ANNUAL REPORT 1988

ernational Soil Reference and Information Centre
Wageningen - The Netherlands

ISRIC was born out of an initiative of the International Society of Soil Science, and was adopted by Unesco as one of its activities in the field of earth sciences. It was formally founded on 1st January 1966 by the Government of The Netherlands, upon assignment by the General Conference of Unesco in 1964.

Most of the working founds are provided by the Dutch Ministry for Education and Sciences, and are accountable to the Directorate-General for International Cooperation (DGIS) of the Ministry of Foreign Affairs.

The constituent members of the Board of ISRIC are the International Institute for Aerospace Survey and Earth Sciences (ITC) in Enschede, the Wageningen Agricultural University (WAU) and the Directorate for Agricultural Research (DLO).

Advice on the programmes and activities of ISRIC is given by a Unesco-FAO appointed International Advisory Panel (IAP) and by a Netherlands Advisory Council (NAC)

The financial-administrative responsibility for the working funds and for the permanent staff of ISRIC rest formally with the Board of Governors of ITC.

Up to 31 December 1983 the name was International Soil Museum (ISM).

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ISRIC
International Soil Reference and Information Centre
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1 THE ORGANIZATION AND ITS DEVELOPMENTS

1.1 ORGANIZATION

The organisational structure outlined in the previous Annual Report remained essentially the same. However, the longer-term activities, for which funds for a fixed-term have been secured, became more prominent in 1988.

ISRIC's activities consists of six sections, three programmes, and consulting and miscellaneous projects.

Sections

Soil monolith collection
This section deals with the building up of ISRIC's world collection of monoliths and encompasses all work from selecting and taking of the soil profile to the final monolith being placed in the exhibition room or reference store ("pedonarium"). The work is related to the National Soil Reference Collection Programme (NASREC) and to the Collection of Reference Laterite Profiles (CORLAT).

Laboratory
Besides routine analytical work for the monolith collection, this section carries out a number of ad-hoc analyses, particularly for reference purposes. This activity is connected with the Laboratory Methods and Data Exchange Programme (LABEX).

Micromorphology
The work includes the preparation and description of the thin sections belonging to the soils of the collection. Like the laboratory, the micromorphology section is involved in a number of other activities as well.

Documentation
This section deals with the development of ISRIC's Soil Information System (ISIS), with the library, and with the map collection.

Soil classification, correlation and mapping
Activities in this section are mainly related to the development of a Revised Legend for the FAO-Unesco Soil Map of the World, to some International Committees for the improvement of the USDA Soil Taxonomy, and to the development of an International Reference Base for national soil classification systems (IRB). Preparatory work is being carried out for updating the FAO-Unesco soil map at 1:5 million scale, and a related activity is the establishment of a World Soils and Terrain Digital Database at 1:1 million scale (SOTER).

Transfer of Knowledge
This section deals with the Course on the Establishment and Use of National Soil Reference Collections and Databases, with receiving visitors, lecturing, and with supplying written and oral information.

Programmes
These are longer term activities, for which however only fixed-term extra funds have been secured.

National Soil Reference Collections Programme (NASREC)
This programme encompasses support for the building up of a number of national soil reference collections in selected countries of Africa, South America and Asia.

Laboratory Methods and Data Exchange Programme (LABEX)
This soil sample exchange programme between about 120 laboratories aims to improve the quality of soil analytical data by providing external references and standard procedures to the participants.

Preparation of a World Soils and Terrain Digital Database (SOTER)
This is a programme to support the establishment of a geographic information system on the soils of the world at scale 1:1 million, an ISSS initiative that is a sequel to the FAO-Unesco Soil Map of the World project of the sixties.
The United Nations Environment Programme (UNEP) in Nairobi awarded a major contract for the global assessment of soil degradation (GLASOD project, see section 4.2) to be accompanied by quantification of status and hazards of the various forms of soil and land degradation in at least one pilot area - the latter based on the ISSS-initiated methodology for the establishment of a World Soils and Terrain Digital Database (SOTER).

Consulting and Projects
This embraces not only missions of ISRIC staff members, but also the employment of extra personnel at ISRIC to carry out specific projects. A prominent project in 1988/89 is the 'Soils and the Greenhouse Effect' activity (ISEC).

1.2 INSTITUTIONAL DEVELOPMENTS

The shift of ISRIC's focus from monolith collection to the application of the assembled documentation continued in 1988. The work of ISRIC as a whole is centered more and more around the specially funded programmes NASREC, LABEX and SOTER/GLASOD. The sections personnel often had to help out at the workload of the programme staff.

The first phase of the NASREC programme was concluded with the official inauguration of soil reference collections and related databases in Ecuador, Indonesia and Mali; the LABEX programme continued its activities at ISRIC and abroad; while the GLASOD/SOTER programme became a well-known initiative. It is hoped that the momentum gained within these three programmes can be kept, and that adequate funding can be secured to implement the plans for the future.

The following other highlights of activities and accomplishments may be mentioned:

- The completion of the Revised Legend of the FAO-Unesco Soil Map of the World. This work was carried out over the last three years in a cooperative effort by FAO, Unesco and ISRIC. The joint report will be published in 1989 by FAO, with a field edition by ISRIC;
- The presentation of LABEX at two IBSRAM meetings in South America and Asia, with the ultimate aim to have all IBSRAM network sites participate in LABEX;
- The publication of ISRIC's Soil pedon Information System (ISIS) in two Technical Papers and on two diskettes. Although primarily developed for the computerization of ISRIC's own soil monolith documentation and data, the system can also be used in a non-ISRIC environment. About 20 sets have already been made available to interested parties, mostly in developing countries;
- The growing interest in the work related to the 'Soils and the Greenhouse Effect' conference, to be held in 1989 at Wageningen (ISEC project). The background study on the potential effects of global changes in soil conditions and land use patterns on world climate is already becoming a well-known publication.
- The enthusiasm with which soil scientists in Argentina, Brazil and Uruguay cooperate with ISRIC in the preparation of the soil and terrain digital database of the first pilot area in Latin America. It is hoped that funding can be obtained for adjoining areas in the three countries involved.
- A preliminary decision by ICSU's Panel on World Data Centres has been taken to accept ISRIC as a 'World Data Centre for Soil Geography and Classification'. The formal entrance into this world-wide system will probably be in 1989. It may lay an extra burden and responsibility onto the few persons available for documentation within ISRIC. An effective computerization must however be regarded as a condition *sine-qua-non* for its functioning as a reliable and up-to-date information centre.

Matters of concern are:

(1) the shortage of working space for the programmes and project staff, of storage possibilities for soil material (whole profiles, horizon samples, bulk samples for LABEX), and of documentation space (library, map collection);

(2) the growing numbers of groups and individuals who like to visit the exhibition, but cannot be guided adequately;

(3) the shortage of staff at the documentation section for the active acquisition of maps, books and reports, and the administrative handling of a computerized database;

(4) the backlog of new soil monoliths awaiting analysis, preparation and final classification.

2 ARTICLE

IDENTIFICATION AND MANAGEMENT OF PROBLEM SOILS OF THE TROPICS AND SUBTROPICS[1]

W.G. Sombroek

There is hardly any soil in the world that has no limitations for plant growth and cropping, not even assuming ideal moisture and temperature regimes. Some groups of soils of the Tropics and Subtropics present however major problems as regards their management. These will be reviewed in this introduction, with special attention to the well-drained, acid or crusting soils of the Tropical and Subtropical Uplands.

1. SOILS OF MOUNTAINOUS LAND ("steepland soils")

Among the steepland soils, two main groups can be distinguished: a) soils derived from recent volcanic materials, especially volcanic ash - Black Volcanic Soils; and b) predominantly shallow soils derived from other rocks and sediments - Shallow Mountain Soils.

1.1 Black Volcanic Soils

The Black Volcanic Soils (**Andosols**/Andepts)[2] are prevalent in the Pacific, Papua-New Guinea, Indonesia (Java, Sumatra), Eastern and Central Africa (Ethiopia, western Kenya, northeastern Tanzania, Rwanda, northeastern Zaire, southern Cameroon), and parts of the Andean mountain range in Latin America (Mexico, Costa Rica, Colombia, Ecuador, Chile). These are in general areas with high population density. In temperate regions major occurrences are in Japan, USA (Oregon) and New Zealand. Andosols are problem soils in some aspects only.

The parent materials of the soils may be lava flows, but more commonly pyroclastics ("tephra": ashes of varying grain sizes from rhyolitic, dacitic and andesitic volcanoes).

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[1]Main text presented at a meeting of CASAFA/ICSU in September 1985 at ISRIC, Wageningen.

[2]Approximate correlation in the FAO-Unesco Soil Map of the World legend (1974), and USDA Soil Taxonomy (1975) respectively. References are sometimes made to the French system Classification des Sols (CPCS, 1967).

Physico-chemically, Andosols are characterized by high percentages of allophanes ("short-range-order" clay minerals) and/or volcanic glass ("cinders"), resulting in high specific surfaces and strongly pH-dependent surface charges of the solid phase. Accessory properties are: high friability, low bulk density and high phosphate and sulphate adsorption.

Most Andosols have a high organic matter content and are deeply rootable. Their permeability for water and their water storage capacity are high, and they are often little prone to erosion because of a high porosity and high inherent structure stability. Some however contain dense and permanently hard layers ("duripans", called "cangagua" in Ecuador), making them particularly liable to erosion.

From fertility point-of-view the main drawback of the Andosols is their high P-retention ("fixation") due to the peculiar nature of the clay minerals. They are often acid, but variants with high base status occur as well, for instance in parts of western Kenya. Depending on the nature of the ashes, micronutrients may be either in short supply or occur in excessive quantities ("toxicity").

In general, Andosols are suitable for a wide range of crops, including horticultural ones, wherever rainfall is sufficient - the predominant situation - and temperatures not too low.

Tillage is easy, but traffic is often difficult. This not only because of the steep topography, but also because of an often "smeary" character of the soil material ("thixotropy").

The open and friable nature of the soils provides for an ideal environment for insect pests. Because of a low thermal conductivity of the soils, especially those of the cindery type, the range of temperature regimes suitable for cropping is somewhat narrower than at non-volcanic soils: stronger altitudinal limitation.

Research needs:
- Nature of the clay minerals and its effect on the chemical and rheological properties.
- Development of special field and laboratory methods for identification of the soils and for class subdivisions relevant to their use possibilities.

New Zealand and Japanese soil scientists are particularly active in studying these soils.

1.2 Shallow Mountain Soils

Shallow Mountain Soils (mainly **Cambisols**/Inceptisols) occur in many countries of the Tropics and Subtropics. The most extensive area is probably the middle-slope section of the Himalaya range (Pakistan, Nepal, Bhutan, India, China), but also many parts of the Andean Cordilleras are concerned (Peru, western Venezuela) as well as parts of the Rift Valley system of Africa (Ethiopia, Burundi, Tanzania, Malawi).

The soils have little in common except their shallowness, stoniness and short-distance spatial diversity (intricate patterns). Parent materials are of many kinds and this factor, combined with strongly varying slope class and a wide range of temperature and moisture regimes, gives rise to soils of strongly differing humus content, acidity, clay mineralogy, texture, density, etc.

Because weathering of the rocks is never very strong, the physico-chemical stability of the soils if often very low. This factor, and the steep slopes, make the soils particularly liable to erosion at cultivation or grazing.

In general the lands concerned were sparsely populated in the past, with farming systems adapted to the harsh environment, as exemplified the pre-Colombian Incaic terraces. With the recent strong increase in human and animal population, and under influence of agricultural mechanization and introduction of fertilizers, small farmers are often pushed out of the fertile valleys onto these mountain lands. As a consequence the inherent ecological fragility of the land is often tried beyond capacity. This results not only in a serious loss of a plant growing medium at the spot, but also in large-scale negative effects downstream: silting up of dams, flash floods, etc. Effective counter-measures are usually beyond the capacities of the individual small farmer or animal herder. In many places moreover an acute shortage of firewood and animal browse has developed. Rehabilitation of such lands (by bench terracing, tree plantings, etc.) out of necessity has to be a community effort, at which financial and technical support of the Central Government or a Foreign Donor is often indispensable.

The food-for-work philosophy of FAO's Freedom From Hunger/World Food Programmes has in a number of cases yielded tangible results in such areas, but it is still chicken-feed in comparison to the extent and the gravity of the problem.

Site-adapted agroforestry techniques can be helpful, but require detailed base-line surveys as regards physical resources and socio-economic conditions (farming systems research). In some cases, massive re-settlement in downstream areas may be the only immediate solution.

Research needs:
- Study of ancient land management techniques of the traditional steepland populations.
- Development of mountain cultivars of ground covering herbs and grasses.

The recently established International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal may provide answers to some of the most urgent problems of the Shallow Mountain Soils.

2. ACID SOILS OF THE HUMID AND SUBHUMID UPLANDS

2.1 The Yellowish Soils of the Tropical Forest Regions

The soils of the humid tropical forest regions of low altitude are predominantly very deep, yellowish, strongly weathered and acid (**xanthic** or **orthic Ferralsols**, ferric Acrisols and ferralic Cambisols or Arenosols / Haplorthox, Paleudults, Tropepts, oxic Quarzipsamments / Sols ferralitiques jaunes).

They occur over very large expanses in the Amazon and Congo regions, but also in parts of the Malaysian archipel (Malaysia, Kalimantan, Sumatra). Human population density was very low until recently, not only because of the low fertility of the soils, but also because of the unsavoury climatic conditions (proliferation of diseases and pests), and difficult access. This picture is now changing rapidly through programmes such as the transmigration in Indonesia and road building in the Amazon region.

The parent materials are often pre-weathered sediments of Tertiary-Pleistocene age, but also large areas with acid crystalline basement rocks are encountered, for instance in Gabon. Physico-chemically most of the soils are characterized by a high percentage of low-activity clay minerals, viz. kaolinite and sesquioxides (goethite, gibbsite, hematite). Apart from the clay minerals the only soil constituent is sand-size quartz and fine gravelly sesquioxide nodules; silt-size particles and weatherable minerals - as a source of nutrients - are practically absent. The soils are however deep, of uniform or near-uniform texture throughout, well drained and porous, with a fairly high degree of inherent stability because of the inertness of the clay minerals. This results in a low liability to erosion. Because of their friability and porosity they are easy to work (high "arability") and easily and deeply rootable. For the same reasons their effective moisture storage per unit of volume has always been assumed to be quite high. It turns out, however, that this is only 10% or so - comparable to temperate-zone sandy soils, apparently because a large part of the moisture is held onto the soil mass with a force stronger than plants can exert for extraction. In areas with a distinct dry season, such as the eastern and southern parts of the Brazilian Amazon, a distinct moisture stress can occur for annual, shallowly rooting crops, after the smoothing-over influence of the forest vegetation has been taken away.

In the soil itself, nutrients are in general in very short supply: the low cation-exchange capacity (less than 16 cmol(+)kg^{-1} per 100 grams of clay, often not more than 1 to 5), in combination with a low base saturation (less than 50%, often 10-15% only) and the virtual absence of weatherable primary minerals (less than 1% of the sand fraction), makes the soil quite sterile in the chemical sense.

