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The role a botanical institute can play in the conservation of the terrestrial biodiversity in a developing country

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The need to integrate *in situ* conservation into the planning process is outlined, and the importance of vegetation survey to determine conservation priorities and to identify areas suitable for *in situ* conservation is stressed. A case is presented, drawing on experience gained in Zimbabwe, of how a botanical institute can become an integral part of biological conservation. The institute should consist of a herbarium, a botanical garden, a gene bank and a vegetation survey unit. The function of each section, how they interlink, and how they can be integrated are discussed.

Keywords: biodiversity; *in situ* conservation; land-use planning; botanical institute; vegetation survey

Introduction

In situ conservation plays a central role in the conservation of biodiversity. It is the most effective way in which biodiversity can be maintained and, more importantly, it gives the best chance for evolution of the conserved organisms to proceed. Emphasis throughout this paper is on the conservation of botanical diversity because vegetation is the base of all ecosystems, and ecosystems are normally classified by their vegetation content. Underlying this approach is the belief that if vegetation and habitat dynamics are protected the rest of the ecosystem will take care of itself.

The impetus for this paper has come from the frustration experienced when witnessing, on the one hand, the disregard man has for nature and, on the other, how ineffectual many conservation efforts are. The paper aims at analysing the present approach, pointing out weaknesses and finding reasons why *in situ* biodiversity conservation is so difficult to implement. An approach, based on the situation in south tropical Africa, is outlined in which vegetation survey and inventory play an important role and the integration of conservation into the planning process is a central issue. This also requires an efficient botanical institute. It is not claimed that the proposals are original, they are essentially based on practical experience. The points made are illustrated with a case study in which Zimbabwe is taken as an example.

Approaches to conservation

The present status

In south tropical Africa (e.g. Zimbabwe) planned *in situ* conservation of plant biodiversity is practically non-existent, and existing protected areas are due to chance rather than enlightened planning. It is agreed that economic and social development must go on. What is, however, unacceptable is the large scale and complete destruction of natural vegetation. Land for conservation is still available in many of the countries concerned, especially if one considers how inefficiently land (especially non-arable land) is often utilized. Fortunately, some parts of the region are still underpopulated and biodiversity is not immediately threatened, and this offers an opportunity to develop a conservation plan ahead of development.

Criteria for reserve selection

Most conservation efforts have been centred on the well-known areas of special biological interest discovered by collectors over the last two centuries, and less diverse areas have been almost totally neglected. Who is to say that a species-rich rainforest should have priority over the less diverse deciduous dry forests which only occur in the mid-Zambezi Valley and which are by now, in their pristine form, close to extinction? One must also not forget that the less diverse regions, which contain most of the natural ecosystems still in existence, have a unique wealth of genetic resources, and serve valuable ecological functions.

South tropical Africa is a good example of a region with a relatively unspectacular flora. The vegetation mainly consists of savanna woodlands, woodlands, dry deciduous forests, small outliers to tropical rainforest, hydromorphic grasslands and deciduous savanna scrublands. Areas of high biodiversity and centres of endemism are rare. However, more than 15 000 species of flowering plants occur in the region. This constitutes a considerable genetic resource, and since similar ecozone occur over extensive areas north of the equator and on other continents, wild plants with agricultural potential from the area have a possible value for a much larger portion of the total land mass than, for instance, plants from tropical rainforest.

Clearly, to attain comprehensive *in situ* conservation of biodiversity a further criterion for the selection of conservation sites is needed – good coverage of the habitats found in a given ecological region. To achieve such a goal a series of reserves has to be selected in which each site makes a vital contribution to the conservation of biodiversity in the country concerned. Diverse sites will obviously play a key role, but sometimes insignificant ecosystems can contain important genetic material worthy of preservation. This approach will also help ensure good coverage of intraspecific variation of economic target species.

