required to maintain the world biodiversity, it is recommended that the concept of ptimal ignorance" be invoked, whereby ignorance is reduced to a level at which it ceases to impede judgement on the best action (but not to zero). Such an approach applied to critical areas within th Convention gives some idea of the level of taxonomic capacity that is in fact needed, compared to what is desirable from a taxonomist's perspective.

What proportion of existing species must be known and described?

116. Increasing the accuracy of estimates of global species richness (and a linked parameter - the current rat of species extinction) is an important scientific pursuit, but may not be a primary goal in the context of th Convention. For example, it is questionable whether the immense sampling and analytic effort required to collect and identify the possible 500,000 to 1,000,000 undescribed nematode species would be justified in terms of th ability of the information generated to affect materially the management and use of the world's biodiversity. This probably remains true despite the fact that nematodes as a group are of great economic importance (chiefly as parasites and pests of both plants and animals) and are extensively used in scientific research. In most circumstances, it is likely that filling gaps in knowledge of the geographic distribution or population condition of described species, particularly in ecologically or economically important groups, and in developing countries, will make a more immediate contribution to achieving the aims of the Convention.

Identifying areas of high diversity

117. Similarly, in the question of identifying areas of high diversity, it is not clear whether the very larg effort required to inventory all taxa in any given geographical area is warranted in terms of increased accuracy. Sampling and inventorying invariably follows a pattern of diminishing returns, so that fairly rapidly the increas in information gained per unit effort becomes very small. Also, some forms of assessment in this field do not necessarily require the naming and classification of all organisms collected.

118. The emerging evidence that areas of high diversity for one taxonomic group may be poorly correlated with those of other groups makes it difficult to assess the significance of such areas. It also remains a moot point whether the discovery that patterns of diversity in hitherto undescribed taxa differed greatly from known patterns (largely of macrofauna and vascular plants) would materially affect planning for biodiversity conservation and, if so, in what way.

Understanding ecosystem functioning

119. The relationship between systematics and the study of ecosystem functioning is not a straightforward one. Studies of ecosystem functioning essentially concern attempts to discern patterns at various spatial and temporal scales in the interactions between different organisms and between organisms and their physical environment. There is obviously a need to be able to identify and distinguish the elements of ecosystems under study to do this, but it is not clear that a full understanding of systematic relationships is necessary. Furthermor

it will be impossible, particularly in diverse ecosystems, ever to look at the relationships between more than a fraction of the species present so that full taxonomic inventories are likely to be redundant.

120. There is admittedly a danger in this approach in that crucial aspects of ecosystem functioning may b overlooked because of inadequate taxonomic knowledge. For example, the relationship between diversity and th maintenance of ecological processes, particularly those involving decomposition processes in highly divers ecosystems such as tropical moist forests, is a crucial area of study in ecology and one that requires a solid understanding of taxonomic diversity.

Sustainable use of species

121. Assessing the sustainability of current use of wild species demands that the population units in question can be identified, characterised, and the demographic links between them determined. Establishing and maintaining sound species-level taxonomy is clearly a prerequisite. On the other hand, the initial investigation of potential benefits from wild species not in use, e.g., prospecting for genetic resources of medicinal importance, demands only that specimens can be at first identified to family or generic level. If a species in some given genus or family already has an established use, it can be predicted that another population not in use but falling within that same genus or family (regardless of its precise taxonomic lev l) has a significant probability of sharing genes that are the basis for desirable biochemical or production characteristics.

Assessing threatened species

122. Determining whether a given taxon is under threat is a rigorous undertaking requiring quite detailed information on the status and distribution of that taxon. It is evident from the global assessments carried out to compile the IUCN Red List and other national and international registers of threatened species that there is inadequate information at present to assess thoroughly more than a small proportion of currently known species. Vastly increasing the number of species to be assessed will compound this problem.

6. CONCLUSIONS

123. Solutions to the problem of inadequate taxonomic knowledge and the shortage of systematists, particularly in many of the most species-rich tropical countries, must be both *strategic* and *pragmatic*. From the point of view of maintaining biodiversity there may be little point in investing heavily in systematics unless there are programmes in place that will make use of the information and of the human resources generated by such an investment. Moreover, as elaborated above, it is evident that the relationship between taxonomy and th assessment and management of biodiversity is not a straightforward one. A greater understanding of the crucial links between the two is necessary before detailed programmes are developed.