The soils may have rather high percentages of exchangeable aluminium which has a negative effect on root development of crops; their absolute amounts are however never very high. Micronutrients for crops and animals are in low supply.

Most of the nutrients are in fact stored in a thin humus-rich topsoil and in the forest vegetation itself. Nevertheless, in the absence of dense or poorly drained layers lower down in the soil profile, the forest vegetation can obtain adequate foothold. It also can capture some nutrients through deep rooting from the less weathered substratum, and encounters a soil biologic environment suitable for quick and effective recycling of moisture and nutrients. The quality of the seemingly very monotonous forest cover (timber volume, penetrability, species richness) varies in fact quite strongly with variations in subsoil conditions - as borne out by early FAO forest inventories and recent radar-based natural resources mapping by the Radamproject of Brazil.

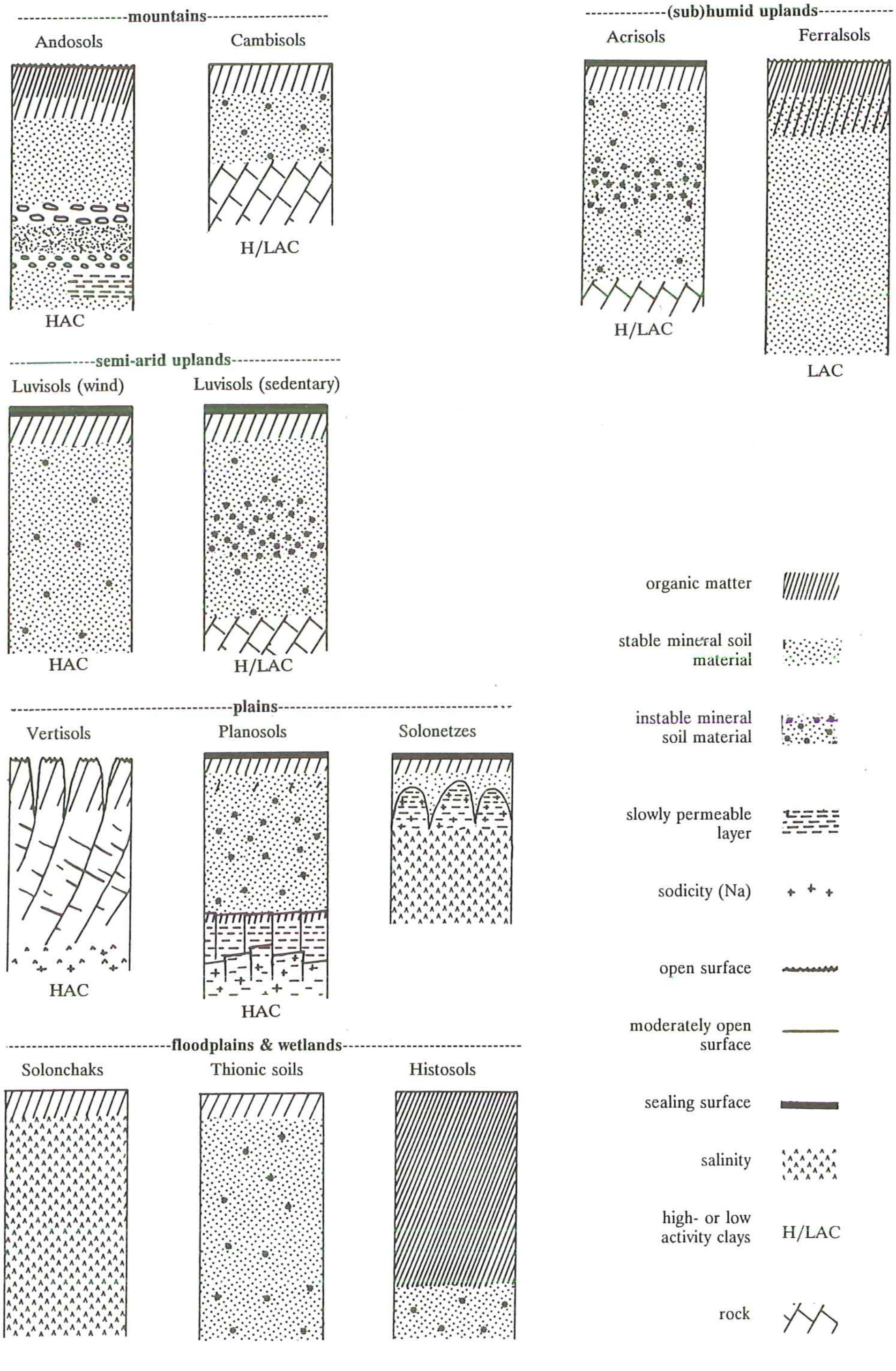
The traditional shifting cultivation system - 2 to 3 years mixed cropping after slash-and-burn land preparation -, although resulting in an ungainly visual landscape at short term, is a well-adapted low-technology use of these tropical forest lands. At high-technology level the same can be said for the growing of perennials such as rubber and oilpalm (Malaysia) or plantation forestry. At land preparation for these purposes care should be taken not to destroy the humus-containing topsoils - as once again demonstrated by the experiences in the Jari silvicultural project on the north bank of the lower Amazon.

Well-managed pastures may also be successful, by planting adapted cultivars of grasses and leguminosas immediately after slash-and-burn land preparation. In practice, however, it often concerns large ranches with less-than-careful management. Experience in Brazil has shown that on such ranches the animal productivity declines rapidly after about six years, through compactation of the topsoil, the proliferance of noxious woody herbs and the multiplication of insect pests. It is moreover difficult to restore a forest cover on such degraded ranching land because of dry spells and excessive insect fretting. The result is often a low bushy type of wasteland for many years, such as the "alang-alang" fields in Sumatra.

Continuous cultivation of annual crops on year-round basis with high-technology inputs such as regular tillage, fertilizing and chemical weed and pest control, has always been considered impossible. In recent years, however, a US-supported pilot programme for such an advanced farming system has been introduced in the Yurimaguas areas of the Peruvian Amazon. This programme has demonstrated that it **can** be done. The technology has therefore been much advocated as **the** solution for the humid tropical forest zone: concentration of high-technology food production on relatively small areas, leaving the surrounding forest intact. At farmer's level, however, the method is turning out to be less than successful. It requires too heavy investment in capital and labour for year-round chemical weed- and pest control. Frequent machine-operated tillage is needed to keep that particular soil in well-aerated condition and to prevent its large-scale washing-away at the occasional excessively heavy rain shower. In practice, the traditional shifting cultivation tends to increase rather than to diminish in the wide surroundings of Yurimaguas. At present, therefore, the Yurimaguas group of scientists is also developing intermediate and low-technology farming systems (alley and perennial cropping).

It should be pointed out that the Yurimaguas soil may be representative for some of the fringe areas of the low-altitude humid tropical forest zones, but is not so for their main, central parts. The Yurimaguas soil, though acid as well, is texture-differentiated, has significant percentages of silt, a less than stable structure (appreciable percentage of water-dispersable clay), and a high-activity clay mineral assemblage (25-30 cmol(+)kg^{-1} per 100 grams of soil: hence 5 to 10 times more active than the xanthic Ferralsols of for instance Manaus/Belém, Yangambi or Malacca). This observation may illustrate that the "transfer-of-technology" value of advanced in-situ agronomic research does hold good only if the spatial diversity of the soil conditions in the humid tropics is established and taken into account.

It should also be noted that the extent of Ferralsols on the existing FAO-Unesco world soil maps has been strongly over-emphasized. With the advance of remote sensing-supported mapping, it is now becoming apparent that within the regions of low-altitude humid tropics there are not only parts with high-activity clays like at


mountains
Andosols
Cambisols
HAC
H/LAC
(sub)humid uplands
Acrisols
Ferralsols
H/LAC
LAC
semi-arid uplands
Luvisols (wind)
Luvisols (sedentary)
HAC
H/LAC
plains
Vertisols
Planosols
Solonetzes
HAC
HAC
floodplains & wetlands
Solonchaks
Thionic soils
Histosols
organic matter
stable mineral soil material
instable mineral soil material
slowly permeable layer
sodicity (Na)
open surface
moderately open surface
sealing surface
salinity
high- or low activity clays
H/LAC
rock

Yurimaguas and Acre State of Brazil, but also very sizeable expanses of land with either steep topography, or with excessive percentages of cobbly or massive laterite concretions and sheets, or with excessively drained very sandy soils, or with imperfectly drained soils with white sandy topsoil (the latter in Rio Negro area of the Amazon, on Kalimantan, and in the eastern part of Congo). These lands are definitely unsuitable for any type of agricultural use. Their original vegetation not only protects the land from irreversible degradation, but also in itself may consist of a very specific floral species composition ("niches"), of unique value as natural gene banks for future breeding programmes, medicinal or ornamental use, etc.

Research needs:
- Development of adapted methods to characterize the different soils, including the nature of their organic matter, and their inherent structure stability.
- Further development of a methodology for multi-purpose forest land evaluation (for forest reserves, forest production areas; perennial cropping, upgraded forms of shifting cultivation, etc.). Socio-economic research on acceptance of such a methodology at forest-people level, ensuring effective planning of alternative land uses on a sustained basis.
- Understanding of the processes involved in the functioning of the many subsystems of the tropical forest ecosystem.

The latter has already been taken up by the International Union of Biological Sciences (IUBS) at its networks of research on "Tropical Forests Diversity" and on "Tropical Soil Biology and Fertility" (TSBF). The second network, in cooperation with Unesco-MAB and ISSS, aims at improvement of soil fertility in the tropics by biological means, through comprehensive studies of the basic interactions between Litter, Plant and Soil.

2.2 Reddish Soils of the Subhumid Savanna Regions

In the subhumid tropical zones the soils are, on the average, more reddish than yellowish. They may be very deep, uniformly textured, very strongly weathered and very acid (**rhodic** or **acric Ferralsols**/Ustox or Acrox/Sols ferralitiques rouges) as in the Cerrado zone of central Brazil, part of the Llanos of Venezuela and parts of northern Mozambique, Zambia and Tanzania. Others are less deep, texture differentiated, less strongly weathered and only moderately acid (**ferric Acrisols**/ Ustults/Sols ferrugineux tropicaux) as in the Forest-Guinea zone of West Africa, many parts of subhumid eastern Africa, southern Thailand, etc. This difference in weathering stage is related to the length in time that the landforms concerned have been stable, and hence the degree to which more humid climates of the past have left their marks in the present day soil profile.

Except for their colour and moisture regime, the Cerrado soils of central Brazil are very comparable to the main soils of the humid tropics with forest cover: very deep, stable, with low or even extremely low-activity clay minerals, little silt, high percentage of exchangeable Al, and high to very high P-fixation (because of more iron oxides than in the yellowish ones, which also accounts for a higher stability). The present vegetation is a fire-resistant and Al-tolerant climax of tree savanna (woodland) of very low nutritive value.

Until recently, it was believed that the improvement and effective occupation of these soils by mechano-chemical or biological means was virtually impossible. Internationally supported agronomic research at several agricultural centres, notably the EMBRAPA-CPAC Centre at Planaltina near Brasilia, has proven that high-technology management of these soils can be very successful. Its economic soundness is moreover proven by the vast increase in commercial farming with the new techniques in the wide surroundings of Brasilia.

The crux of the technology is the deepening of the rootable layer by thorough mixing of the soil with lime till at least 1 m depth. Such thorough mixing of Ca (and Mg and P) can be done either by deep plowing or by sulphate-strengthened superficial dressings. This eliminates the exchangeable Al that otherwise acts as a firm barrier to deep rooting, thereby inducing physiological drought at dry spells within the rainy season. Deep placing of slowly desintegrating rock phosphate in the soil overcomes the high P-fixation, without loss of this expensive fertilizer by leaching to the substratum.

Other fertilizers, including micronutrients, are added in accordance with the specific requirements of the crop and the detailed chemistry of the soil. Rotational growing of leguminous crops, including soybeans, helps diminish the need for application of N-fertilizers.

The economic success is in part due to the fact that not only are the soils very stable and open-surfaced - no need for repeated tillage after heavy showers, and small erosion hazard -, but also because large tracts of flat or nearly flat lands are concerned. The pronounced dry season moreover prevents the proliferation of weeds and pests, thereby reducing the costs of their control. These are all factors not prevalent on many of the yellowish Ferralsols of the humid tropics.

The agronomic experiences on the Cerrado lands of Brazil may well be transferable to parts of eastern and southern Africa with similar topographic, soil and climatic conditions such as the "high veld" areas of northern Mozambique, Zimbabwe and Zambia, parts of Tanzania and some parts of the "medium-potential" climatic zone of Kenya. Most subhumid areas of tropical Africa however have different soils, often on dissected uplands of acid crystalline rocks. These are less weathered and less acid, but with a lower inherent stability and smaller potential rooting depth (less deep soils, and/or with high percentages of laterite gravel). Percentages of exchangeable aluminium may be lower than in the Ferralsols discussed above, but the total amounts of Al can be substantially higher because of somewhat higher activity of the clay-minerals assemblage. Most important however is the tendency of such less weathered soils to surface compactation after rain-showers. It implies a need for repeated tillage before and after sowing or planting, for sufficient rainfall penetration, for aeration and for prevention of erosion of the sheetwash type. This repeated tillage, if done with heavy machinery, has by itself a detrimental effect on the less-than-stable subsoil, making the usually quite undulating lands prone to gully erosion. An additional problem is the low reliability of the rainfall, often bimodal, in many African regions with these soils. This type of problems and their prevention has been amply demonstrated at the soil management trials on the permanent-cropping plots of the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria and at the experimental sites of the International Council for Research in Agroforestry (ICRAF) in Nairobi, Kenya. Intercropping, alley cropping, contour plowing, bench terracing and use of only light machinery at land clearing and tillage are solutions, but obviously at a lower level of feasibility in a macro-economic sense.

To be complete, one should mention that both in the humid and subhumid tropics there are excellent soils, developed often on permeable basic rocks or on older volcanic deposits: the **Nitosols** (*sensu stricto*) of the FAO-Unesco Legend. They are deep, dark reddish brown, porous and have a very stable structure. These soils have low to medium-active silicate clay minerals (including meta halloysites) and relatively high amounts of free, active iron oxides; this combination results in relatively high specific surface of these throughout clayey soils, with associated good moisture and nutrient storage facilities. Many of the older agricultural research stations of Africa and Asia, and small-holder pioneer settlements in forest zones, are located on these special soils - giving an erroneous impression of the agricultural potential of the region as a whole.

On the other hand, there are widespread occurrences of soils with banks of laterite gravel or massive ironstone sheets (petro-plinthite), in particular in West Africa. Though most of these occurrences have originated under different edaphic and climatological conditions than the present ones, they are a strong impediment for agricultural use of the land. This not only in respect of tillage (use of implements), but also because of the reduction of the total soil volume that can store moisture and nutrients - even though the laterite itself may contain a reserve of nutrients in pockets of weatherable minerals. Little or nothing can be done to improve these stony soils.

