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ISRIC

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15 - 18 JUNE 1983

International Soil Museum - Wageningen - The Netherlands

THE METHODOLOGY

Introduction

In 1972 Unesco launched its Man and the Biosphere (MAB) Programme, based on the experiences obtained during the International Biological Programme. In the course of this programme, in the late nineteen seventies, the need was felt for more soil data that could complement the ongoing biological investigations. In this way a more complete picture of a given ecosystem could be assembled, as the soil forms an integral part of terrestrial ecosystems. Often ecological research was carried out without a due attention to soil factors other than merely plant nutrients. The absence of soil work in ecological research in developing countries is usually caused by the exclusively agricultural interests of agronomists with a soil scientific specialization.

It was out of this awareness that a cooperation programme between Unesco's Ecological Division and the International Soil Museum was born. This joint programme envisaged the contractation of three associate experts in soil science by Unesco, to be made available by the Dutch government, who would be stationed at Unesco's regional offices for science and technology in SE Asia, Africa and South America. In 1980 the three soil scientists were contracted and they received a technical briefing at the ISM, during which a common survey methodology was agreed upon, with which the MAB areas were to be surveyed. By mid 1980 the associate experts left for their duty stations and started the work in their respective regions.

Consideration about the survey approach

In view of the numerous approaches and methods used throughout the world in soil survey and the consequent difficulty of comparison of many soil maps, it was imperative that the three associate experts would use the same methodology in their regions. In this way the produced soil maps would be perfectly comparable, which is of high importance for the interregional data exchange in the MAB programme.

But beside the fact that a common survey method be used by the soil specialists, the methodology itself had to be chosen in such a way that it would satisfy the

needs of the users in ecological research projects. Often soil maps are produced using only technical taxonomic terminology in the legend. Such maps do not provide readily available information on soils to the non-pedologist user. He has to go through the whole survey report in an attempt to grasp something of the spatial distribution of the main soils and their position in the landscape. But even there the specialized technical information given often hampers the understanding of the different soils and their relation to geology and landscape.

Therefore, a method of legend construction had to be chosen that would provide a clear overview of the geographic distribution and main characteristics of the dominant soil types. In this sense a physiographic approach appeared more likely to fulfill that requirement than a strict soil morphometric system, and offered the possibility of a more pragmatic delineation of soil mapping units.

The survey method

The survey method that has been adopted in the MAB soil studies is the result of a fifteen-year experience in organizing soil surveys in four tropical countries. This "physiognomic-lithomorphic" approach to soil mapping in general and to the presentation of soil map legends in particular was developed in its most recent form by the joint staff of the Kenay Soil Survey in Nairobi, Kenya. The methodology has been primarily developed for reconnaissance surveys at scales of 1:100,000 and 1:250,000, but can be used at any other scale of survey.

In general it attempts to visualize the complex relationship landform-geology-soils in a pragmatic way.

The landform entry

Landforms are taken as the *first entry* in the soil map legend because these give the reader a preliminary insight into differences of physiography and altitude. The first element (capital letter) of the mapping code indicates the "landform" for example:

Y: Piedmont plains

Pv: Volcanic plains

M: Mountains and major scarps, etc..

For each landform a description can be given of overall slope class, relief intensity, suggested subdivisions, while in addition the practical significance of each landform type, e.g. related soil conditions, drainage, conditions, land use possibilities, etc. can be indicated in the accompanying soil report. The scheme developed in Kenya is given summarized in table 1.

The geologic entry

The *geological units* form the *second entry* in the legend. The grouping is done pragmatically mainly according to the "resistance to weathering" and the "mineral richness" of the parent material/parent rock.

The scheme used in Kenya for the subdivision according to lithology is given in table 2.

In the mapping unit code the lithology is also indicated by a capital (2nd symbol), for example:

YL. Y : Piedmont plains
L: (Soils developed on alluvial from) crystalline limestone

PvB. Pv : Volcanic plains
B: (Soils developed on alluvium from early Pleistocene) olivine basalts

MF. M : Mountains and major scarps
F: (Soils developed on) basement system rocks rich in ferromagnesian minerals.