Vegetation survey

No survey was needed to identify the majority of the conservation sites on which the world is now concentrating. Most of these were selected using non-biological criteria. However, if one wants to move on to a more objective and comprehensive approach to biodiversity conservation, embracing all ecological zones and habitats, vegetation survey and vegetation inventory are of paramount importance. The lack of survey-based data is one of the main reasons why *in situ* botanical conservation has not progressed in the Third World. At present much of the data on threatened or endangered species and habitats in the Third World is compiled in Europe and North America. On the whole the accumulated data are superficial and based on questionnaire rather than field work. What is necessary is to support survey activities in the areas where the conservation effort is supposed to be taking place, which would provide a much clearer picture of conservation needs than is presently available.

Conservation in the planning process

Since *in situ* conservation is a form of land use it is essential that cases for it are considered at the national and local planning level, it will only be able to compete against other forms of land use if access to the planning process is established. At this level political considerations play a major role, and it is therefore important that an objective decision-making framework exists where land-use allocations are made on the basis of geographical information. A great deal of the destruction of possible conservation sites is unfortunately due to unplanned development.

Conservation of sections of biodiversity

Conservation of a specific section of the biodiversity is contrary to the theme of this paper but in some cases it is the only sensible solution. For instance, animals, especially large mammals, are a great tourist attraction in some African countries and bring in considerable revenue. Therefore large sections of game country are managed to favour animals at the expense of overall diversity. A higher carrying capacity for animals can be achieved by allowing a certain level of vegetation degradation or modification.

Management of biodiversity reserves

It should be recognized that, contrary to the popular beliefs of today, optimal biological conservation is generally not compatible with management for resource utilization. There are, of course, exceptions, for instance hunting or tourism which, if properly managed, can provide substantial revenue without negatively affecting biodiversity. However, the main function of a biodiversity reserve should be simply to conserve species and natural ecosystems, and in addition, besides being a site for research, it should provide genetic material for breeding, propagules for horticulture and plant material for research. Apart from this, pristine ecosystems have a tremendous aesthetic value, and are part of a country's cultural heritage which should be kept for future generations.

The role of botanical institutes

To supply the necessary data to the planners, functional botanical institutes are absolutely essential. The local institutes must be in a position to collect, analyse and manage all information needed for a comprehensive and objective biodiversity conservation programme. Most of the scope for biodiversity conservation exists in the Third World where botanical institutes are particularly weak. The lack of taxonomic knowledge and functional taxonomic institutes has been identified as one of the most serious limiting factors in genetic resources conservation (Hedberg, 1991). For a comprehensive conservation programme to succeed, the strengthening of botanical institutes in the Third World is of particular importance.

The remainder of this paper is a case study on botanical conservation in Zimbabwe and an account of how, drawing on the Zimbabwe experience, a botanical institute can be integrated into the conservation process.

Case study – Zimbabwe

Present state of conservation

Of the ca 6000 vascular plant species in Zimbabwe, many are widespread and occur in adjacent countries or beyond. Brenan (1978) estimated 95 endemic species from a sample of 'Flora Zambesiaca', but it is likely that the figure is twice as high (Drummond, pers. comm.). The main centres of endemism are the Chimanimani Mountains with 42 endemics (Wild, 1964) and the Great Dyke with 20 endemics (Wild, 1965). The vegetation of the country is predominantly *Brachystegia-Julbernardia* (miombo) woodland, with large areas of *Colophospermum mopane* (mopane) woodlands in the Zambezi basin in the north and the Limpopo basin in the south. Woodlands dominated by *Acacia* and *Combretum* species cover extensive areas in the west and south-west. *Baikiaea plurijuga*-dominated dry deciduous woodlands and forests occur on Kalahari Sand in the west and north-west. Other dry deciduous forests are locally found on deep sands in the Zambezi Valley and in the south-east of the country. The former are dominated by *Combretum* species, and often *Xylia torreana*, the latter by *Guibourtia conjugata* and *Brachystegia* species. Extensive hydromorphic grasslands occur along the central watershed. Open grasslands interspersed with ericoid thickets cover the higher portions of the mountains on the eastern border, with isolated patches of rainforest occurring on the windward slopes between altitudes of 400 and 2100 m. The main gradients which determine species distribution in Zimbabwe are available moisture and, to a lesser degree, altitude and soil chemistry.