In a number of areas, such as the southwestern part of Amazonas State of Brazil there are large expanses of flat land with the presence of the pre-stage of stony laterite in the subsoil, in the form of reddish mottled clay ("plinthite" or "Buchanan's laterite"). This may harden irriversibly upon removal of the natural vegetative cover. The popular reports of hazards of large-scale "lateritisation" at deforestation in the humid tropics give however an overly negative impression on the nature of the problem. It is more a long term geologic-geomorphologic process, due to changes in climate and in erosion base, than a short term pedological one.

Research needs:

- Study of factors and processes determining surface and subsoil instability of Ferralsols and Acrisols, and development of adapted tillage or no-tillage practices.
- Basic studies of P, S, and Al behaviour in representative examples of different subtypes of these soils, in different agroclimatic environments.

- Development of methods for plant-growth oriented physico-chemical characterization of the soils, not only in the laboratory, but also at field surveys.
- Methods for characterizing organic matter and its biological activity, by non-destructive means.
- Research on age and stability of landscapes in relation to degree of soil weathering.
- Interdisciplinary research on laterites and lateritization processes, including agreement on nomenclature of its textures and structures.

The International Board of Soil Research and Management (IBSRAM) has already taken up the Acid Red and Yellow Soils of the Tropical Uplands as a major item in its soil management networks programme.

3. CRUSTING SOILS OF THE SEMI-ARID UPLANDS

On the drier tropical and subtropical uplands the main problem is not soil acidity but an unfavourable soil structure, especially as regards the topsoil. In many situations the overhead climatic conditions would allow the growing of one annual crop in most years. A three-months rainfall of 700-1000 mm is sufficient for crops such as millet, sorghum, cowpea and groundnuts to provide economic yields. It then depends on whether this rainwater can fully penetrate and be stored in the soil for dryland agriculture to be successful.

Moisture storage per-se is usually not a bottleneck, unless the soils happen to be very sandy (Arenosols) or very shallow (Lithosols; Cambisols, lithic phase). Many of the soils in the semi-arid tropical areas have effective depths of 100 cm or so, with a subsoil structure and a clay minerals assemblage that guarantees an effective soil moisture storage capacity of at least 100 mm. A critical factor is however the degree to which the surface condition allows the rainwater to penetrate, right from the start of the rainy season.

Many soils of the semi-arid savannas have a sandy topsoil. This can be because the over-all texture of the parent materials is sandy (wind-transported coversands, or braiding-river deposits). Another cause is strong textural differentiation between topsoil and subsoil as a result of the pedogenetic illuviation process (formation of an "argillic"-B horizon: **Luvisols**, **Acrisols** / Alfisols, Ultisols) acting on sedentary parent materials from either sedimentary rocks or crystalline basement material. These sandy topsoils may, or may not, be prone to a form of crusting called **sealing**. This is the formation of a thin layer (1-5 mm) at the surface of the soil that is very dense and hard when dry, without any porosity, and sometimes even water repellant with algae growth: "roof-tile" conditions. As secondary processes, local sheetwash may then cause the formation of sheets of loose coarse sand on top of the sealed layer, and wind action may result in sandy micromounds.

As a result of the sealing, rain water falling on bare ground cannot penetrate into the soil, and therefore runs off side-ways, even at very gentle slopes. It may take more than one full month of rain before this sealed layer is sufficiently softened and broken up to allow rain water to enter the soil.

An added problem of this sealing is the impediment or straining of seedling emergence; this because of the strength needed to break through the crust, and the formation of a oxygen-deficient layer immediately below it.

To be complete: practically all soils in regions with seasonal rainfall and absence of a cold or frost season have a tendency to surface compaction. Occasional dry-season showers, sun baking and cattle trampling cause a hard surface layer. What counts is the degree to which the topsoil material re-compacts, re-seals after being tilled. The "liability to re-sealing after tillage operations" is therefore the right name for the soil property concerned.

Examples of failure of large-scale crop production schemes on such lands abound (schemes on groundnut, cotton, maize or fuelwood production). The schemes tended to be located on large unoccupied areas of smooth topography with theoretically sufficient rainfall for one crop and no apparent soil limitation - until actual cultivation started. It was not without reason that the traditional farmers have avoided such areas in the past!

Studies in the Sudan-Sahelian zone of West Africa, but also in Australia, eastern and southern Africa, have demonstrated that this sealing process - or rather the liability to re-sealing - is occurring on soils with a broad size-distribution of the sand fraction. A mixture of coarse, medium, fine and very fine sand particles, together with a fair percentage of silt and clay (each 5 to 10%), apparently favours a very close packing of particles, under the influence of raindrop splash and at low amounts of structure- and porosity stabilizing constituents such as humus and iron compounds. At clear tops of any particular sand fraction, at lower amounts of silt, and/or higher amounts of clay this close packing does not take place.

Sealing-prone mixtures of grain sizes occur in topsoils on the more acidic crystalline rocks such as granites and gneisses, or on sedimentary rocks such as quartzitic sandstones; both contain a large supply of non-weatherable quartz-grains and relatively few sesquioxides or free lime. It concerns sedentary soils, but also alluvial/colluvial ones with such rocks as source.

Sealing-prone mixtures are also prevalent on the older coversands in fringe areas of present-day deserts (Sahara, Kalahari, central Australia), viz. those coversands that have not been repeatedly re-transported by wind action with its automatic relative concentration of the fine sand fraction. Examples are the sealing "sables rouges" of the "brousse tigré" vs. the non-sealing "sables jaunes" of the Sudan-Sahelian zone of West Africa; the non-sealing "red-sand" plain vs. the lower-level "sealing loam" plains of northeastern Kenya.

The absence or presence of a re-sealing hazard has not only determined strong differences in types of vegetation, but also clear patterns of traditional cropping vs. non-agricultural use of the land such as grazing or "forest" reserves. The importance of grain size distribution for re-sealing liability has been recognized at the selection of experimental grounds of the ICRISAT Sahelian research centre near Niamey. An international symposium on "the Assessment of Surface Sealing and Crusting" (Ghent, Belgium, 1985) has given more insight in the spatial distribution and the nature of sealing processes in the semi-arid tropics and subtropics.

Remedial action on sealing-prone soils is quite difficult. Repeated tillage before and during the crop growing season is normally uneconomical, whether done by mechanical means or by traditional practises such as howing. Increase in the humus content of the topsoil is very difficult, not only because this would require several years of reservation of the very valuable rain water for soil improvement, but also because much of the fresh organic matter is oxidized during the hot dry season or brought deeper underground by termite activity. The fresh organic matter would need to be humified soonest in the topsoil to become effective as an open-structure stabilizer. It is quite possible that part of the reported remedial action of P-fertilizing on these soils in the Sahel zone (Wageningen PPS project) is due to a quickening of this humification process through increase of microbiological activity.

Application of artificial soil "conditioners", produced on the basis of polymer technology, may be a solution for the future. At present, however, most of the commercially available conditioners would appear inadequate, if only because of the limited life-span of activity.

Most important at the development of large schemes or small-holders settlement in the agro-climatological zones concerned is a careful mapping of the various soil patterns, in relation to the sources of the parent materials and the geomorphological history of the land. At these inventories one needs to give special attention to topsoil properties, to the relationship soil-vegetation, and to the behaviour of the rain water at the beginning of the rainy season.

For a number of physiographic situations it may be an economically sound proposition to further denude sealing-prone land units, thereby actively concentrating the rainfall on adjoining, lower lying and less sealing prone land units ("water harvesting"). This is in fact not unknown in traditional land use, with North Yemen and northwestern Nigeria as examples.

Finally, it should be mentioned that the pattern of sealing - non sealing sandy topsoils should also be taken into account at the efforts to increase the supply of tree products (fuelwood, timber, cattle feed) through the establishment of communal village-forest production patches. Unused space near such villages has often been in that condition precisely because of soil moisture supply limitations, preventing rapid tree growth. Experiences in the colonial period of northern Nigeria with plantations of *Azadirachta sp.* may serve as an example.

Research needs:

- Further study of the nature of the "sealing" problem and the forces acting upon it.
- Combined geological-geomorphological-sedimentological-pedological inventories of land patterns.
- Study of materials and methods to suppress the sealing hazard through the application of industrial amendments, chemical fertilizing and/or by biological means.

4. POORLY-STRUCTURED SOILS OF SUBHUMID TO SEMI-ARID PLAINS

Two main categories of soils are involved, viz. the strongly cracking black or grey clay soils ("Black Cotton Soils"), and soils with hardpans at depth (Clay-pan Soils; Sodium-pan Soils). These soils predominate in the subhumid to semi-arid tropics, where they usually occur on extensive plains that are propitious for mechanized farming, often with irrigation. A group of Dutch soil scientists has summarized the identification, reclamation and management of these soils, at the occasion of the 25th anniversary of the International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands, in 1980[1]. Therefore discussion on these soils will be relatively short.

4.1 Cracking Clay Soils

The Black Cotton Soils (**Vertisols**) occur in very large expanses in central India, central-south Sudan, Mexico, Uruguay, southern Brazil, and eastern Australia. Minor areas can be found in practically all tropical and subtropical countries, wherever there is rich parent material (basalt, limestone, calcareous clayey sediments) in a position of accumulation rather than leaching of their weathering products.

The soils are moderately deep; of poor internal and often also poor external drainage; black, dark grey or dark reddish brown coloured; of high clay content; very strongly structured (prismatic), and with characteristic cracking features. In dry seasons V-shaped cracks occur right from the surface down to nearly the unweathered rock or sediment. These cracks close through swelling of the clays after the first rains, leading to internal displacement of soil material. This results in vertical homogenisation of the material through a churning process; in polished faces on the large structure elements ("slickensides"), and often in a micro-topographic surface irregularity ("gilgai") which is associated with strongly varying depth of the soil at short distance. These specific properties are due to the dominance of swelling clay minerals, mainly montmorillonite.

Vertisols vary in depth (relatively shallow ones abound in India); in base status (they are usually base-saturated, but acid ones are known, for instance in Venezuela); in degree of cracking and churning (relatively small in the Gezira area of Sudan); in contents of free lime and salts; and especially in their surface properties. Some have a stable open surface structure of fine porous elements (crumb structure: "grumic" Vertisols), others have a thin crusty surface that is hard in the dry season and sealed-off in the rainy season ("mazic" Vertisols). The latter ones present problems as regards rain water penetration, and at mechanical tillage to arrive at a good seed bed.

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[1]Reprinted as ISRIC Technical Paper 12.

The main agronomic problem of Vertisols is the narrow range of soil moisture conditions at which they can be tilled. When wet they are very sticky and plastic, and machines or hand implements get clogged and cause soil compaction. When dry, the soil surface is often very hard, and excessive machine or hand power is then required for any tillage. Land preparation therefore can only be executed during a short period of time at the beginning of the rainy or irrigation season.

A second problem is their drainage. When wet, the clays swell and close off cracks and macropores, with very low infiltration and percolation rates and horizontal hydraulic conductivities as a result. Open surface drains and ridge cultivation is often the only feasible solution; mole or tile drainage systems break down repeatedly because of the swell-shrink nature of the soil.

Annual crops rather than perennials should be grown on these soils. Roots of most shrubs and trees break at crack development in dry periods, and their stems are often inclined in different directions due to the swell-shrink process (as do telegraph and fencing posts!). This is also the reason why in natural state the Vertisol lands are usually devoid of trees or shrubs - with the exception of some adapted species such as *Acacia* and *Balanites spp.*. Road building through Vertisol areas requires deep in-filling with inactive construction material, to avoid the development of undulations and cracking-up of the surfacing material.

Successful agricultural management research for Vertisols has been carried out in India, Australia and the Sudan. In many other countries the lands concerned remain however under-utilized, considering their over-all high-fertility status.

Research needs:
- basic physico-mechanical studies on the processes leading to the formation of the various types of Vertisols and their gilgay patterns.

The IBSRAM organisation (see 2.2) is already organizing a network of management-oriented research on these soils.

4.2 Hardpan Soils

Often physiographically associated with Vertisols are the Clay-pan Soils or **Planosols** (Albaqualfs a.o.). They occur extensively in northeastern and southeastern Brazil; in the Paraná basin of Brazil, Paraguay and northern Argentina; in Bangladesh; in the Chad basin, and in Australia. They are however found in many other countries, too, for instance in Kenya, where until recently they were often mistaken for Vertisols of the mazic type because their subsoil shows similar swell-shrink features.

Planosols are imperfectly to poorly drained and moderately deep in pedogenetic sense. Agronomically speaking they are quite shallow: they have a dense, coarse angular blocky to prismatic clayey layer ("claypan"), abruptly underlying a more or less sandy topsoil which has a poor, massive structure unless quite humic. Just above the transition to the claypan these soils have a poorly drained layer because of water stagnation: "stagnic" features because of a pseudo-phreatic level. In this layer, active destruction of clay particles takes place ("ferrolysis" process) and its micro environment is unsuitable for roots because of lack of oxygen.

The suitability for plant growth therefore depends completely on the properties of the topsoil: it may be humic or low-humic; acid or non-acid; coarse sandy to fine loamy or silty; soft to very hard; and can vary in thickness from 20 cm to about 100 cm - depending on the nature of the parent material and the weathering agressivity of the climate. In general, plant growth is fair at best. Under natural conditions the soils support only grassland, bushed grassland or low forest. The choice of crops is limited: dry-foot crops such as wheat, soybean, maize and cotton do poorly. Trafficability of the fields in the wet season is poor because of low bearing capacity of the water-soaked topsoils with their low structure stability.

Pasturing and paddy rice cultivation are the most appropriate uses. The latter crop in fact finds its natural niche here: puddling of bunded fields to obtain an anaerobic mud layer above an impermeable layer is hardly necessary - it is there already!

Improvement of the structure and the drainage condition of Planosols is difficult. Mechanical breaking-up of the claypan is very expensive and any positive effect often lasts for a few years only. Deep drainage for dry-foot crop growing through a tile drainage system is very costly because of the narrow spacings required and the high incidence of breakdown. The claypan has not only a very low (vertical) percolation rate and (horizontal) hydraulic conductiviy, but often has swell-shrink properties like in Vertisols. Ferrolysis products may moreover clog the pipes. Repetitive mole-drainage in the water stagnation layer just above the claypan is in principle a good proposition, but the waviness of the surface of the claypan - vertical differences of 2-3 dm over distances of 5-10 m are common - may render this impractical at larger fields. Surface-ditch drainage, combined with cambered-bed preparation through judicious plowing, may be the only economical improvement, at both large-scale and smallholders farming.

The Sodium-pan Soils or **Solonetzes** (Natraqualfs a.o.) are in many ways comparable to the Planosols. On plains of old coastal sediments such as the Lower Tana area of Kenya and the Lagunas areas of southern Brazil - eastern Uruguay, they occur often in close spatial association.

The dense subsoil layer of Solonetzes is not prismatic but columnar, with tongues of topsoil material in-between the very coarse structure elements. The subsoil has as added disadvantage that it is saturated with sodium or sodium + magnesium, giving the layer an extremely poor physical condition because of very low structure stability ("natric B horizon"). The arable topsoil is moreover quite thin and has often strong short-distance variation: from 40 cm to less than 5 cm at a few meters distance. Plowing of these soils therefore often results in scraping-off and incorporating part of the sodic subsoil material, thereby further deteriorating the already weak structural stability of the topsoil. Trafficability is even worse than on the Planosols, because of the presence of water-soaked mini-depressions ("slick spots").