The soil descriptive entry

The *third entry* into the legend describes the main soil unit, soil association or soil complex of the individual mapping units in a *descriptive way*. As stated before, such a descriptive terminology is applied to allow the interested non-soil specialist to gain an insight in the features of the

soils concerned without being put off by the complicated terminology of modern soil taxonomists. A rather strict scheme is followed in all descriptions. This description refers mainly to the characteristics of the subsoil, usually the B horizon to 100 cm depth, or less if the bedrock occurs at a shallower depth. The following characteristics are described in the map legend in the sequence as indicated:

- drainage conditions
- depth (effective soil depth)
- colour (moist conditions)
- mottling if present (to be described in the legend only as "mottled")
- consistence (moist conditions; deleted for shallow soils)
- calcareousness if present
- salinity sodicity if present
- stoniness if present
- rockiness if present
- cracking if present
- texture
- additions such as ... "over petroplinthite"; ... "over petrocalcic horizon", etc. if applicable; ("over rock" is not used as this is implied already in the second entry of the legend).

Other characteristics can be added as needed. Also important "inclusions" in the mapping unit are indicated after the description of the dominant soil unit.

Some additional information, notable on top soil features, can be indicated, for instance:

... "with a topsoil of ..." (texture), used when the topsoil texture differs by two or more classes from the subsoil texture".

... "with a humic/acid humic topsoil" (humic in the case of a mollic epipedon; acid humic in the case of an umbric epipedon).

... "with stoneline(s)": if very prominent in a particular mapping unit.

Following the capital codes used for landform and parent material/rock, each mapping unit code contains one or more codes to express the soil properties; for instance, r for red, c for compact, a for abrupt textural change.

An example is:

MFr. M: Mountains and major scarps

F: (Soils developed on) gneisses rich in ferromagnesian minerals

r: well drained, predominantly deep, dark reddish brown to yellowish red, friable, sandy clay loam to clay loam; in places stony and rocky.

A number of properties of the soil or the land that are of direct importance for soil management such as shallowness, stoniness, salinity, strong present day erosion are also indicated by a letter symbol and in general also with "screens" on the map.

For example: MFrP: like MFr, but shallow.

In addition, the slope class of each mapping unit area is indicated in the mapping units code as follows: $\frac{\text{USmr}}{\text{B}}$: slope class B (gently undulating, slopes 2-5%).

The mapping unit description is normally followed by the *taxonomic classification* of the soils concerned. This will allow the soil specialist to correlate the soil unit with soils in different areas, and will ensure the extrapolation of agronomic research data.

An example of this approach to map legend construction is given in table 3 showing a part of the legend of the reconnaissance soil survey map (scale 1:250,000 of the Mount Kulal-Marsabit area).

Cross-sections

In a number of cases full scale soil maps cannot be compiled (either by aggregation or own soil survey work). In such cases schematic cross-sections are prepared, showing the physiographic units and the geology, the vegetation units and the main soils in a summarized way. This may be accompanied by drawings of representative soil profiles, with standardized symbols and graphic coding.

Comparison of soil profile characterisation

Often quite sweeping general statements are made on the soil conditions in major ecosystems, e.g. the "soils under tropical lowland forests are all very poor and liable to irreversible degradation after clearing; they are lateritic", etc..

To verify or refute such statements, one or two representative soil profiles in MAB areas of the same ecosystem, located in different countries or continents, are analysed at a central laboratory, i.e. ISM, with standardised methodology (chemical, physical, mineralogical, micromorphological). Additionally, these profiles may be collected as soil monoliths for preparation and permanent reference at ISM.

Differences already emerging are:

a) Desert ecosystems: Mapimi versus Kulal-Marsabit
   - degree of calcic/gypsic features
   - degree of degradation

b) Tropical lowland forest ecosystems:
   Makokou versus Tai versus Kalimantan versus San Carlos
   - difference in physiography
   - difference in nature of the soils (podzols <—> ferralsols <—> acrisols)
   - difference in nature of the clay minerals, inherent nutrient storage capacity (CEC), in nutrient content (B.S.), in structure stability (Fe content and water dispersable clay)

c) Mountain ecosystems: Gunung Gede-G. Pangrango versus Pampa de Achala
   Although both areas can be grouped under mountain ecosystems, the climate and vegetation of these areas are too different (tropical mountainous forest versus temperate grasslands) to compare the results obtained in each area.

