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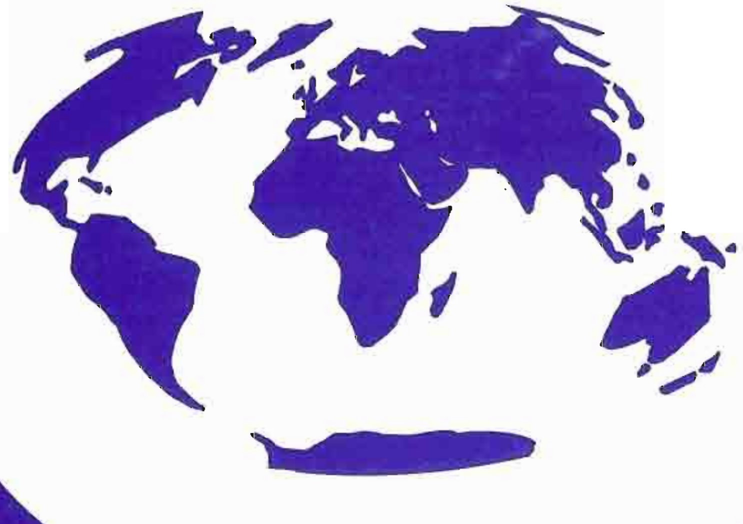

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EDITOR'S NOTE

After almost seventy years since the establishment of the International Union of Biological Sciences (IUBS), the large diversity of scientific disciplines represented, together with the wide variety of tasks to be fulfilled, represent now, more than ever, the most important asset and at the same time the greatest challenge the Union has ever known.

As IUBS represents a unique forum for discussing unifying biological concepts and principles, the challenge consists of finding a common ground and language among its very diverse member societies and affiliated bodies. The Union also has the major task of promoting biological sciences through international cooperative research, training, education and information activities.

The above challenge must be met by way of ensuring that the IUBS scientific programmes are interdisciplinary, requiring international cooperation, and deal with topics that traverse the boundaries of the existing scientific disciplines such as biological diversity, biological complexity, biological taxonomy, bio-indicators and biological education.

Within the framework of the IUBS, *Biology International* represents a means to this end and aims to serve as a two-way inter-active channel for information to help the Union fulfill its stated objectives. This goal cannot be achieved without the genuine participation and full committment of each and every Member of the IUBS Family.

The CGIAR System and Biological Research

Donald L. Plucknett
Consultative Group on International Agricultural Research (CGIAR)
World Bank, 1818 H St, NW, Washington, D.C. 20433, U.S.A.

Nigel J.H. Smith
Department of Geography, University of Florida
Gainesville, FL 32611, U.S.A.

An urgent need to boost food supplies in the Third World spurred the creation of a series of international agricultural research centers during the 1960s and 1970s under the umbrella of the Consultative Group on International Agricultural Research (CGIAR). Spectacular yield increases in wheat and tropical rices achieved by the International Maize and Wheat Improvement Center (CIMMYT-Centro Internacional de Mejoramiento de Maiz y Trigo) in Mexico and the Philippines-based International Rice Research Institute (IRRI) respectively, provided the catalyst for this ambitious undertaking. IRRI, the first international agricultural research center, became operational in 1960, while CIMMYT grew out of a collaborative project between the Rockefeller Foundation and the Mexican agricultural research program in the 1940s and was designated as an international center in 1964 (Plucknett and Smith, 1982; Baum, 1986).

With the World Bank, the U.N. Development Programme, and the U.N. Food and Agriculture Organization as co-sponsors, CGIAR was established in 1971 to nurture the development of international agricultural research centers in developing countries (Fig. 1). Most of the 13 CGIAR centers were set up in the 1960s and 1970s. Technology development takes at least 10 years from concept to marketable product, so some centers are now just coming out with technologies that can be used by national programs, while others have been assisting national agricultural research institutions with useful crop lines and other technologies for more than a decade.

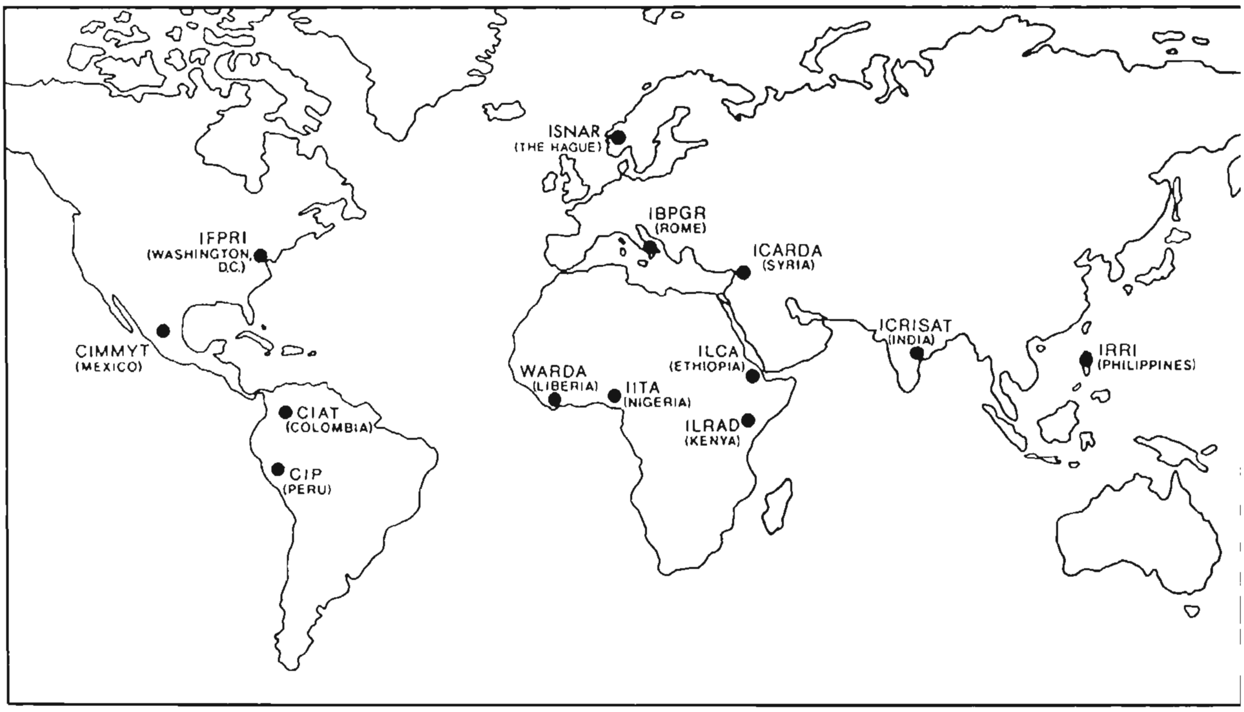

Figure 1. International agricultural research centers within the Consultative Group on International Agricultural Research (CGIAR).

The 13 CGIAR centers fall into three main categories : crop improvement research; livestock diseases and productivity; and policy issues for national and international agricultural research programs (Table 1). A guiding principle of the CGIAR centers is that they should not compete with national research systems but rather should support national programs by supplying technologies and research methods so that national systems can better accomplish their tasks. Here we focus on the biological work with system-wide significance of the crop and livestock-oriented centers. Emphasis is placed on germplasm conservation and use, since genetic resources are central to the work of most of the CGIAR centers. We also discuss the extent and impact of biotechnology and biocontrol research in the CGIAR system.

Table 1

International agricultural research centers within the Consultative Group on International Agricultural Research (CGIAR) with founding dates and research mandates.

Center	Founding Date	Research Programs
IRRI (International Rice Research Institute)	1960	Rice
CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo)	1964	Maize, wheat, triticale, barley
IITA (International Institute of Tropical Agriculture)	1965	Sweet potato, yams, cowpea, soybean, maize, rice, cassava
CIAT (Centro Internacional de Agricultural Tropical)	1968	Cassava, beans, rice, pasture and forage
WARDA (West Africa Rice Development Association	1971	Rice
CIP (Centro Internacional de la Papa)	1972	Potato, sweet potato
ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)	1972	Chickpea, pigeon pea pearl millet, sorghum groundnut
ILRAD (International Laboratory for Research on Animal Diseases)	1974	Trypanosomiasis, theileriosis
ILCA (International Livestock Center for Africa)	1974	Livestock production systems
IBPGR (International Board for Plant Genetic Resources)	1974	Crop and plant genetic resource conservation
IFPRI (International Food Policy Research Institute)	1975	Food Policy
ICARDA (International Center for Agricultural Research in the Dry Areas)	1976	Durum wheat, barley, faba bean, lentil, chickpea, forages
ISNAR (International Service for National Agricultural Research)	1980	Strategic planning and support for national agricultural research programs

Biology Research Integral to CGIAR Centers

Eleven of the centers in the CGIAR system are directly involved in biological research. Eight of the international centers have crop improvement programs that depend heavily on disciplines such as genetics and plant breeding, plant pathology, plant physiology, biochemistry, entomology, and soil science, including soil microbiology.

Crop breeding at CGIAR centers has followed a two-pronged strategy : raising yield levels for food crops, while improving resistance to major pests and diseases as well as tolerance to adverse soils and climates. Comprehensive knowledge of the biology of the crop, pests, pathogens, or other environmental challenges is essential for breeding efforts to be successful. Crop improvement programs usually tap the expertise of several disciplines so that multi-faceted challenges to raising and stabilizing yields can be met more effectively. For pressing problems requiring new basic knowledge, the centers rely on partnerships with advanced institutions that focus mostly on basic research. Such problems include mechanisms of host plant resistance to pests and diseases, adaptation of plants to harsh environments, and mechanisms for alien gene transfer.