Improvement of Solonetzes may be feasible in some circumstances, for instance when they are of localised occurrence within large areas of good soils, or at extreme population pressures. Massive applications of gypsum or incorporation of large amounts of organic matter (for instance form *Sesbania spp.*) is then required. Normally however such soils should be left undisturbed.

Research needs:
- development of adapted cultivars of dry-foot crops and of adapted lightweight tillage machinery.

5. SALINE OR SALINIZATION-PRONE SOILS OF ARID-ZONE PLAINS

Many soils of the flatlands in arid and semi-arid regions have high salinity throughout (**Solonchaks**/Salorthids) or at some depth (**Saline phases** of Gleysols, of Cambisols etc.). The latter may or may not be connected with presence of a permanent phreatic level with saline water.

In areas with high evaporation and sediments of high capillary-rise character such as very fine sands and loams, a contact between such groundwater and the rooting zone results in a high salinization hazard.

High-salinity adapted cultivars can be grown, but improvement of saline lands is often quite feasible, too. Leaching with irrigation water of good quality results in very suitable soils unless high percentages of sodium are present as well, the latter causing structure collapse and pan-formation once the salts have been washed out.

Successful long-term management of desalinized or salinization-prone land depends very strongly on a well designed deep drainage system, to keep any permanent groundwater table from making contact with the moistened rooting zone. This applies also to situations where such a groundwater level was absent originally - that is: at the start of an irrigation scheme - or occurred only at greater depth (deeper than 10 m). There are many examples of irrigation schemes where a salinity problem - or a salinity + sodicity problem - developed after an initial period of success. This because of a slow but steady rise of a phreatic level, thought to be too deep to have any influence. The long-term success or failure of irrigation in closed-basin areas, i.e. areas without external outlet of drainage water such as the Konya basin of Turkey, depends on careful monitoring and management of the scheme's drainage water.

Research needs:
- The US Soil Salinity Laboratory in Riverside, California and the International Institute for Land Reclamation and Improvement (ILRI) in Wageningen are contributing greatly to applied research, publications and training of irrigation- and drainage specialists of arid-zone countries.
- Also in the USSR, Hungary, India, and several Arab countries good research facilities exist.

The daily management of irrigation schemes, however, whether large-scale or at village level, often falls short of formulated objectives and scientific principles. The International Irrigation Management Institute (IIMI) in Sri Lanka is trying to remedy this.

6. POORLY DRAINED SOILS OF FLOODPLAINS AND WETLANDS

6.1 Floodplains

The soils of tropical floodplains vary strongly in their inherent properties (**Fluvisols**, **Gleysols**/Fluvents, Aquepts, gleyic or plinthic subunits of other soils: all expressions of varying texture and texture differentiation, humus content, acidity etc.). Their actual use is strongly conditioned by the type of flooding or submergence. Once empoldered and/or drained they are often highly productive - such as the "varzea" lands along the lower Amazon river - but may then also show or develop management problems because of extremely heavy texture (compare Vertisols), development of claypans (compare Planosols), sodic pans (compare Solonetzes), or high salinity (compare Solonchaks).

The patterns of occurrence of these different soils are often very intricate, requiring adapted lay-outs of irrigation and drainage systems on the basis of detailed topographic, soil and substratum mapping and evaluation. A sound knowledge of the geomorphological-climatological-sedimentological history of such floodplains can be very helpful. This applies for instance to the "fadama" areas of the Sudan-Sahelian zone of West Africa, including the interior delta of the Niger river in Mali.

Research needs:
- A comprehensive and practical system of classification of inundation regimes, as a major element in land evaluation for the areas concerned, whether to be empoldered or to be used for wet-foot crops. The depth, the duration, the flow force and its regularity, the quality of the water (pH, sediment load, salt content) and the period of the year in relation to the growing season, are all elements to be taken into account at devising such a system.
- Study of past climatological-sedimentological conditions as basis for detailed mapping.

6.2 Wetlands

The soils of tropical wetlands present some special problems, especially those of coastal wetlands (east Sumatra and south Kalimantan in Indonesia; parts of the Mekong delta; the Orinoco delta of Venezuela; the Casamance of West Africa etc.).

Large parts of these lands have a peaty surface layer, of 50 cm to several meters thickness, in water-soaked condition (**Histosols**). The peaty material can be of strongly varying character: dominance of little-decomposed fibric, foliar or woody elements; of half-decomposed plant remains ("hemic"); or of strongly decomposed organic material ("sapric"). These differences result in varying degree of shrinking and oxidation upon artificial drainage. In natural conditions they are covered with special types of vegetation ("peat forests").

Coastal peatlands are often underlain or fringed by non-organic mud layers of high sulfide content (called **thionic Fluvisols**, or potential Acid Sulphate Soils). Such soils have, in their natural water-soaked condition ("unripe"), a fair base saturation and can then support mangrove forest or some crops that can stand hydromorphic conditions. However, if the wetlands concerned are drained abruptly the sulfides turn into sulfuric anions that have a very strongly acidifying effect on the soil (to pH below 3.5) with complete structure collapse and compactation. In these conditions the soils are characterized by dirty-yellowish jarosite mottles and are then called **thionic Gleysols**, actual Acid Sulphate Soils, or "Catclays". They have extremely adverse chemical and physical properties for both natural plant growth and for crop production. They are moreover practically impossible to reclaim.

Until future research has come up with non-destructive methods of reclamation of tropical Histosols and Acid Sulphate Soils, the wetlands concerned should be left in their natural, undrained status. Ecologically sound land uses of such undrained wetlands can be grazing, local paddy rice cultivation, fishponds, shrimp production, mangrove pole production, and floral and faunal gene conservation.

Research needs:

- There is an active Working Group on Acid Sulphate Soils of ISSS, promoting exchange of information through organizing international symposia on the subject. Research on Tropical Wetlands Utilization is also strongly supported by Dutch Technical Cooperation (West Africa, Vietnam, Indonesia).

7. FINAL REMARKS

The above review of problem soils in the tropics and subtropics largely refers to the existing FAO-Unesco Soil Map of the World as regards geographic occurrences. For a large part this map, at the very generalized scale of 1:5.000.000, is however more than 15 years old and its preparation relied on soils information that for many tropical and subtropical areas was scanty at best. Partly prompted by the FAO-Unesco publication, there has been a strongly increased effort at soil mapping in these areas, helped by new tools such as aereal photography, radar images, and satellite imagery. This has resulted in vastly better information per country. The information is however often presented at scales, and with classification and mapping methodologies, that vary strongly per country, making international correlation and subsequent agrotechnology transfer a tricky business even for specialists. There is an urgent need for a new soil map of the world at large, and for the tropics and subtropics in particular, that combines all new information in a digestible form and at a scale that is of more relevance for development planning and ecological research at national and state/provincial level. Only then full advantage can be taken of research and management results obtained at one particular site. With newly developed hard- and software for digitized resources mapping, it is now in principle possible and feasible to arrive at digitized international soil maps at much larger scale - say 1:2.000.000 to 1:500.000. Interactive graphical systems make it also possible to combine such soils information with information on land forms, vegetation/land use patterns, agroclimatological zones, flooding regimes and other hydrologic data, etc. This, in turn, would provide the tools for comprehensive land evaluation per major land unit, with due incorporation of parameters inherent to locally existing or feasible new farming systems. A move is underway to start such an international programme[1] It will require the cooperation of many institutions and scientific disciplines, and also substantial funding, but the time would appear to be ripe for such an effort.

[1]See the SOTER project elsewhere in this Annual Report.

Fellowships at ISRIC

During the last decade a number of foreign soil scientists have spent a period from a few months up to one year at ISRIC, mostly for the preparation of a Soil Monograph or a Technical Paper.

Soil Monographs are publications of 100-150 pages on a major group of soils, taking ISRIC's soil monolith collection as starting point. The general aim is to strengthen the state of knowledge on the world's soil resources. They are intended for teachers and students in soil science at university level, soil survey institutes, etc. Up to now Soil Monographs on Podzols and Andosols have been published, those on Ferralsols and Vertisols are in preparation.

Technical Papers mostly concern methods, procedures and standards of analysis and work, and are of varying length.

ISRIC should like to get in touch with soil scientists who are acquainted with an important group of soils, e.g. soils in arid regions (Calcisols, Gypsisols), saline/sodic soils (Solonetz, Solonchaks), claypan soils (Planosols) or low-activity-clay soils (Lixisols, Acrisols).

The fellowships only cover lodging and full board, pocket money and insurance. No travel funds are available. Since the fellowships are tenable for scientists from OECD countries, only citizens of these countries need apply.

Please direct your interest to the Director of ISRIC.

3 REGULAR ACTIVITIES BY THE SECTIONS

3.1 SOIL MONOLITH COLLECTION

During the reporting period the number of soil monoliths increased with 9 to 785 (see table below).

Monolith collection, December 1988

Within parentheses: acquisitions in 1988

Australia	39	Mozambique	8
Belgium	4	Namibia	11
Botswana	7	Netherlands	24
Brazil	29	New Zealand	5
Cameroon	1	Nigeria	14
Canada	21	Norway	3
People's Rep. of China	15	Oman	4
Colombia	19	Pakistan	6
Czechoslovakia	8	Peru	1
Denmark (Greenland)	6	Philippines	6
Ecuador	20	Poland	14
Finland	5	Romania	11
France	12	Rwanda	10
Fed. Rep. of Germany	17	Rep. of South Africa	20
Ghana	4	Spain	20
Gabon	6	Sri Lanka	4
Greece	15	Sweden	17
Hungary	20	Switzerland	1
India	30	Syria	4
Indonesia	25 (9)	Thailand	13
Ireland	11	Turkey	13
Italy	17	United Kingdom	11
Ivory Coast	7	U.S.A.	25
Jamaica	3	U.S.S.R.	62
Japan	4	Uruguay	10
Kenya	65	West Samoa	5
Malawi	1	Yugoslavia	3
Malaysia (East)	11	Zaire	2
(West)	7	Zambia	11
Mali	9		
		Total	785 (9)

Acquisitions in 1988

Indonesia: Within the framework of the NASREC programme nine profiles have been collected by several staff members of the Centre for Soil Research, and ISRIC's soil scientist J.H. Kauffman.
The profiles are representative for the major soil types in four provinces of the Island of Sumatra. Profiles are sampled in the volcanic highlands and in the tropical lowlands. The volcanic profiles form toposequences on the Toba and Merapi volcanos. The lowland profiles are from sites with similar soils but under different land use, viz. forest, tree crops or cleared forest land with annual crops.

General

The number of acquisitions have never been as low as in 1988. Since most activities related to the Nasrec programme were concerned with the institutional building-up of the national collections, and not with taking soil monoliths, there came a nearly standstill in the increase of ISRIC's soil profile collection.

It is envisaged that in the coming few years about 5-10 soils will be sampled per year, depending on the continuation of the NASREC programme.

Preparation of monoliths

Although there is still a large amount of profiles that needs impregnation, the number treated in 1988 was very low due to shortage of personnel for this activity. No training course was given this year.

3.2 LABORATORY

Regular analytical work, related to the collection

Because of the winding up of the current NASREC project, analytical work was focussed on profiles from Ecuador (7), Indonesia (4), and Mali (8). A number of profiles from the first two countries are developed in volcanic ash and their data were included in the database of the now completed Soil Monograph 2 on Andosols.

Other work

- For several departments of ITC a large number of soil and water analyses were carried out related to research and student field work.
- Research was aimed at standardization of procedures included extensive testing of washing procedures in the NH_4Ac CEC determination as well as testing of four "promising" new CEC procedures (LABEX commission).
- Laboratory staff participated in the ITC/University of Pattimura project (Ambon, Indonesia) and was part-time seconded at the Wageningen Agricultural University.

3.3 MICROMORPHOLOGY

Technical work

The treatment of undisturbed soil samples and the subsequent preparation of thin sections is carried out by a technician of ISRIC at the laboratory of the Netherlands Soil Survey Institute (Stiboka) at Wageningen. At the end of 1988 this technical cooperation, which existed since 1972, came to an end. Thin sections will now be made in commission by Stiboka.

In 1988, 102 samples were received for treatment from Indonesia. In the same year 104 thin sections were prepared. For the regular soil collection of ISRIC a total of 88 thin sections were made. These concerned soils from Ecuador, Indonesia, and Mali. Fourteen thin sections were made for other studies, including samples for various research and student's projects of ITC.

Investigations

The regular descriptions of thin sections are carried out according to the system as proposed in the Handbook for Soil Thin Section Description, which was published in 1985 under the auspices of the ISSS. The wide range of soils available at ISRIC permits a critical testing and application of the definitions and terminology of the new system. It is the aim of ISRIC to support the system by making suggestions for improvements so that the Handbook can be strengthened with time.

As part of the NASREC programme, thin sections of representative soils from Ecuador, Indonesia and Mali were studied. Descriptions and photomicrographs were made to be included in the permanent exhibitions which were established in these countries.

On request of the Organizing Committee of the 8th International Working Meeting on Soil Micromorphology, photomicrographs and explanatory descriptions were made of thin sections of 5 soils from Hawaii. This information was made available to soil scientists participating in a field trip in Hawaii, in July 1988.

A study of thin sections of four soils from Oman, in cooperation with Dr. E.M. Bridges of the University of Wales, Swansea, was concluded. The results were presented in an oral paper at the 8th International Working Meeting on Soil Micromorphology, held at San Antonio, Texas, in July 1988.

A study of thin sections of a soil with a cemented subsurface horizon from Ecuador was studied to obtain a better understanding of the cementing agent. The results were presented in an oral paper at the same venue.

A start was made with a planned series of publications on various aspects of micromorphological phenomena. The first set of 10 photomicrographs/slides with an explanatory description of features concerning the decay of organic materials was prepared for discussion. Several other subjects are in preparation.

3.4 DOCUMENTATION

ISRIC Soil Information System (ISIS)

During the year the number of monoliths from which data was entered in ISIS increased from 140 to about 220. This work was realized by Ir. J.H.M. Scholten, using a part of his sabbatical period for studying Brazilian and Mozambican soils and Mr. D. Naujokat, student at the Geographical Institute of the University of Kiel, Fed. Rep. of Germany. A part of the input of data resulted from the first field mission to Indonesia within the framework of the NASREC programme.

The transfer of data from earlier collected profiles stored in classical manual archives in ISIS is very time-consuming, since updating the original information is a careful process of evaluation and completion. This is partly due to the fact that in the course of time the amount of desirable information has increased considerably, which necessitates updating the information from the profiles collected earlier.

The data is entered in ISIS in codes. These codes are given in Technical Paper 14: Guidelines for the description and coding of soil data (revised edition). This publication forms a set together with Technical Paper 15: ISRIC Soil Information System: user and technical manuals, and two diskettes with the computer programme. This set is now available.

The programme runs with database management system dBase III on personal computers of the IBM/MS-DOS type with a 5.25" 360Kb floppy drive and a hard disk of 20 mB or more and a printer which can print condensed characters. It can also store a limited number of profile descriptions on a computer of the same type with two 3.5" floppy drives and a printer of the above mentioned type.