The Department of National Parks and Wildlife Management Estate has 59 components consisting of National Parks, Safari Areas, Sanctuaries, Recreational Parks and Botanical Reserves, totalling 49653 km^2 or 12.7% of the country. The components are widely distributed, contain a good number of ecosystems, and on paper look impressive. However, most of the larger parks are devoted to animals and overpopulation by big mammals, especially elephants, has led to widespread degradation and often devastation of the vegetation, adversely affecting biodiversity. The state of affairs is worse than is generally believed, and much of the vegetation in elephant country is subject to modification where ecological processes are permanently altered. For instance, woodlands over large areas of the Zambezi escarpment the regeneration of woody species is greatly inhibited, and on steep land irreversible changes are taking place due to soil erosion.

There are 19 State Forest Areas under the control of the Zimbabwe Forestry Commission protecting natural woodland or forests, totalling 8250 km^2. All but two are on Kalahari Sand where rotational harvesting of indigenous timber has been taking place. Some good stands of pristine vegetation still exist and there is now some urgency to locate biodiversity reserves on Forest Land.

Under the 1975 Parks and Wildlife Act, 38 plant species are protected, however the list was not compiled objectively and has been recently revised (Anon, 1991), with 24 species and 4 genera listed as Specially Protected Indigenous Plants; and 2 species, 4 genera and 1 family (Orchidaceae) as Restricted Indigenous Plants.

The reason for high species diversity in Zimbabwe is the high diversity of habitats. Many of the more diverse areas have up to now been fairly well protected by their inaccessibility. For the same reason, good examples of most vegetation types that occur on hills and mountains can still be found in the less populated areas. Of the two centres of endemism, the Chimanimani Mountains are well protected within a National Park, and the Great Dyke, although degraded in places, is floristically still in an excellent state. However, a suitable biodiversity reserve has still to be identified for the latter. About 80 km^2 of rainforest occurs in Zimbabwe (covering less than 0.02% of the country and containing 3 endemic plant species), most of it montane (above 1500 m) and well protected (Müller, 1991). Sub-montane and lowland rainforest has been severely reduced, but most of what remains is reasonably well protected. However, some interesting patches of both types occur in communal land and are on the verge of being eliminated. At present, therefore, the conservation of areas of special botanical interest and high biodiversity is fairly sound, although efforts have to be made to bring more areas under legal protection.

As pointed out earlier, to protect and conserve examples of all ecosystems and major vegetation types is considered to be of equal importance to the conservation of particularly diverse stands of centres of endemism.

Reviewing the conservation of ecosystems and vegetation types the situation is not encouraging. For instance, practically all vegetation types that occurred on arable land on the central plateau have been destroyed by commercial farming. In many of the communal lands even the ecosystems on non-arable land are now degraded, often beyond recovery. At present most development is taking place in the less populated north and north-east of the country, usually on land recently cleared from tsetse fly. Here the destruction of natural vegetation is at its most active and some rare vegetation types are in acute danger of extinction.

The elephant problem

National protected area management is often driven by the effects of conspicuous mammal populations. The dynamics of large mammal populations interacting with vegetation change will be a recurring challenge.

Reduction of the natural range of the elephant has made it impossible for them to disperse when high population densities are reached. The result is a consistent pattern of vegetation degradation. It is also likely that at high population densities elephants will change their behaviour patterns and destroy proportionally more trees than they would at lower densities, although this still has to be proved by research. Some research, however, has been carried out on the rate of vegetation loss in relation to elephant density in Matusadona National Park. In areas with elephant density in excess of 1 per km^2 annual rates of loss of the tree *Brachystegia boehmii* of up to 21% have been noted (Martin *et al.*, 1989). Thompson (1975) documented the destruction of *B. boehmii* woodland in Chazarira National Park brought about by elephant at such densities. A good overview of the effect of large herbivores upon vegetation is given by Cumming (1981, 1982).