124. Proposed solutions to the "taxonomic impediment" follow. The foremost priority, however, is for each country to undertake a use -needs analysis. This will allow a first approximation to the central question of balance: *what proportion of total resources available for biodiversity conservation should be allocated to systematics as opposed to other areas?*

125. For some countries, the level of taxonomic knowledge or expertise may be sufficiently high that there is no fundamental taxonomic impediment to that country□ effective implementation of the Convention. For other countries, probably most or all of th ose in the biodiversity-rich low latitudes, there is likely to be a very

significant taxonomic impediment. This will variously lie in a lack of in -country taxonomic expertise, in a lack of access to existing specimens or literature, or in other problems.

Make better use of existing resources

126. Regardless of the particular needs of a Party, the better use of existing taxonomic information is a desirable policy and one that can only be effectively addressed at the global rather than national level; it ould also relieve many of the taxonomic problems besetting developing countries. A great deal of existing taxonomic information remains very little used; many taxonomic collections are infrequently accessed. This may be becaus there is no demand or because the information or the collections are difficult to access. Lack of demand may reflect a lack of current use for the information or may be because potential users are unaware of the existence, or the value, of the information. The creation of use for the information lies outside the realm of systematics, but an analysis of user needs should be fundamental to any organised planning for development of the discipline.

127. Improving awareness of and access to the resource are problems to be tackled primarily by th systematic community and will entail a reappraisal of current working practices. The Convention and its bodies are well placed to make a significant contribution to improving access. Obviously, the development of th clearing-house mechanism can help the dissemination of existing information, especially from those institutions in the developed world that are the repository of a large proportion of the world's taxonomic information to developing countries where it is most needed (further details about the state of the clearing -house mechanism ar given in document UNEP/CBD/SBSTTA/2/9).

128. The Convention as a whole is also well placed to provide further support for developing taxonomic capacity. What follows is a list of areas that would facilitate the development of taxonomic capacity and that the SBSTTA may wish to consider how the Convention can contribute to:

(a) **Taxonomic standards** A central justification for the practice of taxonomy is to ensure that each species has a single, universally recognised name (the Latin binomial) so that wherever this is used there is no doubt about the identity of the species being referred to. There is continual flux in species names but no centralised system to record and make available information on appropr iate scientific names and authorities (and, incidentally, no means of counting accurately the number of described species). The widespread adoption of standard taxonomic systems, buffered from continual short-term change in nomenclature, should be encouraged.

(b) **Taxonomic rules** Research into the validity and taxonomic precedence of names is a fundamental part of the practice of taxonomy, but it is also time-consuming and expensive to pursue. It is desirable to streamline the decision -making process of those bodies charged with ruling on th availability of disputed names.

(c) **Electronic access** Taxonomic lists, some adopted as global standards, are increasingly maintained in electronic format. Most of the world now has access to the Internet. There is a clear need to develop a metadatabase of such lists that would facilitate electronic access to them.

(d) **Publicatio** Standard taxonomic publications are often several years in preparation, many months in the printing process and, once published diffic ult to access in many parts of the world. Taxonomic work is in itself time-consuming, but it is possible and desirable to make the published work (perhaps in abstract form) readily available in every country of the world.

e) **Pragmatic approac** Detailed research into nomenclature and the morphology or other characters of specimens at hand is traditionally the core work of taxonomists. In many, but not all, cases the interest of biodiversity conservation could be best served by abbreviating this proces s and making possible the rapid publication of key taxonomic details rather than delaying the dissemination of results until a lengthy monograph can be finalised.

Develop ways around the problem

129. Indicators A growing body of work is focused on using information on some taxon (or other environmental feature) to indicate some more generalised condition. The use of indicators is discussed in mor detail in the Note prepared by the Secretariat for the previous item of the provisional agenda (document UNEP/CBD/SBSTTA/2/4). The SBSTTA may wish to consider item 3.3 of the provisional agenda in light of the need to support the development of taxonomic capacity in developing countries as well as simply to review the effectiveness of measures taken in accordance with the Convention.