The ISIS programme was demonstrated during the second NASREC missions to respectively Ecuador, Indonesia and Mali. Translation of the English standard profile description appeared to be a necessity. Because the main part of the data is stored in coded form, automatic translation is possible. First draft versions in Bahasa Indonesia and French were developed.

Another addition to the ISIS system is a programme to make selections from the data stored. This programme was made by Ing. A. Verhagen, who also made several adaptations to the original ISIS programme.

In order to make all ISRIC staff familiar with the use of personal computers in 1989, 18 personal computers are on order and a staff training plan was made.

Map collection and Library

Maps and publications form an important part of the Centre's documentation. The coverage is the whole world with strong emphasis on developing countries. The collection is dominated by soil and related geographic information on climate, vegetation, land use, land capability, geology and geomorphology. At present the map collection includes about 4500 sheets and some 600 photo-negatives and transparencies.

One of the purposes of maintaining the map collection is its use for updating of the Soil Map of the World at scale 1:5 million and the compilation of a new, computerized world soil map at 1:1 million. A large draw-back in its usefulness is the fact that the holdings are not yet entered in a computerized database.

The library collection includes about 5000 publications, about 2500 of which are on a regional basis, mostly reports on soil and land surveys. The remainder is constituted mainly by textbooks on soil science and related subjects, bibliographies and atlases. There is an annual increase of two to three hundred publications. ISRIC has subscriptions to about 35 journals. The map and book collection increasingly serves as a source of basic information for scientists, students and consultants in soil correlation studies and in thé preparation of missions. There is especially an increase in its use by students of Wageningen Agricultural University, participants of the M.Sc. Course in Soil Science and Water Management, and the International Course for development-oriented Research in Agriculture (ICRA). Towards the end of the year a computer was installed and the library holdings will be entered during the years to come. Use will be made of the Cardbox Plus computer programme, which easily accepts information from the computers installed at the main libraries in Wageningen, notably that of the University.

3.5 SOIL CLASSIFICATION, CORRELATION AND MAPPING

ISRIC continued to cooperate in the revision of the Legend terminology of the FAO-Unesco Soil Map of the World. An ad-hoc working group, composed of Mr. M.F. Purnell, FAO, Prof.Dr. R. Dudal, Catholic University of Leuven, and W.G. Sombroek of ISRIC reviewed and incorporated many suggestions received from specialists working in different countries. Good use was also made of many of the modifications for the USDA Soil Taxonomy system recommended by its International Committees in which ISRIC staff participates.

A provisional edition of the Revised Legend was published as Working Paper and Preprint 88/1; the final text will be issued by FAO as World Soil Resources Report no. 60, with a pocket edition by ISRIC.

3.6 TRANSFER OF KNOWLEDGE

Group visits

About 1100 persons visited ISRIC in groups, mainly from educational institutions, such as universities, agricultural and technical colleges, and from international training courses, congresses and meetings. The ISRIC collection has been incorporated in the courses on regional soil science of Wageningen Agricultural University and its M.Sc. course on Soil Science and Water Management, of the Tropical Section of the National Agricultural College, Deventer, and of other courses held in the Netherlands, e.g. at ITC, Enschede.

In addition, groups of students are regularly coming from Belgium, the Federal Republic of Germany, Sweden and the United Kingdom. See also Appendix 1.

The lecture room of ISRIC is increasingly being used for lecturing, meetings and courses, e.g. for the neighbouring International Agricultural Centre, the 'Tropenbos' programme, and various commissions and working groups of the Wageningen Agricultural Sciences community.

Individual visits

The number of people coming individually or in small groups is estimated at about 400. Most visitors are professional soil scientists, and two-third come from abroad. They usually visit ISRIC for discussions with staff members or for consulting the monolith collection, the library and the map collection.

Course on the Establishment and Use of National Soil Reference Collections

The objective of this course is to train soil scientists, in particular from developing countries, in all aspects related to national soil reference collections.

Until 1987 the course was held annually. In the future the course will be given bi-annually, therefore no course was held in 1988.

An evaluation of the courses given in the period 1981 - 1987 has been made. The figure illustrates the development of the course, expressed by the number of man-days per course, in the period 1981-1989. The causes for the increases are indicated.

Based on the advice of Netherlands Advisory Council and the evaluation, a project proposal for a revised course in combination with after-training-service has been made.

Major changes proposed are:

- the course programme will be extended from six weeks to two months, mainly because of the introduction of computerized data handling and practical exercises in the use of a soil reference collection and all related information;
- the course will be given once in the two years;
- the number of participants will be increased;
- after-training-service ought to be guaranteed for course participants;
- a larger external financial contribution will be sought.

Extramural lectures

As in the previous years, staff members of ISRIC participated in the Standard course Soil Survey of ITC, Enschede, The Netherlands by giving lectures on special topics of soil genesis and classification, mineralogy and soil chemistry. Both the FAO-Unesco Soil Map of the World and the USDA Soil Taxonomy system were discussed. These lectures are illustrated with slides, hand-outs, lecture notes and other materials derived from the ISRIC collection.

ISRIC was invited by the Swedish University of Agricultural Sciences to give lectures on classification of soils in the tropics and on land evaluation in Uppsala, Sweden. J.H.V. van Baren gave these lectures.

ISRIC arranged a 5-day course on soil classification for students of the Free University, Amsterdam. D. Creutzberg gave lectures and organized the course.

Lectures by guests

Dr. Joel Dan (The Volcani Center, Israel): Soils and Landscapes of Israel, with special attention to dust accumulation.

Publications issued in 1988

Technical Paper

TP 14 Guidelines for the description and coding of soil data, revised edition, 1988

TP 15 ISRIC Soil Information System - user and technical manuals, with computer programme, 1988

TP 17 Soil horizon designation and classification, 1988

Working Paper and Preprint

88/1 Revised Legend of the FAO-Unesco Soil Map of the World (provisional edition of the final text). February, 1988.

88/2 Soter Procedures Manual for Small-scale Map and Database Compilation (for discussion). Compiled by J.A. Shields and D.R. Coote, LRRC, Canada. February 1988.

88/2b Soter Procedures Manual for Small-scale Map and Database Compilation. Procedures for interpretation of soil degradation status and risk (for discussion).

88/3 International Conference on: "Soils and the Greenhouse Effect". Draft background paper. A.F. Bouwman. February 1988.

88/4 Guidelines for General Assessment of the Status of Human-induced Soil Degradation. L.R. Oldeman. April 1988. Also in French version.

88/5 Micromorphology of Cangahua: a cemented subsurface horizon soils from Ecuador. D. Creutzberg et al.

88/6 Soil management of Spodosols with Plaggen epipedon. D. Creutzberg and H. de Bakker. Paper presented at V Int. Soil Correlation Meeting (ISCOM), Lake Placid, USA, October 1988.

88/7 Space and Time Dimensions of a World Soils and Terrain Digital Database. M.F. Baumgardner and R.F. van de Weg. Presented at Symposium on Land Qualities in Space and Time, Wageningen, The Netherlands, August 1988.

88/8 A Model for a Soils and Terrain Digital Database. Development of a database structure for SOTER and implementation in a Relational Database Management System (RDBMS). Prepared by John H.M. Pulles as a M.Sc. study, Wageningen Agricultural University, in the framework of the GLASOD Project, ISRIC.

Consultancy/Mission Report

88/1 Soils of Eastern and North-eastern Africa at 1:1 M scale and their irrigation suitability. R.T.A. Hakkeling and Endale D.M.

88/2 Uitgebreide Korrelgrootte analyse. R. Smaal.

88/3 An Agroclimatic Characterization of Madagascar. L.R. Oldeman.

88/4 Report of the Correlation Field Trip and Meeting First Pilot Area. Glasod-Soter Project, 6-19 June 1988. W.L. Peters. July 1988. Also in Spanish.

88/5 Report of the Second Correlation Field Trip and Meeting First Pilot Area, South America, GLASOD-SOTER Project, 25 August-1 September 1988. W.L. Peters, editor. October, 1988. Also in Spanish.

Also published were:

- Proceedings of the First Regional Workshop on a Global Soils and Terrain Digital Database and Global Assessment of Soil Degradation. W.L. Peters, editor. Soter Report 3. ISSS, in cooperation with UNEP and ISRIC. Also in Spanish.

4 NON-REGULAR ACTIVITIES

4.1 PROGRAMMES

The National Soil Reference Collection Programme (NASREC)

During the last decade, ISRIC has been requested by soil institutes in many countries to support the establishment of National Soil Reference Collections (NASREC's)[1]. Colombia, the People's Republic of China, and Mexico already received assistance through incidental project support. For several others initial steps have been taken through the six-weeks training course on this subject. The NASREC programme, a three-year project financed by DGIS/UNEP, enables ISRIC to strengthen its capacity to support countries initiating such programmes.

In 1988 the activities of the programme embraced:

at ISRIC offices:

- physical and chemical analyses of 150 soil samples;
- micromorphological research on 45 samples of selected profiles;
- about 60 quality enlarged photographs of landscape and land-use for the expositions in Ecuador, Indonesia and Mali;
- computer processing of collected soil, climate and other ecological data from earlier field missions to Ecuador, Mali and Indonesia realized in 1986 and 1987;

abroad, the execution of the second group of field missions to install and present the soil expositions for target user groups in:

- ***Ecuador***: The second field mission to Ecuador took place in April 1988. A national soil reference collection has been established by the Soil Survey Department (PRONAREG) of the Ministry of Agriculture in cooperation with ISRIC. The collection consists of twenty soil profiles from four major ecological regions and is housed in the main exposition hall of the Museo Ecuatoriana de Ciencias Naturales in Quito. On 14 April 1988 the National Soil Reference and Information Centre of Ecuador was officially inaugurated by the Minister of Agriculture, Mr. Rafael Serrano, in presence of a large number of representatives of agricultural institutions. On 15 April a workshop was held for soil scientists. Afterwards a special session was also held for biology teachers of high schools. The news of the establishment of a soil reference collection in Ecuador and its use was widely distributed through press, radio and television. The mission's objectives were realized in cooperation with Mr. Guillermo del Posso, Head of the Soils Department and former course participant at ISRIC.
- ***Indonesia***: The second field mission to Indonesia was made in September 1988. A national soil reference collection has been established by the Centre for Soil

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[1]**Africa**: Egypt, Ethiopia, Gabon, Ghana, Kenya, Mali, Morocco, Mozambique, Nigeria, Sudan, Tanzania, Tunisia, Senegal, Sierra Leone, Zambia and Zimbabwe; **Asia**: People's Republic of China, Indonesia, Japan, Malaysia, Pakistan, Philippines, Sri Lanka and Vietnam; **Latin America**: Argentina, Brazil, Colombia; **Europe**: Czechoslovakia, France, Italy, Portugal, and Spain.

Research (CSR) in Bogor in cooperation with ISRIC. The collection now consists of 25 soil profiles from four provinces of the Island of Sumatra and is housed in the main office building of CSR in Bogor. On 29 September 1988 the National Soil Reference Collection of Indonesia was officially inaugurated by the Director of CSR, Dr. Sudjadi, in presence of representatives of agricultural institutions, Bogor Agricultural University, UNESCO-Jakarta and a number of projects. The collection was presented and explained by the teamleaders of the field teams responsible for the collection of the monoliths. The news of the establishment of a soil reference collection in Indonesia and its use was widely covered in the press and on television. The mission's objectives were realized in cooperation with Mr. A.M. Sudihardjo, a former course participant at ISRIC.
- *Mali*: The second field mission to Mali took place in November 1988. A national soil reference collection has been established by the Projet de l'Inventaire des Ressources Terrestres (PIRT) of the Ministry of Natural Resources in cooperation with ISRIC. The collection now consists of eight soil profiles from the main ecological Sudan and Sahel regions and is housed in the large meeting hall of PIRT. On 12 December 1988 the National Soil Reference Collection of Mali was officially inaugurated by the Director of the Agricultural Research Station at Sotuba, in presence of a large number of representatives of agricultural institutions situated at Sotuba's research station and of the regional agricultural school of Katibougou. The inauguration was followed by a special session for soil scientists of PIRT and of the Ministry of Agriculture and representatives of the above mentioned agricultural institutions. Explanations on soil, vegetation, land-use and climate were given by PIRT and ISRIC staff. The mission's objectives were realized in cooperation with Mr. Oumar Doumbia, a former course participant.

During the first field missions the ISRIC Soil Information System (ISIS) was already used for direct processing 'on the spot' of the collected information in a final format (soil profile descriptions). A user-friendly computerized data handling system was developed at a later stage with the counterpart organizations. A summary of objectives and activities is:
- Ad hoc selections from the database as a necessity for users without experience with databases. For this purpose an additional software facility for the ISIS database was developed and demonstrated to the users;
- Statistical comparison of analytical results of soil samples analyzed by both the Indonesian (CSR) and ISRIC laboratories;
- Graphical analysis and presentation of analytical and climatic data for exposition and publication purposes;
- Automatic translation of ISIS standard profile descriptions in Bahasa Indonesia and French. The translation facility now available must be considered a first draft awaiting further corrections and comments of specialists.

Laboratory Methods and Data Exchange (LABEX) programme

The LABEX programme was initiated by ISRIC on recommendation of the Second International Soil Classification Workshop in 1978. The main aims were to cross-check, correlate and standardize analytical methods for soil characterization to facilitate and improve international soil classification and correlation studies. During the first experimental phase from 1980 to 1984, 20 laboratories participated in the programme. After a research grant from the Directorate-General for International Cooperation (DGIS) of the Dutch Government, the number of participants increased to over 90.

Presently, the funding of the programme by DGIS is extended till 1990. For the years 1988, 1989 and 1990 the funding by DGIS is limited to 100%, 75% and 50% respectively. For this reason the participants in the industrialized countries are asked to pay a participation fee. Additional funds for participants from developing countries are received from sponsors such as USAID/SMSS and GTZ.

One of the main objectives of the LABEX programme is to assess and possibly reduce the within-laboratory and between-laboratory variability. Another aim is to promote Quality Control and Good Laboratory Practice (GLP) in order to improve the mutual acceptance of soil analytical data for soil classification, correlation and other purposes.

In each LABEX exchange round (once a year) a list of available soil samples is issued among the participants. The samples cover a large range of soil types that can be chosen from by the participants. The selected samples have to be analysed according the LABEX procedures and/or the participants' own procedures. The data from the individual participants are published in an Interim Report, which appears soon after each exchange round. A more comprehensive report covering a detailed statistical analysis of the quality of analytical data from successive exchange rounds appears afterwards. Participants are kept informed on the progress of the LABEX programme by a Newsletter. Also recent developments in soil analysis or laboratory equipment are reported and discussed in the Newsletter. In addition to the regular part of the LABEX programme, special research topics such as the testing of new analytical procedures are performed. Recently four new procedures to determine the Cation Exchange Capacity of soils were tested by a selected group of LABEX participants. The results are discussed in one of the Newsletters.