The Botanical Institute

In Zimbabwe the botanical institute comes under the Department of Research and Specialist Services of the Ministry of Lands, Agriculture and Water Development, and comprises the National Herbarium and Botanic Garden, the National Gene Bank and a Vegetation Survey Unit. The four sections are in many aspects complementary and interdependent, but each makes its own vital contribution to genetic resources conservation.

The National Herbarium

The oldest section is the National Herbarium which was established as early as 1910 and now holds in excess of 350 000 pressed plant specimens. It contains a comprehensive collection of plants from Zimbabwe with relatively few areas still under-collected. It has the main holding for Botswana and Zambia, and also holds important collections from Mozambique and Malawi.

The Herbarium stands at the hub of all plant exploration and conservation activities. It is the reference collection by which the plants are named but, more importantly, it functions as a data bank containing information in the form of plant specimens and the data on their labels (such as location, phenology, ethnobotanical usage etc). Preparations to have the Herbarium data computerized are now being made, and this will allow for much more efficient information retrieval than is possible at present, for instance in mapping the distribution of target plants for germplasm collection. This will also assist in identifying areas of high biodiversity and in locating scarce habitats for conservation purposes.

For a herbarium to function properly, it is most important that the specimens are accurately named and, if possible, classified in accordance with modern literature. To achieve this a good taxonomic library is maintained, and specimens for study and identification are sent on loan to specialists all over the world. The cost for maintaining such a library and for posting of specimens is rapidly increasing, and keeping up to date is becoming more and more difficult.

Vegetation Survey

Vegetation survey is considered an important activity, especially in a developing country (Müller, 1983). It can be a valuable aid to land-use planning, it forms the basis for all vegetation resource assessment studies, and is of particular importance in the proper utilization of non-arable land. This is especially true for Zimbabwe where almost two thirds of the land is non-arable and much land use is based on the utilization of natural vegetation. As vegetation surveys are carried out, areas unsuitable for biodiversity conservation become apparent. Unfortunately, the need for vegetation surveys was for a long time not recognized in Zimbabwe and it was only possible to formally establish a vegetation survey unit in 1987, as part of the World Bank financed *Natural Resources Survey of the Communal Lands*. Some ecological survey work had taken place previously, some in conjunction with the Department of National Parks and Wildlife Management (e.g. Craig, 1983) and a detailed survey of the rainforests in Zimbabwe had been carried out (Müller, 1991) resulting in a number of conservation recommendations being made to the Ministry of Natural Resources and Tourism.

To date, half the communal land area has been surveyed (approximately 20% of the country). A vegetation classification and maps for this portion have been completed and are being prepared for publication (Timberlake *et al.*, in prep.). As a by-product, reports on suitable sites for conservation within many of the communal lands surveyed (Timberlake *et al.*, 1991) and on the vegetation in the eastern mid-Zambezi Valley (Timberlake and Mapaure, 1993) have been produced. Besides biodiversity reserves the vegetation survey has also identified areas of relatively undisturbed vegetation which are suitable for sustained utilization of some minor products (e.g. the harvesting of honey, traditional medicine or wild fruit) by the local people (Child, 1984). It is hoped to extend the vegetation survey to cover the whole of Zimbabwe.

The Gene Bank

Collecting germplasm in the field and storing it in gene banks is another approach to preventing the loss of plant genetic resources, and it is an aspect of conservation where significant progress has been made recently (FAO, 1989). Since storage space is limited, *ex situ* germplasm conservation has normally only applied to material which is of use to plant breeders or has economic potential. Medium- and long-term storage of germplasm is too expensive to be carried out by individual countries. Southern Africa has therefore adopted a regional approach and established, under the aegis of the Southern African Development Co-ordination (SADC), the SADC Regional Gene Bank (SRGB). SRGB is a twin project to the Nordic Gene Bank and receives funding from the Nordic countries. The SRGB will promote and co-ordinate a regional network of plant genetic resources management through a system of national gene banks. Most of the collecting, documentation, evaluation, characterization and bulking up of the germplasm will be carried out by the national gene banks.