While crop improvement efforts are central to the mission of most of the CGIAR centers, corollary research thrusts are also underway. Five centers are pursuing studies on biological nitrogen fixation. Most of this research focuses on the legume/Rhizobium symbiosis, but center scientists are also investigating the Azolla/blue-green algae partnership, as well as associative N-fixation in tropical grasses.

The areas of research mentioned above are only a sample of a broad range of biological research activities at CGIAR centers. Rather than undertake an exhaustive review of each of these research areas, we discuss two dynamic areas of biological research that present new opportunities and challenges to the centers : germplasm collection and conservation, and biotechnology. Both are pivotal to the need to broaden the genetic base of our food and cash crops. Both require the forging of new working arrangements with institutions in industrial and developing countries, and both underscore the need for biological research.

Germplasm Collection and Conservation

The ultimate success of crop breeding programs designed to increase and sustain yields and of integrated pest management depends to a large extent on the availability of germplasm resources. All of the crop-related CGIAR centers maintain sizeable germplasm collections of their mandate crops (Table 2). One of the livestock centers, ILCA, maintains a working collection of 9,000 accessions of grass, forage, and browse plants (Hanson, 1987).

Table 2

Germplasm collections maintained at international agricultural research centers within the Consultative Group on International Agricultural Research (CGIAR).

Crops	Accessions	Storage conditions	Center
CEREALS			
Wheat	31,100	Medium term	CIMMYT
	16,500	Short and medium term	ICARDA
Barley	14,200	Medium term	ICARDA
	5,500	Medium term	CIMMYT
Rice	79,000	Medium and long term	IRRI*
	8,600	Medium and long term	IITA*
	8,200	Short and medium term	WARDA
Maize	11,100	Medium and long term	CIMMYT
Sorghum	24,600	Medium and long term	ICRISAT*
Pearl millet	17,000	Medium and long term	ICRISAT*
Foxtail millet	1,200	Medium and long term	ICRISAT*
Finger millet	1,800	Medium and long term	ICRISAT*
PULSES			
Soybean	1,300	Medium and long term	IITA
Common bean	30,000	Short and long term	CIAT*
Lima bean	2,500	Short and long term	CIAT*
Runner bean	1,100	Short and long term	CIAT*
Pea	3,000	Medium term	ICARDA
Groundnut	11,000	Medium and long term	ICRISAT*
Bambara groundnut	1,200	Medium and long term	IITA
Cowpea	12,000	Medium and long term	IITA*
Chick pea	13,800	Medium and long term	ICRISAT*
	5,500	Medium term	ICARDA
Pigeon pea	10,100	Medium and long term	ICRISAT*
Lentil	5,900	Medium term	ICARDA
Faba bean	3,300	Medium term	ICARDA
ROOT CROPS			
Potato	6,500	Short, medium, long term	CIP*
Sweet potato	1,200	Short term	CIP
	1,000	Short term	IITA
Cassava	3,700	Short term	CIAT*
	1,800	Short term	IITA
FORAGES			
Legumes	12,000	Medium term	CIAT
Grasses	1,800	Medium term	CIAT
Forages	9,000	Short and medium term	ILCA

Short term : 6 C to ambient temperature.
Medium term : 0-5 C.
Long term : – 10 to – 20 C.
* Designated as a base collection by IBPGR.

Seeds destined for medium or long term storage are dried to a moisture content of three to eight percent, then sealed in cans, bottles, or foil packets. Under medium term storage conditions of close to freezing, seeds may remain viable for decades. When temperatures are reduced to − 20 °C, seeds may survive for as long as a century (Plucknett *et al.*, 1987). Short term collections, sometimes referred to as working collections, are kept at ambient temperatures and must be planted every year to remain viable. Root crop germplasm, such as the 3,700 accession cassava collection held by CIAT (Table 2), is maintained in field gene banks. Germplasm in field gene banks must be periodically replanted as the plants mature. The Rome-based International Board for Plant Genetic Resources (IBPGR), one of the CGIAR centers, designates certain institutions as holders of base collections. Base collections are major assemblages of germplasm, usually with global coverage, which, in the case of seed crops, are usually kept under long term storage conditions.

International centers within the CGIAR system contain several base collections and rank at or near the top in numbers of germplasm accessions of their mandated crops among the world's gene banks. CIMMYT's wheat (*Triticum* spp.) collection is the world's fourth largest, whereas IRRI's rice (mostly *Oryza sativa*) germplasm collection is more than four times bigger than the next largest collection. CIMMYT has the third largest maize (*Zea mays*) collection, while ICRISAT has the largest germplasm collections of sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum typhoides*), groundnut (*Arachis hypogaea*), chick pea (*Cicer arietinum*), and pigeon pea (*Cajanus cajan*), respectively. CIAT maintains the world's largest collection of common bean (*Phaseolus vulgaris*) and cassava (*Manihot esculenta*), while CIP has the second largest assemblage of potato (mostly *Solanum tuberosum*) germplasm as well as the largest collection of sweet potato (*Ipomoea batatas*) germplasm.

Size alone is no indication of the value of a collection. Comprehensiveness, viability, and degree of evaluation largely determine the usefulness of a collection. Although more evaluation is needed at most gene banks, considerable progress has been made in identifying useful traits in germplasm collections at the international centers. Because of the commitment to maintaining gene banks at CGIAR centers, several of the centers have been designated as base collections : IRRI and IITA for rice; IITA for cowpea (*Vigna unguiculata*); ICRISAT for sorghum, pearl millet, foxtail millet (*Setaria indica*), finger millet (*Eleusine coracana*), chick pea, pigeon pea, and groundnut; CIAT for common bean, lima bean (*Phaseolus lunatus*), runner bean (*Phaseolus coccineus*), cassava, and certain legume forages (*Centrosema, Desmodium,* and *Stylosanthes)*; ILCA for some grass and legume forages (*Neonotonia, Trifolium, Cenchrus,* and *Digitaria*); and CIP for potato. IBPGR has stimulated the collection of crop germplasm and assisted in setting up genebanks at CGIAR centers and many other institutions. Since its inception in 1974, IBPGR has been involved in the collection of over 130,000 crop germplasm samples in over 100 countries (IBPGR, 1987).

Gene banks have proved crucial to breeding programs at all the crop-oriented international centers. IRRI breeders have dipped into the institute's rice germplasm collection, now containing nearly 80,000 accessions, for numerous traits, particularly disease and pest resistance. An accession of a wild rice, *Oryza nivara*, provided resistance to grassy stunt virus which was causing extensive damage to rice fields in Southeast Asia during the early 1970s. The *O. nivara* gene for resistance to grassy stunt has been incorporated into high yielding rice varieties that cover more than 11 million hectares in Asia. IRRI's genebank has also provided CIAT rice breeders with sources of resistance to sogata leafhopper (*Sogatodes oryzicola*), a serious pest in Latin America and a vector for the damaging oja blanca virus.

IITA cassava breeders have located clones that provide some protection from attacks by cassava mealybug (*Phenacoccus manihoti*) and green spider mites. Pubescence on leaves of the hardy clones apparently discourages the pests. In conjunction with a biocontrol program, pubescent cassavas promise to help stem the rising damage caused by the exotic pests which cost African farmers an estimated US $ 2 billion a year in lost cassava production. A two-pronged strategy to combat pests, employing resistant varieties as well as the release of predators, is more likely to succeed than relying on resistant varieties or biocontrol efforts alone.

Biotechnology and the International Centers

Another reason that germplasm collections are becoming increasingly useful is that biotechnology is breaking dow breeding barriers between species. As recombinant DNA techniques are perfected, breeders will be able to move genes from one unrelated plant to another with increasing ease. When looking for desirable traits, breeders first check their working collections of elite material since it is easier to work with. If working collections fail to turn up the desired characteristic, breeders turn to traditional varieties or conspecific wild material located in genebanks. Known as the primary genepool, elite lines, traditional varieties, and conspecific wild material are the major sources of germplasm for crop breeders. Germplasm in the secondary genepool (closely related species) and in the tertiary genepool (unrelated species) is rarely used by breeders since it is so difficult to cross with crops. Biotechnology, however, promises to loosen the boundaries of genepools and create exciting new opportunities for exchanging useful genes.

Rather than invest heavily in recombinant DNA research, however, most CGIAR centers either contract out such work or closely monitor results achieved at other institutions with a view to adopting techniques when they appear closer to the payoff stage. Thus CIMMYT has a contract with the University of Illinois to study the uptake of foreign DNA in pollen tubes of maize.

Various other *in vitro* techniques are routinely used by CGIAR centers. Embryos are rescued through tissue culture to preserve widecrosses with wheat at CIMMYT and crosses between groundnut and related wild species at ICRISAT. ILRAD has used frozen bovine embryos to further research on trypanosomiasis and East Coast fever. Kenyan quarantine authorities severely restrict the importation of livestock to help keep out diseases, and this understandable measure has hampered ILRAD's efforts to learn more about the nature of trypanotolerance in certain cattle breeds in West Africa, particularly N'Dama. In 1984, ILRAD was able to import 10 frozen N'Dama embryos and implant them in Boran cows at headquarters in Nairobi. The resulting calves are now fully grown and are being used in experiments to understand the nature of trypanotolerance in livestock.

ILRAD scientists have also used embryo transfer to gain a better understanding of the major histocompatibility complex (MHC) in immune responses of cattle infected with East Coast fever (ILRAD, 1987). The use of drugs to stimulate superovulation combined with embryo transfer produces multiple offspring from a single mating pair; ILRAD has used this technique with selected Boran cattle since 1984 to increase the number of required genotypes. Some embryos have been dissected to produce genetically-identical twins, each implanted in separate surrogate cows. By the beginning of July 1987, 75 Boran calves had been produced by embryo transfer at ILRAD. This project will help scientists distinguish between the effects of MHC genes on the immune response from other genes.