On June 1988, J. Gerits succeeded L.K. Pleijsier as secretary of the LABEX programme. From January to June 1988, most of the current LABEX affairs were handled by L.P. van Reeuwijk. At the invitation of the organizing committee, Pleijsier gave a presentation on the variability of soil analytical data from the LABEX programme at the international Symposium on "Land Qualities in Space and Time" (Wageningen, August 22-26, 1988). Similar presentations were given by J. Gerits, invited by IBSRAM, at the African Workshop for Acid Tropical Soil Management and Land Development Practices in Peru (Yurimaguas, August 28 - September 11, 1988) and at the Workshop on Site Selection, Characterization and Monitoring in Thailand (Chiangmai, November 7-18, 1988).

The analytical data from the 1987/88 LABEX exchange round were elaborated for publication in an Interim Report, which will appear in January 1989. With regard to the number of available soil samples and required analyses, the set-up of the next exchange round (1988/1989) has been changed. In addition to a limited number of compulsory analyses and soil samples, participants can make a choice from a list of optional soil analyses and samples. Finally, standard soil samples can be chosen to assess the within-laboratory variability. Details on the organization and timetable for the 1988/89 exchange round were given in LABEX Newsletter no. 4 which was sent to the participants in November 1988 together with a sample order form.

The need for Quality Control at all laboratories involved in IBSRAM's Networks in Africa and Asia has been stressed by their compulsory participation in LABEX. An IBSRAM-ISRIC cooperative programme for the networks has been drawn up for the purpose.

4.2 CONSULTING AND PROJECTS

Agroclimatology

At the request of the International Rice Research Institute (IRRI), Philippines, a report "An Agroclimatic Characterization of Madagascar" was prepared by L.R. Oldeman (Consultancy/Mission Report 88/3). The consultancy was carried out over a period of 14 months. The report was submitted to IRRI and the Centre National de la Recherche Appliquée au Developpement Rural (FOFIFA, Madagascar).

The report gives a detailed account of the climatic patterns in Madagascar. The agroclimatic classification is based on the number of consecutive wet months and dry months. A wet month is defined as a month with a precipitation/potential evapotranspiration (P/PET) ratio of more than 1.5, while a dry month has a P/PET ratio of less than 0.5. An agroclimatic map at a scale of 1:2,000,000 was prepared with 15 agroclimatic zones. Also a climatic databank for Madagascar was prepared. Climatic data for 178 sites were collected and stored on diskettes. A hard copy of the climatic data for each station forms part of the report.

At the request of the management of the International Course for development-oriented Research in Agriculture (ICRA) a lecture was given on "Macro and Micro Aspects of Climate and Weather". In the framework of the GLASOD/SOTER project a database structure was developed for a separate climate attribute file.

International Conference on "Soils and the Greenhouse Effect" (ISEC Project)

The International Conference entitled "Soils and the Greenhouse Effect" will be organized by ISRIC under the auspices of the International Society of Soil Science (ISSS). It will be held at the International Agricultural Centre (IAC), Wageningen, August 14-18, 1989. It is a contribution to the International Geosphere-Biosphere Programme of the International Council of Scientific Unions (ICSU) and the World Climate Impact Programme of the United Nations Environment Programme (UNEP), World Meteorological Organization (WMO) and ICSU. ISRIC received a grant from the Netherlands' Ministry of Housing, Physical Planning and the

Environment (VROM) to house the Conference secretariat. Additional support for the Conference is received from the Commission of the European Communities, the Royal Netherlands Academy of Arts and Sciences (KNAW) and the United Nations Environment Programme (UNEP).

The Conference secretariat is formed by A.F. Bouwman, assisted by W.G. Sombroek and L.R. Oldeman. An Organizing Committee and an International Advisory Group were formed to assist in organizational and scientific matters.

There is a consensus amongst most scientists that the global temperature rise will be 1.5 to 4.5 °C within the next 100 years (Villach Conference, 1985). This global warming would be caused by increased concentrations of "greenhouse gases". It forms one of today's most important environmental problems. Greenhouse gases can absorb infrared radiation and thus contribute to the warming of the atmosphere. In addition, changing patterns of evapotranspiration and overall reflectance (albedo) have received much attention in this respect. The world soils and their land use are important sources of a number of greenhouse gases. The most important gases emitted from soils and their land use are carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), nitrous oxide (N_2O), nitric oxide (NO), and water vapour. Apart from their role in the atmospheric radiative balance, CH_4, CO, N_2O and NO are known for their interactions with ozone (O_3).

The improvement and widening of the knowledge base of the geographic distribution of the world soils and land cover types (natural vegetation, cropland or grazing land) and trends in land use, on the one hand, and of greenhouse gas fluxes, evapotranspiration and albedo, on the other hand, can form an important contribution of soil science to the study of climatic change.

The aims of the Conference are:
- to give estimates of the fluxes of greenhouse gases, evapotranspiration and albedo for the major soils of the world and their land cover types;
- to quantify global land use changes and their effect on fluxes of greenhouse gases, evapotranspiration and albedo; and
- to identify research gaps with regard to global geographic data coverage, measuring techniques, model development, collection, collation, storage, dissemination and processing of baseline data, techniques and networks for monitoring.

The keynote papers, extended abstracts, background paper (see below) and conclusions and recommendations will be included in a book to be published by Wiley & Sons (UK).

In 1988 the following activities were carried out:
- Literature study on greenhouse gas fluxes and the surface energy balance (with emphasis on albedo and evapotranspiration). This work was started in April 1987. The report of this study will form the Conference's background paper.
- A literature review was prepared for the "Netherlands Journal of Agricultural Sciences"; the paper will be published early 1989.
- Preparations for the Conference proper including activities such as the compilation and design of the first and second circular for the Conference, reservation of

Conference accommodation and hotels, registration of participants, and requesting financial support. Part of the organizational workload will be taken care of by the International Agricultural Centre.

- A computer soil carbon turnover model was developed to simulate soil organic matter losses and resulting CO_2 fluxes from tropical soils after forest clearing. The modelling results were summarized in a paper submitted to the journal "Land Degradation & Rehabilitation". Another paper concerning the model is in preparation.
- Work on a digital soil/relief map of Europe on a ½ x ½ ° raster was started in November. From this digital map a soil available water capaciiy data set will be derived. This work will be finalized early 1989.

Global Assessment of Soil Degradation (GLASOD Project)

In September 1987 an agreement was signed between the United Nations Environment Programme (UNEP) and ISRIC for the execution of a project: "Global Assessment of Soil Degradation" (GLASOD). The project has two components: (1) preparation of a global soil degradation status map at an average scale of 1:10 Million, and (2) the development of a soil and terrain digital database and an assessment of the status and risk of soil degradation in a pilot area in Latin America (portions of Argentina, Brazil and Uruguay). This project is therefore a first step towards to realization of a World Soils and Terrain Digital Database (SOTER), an ISSS project.

The achievements in relation to the 1:10 M. World Soil Degradation Status map are: Development of Guidelines for General Assessment of the Status of Human-induced Soil Degradation (Working Paper and Preprint 88/4). The first draft was prepared by Mr. J. Riquier (France), reviewed by an ad-hoc committee and a revised second draft was sent for comments to an international panel. Their comments were included in a third draft which was thoroughly discussed during a first regional workshop on SOTER at Montevideo (Uruguay). A final version was then prepared an is now being used by institutions and qualified individual specialists, designated and contracted to prepare regional soil degradation status maps and complementary data sets at an average working scale of 1:5 M. A total of 21 contractors worldwide have commenced their activities, and the first results of draft degradation status maps were received at the end of 1988. It is envisaged that the world soil degradation status map will be compiled in 1989. The enthusiastic support from the majority of cooperators to embark on this complex activity in limited time is encouraging.

The achievements in relation to the 1:1 M. Soil and Terrain Digital Database are: the preparation of a Manual for small scale map and database compilation. This document, prepared by Drs. J.A. Shields and D.R. Coote of the Land Resources Research Centre (Canada) was discussed during the first regional workshop on SOTER, held in Montevideo in March 1988 (Working Paper and Preprint 88/2). During this workshop an implementation plan was developed for the execution of activities in the first pilot area in Latin America, covering portions of Argentina, Brazil and Uruguay. Correlation teams were formed and an agreement was signed with each of the three countries. Prof. W.L. Peters of the Maracaibo University in Venezuela agreed to be the technical coordinator of this first pilot area project. During a period of eight months the correlation teams developed the necessary technical skills to prepare the soil and terrain database. Various correlation field trips were held and the results of their work was presented and discussed during a second regional workshop, held in Porto Alegre, Brazil, in December 1988. The achievements were impressive: more than 80% of the work was completed. Meanwhile, a database management group at ISRIC developed a database structure for entering the coded information in a relational database management system. An ad-hoc committee chaired by Dr. K.B. MacDonald of Ottawa, Canada, is formed to advise the SOTER management on the choice of an appropriate Geographic Information System.

The following further developments can be mentioned. A second pilot area of high priority has been tentatively delineated in the West African region, covering portions of Benin, Burkina Faso, Ghana, Niger, Nigeria and Togo. A draft project proposal was prepared and discussed at the ICRISAT-Sahelian Center in Niamey, Niger as well as during FAO's West African Soil Correlation Meeting at Cotonou, Benin. First reactions were very positive and more formal contacts will be made at government level with the six countries involved. At the same time, informal contacts were made with the EEC, Brussels for possible funding.

A third pilot area was delineated in North America, covering portions of western Canada and U.S.A. The Soil Conservation Service of the United States Department of Agriculture and the Land Resources Research Center in Canada have indicated their interest to test the SOTER manual in this pilot area.

5 GUEST RESEARCH

Soil Horizon Designations

Dr. E.M. Bridges, University College, Swansea, U.K.

Funding: Fellowship of the Dutch Ministry of Agriculture and Fisheries - International Agricultural Centre.

During stays of several months in 1987 and 1988, a discussion document was formulated on the historical development of systems of horizon designation, on systems currently in use with their areas of agreement or disagreement, and on proposals for unification based upon current practices and in line with the International Reference Base for soil classification of the ISSS.

A draft report was published as Working paper and Preprint 87/3. An accompanying bibliographic list of books and articles was published as no. 87/4 in the same series.

After the incorporation of changes the document will be discussed at the International Meeting on Soil Horizons, to be held in Rennes, France, September 1989. The final texts will be published as Technical Papers.

Memory and heart of ISRIC: cheerful Yolanda Karpes-Liem, senior secretary

6 TRAVEL AND MISSIONS

Visits to Institute of Hydrology, Wallingford, England and University of Leuven, Belgium,*) January 1988. *Participant: W.G. Sombroek*

To attend meeting of the IGU/ICA joint Working Group on Environmental Atlases and Maps for a discussion on the World Digital Topographic Database for Environmental Sciences, now in production. Visit to the Commonwealth Agricultural Bureaux International (CABI).

To attend a meeting of the ISSS Commission V core group on the development of an International Reference Base for soil classification (IRB) and to discuss the Revised Legend of the FAO-Unesco Soil Map of the World.

5th International Soil Conservation Conference, Bangkok, Thailand, January 1988. *Participant: W.G. Sombroek*

To familiarize with present trends in soil conservation research and execution, to explain the GLASOD project through a poster presentation, and to request cooperation at regional and national level.

Consultancy to Ambon, Indonesia, January-February 1988. *Participant: J.R.M. Huting*

During this follow-up visit to the Maluku Regional Development Project, University of Pattimura, some new apparatus were installed at the soil, water and plant analysis laboratory and instruction and training was given in analytical methods, laboratory management and computerized data handling. Procedures for water and leaf-analysis were made.

Visit to Max Planck Institute, Mainz, Fed. Republic of Germany, March 1988. *Participant: A.F. Bouwman*

This travel was made to discuss the plans of the IGBP Panel on Terrestrial Biosphere-Atmospheric Chemistry Interactions (early 1990) and ISRIC's Conference on Soils and the Greenhouse Effect to ensure coordination between the various programmes.

Glasod/Soter: First Regional Workshop on a Global Soils and Terrain Digital Database and GLASOD, Montevideo, Uruguay, March 1988. *Participants: W.G. Sombroek and L.R. Oldeman*

To discuss methodologies for small-scale map and database compilation, to assess availability and organization of data for the pilot area in South America (Argentina, Brazil and Uruguay) and to develop an implementation plan for the execution of SOTER activities in this South American pilot area.

SADCC Soil Resources and Land Evaluation Workshop, Harare, Zimbabwe, April 1988. *Participant: J.H.V. van Baren*

To attend workshop and introduce the GLASOD project through a poster presentation and to request cooperation at regional and national level.

Lecturing at the Swedish University of Agricultural Sciences, Uppsala, Sweden, May 1988. *Participant: J.H.V. van Baren* (see section 3.6).

Visit to Global Resource Information Database (GRID) of UNEP, Geneva, Switzerland, May 1988. *Participant: A.F. Bouwman*

To acquire global digital data sets of soils (FAO 1:5,000,000 Soil Map of the World) and of land cover (Mathews 1 x 1 degree LON-LAT). GRID also produced an overlay of above data sets to calculate areas of land cover type per major soil unit; this scheme will be used during the Conference "Soils and the Greenhouse Effect".

Visits to Argentina, Brazil and Uruguay for GLASOD, May-June and August-September 1988. *Participant: Prof. W.L. Peters*, guest researcher.

Preparation and coordination of the first and second correlation meeting-field trip, within the first pilot area in South America (see section 4.2).

Meetings of the Technical Sub-Committees on Sampling (2) and Chemical Methods and Soil Characteristics (3), of ISO-TC 190, London, England, June 1988. *Participant: J. Gerits*

To attend meetings as observer for the ISSS and as member of the Dutch Normalization Subcommissions on soil chemical analysis and soil physical analysis of the unsaturated zone.

General Assembly of SCOPE, Budapest, Hungary, June 1988. *Participant: W.G. Sombroek*

As member of the delegation of the Royal Netherlands Academy of Arts and Sciences (KNAW) to promote the participation of Dutch scientists in the work of ICSU's Scientific Committee on Problems of the Environment (SCOPE) and to strengthen the involvement of soil scientists in the forthcoming IGBP programme.

Visit to FAO, Rome, Italy, June-July 1988. *Participant: L.R. Oldeman*

Meetings to discuss possibilities for a second SOTER pilot area in West Africa, and possible cooperation with countries involved for collection of relevant documents on human-induced soil degradation for the GLASOD project region I (West Africa).

International Working Meeting on Soil Micromorphology, San Antonio, U.S.A., July 1988. *Participant: D. Creutzberg*

To attend the meeting and two field trips for strengthening ISRIC's involvement in micromorphological research. Two papers were prepared with co-authors on micromorphological characteristics of soils from ISRIC's collection: one on a cemented subsurface horizon in a soil from Ecuador, and one about some soils developed in fluviatile deposits in Oman.

African Workshop for Acid Tropical Soil Management and Land Development Practices, Yurimaguas, Peru, August-September 1988. *Participant: J. Gerits*

This workshop was organized by IBSRAM, INIAA and NCSU. A lecture was given on the role of LABEX in laboratory quality control, and LABEX activities were promoted among the participants of the IBSRAM networks in Africa, also in the framework of a close cooperation between IBSRAM and ISRIC for LABEX.