Table 1: Subdivision of landforms in relation to soil mapping and map legend construction (example from Kenya)

Symbol	Landform	Overall slope class	Relief intensity	Some suggested subdivisions
M	mountains and major scarps	> 30 % (no overall slope direction)	> 300 m	elevation; relief intensity; shape of the summits; shape of the valleys; density drainage pattern; average slope; slope shape; slope pattern; slope length; relief elements
H	hills and minor scarps	8-30 %, max. 40 %, (no overall slope direction)	up to 300 m, in general lower	as for mountains
R	dissected lower slopes of major older volcanoes and mountains	crests: 0-5 %; valley sides: 5-16 % (up to 30 %)	up to 100 m	relief; average slope
F	footslopes (incl. pediments, glacis, coalescing fans)	2-8 % (up to 16 %)	up to 20 m	average slope; position; degree of erosion; weathering depth; thickness accumulation cover
L	plateaus and high-level structural plains	0-8 % (up to 16 %)	< 50 m	position; topography; dissection; origin; altitude
Lc	coastal plateaus			
Lu	plateau/upland transitions			
U	uplands (incl. dissected "peneplains")	2-16 %	< 50 m	elevation; topography; dissection; origin; position; e.g. upper-level, middle-level, lower-level
Uc	coastal uplands			
Up	upland/plain transitional lands			
Y	piedmont plains	0-5 %	< 20 m	topography; type; position; degree of erosion; elements
P	plains	0-5 %	< 10 m	topography; position; dissection
Pn	non-dissected erosional plains			
Pd	dissected erosional plains			
Ps	sedimentary plains ("aggradational plains")			
Pt	sedimentary plains of upper river terraces			
Pf	sedimentary plains of large alluvial fans			
Pc	coastal plains			
Pv	volcanic plains			
Pl	lacustrine plains			
A	flood plains (incl.lower terraces)	0-2 %	< 5 m	origin; type; location; elements
B	bottom lands	0-2 %	< 5 m	origin; location
Miscellaneous landtypes				
D	dunes			
La	(recent) lava flows			
S	swamps			
T	tidel swamps/flats			
V	(minor) valleys			
W	"badlands"			
Z	beach ridges			

Table 2. Lithological subdivision of parent rocks/parent materials (example from Kenya)

Igneous rocks

acid igneous rocks
- Y rhyolite, aplite, etc.
- G granite, diorite, etc.

intermediate igneous rocks
- I andesite, trachyte, phonolite, syenite, etc.

basic and ultrabasic igneous rocks, rich in Fe-Mg minerals
- B basalt, gabbro, serpentinite, etc.

undifferentiated igneous rocks
- V (complex of) unspecified igneous rocks

Pyroclastic rocks
- P ash, pumice, tuff, welded tuff, etc.

Metamorphic rocks (predominantly "Basement System" rocks)
- L marble, crystalline limestone
- Q granitoid gneiss, quartzite
- R quartzo-felspatic gneiss
- M quartz-muscovite gneiss
- N biotite gneiss
- F gneiss rich in Fe-Mg minerals (e.g. hornblende gneiss)
- U undifferentiated "Basement System" rocks (pred. gneiss)

Sedimentary rocks (predominantly consolidated)
- Z conglomerate
- S sandstone, grit, arkose, greywacke
- K siltstone
- D mudstone
- W marl
- T shale
- L (coral reef) limestone, travertine
- H chert, flint, chalcedonite, diatomite
- O "bay sediments" of Plio-Pleistocene age
- J lagoonal deposits
- E aeolian sediments ("cover sands")

Unconsolidated sediments, undifferentiated
- A alluvial, colluvial, marine deposits from various sources
- Z gravel

Table 3. Example of a legend construction

H HILLS AND MINOR SCARPS (relief intensity 50-300 m, slopes from 8 to over 30%)

HU Soils developed on undifferentiated Basement System rocks

HUP excessively drained, shallow, dark brown, extremely rocky, very stony, sand to sandy loam; in places strongly calcareous.
(eutric LITHOSOLS, stony phase and ROCK OUTCROPS)

HV Soils developed on various volcanic rocks

HVP somewhat excessively drained, shallow to deep, dark reddish brown, friable, strongly calcareous, stony clay, with an exceedingly bouldery and stony surface; in places moderately saline and sodic.
(haplic YERMOSOLS, boulder mantle and partly saline and sodic phase)

HP Soils developed on pyroclastic rocks

HP1P excessively drained, shallow, dark reddish brown to dark yellowish brown, very stony, loamy sand to sandy clay.
(eutric REGOSOLS, stony phase)

HP2P excessively drained, shallow, reddish brown, strongly calcareous, very stony, loamy sand to sandy loam.
(calcaric REGOSOLS, stony and lithic phase)

L PLATEAUS

Ls STEPPED PLATEAUS (relief intensity less than 10 m, steps of 10 to 20 m, slopes 0-3%)

LsV Soils developed on various volcanic rocks

LsV1P somewhat excessively drained to well drained, shallow to moderately deep, yellowish red, very friable, strongly calcareous, moderately sodic, very stony, loamy sand to sandy loam.
(calcaric REGOSOLS, stony, sodic and partly lithic phase)