IRRI scientists are using pollen culture to generate homozygous rice lines in order to accelerate screening and capture of useful traits (Cohen et al., in prep.). Although the purposes are different from ILRAD's embryo transfer project, the idea behind pollen culture is the same : rapid generation of similar or identical genotypes for screening purposes. The recent generation of rice plants from protoplasts is a development that will be accompanied closely by IRRI scientists, for it could open more doors in widecrossing. Protoplast fusion has been in the experimental stage for several years, but its inclusion in breeding programs has been hampered by the random nature of gene mixing and difficulties encountered in trying to regenerate plants from cells.

Micropropagation is a standard procedure at CGIAR centers with root crop mandates to produce disease-indexed plants for shipment and *in vitro* storage. CIAT uses tissue culture to produce and distribute disease-indexed lines of cassava, CIP uses the same procedure for potato and sweet potato shipments, while IITA employs the technique to export cassava and sweet potato lines.

Novel phenotypes sometimes arise from somatic embryos and apical meristems and this apparently random occurrence has stirred the interest of breeders (Walbot and Cullis, 1985). Perhaps only a small fraction of mutants arising from tissue cultures are likely to prove useful, but they are nevertheless coming under increased scrutiny. Several CGIAR centers and other research institutes are investigating somaclonal variation in tissue cultures for possible sources of novel traits for breeding programs. IRRI, for example, is inducing rice mutants *in vitro* to screen for such valuable traits as tolerance to high levels of aluminium and salt (Swaminathan, 1982). Genetic changes in tissue culture may be a boon to breeders but are a bane for germplasm curators. Because of unpredictable and uncontrollable somaclonal variation, no field genebanks of root crops, for example, are currently being dismantled in favor of *in vitro* germplasm storage. When cryopreservation techniques are perfected, however, *in vitro* storage for root crop germplasm may become an effective way of preserving the germplasm of clonally-propagated crops. CIAT and IBPGR are actively involved in cryopreservation research.

System-wide Challenges

Major advances in raising agricultural productivity have been achieved in some cases, particularly at the older international centers, but many challenges lie ahead. Here we sample major themes, rather than run down a checklist of specific problems faced by agricultural scientists.

A nagging question that continually surfaces among cereal crop scientists is whether yields have realistically peaked for major cereals such as wheat, rice, maize, and sorghum. We know that there is work to be done in closing the gap between yields achieved at experiment stations and in farmers' fields, but an important question still must be raised-how much further can grain yields be pushed up under ideal conditions ? Several scientists have argued that we are approaching the yield limit with wheat (Jensen *et al.*, 1978; Austin *et al.*, 1980). Some rice researchers are concerned that the yield of recent IRRI rice lines, such as IR58 or IR65, are essentially unchanged from yield levels of IR8 launched over twenty years ago.

The history of human endeavors, from science and technology to sports, has been one of striving to break barriers and overcome seemingly insurmountable constraints. No scientist can declare with assurance that further yield advances are impossible with wheat or rice, for example. Further research on finding ways to manipulate the germplasm of the major cereals to achieve still higher yields is desirable, particularly in view of the likelihood that the world's population will at least double before it stabilizes, and most of the expected population increase will take place in the Third World. Indeed, we may only be on a step rather than a plateau with regard to yield levels of the major cereal crops. With some crops, such as maize, yields appear to have increased relatively steadily since the advent of modern plant breeding in the early part of this century. In the case of other crops, such as sugarcane in Hawaii, yield history has been characterized by stagnant periods punctuated by sudden increases (HSPA, 1983).

While researchers in such disciplines as plant physiology and molecular genetics seek to stretch the yield potential of major cereal crops, agricultural scientists need to remain vigilant regarding the constant evolution of crop pests and pathogens that threaten to undercut crop productivity. A balance needs to be struck between sustaining crop yields, also referred to as maintenance research (Plucknett and Smith, 1986), and research thrusts aimed primarily at achieving ever higher levels of productivity.

Ironically, the successful development of high-yielding varieties of major cereals, particularly wheat and rice, has created the impression in some quarters that the job is essentially done with those crops, and scientists can now devote more time to the minor or «alternative» crops. It has been suggested, for example, that IRRI's mandate should be broadened to include satellite crops grown by rice farmers. Such a policy, if undertaken, could well dilute IRRI's effort to raise and stabilize rice yields. While more attention to crops of local importance is certainly warranted, the channeling of substantial amounts of funds to such crops at the expense of the major staples is likely to prove self-defeating. The livelihoods and wellbeing of hundreds of millions of farmers and consumers would be jeopardized if research efforts on high-yielding rices and wheats slackened. While embarking on efforts to improve the productivity of minor cereals and root crops, for example, it is wise to shore up, and whenever possible increase, yields of the major crops.

The ability to sustain crop yields hinges on a number of biological and socio-economic factors. Among the biological factors, germplasm manipulation and biological control of pests and diseases emerge as major concerns of the international agricultural research system. To reduce costs, both financial and ecological, of heavy pesticide use, several of the CGIAR centers are pursuing research on integrate pest management. Integrated pest management, a concept that developed in the late 1960s, involves a number of strategies, including deploying resistant crop varieties, crop rotation to avoid buildup of pests and pathogens, and the release of predators of crop pests (Zelany *et al.*, 1985).

The concept of biological control is widely accepted, but it has often been difficult to put into widespread practice. Thus far, most successes with biocontrol have been with perennial crops, such as citrus and stone fruits, and on islands where the agroecosystems are more contained (McCoy, 1985). Devising biocontrol strategies for food producing systems in continental settings is a major challenge for the crop-oriented agricultural research systems and national programs worldwide.

The tailoring of integrated pest management schemes to the conditions of Third World farmers is particularly difficult in view of the paucity of data on the ecology of most tropical pests. Much work needs to be done in furthering our understanding of pest population dynamics and systematics before integrated pest management is widely adopted in developing countries. The international agricultural research centers, CABI (The Commonwealth Agricultural Bureaux International), and FAO, are poised to help national programs in this effort with scientific expertise as well as first class research facilities in the case of CGIAR centers and CABI laboratories. Here we briefly explore two different strategies adopted by a couple of international centers : IITA's regional approach to biocontrol of a major cassava pest in Africa, and IRRI's field studies of pest-predator interactions in rice fields in the Philippines coupled with mass education drives to alert farmers of the benefits of some insects in their fields.

IITA instigated an ambitious biocontrol program aimed at reducing damage by cassava mealybugs in the early 1980s (Herren, 1982; Smith, 1985). Both pests arrived in Africa around 1970 and have spread to over two-thirds of the cassava growing region of Africa. Once liberated from their natural predators in South America, the introduced pests proliferated and have caused substantial damage to cassava plantations in a continent struggling to feed itself. IITA scientists have experimented with several introduced parasites and predators of cassava mealybug, and an encyrtid wasp that inserts eggs in cassava mealybugs shows promise in bringing populations of the pest under control. Working with various national programs in West and Central Africa, IITA researchers are testing the effectiveness of this biocontrol agent in numerous locations in West and Central Africa. In the event that early promise is confirmed, the parasitic wasp is expected to be released over wide areas. An important accomplishment of this effort thus far has been the forging of efforts from numerous national programs to tackle a common problem. African agricultural research programs are learning the benefits of collaboration on a wide scale.

IRRI is also involved in integrated pest management. IRRI's two-fold approach involves educating farmers about the value of insects that feed on crop pests and investigating pest management strategies within the grasp of resource-poor farmers. IRRI seeks to raise awareness among rice farmers of beneficial insects that prey upon rice pests and the dangers, as well as the high cost, of inappropriate insecticide use. In cooperation with various Asian Ministries of Agriculture, a poster with 54 color photographs has been published in several Asian languages to alert farmers that some insects in their fields can be helpful. Integrated pest management is not a panacea for insect and pathogen damage to crops and in many cases requires high levels of management to be successful. IRRI is thus concentrating on devising pest management strategies that are appropriate for small-scale farmers backed by national programs with limited scientific expertise.

Conclusions

Most of the international agricultural research centers are heavily involved in biological research, and their programs are continually changing in response to new technologies and challenges. Biotechnology is emerging as a valuable tool for plant breeders, and several of the centers are exploring the applications of various biotechnologies in their respective research programs.

In the area of germplasm collection and conservation, international centers with crop mandates are expanding their collections of traditional varieties and wild relatives. As the germplasm collection picture for major food crops continues to improve, IBPGR is turning its attention more to industrial and fruit crops as well as food crops of local importance. Several of the centers have recently upgraded their germplasm conservation programs to include long term storage facilities, and the volume of both incoming material and outgoing samples to breeding programs is expanding noticeably.

As national programs in the Third World strengthen, particularly in Brazil, China, India, and Thailand, international agricultural research centers are shifting their research emphasis «upstream» to more basic problems in order to avoid competing with developing country programs. Strategic rather than the more immediate applied research will increasingly flavor the work of the international centers as they seek to re-adjust their roles to accomodate growing national programs in the Third World. International agricultural research centers will increasingly forge collaborative research projects with universities and other research organizations in industrial and developing nations to further work in such areas as plant physiology, immunogenetics, plant systematics, and pest and pathogen ecology. Biology is an integral part of the work of the CGIAR system, and the international centers are responding readily to advances in the diverse areas of biological research to help raise agricultural productivity.

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The Potential of Biological and Integrated Control of Pests in Sub-Saharan Africa, and Conditions for its Implementation.