The National Herbarium and Botanic Garden has recently been entrusted with the national gene bank project, and it is hoped to extend the herbarium building in the near future to provide space for this new venture. A plan of action has also been developed. Initially work will concentrate on bringing together and cataloguing germplasm which has been collected in Zimbabwe in the past, but which is at present kept in various local plant breeding institutes and in gene banks abroad. This material, together with other presently available germplasm considered worthy of medium- or long-term storage, will be tested for its viability and rendered ready for storage in the SRGB. Collecting activities will initially centre on landraces of cereal crops and castor bean (*Ricinus*), and on crops or forage plants where the primary or secondary gene pool occurs in Zimbabwe, e.g. cowpea (*Vigna*). Long-term projects will be the collecting of forage legumes and grasses, and a survey of traditionally used indigenous plants.

The Botanic Garden

Development of the garden commenced in 1962. Basic to all planning is the intention to build up a comprehensive collection of native plants, but at the same time to arrange them so as to create an aesthetically pleasing landscape.

The largest portion of the 68 ha site is devoted to the flora of Zimbabwe. Plants are arranged in broad ecological units and the detailed groupings often represent authentic vegetation types. It is fortunate that the environmental conditions that prevail at the garden make it possible to grow plants from all parts of Zimbabwe. So far it has been possible to establish 1060 (82%) out of the 1230 woody species recorded for Zimbabwe, without manipulating the soil. Another 20 species have been added after bringing in soil from their habitat. Fifty woody species have so far proved impossible to grow and of the remaining 100 or so propagation material has not been available up to now.

For ecologically important genera, systematic sections, embracing plants from the whole of sub-Saharan Africa, have been established (e.g. *Acacia, Combretum*). About 20 ha are used to exhibit exotic species. Emphasis here is on plants that originate from similar ecological zones to those found in Zimbabwe. Ten hectares of the garden have been left in their natural state as a witness stand of the woodland type which occurs on a gabbro outcrop in the Harare region. The Institute also has a nature reserve about 26 km to the north of Harare containing several granite outcrops with well-preserved natural vegetation, and one of the finest riparian forests left on the central plateau.

Unless land is available to develop a field gene bank, there is not much scope for a conventionally landscaped botanic garden to become directly involved in *ex situ* conservation. Most land at this garden is taken up with display area and there is not enough space to plant the number of individuals required to preserve the genetic variation within a species. Nevertheless, the way the garden is planned allows it to make some contribution towards the conservation of endangered species, although this is very much a last option. As part of the indigenous flora display, an area of 5 ha of artificial rainforest, separated into montane, sub-montane and lowland types, has been created. After 28 years of development the forests are sufficiently established to have their own microclimate and dynamics and an environment prevails which allows the growing of naturally expanding populations of rare herbaceous species and shrubs. Obviously some management is necessary since the plants are variously competitive. A recent project is the development of fairly large natural grassland beds in the savanna woodland section, and it is hoped to establish populations of rare herbs, especially orchids, here. Efforts are also being made to grow endangered woody species, and most of them have been successfully brought into cultivation.

Indirectly, the garden is able to make various contributions towards conservation. Indigenous plants are used by local people for a multitude of purposes, seriously depleting the numbers of many species. This includes the over-collection of *Bivinia jalbertii* for timber, and *Warburgia salutaris* for medicinal usage (Anon, 1991). The Botanic Garden, with its experience and expertise in the growing of indigenous plants, is encouraging the cultivation of useful plants and gives advice to such projects, hoping that this will eventually lead to reduced pressure on the wild populations. The experience gained with the growing of indigenous and exotic trees enables the garden to advise on agroforestry projects.