LsV2 well drained, deep to very deep, dark reddish brown, very friable clay; in places very stony.
(chromic LUVISOLS and chromic CAMBISOLS; partly stony phase)

LsV3p well drained, moderately deep, dark reddish brown, friable to firm, slightly calcareous, very bouldery, very stony, cracking clay, with an exceedingly stony surface.
(chromic VERTISOLS, stony phase)

LsVC1 complex of:
- somewhat excessively drained to well drained, shallow to moderately deep, reddish brown to dark brown, very friable, strongly calcareous, very stony, sandy loam to sandy clay loam, with an exceedingly stony surface, in places over petrocalcic material.
(calcaric REGOSOLS and haplic YERMOSOLS, stone mantle and partly petrocalcic and/or lithic phase)

CASE STUDIES FROM AFRICA

Area: Mount Kulal - Marsabit area

Country: Kenya (Eastern Province, Marsabit District)

Coordinates: 2° - 3° N and 37° - 38° E

Altitude: 400 to 700 m for the plains with a few mountains rising up to over 2000 m

Surface area: around 14.000 km^2

Background of the study:

The Unesco Integrated Project on Arid Lands (IPAL) was established in 1976 and is one of the pilot projects under the MAB programme. The aim of the project was to find direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. In the last seven years IPAL has been carrying out research on many components of the ecosystem: Human, livestock, vegetation, geomorphology, soil, climate and hydrology in order to study the processes leading to degradation and to find solutions for restoration of stability and improved productivity. The results of the studies are being integrated in a management plan for the area, which may lead to an improvement of the natural environment and of the existence base of the pastoralists.
The soil survey forms an important part in the study of the functioning of the ecosystem and together with studies on the vegetation is the base for a land evaluation study.

Environment:

climate: The average annual rainfall in the plains is about 250 mm. The tops of the mountains have an average annual precipitation of about 700 mm. The variability of the rainfall is very high. The rainfall pattern is clearly bimodal, with March/April-May and October-November as the two rainy seasons.
The average annual temperature is 25°C for the plains and about 20°C for the mountains with very little variation during the year.
Climatic classification (Köppen): BWh.

geology: The oldest rocks present in the area belong to the Precambrian Basement System and consist mainly of gneisses (southwestern part). Tertiary/Quaternary volcanic rocks (mainly basalts and pyroclastic materials) occupy large areas (northwest, north, east). The central part is covered with recent sediments, mainly derived from Basement System rocks and partly enriched with volcanic ashes.

vegetation: Mainly open shrubland with Acacia reficiens, A. mellifera and Commiphora as the most common species with dwarfshrubs (Duosperma eremophilum and Indigofera spp.) and grasses (mainly Aristida mutabilis) in the understory. The mountain tops are covered with montane, evergreen mist forest.

land use: The overall land use is nomadic to semi-nomadic, extensive grazing and browsing with camels, sheep and goats and cattle.

Soil studies:

kind of study: Reconnaissance soil survey at scale 1:250.000. Field work was done at 1:100.000 scale. Satellite image interpretation and aerial photo interpretation were very important tools. Several hundreds of field observations were made in the period 1980-1983.

previous work: The most important source was the exploratory soil map of Kenya (1:1.000.000) (Sombroek et al., 1981).

progress made: The soil map at scale 1:250.000 is ready in a preliminary form and is available in black and white. A final version, which will be published in colours, is in preparation. The report is in an advanced stage and includes detailed descriptions of the soil mapping units with a chapter on land evaluation.

Land evaluation

Because of the integrated character of the project many socio-economic, climatic and vegetation data are available. In combination with the soil data a land evaluation study can be carried out for the relevant land utilization types, (e.g. extensive, nomadic to semi-nomadic grazing and browsing). It is envisaged that a land suitability classification be carried out for present conditions and future conditions after a

proposed management plan has been implemented. For the classification under present conditions the vegetation forms the most important attribute, for future conditions the soil will be the most important.

Problems encountered:

In general the cooperation with the various IPAL scientists and the Kenya Soil Survey was very good. Due to the frequent changes of the range ecologists, no good cooperation was possible at the study soil-plant relationships. This really limits the possibilities of the land evaluation. The soil surveyor proposed an approach for the land evaluation following to the FAO guidelines while trying to quantify the different land qualities as good as possible. Although many hard data on the vegetation are present, the IPAL scientists felt that the proposed systematic approach was too time consuming.