A Proposal Aimed at Formulating Legal Guidelines for the Use of Biological Control Agents

by Jean-Paul Aeschlimann
Secretary-General of the global IOBC/OILB (1),
CSIRO Biological Control Unit,
335, avenue Paul Parguel, 34100 Montpellier, France.

INTRODUCTION : CURRENT PEST CONTROL PRACTICES

Like all other continents, Africa has its share of noxious plants and animals of both exotic and indigenous origin. Several of these are very difficult to control and consequently represent serious economic problems for the African agriculture. When considering the current pest control practices, a distinction should be made between the attitude of cash crop producers on the one hand, and of subsistence farmers on the other.

A) Pest control in cash crops

Producers of cash crops are usually able to solve their pest problems by spraying chemical pesticides. In many countries, the cost of chemical applications may be met by obtaining support from special financial institutions, and these expenses are incorporated in the price of the end product. Over the last two decades or so, this picture has been considerably altered by the policy of many Third World governments of officially subsidizing the sales of synthetic pesticides. Quite apart from the difficulties these nations have had in purchasing the insecticides, herbicides, fungicides, etc, needed to be paid with hard currency, the extremely — and artificially — low price of these chemical substances on the local market has encouraged farmers to use them as a regular prophylactic treatment, without any regard to the actual infestation rates of the supposed «pests». Most of the problems (wide-ranging resistance to various chemicals in pest plants and animals; outbreaks of so-called secondary pests; multiple risks of environmental pollution, etc,; (cf. van den Bosch and Aeschlimann, 1986) created by the overuse of these compounds stem from the unrealistically low cost of these spraying campaigns.

In these circumstances, the new trend, noticeable recently in the attitude of Third World officials (see the example of Indonesia as described by England (1987) in a recent article), to shift away from systematically subsidizing the purchase of pesticides, is a welcome move towards a more realistic perception of the impact and interaction of pest organisms in field situations.

B) Pest control in subsistence crops

Farmers producing subsistence crops, by contrast, are in a much more precarious position. By definition, their yield has virtually little or even no market price. Farmers are hence most of the time unable to invest any money in any kind of treatment and due to the absence of control measures, subsistence crops are threatened to a higher extent than cash crops by noxious plants and animals.

The presence of natural enemies is an essential requirement for developing control strategies aimed at maintaining pest populations below levels that are economically tolerable while minimizing the inputs of non-renewable resources into the production system (cf. Geier *et al.*, 1983). As a consequence, pests accidentally introduced into a new environment are unlikely to be satisfactorily controlled, even in the short term, unless an adequate guild of well-adapted and efficient natural enemies (parasitoids, predators, and pathogenic microorganisms) are established as well. Yet, the occurrence of accidentally introduced pest organisms, of invading weedy plants, of endemic phytophagous species that for one reason or another escape acceptable levels of population density is rather common (Greathead, 1986; Aeschlimann and Carl, 1987; Outbreaks and New Records, 1987, etc.). In each of these situations the existing natural enemies are usually not capable of efficiently controlling the introduced pest and cash crops may be in fact equally difficult to protect as subsistence crops. Therefore, there is a need for

(1) The International Organization for Biological and Integrated Control of Noxious Plants and Animals (IOBC, with headquarters at Zürich, Switzerland), or Organisation Internationale de Lutte Biologique (IOLB), is a scientific member of IUBS as its Section of Biological Control.

a thoroughly scientific approach, particularly in terms of initially considering the possibility of «classical» (2) biological control, before embarking on any other pest control strategy.

Generally, the mere presence of natural enemies in the agroecosystem is not enough to achieve efficient control of the pest species. Where biological control agents are insufficient to maintain the pest organisms whitin acceptable limits, the strategy called integrated pest management (IMP, 3) may be developed. This more sophisticated strategy, again, is based on the activity of natural enemies that have co-evolved with the pest in its original distribution range. The fairly recent and comprehensively documented example of the cassava mealybug invasion will serve to demonstrate that biological control alone, or in combination with other methods in the frame of an IPM strategy has a tremendous potential and could indeed represent the only way to cheaply and efficiently protect a number of cultivated plants in Third World countries.

THE CASSAVA MEALYBUG EXAMPLE

Cassava (*Manihot esculenta* Crantz) is assumed to have been introduced from Latin America into Africa some 400 years ago. This representative of the family Euphorbiaceae is now widely cultivated in the so-called «cassava-belt» of sub-Saharan Africa, where its large tubers are routinely processed to provide the major staplefood for some 200 millions people. Apart from the tubers, fresh leaves are also consumed. The plant thrives on a wide range of soils, its cultivation is not labour-intensive and it can be very conveniently stored in the ground until needed. For several centuries, cassava has been little or not at all affected by any significant herbivores in its extended African distribution. This highly favourable situation changed drastically, however, from the beginning of the 1970's, when two new invaders, the cassava mealybug (*Phaenacoccus manihoti* Matile-Ferrero (Homoptera : Pseudococcidae); Matile-Ferrero, 1977), and the cassava green mite (*Mononychellus progresivus* Doreste (Acarina : Tetranychidae); cf. Gutierrez, 1987) were inadvertently introduced into Africa. Both spread very rapidly throughout most of the cassava belt and *P. manihoti* soon became the main pest of this crop. Since 1973, when it was first discovered on the African continent, the mealybug has caused a minimum loss of 30 % of tuber yields each year. At its peak infestation, the damage produced in terms of plant growth reduction, loss of seedlings, etc. was enormous and repeatedly led to the disappearance of whole groups of local cultivars (Fabres, 1981; Herren *et al.*, 1987; Arnold *et al.*, 1987).

In the late 1970's, the African countries confronted with the most severe losses asked the International Institute of Tropical Agriculture (IITA) based at Ibadan (Nigeria), one of the Consultative Group on International Agricultural Research (CGIAR) centres, to tackle the pest problems of cassava, which is one of the mandate crops of this institution. Surveys aimed at detecting efficient natural enemies of the cassava pests suitable for introduction into Africa were initiated in Central and South America by research workers of IITA, in collaboration with scientists of the Commonwealth Agricultural Bureaux International's (CABI) Commonwealth Institute of Biological Control (CIBC) (Herren, 1982; Yaseen, 1982). Out of the complex of natural enemies attacking the cassava mealybug, the parasitoid *Epidinocarsis lopezi* De Santis (Hymenoptera : Encyrtidae) was the first biological control agent to be introduced. It was collected in Latin America in 1981, quarantined in the United Kingdom and shipped to Ibadan for mass-rearing and liberation in Africa. Following early signs of succesful establishment (Herren and Lema, 1982), a huge effort was undertaken to multiply this natural enemy and distribute it to the countries most affected by the mealybug. Follow-up studies have revealed that *E. lopezi* adapted quickly to its new environment, and dispersed from the release sites at an average rate of up to 100 km per dry season (Herren *et al.*, 1987).

Within 48 months from the initial liberations, the parasitoid was recorded in 13 countries of the cassava belt, where it colonized a territory of over 650 000 km² and has apparently brought the cassava mealybug under control (Herren *et al.*, 1987). Following the release, the economic importance of *P. manihoti* has consistently dropped over the whole area occupied by *E. lopezi*, almost certainly as a result of the activity of this natural enemy. At this stage, it can be assumed that, though the mealybug front has still not stabilized, any new outbreaks are likely to be controlled by means of this parasitoid, alone or in combination with another species of natural enemy.

A review of the Africa-wide Biological Control Program (ABCP) of IITA was recently carried out on behalf of the International Fund for Agricultural Development (IFAD), Rome, and included an economic analysis of the cassava mealybug case (Arnold *et al.*, 1987). This was subsequently described in more detail by Norgaard (1988); using very conservative

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(2)«Classical» biological control strictly refers to the deliberate introduction of specific natural enemies of a pest organism, which did not follow the spread of their host into a new geographic range.

(3)According to IOBC/SROP (1977) definition : «IPM is a strategy that aims at maintaining noxious organisms below the threshold of economic damage, first by exploiting all the factors of natural mortality, and second by using all control methods which are acceptable from the economic, ecological, and toxicological viewpoints».

estimates, the author nevertheless concluded that the benefit cost ratio resulting from this magnitude is extremely high and compares impressively with the usual rate of return from well-planned development investments, for which a ratio of > 1 : 1 is already acceptable (Norgaard, 1988). The figures for the cassava mealybug project also compare well with those of other successful biological control programs. One of the highest economic returns obtained to date was calculated for the Australian example of skeleton weed, *Chondrilla juncea* Linnaeus (Compositae), with ratios comprised between 51 : 1 and 192 : 1, according to the discount rate incorporated in the analysis (Marseden *et al.*, 1980). Clearly, the magnitude of the benefit-cost ratio calculated for the cassava mealybug or the skeleton weed programs are unlikely to be easily repeated; smaller returns are the norm, but they are all immensely valuable and justify classical biological control to be attempted in the first instance whenever possible.

PROSPECTS FOR THE FUTURE

Realistic estimates show that the strategy of biological control, when applied alone, has brought a complete and long-lasting solution to about 10-20 % of the problems posed by weeds and arthropod pests (Pimentel, 1980; van Lenteren, 1983; Aeschlimann and Carl, 1987; Julien, 1987). In all other cases, the only acceptable method for keeping noxious organisms within limits that are economically bearable and environmentally acceptable is to develop an appropriate IPM strategy. The implementation of IPM systems and their adoption by farmers, again require the presence of efficient natural enemies in the field where detrimental species are to be combated. In spite of wide discrepancies in the cohort of pests that attack a particular crop, a convenient IPM strategy can in effect be proposed for various biogeographic regions, as was recently described for the protection of rice for instance in India, Thailand and Malaysia (IOBC, 1981), China (Li Li-Ying, 1982), Indonesia (Kenmore, 1987) and Madagascar (Delucchi, 1987).