The layout of the garden lends itself to conservation education and at present a major thrust is being made in this direction, including proposals for an education officer and an education centre. For many years the garden has conducted educational tours for schools, teachers' training and agricultural colleges and the University. It is hoped to intensify these tours and extend them to adult groups such as rural conservation committees, women's clubs, rural planners and teachers.

Suggested strategy and plan of action

The ideas developed in this paper have not reached the stage where they are the accepted strategy for Zimbabwe. Most of them were presented when the National Conservation Strategy (1987) was drawn up. In this section an outline is given on how it is hoped to apply these ideas in Zimbabwe and also where further work is needed.

Three categories of biodiversity conservation reserves are envisioned:

- Areas of international significance with high ecosystem, habitat and species diversity, with an area of between 150 km^2 and 600 km^2. Four areas fall within this category (Chimanimani Mountains, Nyanga Mountains, Busi-Sengwa Rivers and Chewore-Angwa Rivers) and lie essentially within the National Parks and Wildlife Estate. For full protection one area needs to be extended into Mozambique and two will have to be enlarged to include some unique vegetation types that occur close by. Two areas contain large mammals and management plans need to be developed to ensure a balance between possibly conflicting conservation aims. All four are well known for their exceptional scenic beauty and a significant number of the country's endemics and rare species occur within them. Accounts of the four reserves are being prepared and exact boundaries have still to be defined.

- Areas in which specific ecosystems or vegetation types (preferably 2–3 together) are preserved. Their size will be between 5 and 100 km^2. So far about 30 such reserves have been identified, some of which are already protected. More will be located as the vegetation survey progresses. It is estimated that the eventual total will be between 50 and 60. This category is particularly important in order to achieve a good coverage of genetic resources conservation.
- Sites of particular biological interest. There are smaller areas (0.1–5 km^2) which protect individual rare species, areas of particularly well preserved pristine vegetation (e.g. old burial grounds), or outliers of locally rare vegetation. Some sites are already protected, and more need to be identified.

It is important that vegetation inventory of the National Parks and Wildlife Estate and of Forest Land, presently in progress, is completed as soon as possible, and that biodiversity reserves are located in these areas. This will give a clearer picture about which ecosystems and vegetation types occur on land already set aside for conservation. There are considerable political difficulties in securing additional land for nature reserves and this should only be done if it is absolutely essential. The inventory should also reveal which of the ecosystems and vegetation types required for biodiversity conservation are threatened or in the process of being degraded and therefore in need of being protected. Fencing within National Parks will be one of the main tasks which has to be tackled if botanical conservation is to succeed. It is of great importance that funds become available to complete the national vegetation survey so that all the prospective conservation areas can be identified.

To implement the suggested botanical conservation strategy an objective decision-making framework for assessing conservation priorities has to be established. There is also a need for an agency accountable for implementation and responsible for monitoring progress. Once a reserve is established, enforcing its protection will be another difficult problem.

The one major aspect which still has to be solved is access to the planning process. Destruction is proceeding rapidly and there is an urgent need to protect examples of ecosystems and vegetation types which occur on communal and private land. Legislation is needed to ensure planners consider biodiversity in land-use planning. At present recommendations are made and end up buried in a drawer. This is an aspect where it is hoped that international conservation agencies with their diplomatic status might be able to assist.

Conclusions

Conservation should be based on national or regional programmes and international conservation agencies should support these programmes. The approach suggested in this paper requires efficient national botanical institutes and their strengthening in the Third World is considered of particular importance. *In situ* conservation is the principal means to achieve biodiversity conservation and vegetation survey is considered absolutely essential. Sustained utilization of biodiversity reserves should only be an option in exceptional circumstances, and generally the reserves should be paid for by supporting projects which benefit the people in the vicinity. *In situ* conservation should be part of the general planning process and there is a need for more objective priority setting at national and international levels. There should also be an agency responsible for the implementation of biodiversity conservation and for monitoring progress.

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