Area: M'Passa Biosphere Reserve, Makokou

Country: Gabon

Coordinates: 12°48' E 0°12' N

Altitude: 450 to 550 m

Surface area: around 11.000 ha

Background of the study:

The rain forest ecosystems in Gabon, and in particular the forest of the M'Passa reserve, have been little disturbed by man and are rich in animal life. From the IRET (Institut de Recherches en Ecologie Tropicale) research station numerous studies on the natural environment (vegetation, forest inventories, fauna) have been carried out. A few years ago a research project has started on the balance and the functioning of the forest ecosystem, including the human element. Recently experiments with agroforestry systems started as well. So far, no soil survey was done in the Reserve. As the soil is an important natural resource and plays an important role in the functioning of the ecosystem, the need for soil survey was felt.

Environment:

climate: Average annual rainfall of 1700 mm with a high reliability. Four seasons can be recognized:

(1) June-July-August: Major dry season

(2) September-October-November: Major rainy season

(3) December-January-February: Minor dry season

(4) March-April-May: Minor rainy season

Average annual temperature around 25°C with little variation throughout the year.

Climatic classification (Köppen): Af

geology: The rocks occurring in the area consist of Precambrian Basement System rocks (gneisses and leptynites with a few basic rocks, e.g. amphibolites).

vegetation: Primary, humid tropical forest with a very high variety of species (over 2000) including lianes. The trees are 30 to 40 m of height and do not show a stratification.

land use: The area is a protected forest reserve with no human settlement. Some illegal hunting may take place.

Soil studies:

kind of study: The research plots (300 ha) have been mapped at scale 1:10.000. The whole of the Reserve at 1:50.000. Maps were compiled on the bases of field work and with the aid of existing topographical maps.

previous work: No soil survey of the area existed.

progress made: The above mentioned soil maps have been completed and are available in a black and white version. The report on the soil survey is in preparation.

Land evaluation:

So far no land evaluation study was carried out of the survey area.

Area: Tai National Park

Country: Ivory Coast

Coordinates: 5°52' N and 7°28' W

Altitude: 0-370 m

Surface area: 330.000 ha

Background of the study:

Since 1978, the area is recognized as a Biosphere Reserve. The Park is the last remaining portion of the vast primary forest of West Africa. The Park is the site of the MAB project on effects of human interference with the natural forest ecosystem.
To date only 1600 ha has been subject to a soil survey. As the soil plays an important role in the functioning of the ecosystem, it is envisaged that a soil map be made of the whole Park.

Environment:

climate: Average annual rainfall 1800 mm with a minimum of 1400 and a maximum of 2500 mm.
Four seasons can be recognized: March-June: the major rainy season; July-August: the small dry season; September-October: minor rainy season; November-February: major dry season.
Average annual temperature: 26°C with little variation throughout the year.
Climatic classification (Köppen): Af

geology: Precambrian Basement System rocks. In the Tai region mainly migmatites and some granites.

vegetation: Dense, humid, tropical forest, dominated by Eremospatha macrocarpa and Diospyros manni. The forest is characterized by a great variety of species, abundant undergrowth, many lianas and a lot of fallen trees.

land use: Protected forest reserve; only in the fringes some agricultural practices.

Soil studies:

kind of study: ORSTOM has carried out a soil survey of 1600 ha at 1:15.000. The whole Park will be mapped at scale 1:250.000 by the author.

previous work: Fritsch, E. 1980. Etude pédologique et répresentation cartographique a 1/15.000ème d'une zone de 1600 ha representative de la région forestière du sud-ouest Ivoirien. In this study the ORSTOM methodology and the CPCS soil classification system was used.

progress made: The soil map with survey report of the 1600 ha is available. No other field work for soil survey purposes has been carried out sofar.

Selected Miscellaneous Activities

A.J. van Kekem

Papers presented

- IPAL scientific seminar, with review mission. Nairobi, Kenya, 1980.
- IPAL orientation seminar for French speaking countries. Marsabit, Kenya, 1982.

Meetings attended

Soil Science meetings

- East African Soil Science Society Annual Meeting. Arusha, Tanzania, 1980.
- East African Soil Correlation and Land Evaluating Meeting (FAO). Arusha, Tanzania, 1980.
- First Organisation of African Unity Soil Science Congress. Accra, Ghana, 1980.
- West African Soil Correlation Meeting (FAO). Lomé, Togo, 1981.
- 12th International Congress of Soil Science Society. New Delhi, India, 1982.