PRACTICAL PROBLEMS FACING BIOLOGICAL CONTROL

Whether pure biological control in its classical sense or IPM become more common, natural enemies might need to be transferred from one area to another. Success in this type of operation is largely dependent upon a number of factors, amongst which the organization involved, and the skill and determination of the scientists in charge, each play their part (Julien *et al.*, 1984). It should also be recognized that research in this discipline needs an adequate core-funding for several years. Not surprisingly, shifting live organisms across national boundaries for biological control purposes also creates problems of a diverse nature. The local political situation may make it very difficult or impossible to survey those areas in which biotypes suited for release in a climatic homologue are most likely to be discovered. Several nations are also highly reluctant to agree to collection as exportation of natural enemies to be carried out on their territory, all living organisms being considered as part of the national heritage.

Conflicts of interest might also arise between research and extension services of one particular recipient country; or among different associations of primary producers. This has recently led to considerable legal conflict in Australia, where a High Court injunction was issued, which prevented field release of natural enemies against the weed *Echium plantagineum* Linnaeus (Borraginaceae) (Delfosse, 1988). This weed is generally thought of as noxious in most of the southeastern part of the country and as such is regularly sprayed with herbicides over vast acreages. However, apiarists value its pollen and nectar and some cattle growers during particularly dry seasons use it as fodder, despite its being poisonous (IAC, 1985). This case emphasizes the risk of embarking on disputes based on arguments of political nature with groups of interest opposed to the release of biological control agents, and shows that a legal framework is needed to regulate their transfer. To date, however, even in the most industrialized nations of Europe and North America, little thought has been devoted to these inhibitory and potentially frustrating legal implications.

LEGAL IMPLICATIONS

In practice, constraints of the distribution and utilization of natural enemies for biological control purposes result mainly from the understandable caution exerted by national authorities in allowing useful, but foreign, organisms to be imported and released within their boundaries. It is indeed not always easy or straightforward to convince politicians and officials that all possible and reasonable precautions have been taken; that natural enemies which consume insects, for instance, are completely unable to live at the expense of cultivated plants; or that biological control agents for use against a weedy plant are specific enough to never become harmful to crops; or that entomopathogenic viruses will never infect homeotherms.

To date, only Australia has addressed this situation with a legislation which protects biological control programs that are in the best interests of the country. The introduction of a biological control act is still being contemplated in New Zealand, the USA and Canada *(Agri-*

culture Canada, 1987). In all other countries, due to the total lack of an appropriate legal framework, the terms of reference for granting permission to import a beneficial organism are, in fact, the quarantine requirements adopted for the safe circulation of plant material (EPPO, 1982). These phytosanitary regulations mainly stipulate how to prevent contamination by undesirable organisms. Even recently adopted legal dispositions in this area only apply to noxious species (JORDM, 1986 a; b), and rarely cover biological control agents. Should the same restrictions as stipulated for introduced cultivars (up to 8 years quarantine for sugarcane cultivars in one African state !), now be enforced for biological control agents ?

On the African continent, some of the countries confronted with the dilemma have tried to find a way around the problem. To our knowledge, the People's Republic of Benin is the only example to date of a country where an appropriate legislation is being prepared. In this country, the only paragraph dealing with biological control operations now reads as follows : « The Minister in charge of agriculture may issue a decree authorizing the introduction and utilization of animals, plants, and microorganisms to control pest species» (Phytosanitary Law, Article 24). Initial steps towards the elaboration of a new legislation are usually made under emergency conditions, and in Benin, this happened as the badly needed *E. lopezi* was about to invade the country's cassava crops and populations of *P. manihoti* of its own accord. This is typical of the current situation, where several important aspects of biological control tend to escape the legislator's attention (importation of useful microorganisms whether for experimentation and screening or as commercially formulated products for sale, etc.).

This far, operations of biological control are at a high risk, especially in a continent like Africa, where legal objections may be raised at any time and apparently without good reason against a projected campaign, by any group with a vested interest. The only answer that could solve the problem would seem to propose the broad lines of a Biological Control Act, perhaps similar to that passed in Australia, with which all governments of sub-Saharan countries could agree (cf. Cullen and Delfosse, 1984).

HOW TO ELABORATE A BIOLOGICAL CONTROL ACT FOR SUB-SAHARAN AFRICA ?

We suggest that a Biological Control Conference be convened in Africa as soon as feasible, i.e., at some stage towards the end of 1989. This Conference should involve all parties interested in biological and integrated control pests, i.e., official representatives of :

- all countries concerned;
- lawyers specializing in problems associated with international trading and the protection of inventions in natural sciences;
- international insurance companies;
- air freight (shipping) companies;
- the Organization for African Unity/InterAfrican Phytosanitary Council (OAU/IAPSC, Yaoundé);
- the Organization for African Unity/Scientific, Technical, and Research Commission (OAU/STRC, Lagos);
- the United Nations Food and Agriculture Organization (FAO, Rome or its local delegations);
- the World Health Organization (WHO, Geneva);
- the International Organization of Biological Control (Montpellier);
- the IITA (in particular ABCP, Cotonou);
- the International Centre for Insect Physiology and Ecology (ICIPE, Nairobi);
- the United States Agency for International Development (USAID, Washington);
- the CIBC (CABI, London);
- the Centre de Coopération Internationale de Recherche Agronomique pour le Développement (CIRAD, Montpellier);
- the Organisation de Recherche Scientifique et Technique Outre-Mer (ORSTOM, Montpellier);
- the German Agency for Technical Cooperation (GTZ, Eschborn);
- other potentially interested parties or agencies (e.g.) the Australian Centre for International Agricultural Research, ACIAR, Canberra; the CSIRO Division of Entomology, Canberra, etc.).

In view of its declared aims and international repute, IUBS would be in a privileged position for providing the incentive to organize such a Conference, intended to pave the way for the future of biological and integrated control of pests in Africa. Funding should be sought, possibly from donors already committed to the development of similar programs in sub-Saharan Africa (IFAD, Rome, etc.; cf. Arnold *et al.*, 1987).

On behalf of the Section of Biological Control of IUBS, I would like to ask the General Assembly of IUBS to approve and support this proposal, and to commission the General Secretariat of IUBS, and IOBC to prepare such a Conference.

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Biological Diversity in the Context of Ecosystem Structure an Function

Proposal for an IUBS Program submitted by the
U.S. National Committee for IUBS
(Beryl B. Simpson, Ph. D., Chairman). National Academy of Sciences, 2101 Constitution Avenue Washington, DC, 20418

Introduction

The U.S. National Committee for IUBS (USNC/IUBS) proposes that IUBS adopt a program which examines the topic of biological diversity in the context of ecosystem structure and function. Such a program addresses concerns about biological diversity which are expressed by scientists as well as the lay public; involves the many types of expertise which make up IUBS; and fosters collaboration on a worldwide basis such as has been seen in the IUBS Decade of the Tropics Program. A general description of the proposed program is provided here for adoption by the IUBS at its 23rd General Assembly in Australia. We further propose that IUBS appoint an international committee to identify the experimental approach, including the specific ecosystems and processes to be examined.

Biological Diversity and Ecosystem Processes

The topic of biological diversity is receiving widespread attention today, in both the scientific and the popular press. Articles frequently discuss the numbers of species which currently exist, particularly in the tropical forests, and estimates are made of the number of species which are predicted to disappear due to the destruction of those forests.

In 1985, at its XXII General Assembly in Hungary, the IUBS dicussed the planning of workshops on biological diversity, with one workshop topic to emphasize rates of extinction and speciation and another the study of biological diversity in ecosystem processes. In the opinion of the USNC/IUBS, this second topic should be the subject of a major IUBS program.

Biological diversity encompasses variation in organization and interaction that ranges from genetic differentiation within populations, through species diversity (including the numbers of species and relative abundances of each), to differences among landscape patches (or mosaics) and ecosystems. There is increasing evidence that diversity at all these levels is undergoing unprecedented change. Change in the Earth's processes and characteristics is not new, but it is accelerating and increasing in scope. It is apparent that humans are a primary cause of the acceleration.

A direct relationship between fragmentation of ecosystems and many of the global changes (e.g., increasing level of CO_2 in the atmosphere, rates of soil erosion) that have been detected in the last few decades seems undeniable. More subtle changes in diversity and species composition within ecosystems probably also lead to alterations in processes and thus are ultimately global changes. The changes that are occurring are of such magnitude that the human environment itself might well be drastically transformed. If we are to preserve, manage, or design our environment, we must understand the interactions between biological diversity and global processes.

Extinction, or loss of biological diversity, is already the subject of a great deal of research, as described in the recently published volume, *Biodiversity*, which is based on the National Forum on Biodiversity held September 21 - 15, 1986, in Washington, D.C., under the cosponsorship of the U.S. National Academy of Sciences and the Smithsonian Institution (Wilson, 1988).

The relation of biological diversity to ecosystem processes has received less attention and, in our opinion, is an especially appropriate subject for IUBS. We propose that IUBS, as the union within the International Council of Scientific Unions (ICSU) that is most intimately concerned with the Earth's biota and as the organization responsible for cooperative international programs in the biological sciences, launch and coordinate a program on the relation of biological diversity to ecosystem processes. The goal of this program should be :

TO UNDERSTAND BIOLOGICAL DIVERSITY IN THE CONTEXT OF THE STRUCTURE AND FUNCTION OF ECOSYSTEMS.