130. Parataxonomists In many circumstances, persons with some basic training in collection and/or in identification to some determined taxonomic level, but without experience in the preparation of detailed taxonomic monographs with all that this entails, can generate very useful information on local diversity. This represents a sound compromise position and one increasingly used in rapid survey techniques.

Investment and Support from the Developed Countries

131. The fundamental importance of continuity and of guaranteed, long -term stability in funding for taxonomic institutions cannot be over-emphasised. Declining levels of investment have been a major factor in th decreasing levels of taxonomic capacity in the developed countries.

132. Support of some kind from the Convention will probably be critical to initiating the necessary measures. One particularly successful programme of support in this respects has been the UK's Darwin Initiative. Under this Initiative the UK Government has provided a small fund to support joint research initiatives to look into biodiversity issues, where one party is a UK education or research institution and the other party is an appropriate institution in a developing country. Such a scheme has meant that the enormous wealth of the UK's taxonomic capacity has been offered along with enough financial support to fund a mediu -term research programme. This is a particularly effective way of addressing the need for more taxonomists because it not only provides financial support but also encourages the transfer of technology, which, as noted before, is so vital in this area. The SBSTTA may wish consider examining ways in which this programme may be expanded so that other developed countries rich in taxonomic resources and collections could contribute both financial resources and technical support to developing taxonomic capacity building.

133. Core funding of a long-term nature is also crucial. As noted before, support for this type of funding might be provided by the financial mechanism of the Convention; the SBSTTA may wish to consider a recommendation to the COP requesting the COP to amend the necessary guidelines to the GEF. However, th SBSTTA may wish to consider less costly options and a more organic or incremental approach to seeking financial support for the development of taxonomic support. Many of the observations made above about facilitating access to existing information would benefit from financial support from the GEF. Indeed, there ar a number of systematics proposals in the GEF process already. The SBSTTA may wish to recommend to th COP specific guidance about the type of systematics projects that would be most effective in meeting th requirements of the Convention.

134. Centres of Excellence would no doubt benefit enormously if they were given some award of excellenc by the SBSTTA or the COP. It would assist them in seeking funding from donors, private interests, and even perhaps the GEF. It would also help them in seeking support in kind from other institutions. For example, it might facilitate the exchange of personnel from institutions in the developed countries to developing countries where the institutional structure does not have an international reputation. Such a scheme wou ld have th attraction of requiring little financial commitment. The SBSTTA may wish to consider developing a scheme under which an award of excellence has some official seal of approval from the Convention. The SBSTT may, however, wish to consider supporting such a scheme with the allocation of a limited number of scholarships in order to provide a further catalyst to the exchange of personnel and technology.

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ANNEX 1

Examples of Significant Outcomes of Applied Taxonomy

1. Presented below are several brief case studies showing how taxonomy has played a crucial role in providing solutions to, or cost saving predictions on, otherwise intractable problems relating to sustainabl development, utilisation of genetic resources in primary industry, or environmentally related human wel fare issues generally in developing countries. The economic and social gains are incalculable.

Genetic enhancement in primary industry

2. *Tolerance in Cotton.* Cultivated cotton has been developed through the selection of desirable strains from a single species, Gossypium hirsutum. This narrow genetic base (as well as broad-acre farming methods) has resulted in cotton crops becoming increasingly susceptible to a wide range of fungal and insect pests. Efforts to control these pests have led to intensive spra ying regimes, impacting heavily on the environment, including th pollution of ground water and the decimation of non -target species. Feeding cotton waste to cattle has, in th recent past, led to the contamination of the human food chain with insecticide and fungicidal residues, leading to large economic losses. Cultivated cotton also has a relatively narrow water availability and temperatur tolerance, limiting the areas in which it can be grown.

3. Recent taxonomic work on Australian native Gossypium species has identified taxa with several desirable characteristics, including cold tolerance, lack of terpenoid aldehydes in seeds, and resistance to insects and microbial pests. Hybridisation work is underway to introduce these characteristics into cotton cultivars, to increase their disease resistance and their climatic tolerance. Biological solutions to pest problems offer longer term and safer alternatives to spraying regimes, while increased climatic tolerance will allow cultivation in mor marginal areas.