Other meetings

- 6th African Wildlife Conference. Nairobi, Kenya, 1980.
- UNEP Conference (Mainly providing assistance to MAB exhibition). Nairobi, Kenya, 1982.

Missions (other than in conncection with field work)

- Visit to Geoscience Research Project. Kilifi, Kenya, 1980.
- Orientation and preparation mission to Ivory Coast, 1980.
- Idem, to Gabon, 1980.
- Idem, to Zaire, 1981.
- Idem, to Congo, 1981.
- Collection of soil monoliths in northern Kenya with H. van Baren (ISM), 1981.
- Field trip with Dutch Training Project in Pedology. Kilifi, Kenya, 1982.

Other activities

- Interviews for Rendille Radio Programme on the importance of soil research in the IPAL study area. Nairobi, Kenya, 1981.

Future soil studies in Africa (July 1983 - May 1985)

Kenya

Mount Kulal - Marsabit area

Continuation with the writing of the report on the soils of the survey area.

Ivory Coast

Tai national park

Carry out a soil survey of the Park area (3300 km^2) at scale 1:250.000. Use can be made of a detailed soil map produced by ORSTOM of an area of 1600 ha. It is foreseen that one or two counterparts are going to assist the author. Special attention will be given to soil-vegetation relationships. Close cooperation with Mr. A.P. Vooren of the Dutch Agricultural University is envisaged.
Expected problems: Local transport; purchase or borrowing of camping equipment; funding of the analyses of soil samples.

Zaire

Yangambi floristic reserve

Compile a soil map of the reserve (2500 km^2) at scale 1:250.000. Existing soil maps at scale 1:50.000 can be used. Physical and chemical data are however very poor, so additional field work is necessary. Close cooperation with the project leader is foreseen in studies on soil-vegetation relationships and on the influence of man on the functioning of the ecosystem (especially on the soils).
Expected problems: Local transport; the availability of chemicals in the laboratories in Yangambi.

Gabon

M'Passa Biosphere Reserve

Monitoring of the soils of the agroforestry trial plots.
General: Collection of soil monoliths, representing the most important soils of Gabon, for the ISM.

Congo

Dimonika area

Possibly, ORSTOM is going to carry out a soil survey of an important part of the research area. If so, a soil correlation trip will be made to compare the French and the FAO/Unesco soil classification systems.

Nigeria

Omo Biosphere Reserve and Kainji Lake area.

An orientation visit was foreseen in 1982, but due to various circumstances, could not be carried out. Time constraints will make it impossible to carry out this mission in the coming two years.

Central African Republic

Basse Lobaye Forest

Although an orientation visit to the area was planned, neither time nor opportunities were available in the past and cannot be expected to be available in the near future.

CASE STUDIES FROM SOUTH-EAST ASIA

Area: Ujung Kulon National Park

Country: Indonesia (West Java Province)

Coordinates: 6°35' - 6°52' S and 105°12' - 105°30' E

Altitude: 0 to 620 m

Surface area: approx. 52.475 ha

Background of the study:

The Ujung Kulon National Park is especially famous for the occurrence of the last Javan rhinoceros (Rhinoceros sendaicus). At this moment about 50 rhino's are living in the area.
The World Wildlife (WWF) is sponsoring several projects to save these animals from extinction.
One project is to study the behaviour of the rhino's especially regarding the food requirements and preferences. A complementary project is the preparation of a vegetation map and to determine the carrying capacity regarding the food availability. Resulting from the vegetation study some vegetation management activities might be proposed to increase the food availability.
The soils studies have been requested for characterization of the soils of the different vegetation mapping units.

Environment:

climate: At only one station the rainfall has been recorded for a substantial period and the annual average amounts approx. 3250 mm.
However due to the location of this station, at the western coast, this amount cannot be considered as representative for the whole National Park. In the eastern part the rainfall will be considerably less.
The rainy season is from October to April. During the dry season, the rainfall is still over 100 mm per month.
Climate classification (Köppen): Af.

geology: The hills of the area consist of sedimentary rocks (Miocene). Around these hills marls (Pliocene) have been deposited. This area is now situated at 80-100 m above sealevel.
Along the northern and eastern coast a coral reef is found. The reef is located at some distance of the marl plateau with in between a lagoon.