Many aspects of the role of diversity in ecosystems could be addressed in such a program. What is important here is the connection between diversity and global processes. Processes that are occuring at the level of the landscape constitute a link between global changes and changes in species diversity. The fragmentation of ecosystems creates new patterns that often lead to alterations in the production of trace gases, in nutrient or water requirements or retention, and in primary and secondary productivity causing mosaics that involve simplification and degradation of systems. In all cases of major fragmentation of ecosystems, changes in species diversity and species composition are found.

The overall goal can be addressed by investigating fundamental characteristics of landscape and species diversity and by analyzing the relationships of each characteristic to ecosystem processes. Sites for these studies would most profitably include those designated for longterm ecological research, such as the Biosphere Reserves established by the UNESCO Man and the Biosphere (MAB) Program, the Long-Term Ecological Research sites established by the U.S. National Science Foundation, and other sites such as national parks and reserves. In each site, the pattern of landscape mosaics would be characterized and the effects of anthropogenic fragmentations or reconstructions of ecosystems would be assessed.

We propose that IUBS collaborate with such organizations as the World Wildlife Fund, the International Union for the Conservation of Nature, UN agencies, ICSU, and others concerned with studies of diversity and global ecological processes. IUBS should also use its own members and programs, such as INTECOL and the Decade of the Tropics networks, in the organization and implementation of the program on biological diversity.

Program Definition

A complete program will involve many steps, including the determination of the extent of complementary research already under-way, the outlining of experiments, and the delineation of methods that allow comparable data analysis. These steps should appropriately be taken by IUBS after its approval of a scientific program. We suggest the following questions as a basis for developing a research program.

I - Questions dealing with diversity at the level of the landscape.

The distribution of biological communities has a major effect on the control of the flow of water, energy, and materials across landscapes.

- How do the shapes, positions, and connections of relatively undisturbed landscapes affect flows in tropical, temperate, and arctic regions ?
- How do the fragmentation, simplification, and reshaping of biotic patches change flow rates ?

Observations and experiments directed toward answering such questions will require large areas where replicated sets of communities can be manipulated and studied over long periods. They will also require teams of scientists committed to long-term research. Because IUBS could plan and manage only a few sites, it will be important to review current work of this type and build cooperative networks among biologists involved in similar studies.

II - Questions dealing with species diversity within biotic communities.

Ultimately, it is the biological composition of communities that controls rates of flow within patches and across landscapes. Mechanistic explanations of landscape processes must be developed.

- Are some keystone species the major controlling elements within patches ?
- Do the major components of a patch (in terms of ecological processes) depend on general structural characteristics or on specific taxonomic identities ?

In some cases, results of prior studies can be used to determine which units of a community should be examined to improve understanding of the control of ecosystem processes. In other cases, however, it is not known how a biological community operates. Therefore, surveys of selected parts of flora and fauna, and studies of the life histories of the most important forms will be required.

III - Questions dealing with connections between changes in landscape diversity and species diversity within mosaics.

The diversity and composition of species within patches ultimately influence patterns of flow across landscapes, but modifications of components of a landscape might lead to further disruptions in the same or connected patches within the landscape. Such feedback could lead to continuing ecosystem fragmentation.

- How do changes in ecosystem processes affect diversity within patches and across landscapes ?

Such questions of ecosystem change at the global level are now of great interest because attention has been drawn to global processes by the International Geosphere-Biosphere Program (IGBP), which is being organized by ICSU to look at such processes. IUBS could contribute to an understanding of global processes through the program proposed here.

Conclusion

In the context of today's rapid global change, there is an urgent need for a program to determine the role of biological diversity in global processes. Only by understanding how diversity is related to the structure and function of both natural and managed ecosystems can one predict the global changes that will result from anthropogenic changes in diversity. This proposal provides a program goal and indicates the kinds of processes that should be studied. It also suggests a number of specific questions that might be addressed to reach the program goal. However, before IUBS can launch the program, the scientific issues and questions must be refined. Experimental approaches for answering questions and addressing the issues must be carefully outlined.

A structure for overseeing the program must be instituted. Diversity is seldom included in models of ecosystem. Many models have already been extrapolated to the limits allowed by the data on which they are based. For models to be extended, their data bases must be improved. Ideally, models of ecosystem processes relevant to global questions would rest on complete data, but that is not feasible, and IUBS must identify those questions which are the most important or manageable.

The proposed program potentially involves all types of biologists. However, the selection of specific types of biological expertise must await detailed design of research. IUBS appears uniquely qualified to integrate the research required and to make a long-term cooperative program successful.

Therefore, the USNC/IUBS urges IUBS to begin a program that will contribute to the understanding of biological diversity in the context of ecosystem structure and function, and that will foster worlwide collaboration of biologists.

(Reference : Wilson, E.O., Ed *Biodiversity*. Washington, D.C. : National Academy Press, 1988. 521 pp.).

Vegetation Map of Europe

Progress Report 1985 - 1988

Robert Neuhäusl
Botanical Institute, Czechoslovak Academy of Sciences
CS - 252 43 Prühonice, Czechoslovakia

Summary

The report informs on gradual compilation of the unified Vegetation Map of Europe/scale 1 : 2 500 000/ from 1985-1988. The most important results concern the second version of model sheet x, the third approximation of the entire legend, the completion of Central and East European map sheets including the preparation of the structure of the explanatory book.

Introduction

Information about the origin, scientific concept and results of the project of 1985 was published in Biology International (Gribova, Karamyševa & Neuhäusl 1985). Current results have also been submitted to the Symposium on the Vegetation Map of Europe adjoining the 22nd General Assembly of the IUBS in Budapest, Vácrátót 1985 and during the 14th International Botanical Congress in Berlin-West 1987. A survey of the workshops from 1981-1985 including a detailed evaluation of their contribution was also published (Neuhäusl 1987). The purpose of this project is to blend the different approaches to the mapping of natural vegetation while using Europe as a model territory. The resulting map shows the most important features of latitudinal, longitudinal and altitudinal vegetation regularities, azonal vegetation types and their differentiation, as well as the edaphic, geographic and floristic varieties of the natural plant cover.

Results and current state

Model sheet X was completed as a manuscript by P. Ozenda, U. Bohn and R. Neuhäusl and put on display during the 22nd General Assembly of the IUBS in Budapest (1985). According to the conclusions of the Editorial Board meeting in Vácrátót, Hungary, 1985, the work from 1985-1988 was aimed at the second approximation of the model sheet X and at the third approximation of the entire legend. New national contributions from Italy, France and Switzerland were included and the new edition of the Map of the Natural Vegetation of the Europe Council Lands (Noirfalise, 1987) was evaluated. The model sheet will be prepared for printing in 1988 and published next year.

The current state of the map project (Fig.1) is self-explanatory. Manuscripts of East European sheets IV, VIII, XI and XII have been completed and prepared for printing; they are being partly made for use as a basis for the first edition of a unified vegetation map of European C.M.E.A. countries. As for sheet II and III, all national contributions have been completed with the exception of Norway and are currently under preparation. The territory of Italy including Sardinia (sheet XIX) has been compiled. Joint contributions from Great Britain, Spain, Portugal, Greece, Albania and of the European part of Turkey will be made in 1988.

The Vegetation Map of Europe Project was submitted to the 14th International Botanical Congress in Berlin/West in July, 1987. As an introduction to the "Symposium on the Present Problem of Maintaining Natural and Semi-natural Vegetation in the European Temperate Zone", G. Hofmann (Eberswalde, GDR) gave a lecture on the unified Vegetation Map of Europe in which the scientific concept and application were explained in detail. A poster by R. Neuhäusl, S.A. Gribova and U. Bohn, "The Vegetation Map of Europe : its Concept and Elaboration Demonstrated by Exemplary sheet XI", was exhibited and an explanation given at the poster session on Flora and Vegetation in the Temperate Zones. Exemplary sheet XI covers the Eastern part of Central Europe including a large part of Southeastern Europe. The occurence of 14 formation units (out of a total of 19) including 138 mapping units (out of about 500) give evidence to a great diversity of biological systems and environmental conditions in this area. Possible systems of application (in synchorology, nature and environment protection, landscape ecology and as a guideline for landscape planning) were also demonstrated. The structure of the entire legend was presented together with the exemplary sheet at the 14th Botanical Congress in Berlin-West.

A meeting of the Editorial Board took place between 1986-1987, Prague, 8-12 June, 1987, with the following results :

1 - The third approximation of the entire legend to the Vegetation Map of Europe has been confirmed and recommended as a baseline for the elaboration of a joint map concept.
2 - The second version of model sheet X has been accepted for publication purposes. The sheet editors have been entrusted with the final arrangement of the map.
3 - The completed sheet manuscript VII and XI including several new national contributions