4. *Tolerance in soybean.* In recent years considerable work has gone into better understanding th taxonomy of the genus Glycine. This genus has two subgenera, subgenus Soja containing only the annual wild species G. soja, and its cultivated descendant, G. max, and subgenus Glycine, of 14 wild perennial species, all indigenous to Australia. Five of the latter have only been discovered in the last 10 years, as part of the research described below.

5. The perennial species range from the tropics to the arid zone and the alpine areas of Australia, and hav a wide range of characteristics that could improve soybeans, including a perennial lifestyle, drought, heat and cold tolerance, apparent insensitivity to daylength, and resistance to fungal diseases such as that caused by Phakopsora pachyrhizi (soybean leaf rust). Recent work by Australia has gone a long way towards transferring these characteristics to the soybean, a staple food in many parts of the world.

6. Spin-offs from this project have been the development of a cultivar of Glycine tabacina as a ground cover in South Africa, and of a strain of Glycine latifolia as a pasture plant in southern Queensland.

Environmental management

7. *Control of introduced water fern.* Water ferns of the genus Salvinia live on the surface of ponds, lakes and waterways. In the 1950s and '60s an introduced species became an environmental pest with serious economic and social implications in many parts of the tropics when it spread out of control in all freshwater habitats, including rice paddies and fish ponds, due to a lack of natural control agents. Nowhere was the impact harsher in terms of affecting human society than in Papua New Guinea, where waterways became completely blocked by metre-thick mats of the fern. As local residents were deprived of the use of the resources of rivers and their traditional means of inter-community communication, they were forced to abandon their villages.

8. It became apparent that biological control would be the only effective and environmen tally acceptabl means of averting a long-term disaster throughout the tropics. The first step was to determine taxonomically th exact species involved. It was found to be an undescribed species, now known as Salvinia molesta. Its origin was traced to Brazil, where it was found to be controlled by tiny weevils.

9. Further biocontrol experiments were largely unsuccessful until, in the early 1980s, Australian entomologists undertook a detailed taxonomic study of the weevils. They discovered that what was thought to b one species, in fact comprised a species complex of which only on -- a previously undescribed species now known as Cyrtobagous salvinia -- was the only effective control agent for Salvinia. Within a year of applying this taxonomic breakthrough, waterways in Papua New Guinea were cleared of the pest, and abandoned villages were re-occupied. The environmental success and socio-economic benefits of this control program were readily available to affected countries in tropical Indo-Pacific and Africa.

10. *Lichens as cheap and sensitive air pollution monitors.* In the last 30 years, evidence of the variable sensitivity of lichen species to changes in air quality has led to their increasing use as cheap but accurat biological monitors. Throughout western Europe and, more recently, North America, the lichen floras in and around urban and industrial areas have been mapped, and the environmental implications of depauperat vegetation have had a considerable influence on planning and regulatory agencies. T his enhanced profile for what had been a neglected group of organisms has had as its basis an increasing understanding of lichen taxonomy and, concomitantly, more reliable lichen-mapping studies.

11. The ability to distinguish between apparently similar species of lichen has led to the development of air quality monitoring kits. These have enabled high -school children throughout Europe and North America to undertake local surveys and provide reliable indications of air quality.

12. That solid and reliable taxonomy continues to underpin such studies can be seen in the flurry of interest that recently accompanied the apparent discovery of the lichen Lecanora conizaeoides in North America. This polluti -sensitive species is the dominant lichen in urban and industrialised areas of western Europe. However, a recent taxonomic monograph of the genus Lecanora was able to confirm that this lichen had not in fact migrated across the Atlantic. The American plant was shown to be a related species of minimal value as a biological monitor.

Pest control in Agriculture

13. *Taxonomy as a predictive tool.* The Chinese wax-scale insect, Ceroplastes siniensis, is a serious introduced pest in the citrus-growing industry around the world. Early attempts to find natural enemies for biological control failed largely because researchers assumed, on account of the bug's scientific and common name, that its native habitat was to be found in China. As it turned out, Ceroplastes siniensis does not occur in China (its scientific name has a different origin), and its native habitat could not be predicted from its choice of plants, because it attacks more than 200 plant species.