IIASA Workshop on Land Use Change in Europe, Warsaw, Poland, September 1988. *Participant: L.R. Oldeman*

To represent ISRIC in this workshop on processes of land use change, environmental transformations and future patterns. Presentation of poster and discussion note on GLASOD. The project was also discussed with the Polish Society of Soil Science.

Visit to People's Republic of China, September 1988. *Participant: W.G. Sombroek*

To discuss GLASOD project with the Institute of Soil Science - Academia Sinica (ISS-AS) in Nanjing and the cooperation programme of ISRIC with ISS-AS in 1989-1990. Lectures were given on "soil management and food supply" and "soil degradation and environment".

The General Assembly of the International Council of Scientific Unions (ICSU)[*)] was attended as representative of the ISSS. Discussed were i.a. the IGBP programme in general and the soil element in particular.

Meeting on the International Reference Base for soil classification (IRB), Alma Ata, U.S.S.R.,[*)] September 1988. *Participant: W.G. Sombroek*

To review the progress of IRB and to discuss the need for a list of defined soil characteristics. Chairpersons and co-persons for texts on main soil units were identified.

Workshop on Long-Term Ecological Research (LTER), Berchtesgaden, Fed. Rep. of Germany,[*)] September 1988. *Participant: W.G. Sombroek*

To review on-going LTER activities in various countries and to discuss the purpose, methodologies and need for international coordination, also in view of IGBP's Global Change Programme.

Contributed was a draft proposal for LTER research, mainly through 'back-tracking' of natural and man-induced organic matter and compaction profiles of upland soils in tropical Latin America.

Fifth International Soil Correlation Meeting, northeast United States and Canada, New England, U.S.A., October 1988. *Participant: D. Creutzberg*

To participate in the discussions about the spodic horizon, a diagnostic subsurface horizon in Soil Taxonomy, with a view to adapt and improve its requirements. The new Legend of the FAO-Unesco Soil Map of the World was propagated and its conformities and discrepancies with Soil Taxonomy were demonstrated. An invited paper 'Spodosols with a Plaggen Cover' was prepared in cooperation with Dr. H. de Bakker.

Visits to EEC, Brussels, October and December 1988. *Participants: W.G. Sombroek and L.R. Oldeman*

Meetings with Directorates-General VIII and XII to introduce the West African SOTER proposal and to informally discuss possible strategies to secure funding from EEC.

Training workshop on Site Selection, Characterization and Establishments of Experiments for Soil Management Networks, Chiangmai, Bangkok, Thailand, November 1988. *Participant: J. Gerits*

This IBSRAM workshop was used to promote LABEX activities among the participants of the IBSRAM networks in Asia. Papers were presented on laboratory quality control and soil and plant analyses. The possible cooperation between IBSRAM and ISRIC for LABEX was discussed.

ICRISAT Sahelian Center, Niamey, Niger, and 9th Meeting of the West African Soil Correlation Committee (WASCO), Cotonou, Benin, November 1988. *Participant: L.R. Oldeman*

Introduction of the West African SOTER project proposal at the ICRISAT Sahelian Center and presentation of this project proposal at the WASCO meeting. The proposal was positively received and support was given by the Executive Director of ICRISAT Sahelian Center and participants of the WASCO meeting. The project was also discussed with the Director General of Rural Development of Benin, who indicated his strong support.

FAO Consultancy to Brazil (Amazon Region), November 1988. *Participant: W.G. Sombroek*

On FAO's invitation to prepare the ground for a 10-member FAO-Brazil consultancy mission for the formulation of a project proposal for systematic agro-ecological zonification and land use planning of the whole Brazilian Amazon Region.

Visit to Ain Shams University, Cairo, Egypt, November/December 1988. *Participant: W.G. Sombroek*

Discussions with Soils Department of Ain Shams University in Cairo and others, on project proposal for a national and regional soil reference collection.

Second Regional Workshop on a Global Soils and Terrain Digital Database, Porto Alegre, Brazil, December 1988. *Participants: L.R. Oldeman and V.W.P. van Engelen*

The three correlation teams (Argentina, Brazil, and Uruguay) presented progress reports of their SOTER activities in the first pilot area. ISRIC presented activities related to Database management for SOTER, while methodologies to assess soil degradation risks were discussed in detail. A field trip to the pilot area concluded the workshop.

Missions carried out in 1988 in the framework of NASREC project: March-April: **Ecuador**; September: **Indonesia**; November-December 1988: **Mali.** *Participant: J.H. Kauffman*

The missions consisted of the installation and presentation of NASREC with a pedon data bank for target user groups (for more details see Chapter 4).

*) travels partly or wholy made by W.G. Sombroek in his capacity of Secretary-General of the International Society of Soil Science (ISSS).

IIASA's Professor Victor Targulian visiting the soils exposition

7 RELATIONS WITH OTHER INSTITUTIONS

7.1 INTERNATIONAL RELATIONS AND ACTIVITIES

Contacts and activities with international institutions included the following:

Food and Agricultural Organization of the United Nations (FAO, Rome)
- Further development and completion of an improved legend for small-scale soil mapping, as a successor to the FAO-Unesco Soil Map of the World Legend.
- Collection of maps for the updating of the FAO-Unesco Soil Map of the World at scale 1:5 million, and for a digitized soil and terrain map at 1:1 million.
- Exchange of publications and documentation on soils and their management, agroclimatic zones, etc.

United Nations Educational, Scientific and Cultural Organization (Unesco, Paris)
- Unesco's financial support and identification of candidates for ISRIC's International Course on the Establishment and Use of National Soil Reference Collections.
- Unesco's interest to have several associate experts ecology/soil science cooperate with the Dutch "Tropenbos" programme.

United Nations Environment Programme (UNEP, Nairobi)
- Advise on the promotion of UNEP's World Soils Policy and National Soil Policies programmes.
- UNEP/DGIS financial support, through its "Clearing House Facility", for ISRIC's programme to assist in the establishment of national soil reference collections in a number of developing countries (NASREC programme).
- Consultancy to assess the global extent of soil degradation at an average scale of 1:10 million, and its quantification in a pilot area in South America (GLASOD project) at a scale of 1:1 million.

International Society of Soil Science (ISSS)
- Administrative assistance to the Secretariat-General of ISSS, housed at ISRIC.
- Organizing and editing of the book-review section of the six-monthly Bulletin of the Society.
- Participation in the ISSS Working Group "International Reference Base for soil classification" (WG/RB), through formulation of proposals and assembling of documentation.
- Participation in the ISSS Working Group on the preparation of a digitized international soil and terrain map (WG/DM).
- Establishment of a reference collection of soil thin sections for the ISSS Subcommission of Soil Micromorphology.
- Registration of visual training aids on soil science.

- Repository of biographical material on outstanding soil scientists and on the early history of organized soil science for the ISSS Working Group on the History, Philosophy and Sociology of Soil Science (WG/HP).

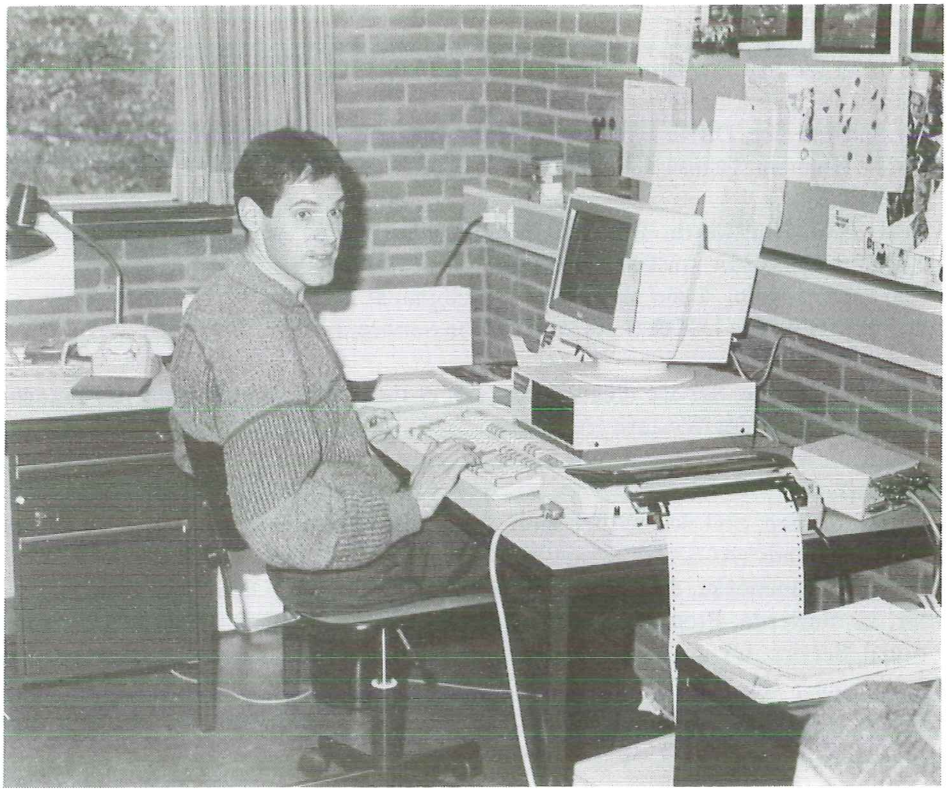
Other international contacts

- Commission of the European Communities (Brussels); submission and screening of research proposals; contacts on support for educational functions of ISRIC.
- International Service for National Agricultural Research (ISNAR, The Hague); exchange of programmes information.
- International Development Research Centre (IDRC, Ottawa); support for soil data centres.
- Institut français de recherche scientifique pour le développement en coopération (ORSTOM, Paris); exchange of information.
- Centre Technique de Coopération Agricole et Rurale of EEC/Lomé Convention countries (CTA, Wageningen/Ede); exchange of data.
- U.S. Agency for International Development (USAID) and several of its soil-related programmes (IBSNAT, SMSS); exchange of information; attendance of workshop; requests for financial support.
- Several of the International Agricultural Research Centres of the Consultative Group on International Agricultural Research (IITA, IRRI, CIAT, ICARDA); exchange of information.
- International Union of Biological Sciences (IUBS); cooperation on formulation of a proposal for network research on Tropical Soil Biology and Fertility (TSBF), and preparation of a manual for the project (site selection and characterization; methods for chemical analysis of soil and water samples).
- National Soil Survey, Soil Research Institutes and Agricultural Universities in many countries.

7.2 NATIONAL RELATIONS AND ACTIVITIES

- Royal Netherlands Academy of Arts and Sciences (KNAW, Amsterdam); continuation of cooperation programme with Nanjing Institute of Soil Science of the Academia Sinica; participation in a Dutch national committee for CASAFA.
- Netherlands Foundation for the Advancement of Tropical Research (WOTRO); board membership.
- International Institute for Aerospace Survey and Earth Sciences (ITC, Enschede); management servicing of ISRIC; lecturing at ITC Soils Course; analysis of soil and water samples; soil data base development.
- Department of Science Policy of the Dutch Ministry of Education and Sciences (MOW-WB, The Hague); cooperation on the elaboration of a multidisciplinary research programme on tropical forests (Tropenbos).
- Centre for World Food Studies (SOW, Wageningen/Amsterdam); exchange of information.

- Department of Soil Science and Geology of Wageningen Agricultural University; cooperation on clay mineralogy; exchange of information; representation at international meetings; lecturing.
- International Agricultural Centre (IAC, Wageningen); visitors accommodation; guest researcher's fellowships; advice on soil-related projects in developing countries.
- M.Sc. Course in Soil Science and Water Management of Wageningen Agricultural University; guidance of students at thesis work.
- Netherlands Soil Survey Institute (Stiboka, Wageningen); cooperation on micromorphology, including methodology of description; exchange of information; representation at international meetings.



ISEC's coordinator Lex Bouwman

8 PERSONNEL

8.1 BOARD OF MANAGEMENT

Members of the Board of Management on 31 December 1988 were:
- Dr. J.P. Andriesse, Chairman Netherlands Advisory Council
- Dr.Ir. A.W. de Jager, Free University, Amsterdam
- Prof.Dr. L. van der Plas, Wageningen Agricultural University
- Dr.Ir. F. Sonneveld, Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, Wageningen (Chairman)
- Dr.Ir. L. Fresco (personal member).

Mutations:
After a long time of association with ISRIC, Ir. P. van der Schans was succeeded by Dr.Ir. A.W. de Jager.

8.2 INTERNATIONAL ADVISORY PANEL

The International Advisory Panel (IAP) met in 1967, 1972, 1979 and 1983. The members of the last IAP were:
- Dr. F. Fournier, Division of Ecological Sciences, Unesco, Paris, France
- Dr. H. Ghanem, Institut Agronomique et Vétérinaire, Rabat, Morocco (for northern Africa)
- Prof. E.G. Hallsworth, IFIAS Save-Our-Soils Project, Brighton, U.K. and past President ISSS (for Australia and ISSS)
- Mr. G.M. Higgins, Land and Water Development Division, FAO, Rome, Italy
- Dr. C.S. Holzhey, USDA Soil Conservation Service, Lincoln, Nebrasca, U.S.A. (for North America)
- Dr. M. Jamagne, Service d'Etude des Sols et de la Carte Pédologique de France, Olivet, France (for Western Europe)
- Mr. F.N. Muchena, Kenya Soil Survey, Nairobi, Kenya (for Africa South of the Sahara)
- Dr. A. Osman, Soil Science Division, Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD), Damascus, Syria (for the Middle East)
- Dr. C.R. Panabokke, Sri Lanka (for South and East Asia): could not attend
- Dr. C. Valverde, Programa Nacional de Suelos, Lima, Peru: at present International Service for National Agricultural Research (ISNAR), The Hague, The Netherlands (for Latin America and CGIAR institutes)
- Dr. G. Varallyay, Research Institute for Soil Science and Agricultural Chemistry, Budapest, Hungary (for eastern Europe).