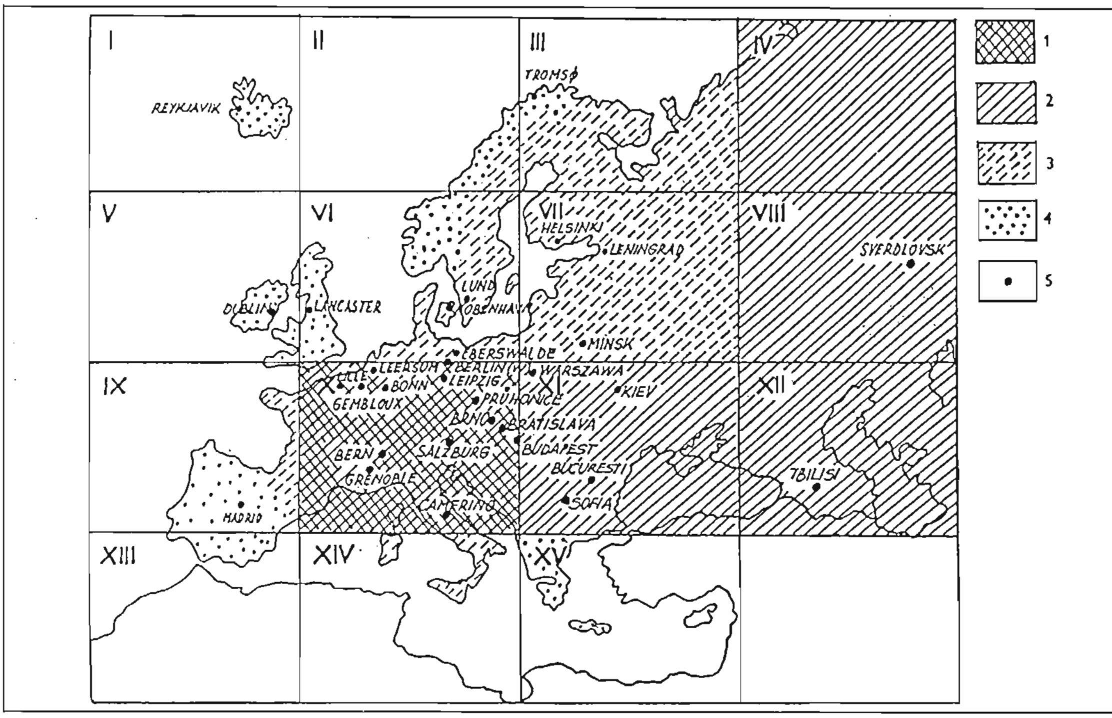

Fig.1 - Vegetation map of Europe project, current state : 1 - prepared for publication, 2 - sheet manuscripts completed, 3 - national contributions finished, 4 - national contributions under preparation, 5 - co-working institutions

from Finland, Sweden, Denmark and Italy have been performed and accepted with comments. The final arrangements will be carried out in the editorial process.

4 - The structure of the explanatory book has been prepared and examples of the text approved as a working basis.

Outlook for 1989 - 1991

The most important task is to complete the entire map manuscript with regard to the map sheets where those national contributions are under preparation (Iceland, Norway, Great Britain, Ireland, Spain, Portugal, Greece and the European part of Turkey). The collaborators in all the above-mentioned countries should have finished their contributions in the course of 1988. After having completed all sheets, the final version of the entire legend of the Vegetation Map of Europe will have been printed in the course of 1989. A meeting of the Editorial Board is to take place in Warsaw in September 1989. At this meeting, the unified interpretation of the natural vegetation of Europe is to be approved.

The second task for 1989-1991 is to compile the explanatory text. The plan including the detailed structure of the text book was accepted at the last meetings of the Editorial Board together with the exemplary chapters characterizing various formations and mapping units. The first draft of the commentary volume (700 Ms. pages) is to be presented at the meeting of the Editorial Board in 1989. A team of 40 authors have been preparing the explanatory text which is to be projected as a book item entitled The Natural Vegetation of Europe (VEB- Gustav Fischer Publishers Jena). In the General Part of this book, basic data on European vegetation mapping, information on the development of the project, scientific concept and principles of the cartographic interpretation will be presented. The Special Part includes a chapter on the development of European vegetation during the Holocenic era, the structure of applied vegetation classification and an extended explanation of 19 vegetation formations including about 500 mapping units occurring in Europe. Examples of how the vegetation map is utilized in different branches /Neolithic settlement history, nature protection and conservation, the assessment of anthropogenic vegetation and environmental changes, the assessment of potential bioproductivity, evaluation of land use, landscape planning and management, etc. terminate the book project.

References

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Neuhäusl, R. 1987. Fortschritte der Arbeiten am Projekt der Vegetationskarte Europas. Folia Geobot. Phytotax., Praha, 22 : 89-95.

Noirfalise, A. 1987. Carte de la végétation naturelle des États membres des Communautés européennes et du Conseil de l'Europe carte 1 : 3 000 000 et texte explicatif. Conseil de l'Europe, Commission des Communautés Européennes, Luxembourg, 78 pp. et carte.

Recommendations of the Meeting on Comparative Studies in Tropical Mountains

During the period 15 to 25 May, 1988, the IUBS group on "Comparative Studies of Tropical Mountains" held a very well attended workshop-symposium on the Canary Islands and the Island of Madeira sponsored by ICONA, the Spanish Institute for the Conservation of Nature, The Park System of the Kingdom of Spain; the Autonomous Governments of the Canary Islands; the Park System of the Portuguese Republic; the Autonomous Governments of the Island of Madeira; UNESCO/MAB and IUBS. The meeting was attended by over 50 scientists from Argentina, Bolivia, Chile, France, Netherlands, Portugal, Spain, United States of America, and Venezuela.

A) GENERAL RECOMMENDATIONS.

1) The archipelagos of Canarias and Madeira, although situated north of the geographical border of the tropics, have environmental, ecological, and cultural characteristics that link them very closely to the tropics. Furthermore, given their condition of relatively recent volcanic islands with a succession of altitudinal floors, these islands present a great diversity of natural environments where human occupation has structured a set of unique agricultural landscapes. Undoubtedly the systematic comparison of these landscapes with similar ones in tropical mountains will increase our knowledge of the relations between the natural and human landscapes in tropical mountains. Furthermore, because of their geographical position these islands form a bridge between Europe, Africa, and America, a unique link in the chain of environments, systems of use, and peasant cultures within the tropical mountains of the Globe.

2) The Canary Islands and the Islands of Madeira represent not only a unique laboratory of organic evolution, but due to their geographical position have historically served as a testing ground for different agricultural techniques. The study of this biological richness, of the diversity of the traditional uses, and the exceptional experience in the testing of new models of conservation, make of these archipelagos of the Macaronesian Region a very privileged scientific laboratory.

3) In this framework, it can be of great value for the Canary Islands and the Islands of Madeira, the interchange of information and experiences with other places in the planet, within the international program on Tropical Mountain Ecosystems which has three basic objectives :

a. To increase the knowledge of the function and productivity of tropical mountain ecosystems.

b. To analyze the interrelationships between the natural vegetation and land use, putting special emphasis on the potential use of the natural systems and the impact of human activities on these systems, in order to determine the sustainable carrying capacity.

c. To identify and evaluate the general principles of development programs and resource management, the management strategies, and the utility of protected areas, with the objective of preserving environmental and social stability of fragile tropical mountains.

4) The positions which have been analyzed and discussed in these working sessions converge, as far as these Islands are concerned, in the interest in the programs of study and research that are being conducted in these islands, as well as in the enlargement of the perspectives of the Program of Research on Mountain Ecosystems.

For this purpose it is recommended the incorporation into the Mountain Program of those activities taking place in these islands that fit the philosophical, intellectual and scientific objectives of the Mountain Program. It is suggested that a formal application to IUBS be made.

5) It is suggested that the Canary Islands and the Islands of Madeira be considered as the focal point of the research programs contemplated in the National Research Program of Spain for Latin America and the programs of technical, scientific, and cultural cooperation of Portugal with the Ibero-Portuguese countries.

B) RECOMMENDATIONS OF THE TRANSECT WORKING GROUP.

After analyzing and discussing the characteristics of the transect program, its methodology, and the results to date, the participants from the Canary and Madeira Islands expressed their interest to incorporate themselves into the transect group, and accompanying functional and dynamic studies. It is the opinion of the participants that these studies can be the base for a more rational use of the territory of these Islands. Of course, final participation depends on approval by the parent institution of the participants.

In particular it is considered likely to develop a minimum transect on the bases of existing information, and they consider likely the establishment of a small team to perform more detailed studies of the vertical variability and the bio-environmental patterns in these islands.

The participants propose as a next step after the analysis of the bio-environmental patterns the following subjects :

a. Studies about the functioning and dynamics of the laurisilva forest.

b. Detailed studies of the high mountain ecosystems of the Canary and Madeira Islands, such as the demography of some important species.

c. Recovery of species in danger of extinction.

d. Use of the weather station network in these islands for a detailed analysis of the relation between climate and ecosystem.

Finally the local participants wish to note their desire that the program develop an interchange of information and bibliography to help overcome a condition of relative isolation.

C) RECOMMENDATIONS OF THE LAND USE GROUP.

a. That the Program on Mountain Ecosystems increase and stimulate the interchange of information among workers in this field.

b. Institutions and researchers will act as providers of information.

These recommendations take three concrete forms :

1) Publication of a bi-yearly newsletter. A person in each country will serve as a gatherer of information regarding publications, projects, and meetings, which will be sent to Dr. O. T. Solbrig, who will edit the newsletter.

2) Produce a publication with an analysis of the methodologies utilized in the papers that were presented : cartography of vegetation and land use; use of satellite information in the evaluation and analysis of satellite images; regeneratin of soil fertility; production of technology based on popular knowledge; high mountain peasant economies; regional analysis with an integrated focus.

Dr. Michele Ataroff has been made responsible for the editing of this publication.

3) Organize a meeting to discuss specific conceptual issues regarding the development of technologies based on popular knowledge. Dr. Mario Rabey is in charge of the organization of this meeting.

D) RECOMMENDATION OF THE GROUP ON CONCEPTS AND MANAGEMENT SYSTEMS FOR CONSERVATION AND DEVELOPMENT OF MOUNTAIN ECOSYSTEMS.

The principal recommendation is that the program should stimulate the interchange of information and experiences among mountain researchers. Attention is called to the experiences of the National Institute for the Conservation of Nature (ICONA) of Spain, and of the National service of Parks, Reserves, and Nature Conservation (SNPRCN) of Portugal, as well as those of the respective regional administrations that deal with these matters.

This recommendation should be effected through the following two actions :

a) Prepare a publication about concepts and methodologies relevant to Mountain Ecosystems, with special reference to Ibero-America including Macaronesia.

b) Organize a meeting to discuss terminologies and concepts in this subject.