Due to the later upheaval the lagoon is now located above sealevel.
The whole National Park area has been covered by a approx. 20 cm thick ash layer of the Krakatau eruption of 1883.

vegetation: The Ujung Kulon area is one of the largest remaining areas of natural forest on Java. However the vegetation has been influenced by several factors: human influences, tidal waves and ash deposition.
The hills are covered with rain forest. The marl plateau is characterized by an open forest with many palms, especially Langkap (Arenga obtusifolia) and Salak (Salacca edulis).
In the eastern part an area with mangrove swamps is found.

land use: In the past Ujung Kulon served as an important resting point for the sailing boats coming from Europe to the Indonesian archipelago.
The villagers sold fresh fruits and vegetables therefore small scale agriculture was practised.
The 1883 Krakatau eruption influenced the area drastically. The tidal waves accompanying the eruption destroyed the villages and large parts of the vegetation.
Due to outbreaks of diseases in the beginning of this century the area has been evacuated. In 1921 the area received the status of nature reserve and became in 1980 one of the first 2 National Parks.

Soil studies:

kind of study: The WWF vegetation survey produced a photo interpretation map and during the survey a soil augering has been made in each plot.
Based on these data an intensive soil sampling trip has been made.
The vegetation map will be published at a scale of 1:50.000.
The soil data will be incorporated in this map. It has not yet been decided if a separate physiographic soil map will be incorporated.

previous work: In the past some soil research has been carried out but no maps have been produced.

progress made: The soil data are partly processed and a preliminary physiographic map has been prepared by the author at scale 1:150.000.
The report is in progress.

Area: Bukit Raya Nature reserve

Country: Central Kalimantan, Indonesia

Coordinates: 0°40' - 1°10' S and 112°30' to 113°20 E

Altitude: approx. 150 to 2278 m

Surface area: 110.000 ha

Background of the study:

The National Biological Institute of Indonesia and the Rijksherbarium, Leiden, the Netherlands, organized an expedition to the Bukit Raya Nature reserve in Central Kalimantan.

The expedition had a two fold aim:

- The inventarization of the lowland rainforest, and possibly the low mountainous forest, by collecting botanical material.
- To study the forest architecture and growth dynamics by the transect method.

The above mentioned institutes are cooperating in the framework of the Flora Malesiana Project. Therefore, at regular intervals, expeditions are organized to areas of which scarcely or no data are available.
The soil studies could contribute to both aspects of the programme by respectively reconnaissance and detailed studies.

Environment:

climate: The Bukit Raya area has an estimated rainfall of over 3000 mm per year. More precise data are not available due to the lack of stations.
Climatic classification (Köppen): Af

geology: Field observations indicate granites and andesites.
Hardly any fresh outcrops have been met.

vegetation: The lowland forest up to about 500 m is characterized by a large number of Dipterocarpaceae species.
The zone between 500 and 1500 m can be indicated as hill forest. In this zone no special family is dominating.
Above 1500 m the so-called moss forest occurs. At the top of the Bukit Raya at 2278 m a shrub vegetation has been found dominated by Ericaceae.

land use: The Bukit Raya area has the status of strict nature reserve, so no activities are allowed.

Along the rivers shifting cultivation is practised.

The lowland forest is threatened by logging activities.

Soil studies:

kind of study: Two types of soil studies have been carried out:

- A reconnaissance soil study has been carried out from approx. 170 m altitude to the top of the Bukit Raya.
- A very detailed soil map (1:1000) has been made of the plot where the forest dynamics have been studied.

previous work: No other soil studies have been carried out in the area. South of the Bukit Raya area, ORSTOM has carried out a reconnaissance survey in the framework of the Indonesian Transmigration programme.

progress made: When all the analytical data are available, the very detailed map can be finalized. The reports are in progress.

Land evaluation:

Due to the character of this study the land evaluation will be very limited.

Area: Gunung Gede - Gunung Pangrango National Park

Country: West Java, Indonesia

Coordinates: 6°50' to 7°10' S and 107°15' to 107°40' E

Altitude: 1500 to 3019 m

Surface area: 15.000 ha

Background of the study:

The Gunung (= mountain) Gede area is the oldest nature reserve in Indonesia. The lower part of this mountain is called Cibodas and has the status of Biosphere reserve. In this small area of 1040 ha a lot of botanical research has been carried out.
The soil studies of the whole National Park have been requested to complement these data.

Environment:

climate: The area is located in the wettest part of Java with an annual rainfall between 3000 and 4200 mm. The rainy season is from October to May with more than 200 mm rain per month and over 400 mm per month between December and March. In the dry season the rainfall is still over 100 mm per month.
Due to the elevation rather low temperatures are common. Occasionally nightfrost occurs at the top of the mountains.
Climatic classification (Köppen): Af.

geology: The G. Gede volcano is still active. The most recent, but minor eruption took place in 1947. The major part of the area is covered by so-called lahars (= mudstreams) and the material is andesitic.

vegetation: Primary forest which can be indicated as montane from 1500-2500 m, and as subalpine above 2500 m.

land use: The G. Gede - G. Pangrango area is a National Park.