14. To narrow down the possibilities, an Australian entomologist embarked upon a detailed taxonomic study and analysis of the evolutionary relationships (phylogeny) among the more than 100 species known in the genus. The resulting hypothesis suggested that Ceroplastes siniensis is closely related to a small group of species nativ to south and central America. Consequ ntly, a search for the species in South America was undertaken, and in 1993 it was discovered at La Plata in Argentina. It was also found that the native populations were heavily parasitised by a local species of wasp, which appeared to exert natural control over the wax -scale. The potential for using the wasp as a biological control agent of introduced populations of Ceroplastes siniensis without unintended effects is being investigated, but predictions from a taxonomy -based hypothesis of evolution and origin changed the hunt from a larg -scale search on several continents to a well-focused exercise.

15. *Pest mites in horticulture and agriculture.* In about 1950, fewer than 20 species of the mite family Phytoseiidae were known. About that time it was realised that this group of mites preys on and controls another mite group, spider mites, which cause enormous damage to crop plants all over the world. This discovery led to intensive taxonomic research, with the result that more that 1000 phytoseiid mites hav been described. This biological diversity is now being exploited by the use of many species in the control of spider mites and other plant pests in orchards and other horticultural situations around the world. One of the most important phytoseiid mites, only recently recognised scientifically, can provide complete protection against spider mites in glasshouses. The genetic diversity in phytoseiid mites is also being exploited to develop pesticid -resistant strains that can be used in biological control in integrated pest-management programs.

16. *Potato and beet pests.* Many species of roundworms (nematodes) attack crop plants, and are almost certainly responsible for the crop failures in central Europe and Russia last century and early this century. At first, the causal organism was unknown, but detailed research initially revealed that the organisms wer nematodes, and subsequently that different nematode species and genera were involved. The recognition that different genera were involved was, and continu s to be, very important in devising control strategies. Some whole genera are readily controlled by crop rotation. In other genera, the exact species needs to be known to determine the correct control approach. In both cases, taxonomy has had a major impact on the development of crop rotation. Other nematode species have very wide host ranges, so different methods must be used; but th identification of the nematode involved is the crucial first step for determining occurrence and control strategies, and for providing identification tools to ensure that the correct strategy is adopted.

Soils

17. *Conservation of arid zone soil crusts.* It has been recognised for many years that various cryptogra groups, particularly bryophytes and lichens, were crucial in arid-zone soil crusts. In dry periods these organisms bind the surface layers of the soil, greatly reducing wind erosion of these thin soils and their scarce nutrients. Until recently, however, the application of this knowledge to soil conservation had been hampered by a lack of knowledge about the numbers and identities of the organisms involved.

18. Recent investigations of the taxonomy of groups of Australian lichens, and the production of monographs and floras dealing with lichens has provided a new impetus for a greater understanding of th importance of lichens and other non-vascular plants in the conservation of soil in arid and semi -arid regions. In the last 5 years, taxonomic advances have enabled rangeland scientists to identify lichen species and to produce illustrated guides for agricultural advisers who will inform pastoralists of the value of these organisms as indicators of soil quality.

19. The taxonomic knowledge in this case spurred the development of management tools, which will hav incalculable economic benefits in soil conservation.

The importance of symbiosis

20. *Orchids and Fungi.* All orchids, both terrestrial and epiphytic, are associated with and dependent upon certain types of fungi. These fungi form an intimate (mycorrhizal) association with the roots of the orchid. This symbiotic association is essential during the germination phase of the orchid life cycle, and often during th remainder of the life cycle as well. Research on the symbiotic germination of the orchid in the presence of fungi showed that for each group or species of orchid there is a preferred fungal partner. Without the appropriat fungus present, the likelihood of a particular orchid seed germinating and/or a plant becoming established and reaching maturity is extreme ly low. Knowledge of this relationship, and the specific type of fungus needed for each orchid, has proved essential in the germination and r -establishment of certain orchids into the wild. program involving the conservation and protection of rare and endangered orchids in England has been running for 12 years, based on the knowledge of the orchid/fungus relationship and their taxonomies.

21. Similar strategies are also of relevance to the cultivation of orchids for horticulture and the cut flower trade. Plant breeders need to understand the taxonomy of the groups that they are working with, as well as th taxonomy of the fungus symbionts, to establish new seedlings in cultivation. The other side of the coin is that th knowledge of which groups of fungi are compatible with particular orchids provides additional insights into th underlying relations of the orchids themselves.