Palynologists Active Internationally

The 7th International Palynological Congress (IPC) in Brisbane, Australia from August 28 to September 3 of this year, will bring together practicioners of many scientific specialties. The program will cover a wide spectrum of applications of palynology including (among others) allergy studies, pollen morphology, evolution, ecology, oceanography, biogeography, environmental quality, climatic change, vegetation history, biostratigraphy, hydrocarbon source-rock analysis, computer applications, forensic studies, and archeology. The on-site organizing committee is offering 9 multi-day excursions in Australia and New Zealand, and 9 short excursions in eastern Australia.

The congress program reflects the fact that palynology is a truly interdisciplinary science, with roots in botany, zoology, and geology. It is the study of modern or fossilized organic-walled microstructures, collectively called palynomorphs, among the most important of which are pollen, spores, and phytoplankton.

The palynologists of 62 countries of the world are united through 22 regional, national, linguistic and specialist societies into the International Federation of Palynological Societies (IFPS). Because of its interdisciplinary character, the IFPS is affiliated with both the International Union of Biological Sciences and the International Union of Geological Sciences. Its aim is to advance knowledge in palynology and related subjects by promoting and coordinating international cooperation and meetings between scientists of all regions and countries.

The IFPS had its beginnings in the commissions and committees created in 1953, 1962 and 1966 to organize international conferences and to "prepare for a permanent international organization". The latter became a reality in January, 1971 in Novosibirsk, U.S.S.R., with the creation of the federation's ancestor the International Commission for Palynology, with a 12-member Council and Norman Hughes of Cambridge, England as its first President. Subsequent presidents, serving four year terms, have been Alfred Traverse (U.S.A.), Claude Caratini (France), and Colin McGregor (Canada). The IFPS received its present name at the 1984 international conference in Calgary, Canada.

The first edition of the World Directory of Palynologists is now being distributed to all of the societies comprising the IFPS. It contains more than 4 000 names, with addresses and specialties, not only of members of the affiliated societies, but also of many palynologists who for political, geographical, financial or other reasons are not members of any society.

In anticipation of the Brisbane congress, the "Australian Bicentennial Issue" of the federation's semiannual newsletter *Palynos* was devoted to an account of the accomplishments of Australian and New Zealand palynologists.

Organizations affiliated with the

International Federation of Palynological Societies

AASP — American Association of Stratigraphic Palynologists
ALPP — Asociacion Latinoamericana de Paleobotanica y Palinologia
APLE — Asociacion de Palinologos de Lengua Espanola
APLF — Association des Palynologues de Langue Francaise
APP — Arbeitskreis fur Palaobotanik und Palynologie
BMS — British Micropalaeontological Society
CAP — Canadian Association of Palynologists
CIMP — Commission Internationale de Microflore du Paleozoique
CPS — Collegium Palynologicum Scandinavicum
GPSBI — Gruppo di Palinologia della Societa Botanica Italiana
LS — Linnean Society Specialists Group
OCP — Organization of Czechoslovak Palynologists
PK — Palynologische Kring
PPAA — Palynological and Palaeobotanical Association of Australasia
PSC — Palynological Society of China
PSI — Palynological Society of India
PSJ — Palynological Society of Japan
PSL — Palaeobotanical Society, Lucknow
PSP — Palynological Society of Poland
PTPB — Precambrian to Tertiary Palynologists of Belgium
SPC — Soviet Palynological Commission of the Botanical and Paleontological Societies
TCP — Turkish Committee for Palynology

Financial Statement of IUBS for the Year 1987

Statement 1. Balance sheet at December 31, 1987 (Expressed in US dollars)

ASSETS		
Cash and Banks		
The Chase Manhattan Bank :		
Paris, in US $	29 703	
Frankfurt/Main, in US $	41 095	
Paris, in FF	9 897	
Paris, in US $ (Deposit account)	719 510	
		780 411
Other Assets		
Other receivables	76	
		76
		780 487
LESS : Liabilities		
Sundry creditors		147 377
Excess of assets over liabilities		633 110
Represented by		
Accumulated Fund		633110

Statement 2. Income and expenditure for the year ended December 31, 1987 (Expressed in US dollar)

1. Income		
ICSU subventions	40 996	
Special Subventions from International Organizations (UNESCO, EEC, etc)	292 750	
Contributions from National Members	208 393	
Interests and dividends	35 660	
Gain or loss over exchange	660	
Other income	40 223	
		618 682
2. Expenditure		
A. Meetings		
Executive committee meetings	29 778	
Officers' meetings and travels	8 534	
		38 312
B. Publications		**19 086**
C. Scientific Activities		
Grants to IUBS programmes	337 794	
Representation at scientific meetings	6 384	
Contributions to other scientific organizations	6 006	
		350 184
D. Administrative Expenses		
Salaries	65 874	
Related charges	49 305	
General Office expenses	37 922	
		153 101
E. Other		
Bank charges	1 017	
Audit fees	4 454	
Others	1 270	
		6 741
Total expenditure		567 424
Total Income		618 682
Total Expenditure		567 424
Excess of income over expenditure		51 258
Accumulated balance brought forward		581 852
Accumulated balance carried forward		633 110

FAUNA OF AUSTRALIA
Volume 1.A. General Articles

Dyne, G.R. and Walton, D.W. (editors), Canberra, Australian Government Publishing Service, 1987, (339 pages).

This new series is a by-product of the celebration of the bicentennial of modern Australia. Quite rightly, the Federal Government felt that the native fauna of the continent was indeed part of the nation's natural heritage, and therefore deserved to be better known by the educated public. Ten volumes are planned, three on vertebrates and the rest for invertebrates and protozoans. They will be published during the coming decade, as too many groups still remain poorly known. About one thousand specialists have been asked to contribute to this ambitious review of the australian fauna and its biology, down to the family level.

The first eight chapters of this introductory volume deal with the paleoenvironments of the continent, and the history and ecology of the marine, terrestrial, and freshwater animals. Written by well known specialists, they provide an excellent introduction to the biogeography and ecology of Australia. Then, two extra chapters summarize the history of zoological exploration, the establishment of national collections, the over-exploitation of the native animals and the introduction of exotic species. Two final chapters on conservation and management legislation, and on classification and nomenclature, conclude the volume.

Altogether, this is a well written and attractive introduction to a fascinating fauna, which whets our appetite for the next volumes to appear.

François Bourlière

COMPUTERS AND BIOLOGICAL EDUCATION
The Expanding Universe

Edited by T. Crovello

IUBS Monograph Series N° 5, 1988 (178 pages).

This monograph consists of the presentations made at a workshop "Use of Computers in Biological Education", organized by the IUBS Commission for Biological Education in cooperation with Unesco and the University of Helsinki, 3-5 Sept., 1986, in Helsinki, Finland. It includes chapters on the basic concepts of bio-educational computing systems, microcomputer based laboratories and simulation, some country reports from Japan, USA and Federal Republic of Germany, and future development and prospects.

BREEDING FOR RESISTANCE TO INSECTS AND MITES

West Palaearctic Regional Section Bulletin of the IUBS Section for Biological Control, 1988 (103 pages).

This volume includes the report of the fourth triannual meeting of EUCARPIA/IOBC working group on 'breeding for resistance to insects and mites', held 23-25 Sept., 1986, in Hundested (Denmark). 32 papers were presented at four workshops dealing with protected vegetables, fruit and arable crops, outdoor vegetables and arable crops.

INTEGRATED CONTROL IN FIELD VEGETABLE CROPS

West Palaearctic Regional Section Bulletin of the IUBS Section Biological Control, 1988 (149 pages).

This bulletin consists of an account of the activities of the IOBC newly established 'Working Group in Field Vegetables', which has replaced the 'WG on Integrated Control in Brassicas'. It includes reports on pest and damage thresholds, methods for monitoring vegetable pests and the development of their use in commercial crops.

MODELS IN INTEGRATED CROP PROTECTION

West Palaearctic Regional Section Bulletin of the IUBS Section for Biological Control, 1988 (95 pages).

This issue marks ten years of activities of the IOBC working group on the use of models in integrated crop protection. It consists of a set of reviews on pest and disease forecasting, crop loss and disease monitoring and implmentation of pest and disease management systems.

ELEPHANTS-TREES-GRASS-GRAZERS.

By Willem van Wijngaarden
ITC Publication, N° 4, 1985, (159 pages).

This research report on the relationships between climate, soil, vegetation and large herbivores in a semi-arid savanna ecosystem (Tsavo, Kenya), presents a static and dynamic model "Elephants-Trees-Grass-Grazers", based on a good analysis of the soil, plantation and large herbivore population dynamics, with its implications for Tsavo National Park and ranches management.

PHYTOECOLOGY OF THE MONTES DEL BUIO AND SIERRA DEL XISTRAL

By M. P. A. Castroviejo Bolibar
Published in Spanish by Conselleria de Agricultura, Xunta de Galicia, Spain. 1988, (323 pages).

This book presents a comprehensive descriptive and comparative analysis of the four vegetal formation found in the area of "Montes del Buio and Sierra del Xistral", in Spain. It also includes recommendations on how to use ecological data for the planning and management of this area.

TECHNOLOGIES TO MAINTAIN BIOLOGICAL DIVERSITY

Prepared and published by the Office of Technology Assessment, U.S. Congress, Washington, DC 20510-8025, USA. 1987 (334 pages).

This volume includes the report of a workshop organized by the U.S. Congress Office of Technology Assessment, to clarify the nature of the problems of reduction of the Earth's Biological Diversity, to deal with the broad implications of loss of bio-diversity and to set forth a range of policy options available for decision makers in the United States.