8.3 NETHERLANDS ADVISORY COUNCIL

Members of the NAC on 31 December 1988 were:

- Ir. J.G. van Alphen, International Institute for Land Reclamation and Improvement, Wageningen
- Dr. J.P. Andriesse, International Course for development oriented Research in Agriculture, Wageningen
- Prof.Dr. J. Bouma, Department of Soil Science and Geology, Wageningen Agricultural University
- Prof.Dr.Ir. N. van Breemen, Soil Science Society of the Netherlands, Wageningen
- Prof.Dr.Ir. A. van Diest, Royal Netherlands Society of Agriculture, Wageningen
- Dr.Ir. P.M. Driessen, Centre for World Food Studies, Amsterdam-Wageningen
- Dr.Ir. G.W.W. Elbersen, International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede
- Ir. J. van der Heide, Institute for Soil Fertility, Haren
- Ir. W.B. Hoogmoed, Soil Tillage Laboratory, Wageningen Agricultural University
- Ir. E.R. Jordens, M.Sc. Course in Soil Science and Water Management, Wageningen Agricultural University
- Dr. F. Kadijk, Laboratory for Soil and Crop Testing, Oosterbeek
- Prof.Dr.Ir. H. van Keulen, Centre for Agrobiological Research (CABO), Wageningen
- Prof.Dr. Th.W.M. Levelt, Free University, Amsterdam
- Ir. J. Schilstra, Euroconsult, Arnhem
- Prof.Dr. J. Sevink, University of Amsterdam
- Prof.Dr. A.W.L. Veen, State University Groningen
- Ir. W. van Vuure, Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, Wageningen
- Drs. R.F. van de Weg, Soil Survey Institute, Wageningen
- Dr.Ir. A.L.M. van Wijk, Institute for Land and Water Management Research (ICW), Wageningen

8.4 ISRIC STAFF

Staff members of ISRIC on 31 December 1988 were:

Dr.Ir. W.G. Sombroek	: Director, soil classification and correlation, soil ecology
Drs. J.H.V. van Baren	: Curator, documentation and publications
Ir. A.F. Bouwman	: ISEC project
Drs. D. Creutzberg	: Soil micromorphology, educational matters
Drs. J.J.P. Gerits	: LABEX programme secretary
Ir. J.H. Kauffman	: NASREC programme
Dr.Ir. L.R. Oldeman	: GLASOD project
Dr.Ir. L.P. van Reeuwijk, M.Sc.:	Soil chemistry, mineralogy and physics

Drs. J.G.R. Beemster	: GLASOD project
Ing. R.O. Bleijert	: Soil micromorphology, map documentation
W.C.W.A. Bomer	: Technician, photography and drawing
Ing. A.B. Bos	: Monolith preparation, technical services, soil documentation
J. Brussen	: Internal administration*)
Drs. V.W.P. van Engelen	: GLASOD project
J.R.M. Huting	: Laboratory analyst
B. van Lagen	: Laboratory analyst
A.J.M. van Oostrum	: Senior laboratory analyst
Ir. J.H.M. Pulles	: GLASOD project
J.D. Schreiber	: Technician, thin section preparation
R.A. Smaal	: Laboratory analyst
Ms. M.B. Clabaut	: Clerical services
Ms. Y.G.L. Karpes-Liem	: Clerical services
Ms. J.C. Jonker-Verbiesen	: Library assistant

*) External administration by ITC, Enschede.

8.5 GUEST RESEARCHERS

Soil and other scientists working at ISRIC during (part of) 1988 as guest researchers were:

- Dr. E.M. Bridges, U.K.
- Dr. P.J. Farres, U.K.
- Ir. J.A. Groenendijk, The Netherlands
- Mr. D. Naujokat, F.R. of Germany
- Prof. W.L. Peters, Venezuela
- Dr. N.M. Pons-Ghitulescu, The Netherlands
- Ir. J.H.M. Scholten, The Netherlands
- Ir. J. Tersteeg, The Netherlands

APPENDIX 1 - GROUP VISITS IN 1988

Institutions	Approximate number of persons
Belgium	
- Dept. of Agric. Science, University of Ghent	10
- International Training Centre for Post-graduate Soil Scientists, Ghent	37
Fed. Rep. of Germany	
- University of Bochum	27
- University of Hamburg	35
- University of Hannover	35
- University of Kiel	35
- Fachhochschule Osnabrück	two visits of 25
France	
- Ecole Nationale Ingenieurs Travaux Agricoles et Horticultures, Angers	25
Iceland	
- Association of Icelandic Agricultural and Horticultural Teachers	25
The Netherlands	
- Free University, Amsterdam	3 visits of 8
- University of Amsterdam	40
- Royal Tropical Institute, Amsterdam	10
- Technical University Delft, Faculty of Mining and Petroleum Engineering, Delft	30
- National Agricultural College, Deventer	4 visits of 25
- International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede	25
- University of Groningen	3 visits of 16
- Horticultural College Warmonderhof, Kerk Avezaath	35
- IGF Geotechnics, Utrecht	20
- University of Utrecht	60
- College for Forestry and Land and Water Management, Velp	7 visits of 30
- International Course for Development Oriented Research in Agriculture (ICRA), Wageningen	21
- International Institute for Land Reclamation and Improvement (ILRI), Wageningen	20
- Netherlands Advisory Council ISRIC, Wageningen	22
- Wageningen Agricultural University	10 visits of 15
Sweden	
- University of Agricultural Sciences, Uppsala	3 visits of 10
United Kingdom	
- University of Wales, Aberystwyth	16
- Portsmouth Polytechnic, Portsmouth	3 visits of 24

APPENDIX 2 - LABORATORIES PARTICIPATING IN THE LABORATORY METHODS AND DATA EXCHANGE PROGRAMME (LABEX)

Instit. de Evaluacion de Tierras
Lab. de Suelos CIRN-INTA
1708 Castelar Pcia Buenos Aires
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Glen Osmond SA 5064
AUSTRALIA

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306 Carmody Road
St. Lucia QLD 4067
AUSTRALIA

Institut für Bodenforschung
Gregor Mendelstrasse 33
A-1180 Wien
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Bodemkundige Dienst van Belgie
De Croylaan 48
B 3030 Leuven
BELGIUM

Mision Brit. en Agricult. Trop.
Casilla 359
Santa Cruz
BOLIVIA

Department of Agric. Research
Private bag 0033
Gaborone
BOTSWANA

Bureau National des Sols
B.P. 7028
Ouagadougou
BURKINA FASO

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22460 Rio de Janeiro RJ
BRAZIL

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BRAZIL

IRA/CNS Ekona
PMB 25
Buea
CAMEROON

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Edmonton, Alberta
CANADA T6H 3S5

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Cali
COLOMBIA

CATIE
Turrialba
COSTA RICA

Instituto de Suelos
Apartado 8022
Ciudad Habana 8
CUBA

Faculty of Agriculture
University of Cairo
Giza
EGYPT

Soil Science Department
El Minia University
El Minia
EGYPT

National Soil Service, LUPRD
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Institute of Natural Resources
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FRANCE

Soil Research Institute
Academy Post Office
Kwadaso-Kumasi
GHANA

Agricultural Research Service
Land Reclamation Institute
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GREECE

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Regional Centre, Hebbal
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Centre for Soil Research
Jalan Juanda 98
Bogor
INDONESIA

Nigerian Inst. Oil Palm Research
P.M.B. 1030
Benin City
NIGERIA

Rubber Research Institute
Dartonfield
Agalawatta
SRI LANKA

Soil Institute of Iran
Kargar Shomali Avenue
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Ibadan
NIGERIA

Land Use Division
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SRI LANKA

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Soil Survey of Pakistan
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PAKISTAN

Soil Survey Administration
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SUDAN

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Lab. Soil Science Plant Nutrit.
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Forest Research Institute
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PUERTO RICO

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Arusha
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Soil Bureau DSIR
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Honiara
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THAILAND

Labosol
ICRISAT Centre Sahelien
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NIGER

Departamento de Edafologia
La Laguna Tenerife
Islas Canarias
SPAIN

Dir. des Etudes Pedologiques
B.P. 1026
Lome
TOGO

Direction des Sols
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2080 Ariana
TUNISIA

Trop. Soils Analysis Unit ODNRI
Coley Park
Reading RG1 6 DT
UNITED KINGDOM

Soil Conservation Service
100 Centennial Mall North
Lincoln NE 68508-3866
U.S.A.

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Apdo. 4653
Maracay 2101
VENEZUELA

IBSNAT/Trop. Soils Projects
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2500 Dole Street
Honolulu Hawaii 96822
U.S.A.

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Chilanga
ZAMBIA

Caleb Brett Laboratories Ltd.
Lancots Lane
St. Helens Merseyside WA9 3ES
UNITED KINGDOM

Chem. and Soil Research Inst.
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Causeway, Harare
ZIMBABWE

Map collection and filing cabinets in corridor, illustrating scarcity of space

APPENDIX 3 - ACRONYMS USED IN ANNUAL REPORT 1988

ACSAD	Arab Centre for the Studies of Arid Zones and Dry Lands, Syria
CABO	Centre for Agrobiological Research, The Netherlands
CABI	Commonwealth Agricultural Bureaux International, U.K.
CASAFA	Commission on the Application of Science to Agriculture, Forestry and Aquaculture, ICSU
CGIAR	Consultative Group of International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CORLAT	International Collection of Reference Laterite Profiles, ISRIC
CPAC	Centro de Pesquisa Agropecuária dos Cerrados, Brazil
CSR	Centre for Soil Research, Indonesia
CTA	Centre Technique de Cooperation Agricole et Rurale, The Netherlands
DGIS	Directorate-General for International Cooperation, Ministry of Foreign Affairs, The Netherlands
DLO	Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, The Netherlands
EEC/EC	European Economic Community
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brazil
EUROLAT	European Network on Laterites, France
FAO	Food and Agriculture Organization of the United Nations
FOFIFA	Centre national de la recherche appliquée au développement rural, Madagascar
GLASOD	Global Assessment of Soil Degradation project, ISRIC
GRID	Global Resource Inventory Database of UNEP
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit, F.R.G.
IAC	International Agricultural Centre, The Netherlands
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer, U.S.A.
IBSRAM	International Board for Soil Research and Management, Thailand
ICA	International Cartographic Association, U.K.
ICARDA	International Center for Agricultural Research in the Dry Areas, Syria
ICRA	International Course for Development-oriented Research in Agriculture, The Netherlands
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
ICSU	International Council of Scientific Unions
ICW	Institute for Land and Water Management Research, The Netherlands
IFIAS	International Federation of Institutes for Advanced Study, Sweden
IGBP	International Geosphere-Biosphere Programme, Sweden
IGU	International Geographical Union, U.K.
IIASA	International Institute for Applied Systems Analysis, Austria
IITA	International Institute of Tropical Agriculture, Nigeria
ILRI	International Institute for Land Reclamation and Improvement, The Netherlands
INIAA	Instituto Nacional de Investigación Agropecuaria y Agroindustrial, Peru
IRB	International Reference Base for soil classification, ISSS
IRRI	International Rice Research Institute, The Philippines
ISEC	International Conference "Soils and the Greenhouse Effect", ISRIC
ISIS	ISRIC Soil Information System
ISNAR	International Service for National Agricultural Research, The Netherlands
ISO-TC 190	International Standards Organization, Technical Committee on Soil Quality

ISSS	International Society of Soil Science
ITC	International Institute for Aerospace Survey and Earth Sciences, The Netherlands
IUBS	International Union of Biological Sciences
KNAW	Royal Netherlands Academy of Arts and Sciences
LABEX	Laboratory Methods and Data Exchange Programme, ISRIC
MAB	Man and the Biosphere Programme, Unesco
MOW-WB	Department of Science Policy, Ministry of Education and Sciences, The Netherlands
NAC	Netherlands Advisory Council of ISRIC
NASREC	National Soil Reference Collections, ISRIC
ORSTOM	Institut français de recherche scientifique pour le développement en coopération, France
PIRT	Projet de l'Inventaire des Ressources Terrestres, Mali
PPS	La Productivité des Pâturages Sahéliens, Wageningen Agricultural University
PPT	Centre of Soil Research, Indonesia
PRONAREG	Programa Nacional de Regionalizacion Agraria, Ecuador
SCOPE	Scientific Committee on Problems of the Environment of the ICSU
SCS	Soil Conservation Service, USDA, U.S.A.
SMSS	Soil Management Support Services, SCS, U.S.A.
SOTER	World Soils and Terrain Digital Database, ISSS
SOW	Centre for World Food Studies, The Netherlands
STIBOKA	Netherlands Soil Survey Institute
TSBF	Tropical Soil Biology and Fertility Programme, IUBS/Unesco
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VROM	Ministry of Housing, Physical Planning and the Environment, The Netherlands
WASCO	West-African Soil Correlation Committee, FAO
WDDES	World Digital Database for Environmental Sciences
WMO	World Meteorological Organisation
WOTRO	Netherlands Foundation for the Advancement of Tropical Research

PUBLICATIONS

Soil Monolith Papers

1. Thionic Fluvisol *(Sulfic Tropaquept)* Thailand, 1981
2. Orthic Ferralsol *(Typic Haplustox)* Zambia, in prep.
3. Placic Podzol *(Placaquod)* Ireland, in prep.
4. Humic Nitosol *(Oxic Paleustalf)* Kenya, in prep.
5. Humic Acrisol *(Orthoxic Palehumult)* Jamaica, 1982
6. Acri-Orthic Ferralsol *(Haplic Acrorthox)* Jamaica, 1982
7. Chernozem calcique *(Vermustoll Typique)* Romania, 1986
8. Ferric Luvisol *(Oxic Paleustalf),* Nigeria, in prep.

Technical Papers

1. Procedures for the collection and preservation of soil profiles, 1979 - out of print
2. The photography of soils and associated landschapes, 1981
3. A new suction apparatus for mounting clay specimens on small-size porous plates for X-ray diffraction, 1979 (exhausted, superseded by TP 11)
4. Field extract of "Soil Taxonomy", 1980, 4th printing 1986 - out of print
5. The flat wetlands of the world, 1982
6. Laboratory methods and data exchange program for soil characterization. A report on the pilot round. Part I: CEC and Texture, 1982; 1984 - out of print
7. Field extract of "classification des sols", 1984
8. Laboratory methods and data exchange program for soil characterization. A report on the pilot round. Part II: Exchangeable bases, base saturation and pH, 1984
9. Procedures for soil analysis, 1986; 2nd edition, 1987, 3rd ed. in preparation
10. Aspects of the exhibition of soil monoliths and relevant information (provisional edition, 1985) -out of print
11. A simplified new suction apparatus for the preparation of small-size porous plate clay specimens for X-ray diffraction, 1986
12. Problem soil: their reclamation and management (copied from ILRI Publication 27, 1980, p 43-72), 1986
13. Proceedings of an international workshop of the Laboratory Methods and Data Exchange Programme: 25-29 August 1986, Wageningen, The Netherlands, 1987
14. Guidelines for the description and coding of soil data, revised edition, 1988
15. ISRIC Soil Information System - user and technical manuals, with computer programme, 1988
16. Comparative classification of some deep, well-drained red clay soils of Mozambique, 1987
17. Soil horizon designation and classification, 1988
18. Historical highlights of soil survey and soil classification with emphasis on the United States, 1899-1970, 1988
19. Soil horizon designations, 1989, in prep.

Soil Monographs

1. Podzols and podzolization in temperate regions, 1982
   with wall chart: Podzols and related soils, 1983
2. Clay mineralogy and chemistry of soils formed in volcanic material in diverse climatic regions, 1989
3. Ferralsols and similar soils; characteristics, classification and limitations for land use, in prep.

Wall charts

- Podzols and related soils, 67 × 97 cm, 1983 (see Soil Monograph 1)
- Soils of the World, 85 × 135 cm, 1987 (Elsevier Publ. Company, in cooperation with ISRIC, FAO, and Unesco)

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- to improve methods of soil analysis - through research and international correlation; with emphasis on soil characterization and classification

- to transfer specialized information - by lecturing and by publishing on the collected materials and on research data, and by advising on the establishment of national and regional soil reference collections

- to stimulate and contribute to new developments in soil genesis and classification, soil mapping and land evaluation - through active participation in international scientific working groups

- to carry out consultancies in the aspects of soil science and agro-climatology and give training - by employment of ISRIC staff in developing countries and giving education and training at ISRIC and elsewhere

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