Soil studies:

kind of study: The kind of study is not yet fixed depending whether aerial photographs are available. Up to now the available photographs are useless due to a very high cloud coverage.

previous work: No other soil studies have been carried out in the National Park.

progress made: Some reconnaissance trips have been made to the area. The mountainous character of the area limits the accessibility highly. Without photographs and reliable topographic maps intensive field work is not efficient.

Land evaluation:

It is not sure whether also a vegetation survey will be carried out. Consequently, it is not sure what kind of land evaluation exercise will be made.

Area: Krakatau islands group

Country: Sunda Strait, Indonesia

Coordinates: 6°30' to 6°35' S and 105°30' to 105°40' E

Altitudes: 0 to 813 m

Surface area: approx. 2500 ha

Background of the study:

In 1883 the Krakatau volcano erupted. To commemorate this event the Indonesian Institute of Sciences has organized a Symposium.
In the framework of this Symposium soil studies has been carried out on the remnants of the 1883 volcano.
Due to the 1883 eruption all the flora/fauna has been destroyed. The islands group form an ideal place to study the recolonization and the rate of soil formation.

Environment:

climate: Approximately 2500 mm per year. No rainfall station is present at the islands.
Climatic classification (Köppen): Af.

geology: The basement rocks of the islands have an andesite character. The chemical composition of the eruption products is changing with time and varies between basaltic and highly acid.

vegetation: The islands are now covered with a dense secondary vegetation. Only the youngest volcano, Anak (= child of) Krakatau which appeared above the sealevel in 1929 is still bare.

land use: The area has the status of strict nature reserve, consequently no activities are permitted.
In case of heavy weather fishermen use the islands as resting place.

Soil studies:

kind of study: The soils developed in materials erupted by the 1883 eruption have been studied along two transects.

previous work: In the framework of the Centennial Commemoration also the University of Hull has carried out soil studies.
In 1933 Van Baren studied the mineralogical changes in fifty years.

progress made: When the laboratory results are available the report can be finalized.

Land evaluation:

Due to the character of the study only a few remarks about the land evaluation will be made.

Selected Miscellaneous Activities

H. van Reuler

Papers presented

- Comparison of the Indonesian soil classification system with the USDA Soil Taxonomy and FAO/Unesco legend of the Soil Map of the World. Bogor, August 1982.
- An expedition to the Bukit Raya Nature reserve in Central Kalimantan, Indonesia (in Dutch, submitted to Panda, magazine of the Dutch branch of the WWF).

Meetings attended

Soil science meetings

- Soil correlation workshop, Bogor, Indonesia, 1981.
- Phospotrops Conference in Kuala Lumpur, Malaysia, 1981.
- 12th Congress of the International Soil Science Society, New Delhi, India, 1982.
- 1st Landplan I Conference. Bangkok, Thailand, 1982.

Missions (other than in connection with the work in MAB areas)

- Orientation visit to Thailand, Malaysia, and the Philippines, 1981.
- Collection of soil monoliths of the Benchmark Soils Project in Lampung, S. Sumatra (Typic Paleudult) and W. Java (Hydric Dystrandept).
- Collection of soil monoliths of two paddy profiles in Malang, E. Java.
- To assist Dr. Somasiri in Sri Lanka with the collection of some monoliths.
- To participate in a field trip of the School for Environmental Conservation Management, during this trip a half day long soil science excursion has been organized.

Future soil studies in South-East Asia (July 1983 - July 1984)

Indonesia

Gunung Gede - G. Pangrango National Park

The type of studies will depend on the availability of good quality aerial photographs.

If available a survey at a scale of approx. 1:50.000 will be carried out, otherwise some transects will be studied.

Berbak Nature reserve

Three students of the State University Utrecht are carrying out research in the framework of their M.Sc. programme.

The author assists the students in the preparation of a physiographic map and with the collection of some soil monoliths.

Expected problems: accessibility of the area.

G. Leuser National Park

One of the largest National Parks of Indonesia.

The author has been requested to prepare a detailed soil map of an area where some permanent vegetation plots are located. In this area also research on primates has been carried out.

Thailand

Sakaerat Environmental Research Station (SERS)

Last year soil studies were planned in SERS, but this had to be postponed due to other obligations of the author.

In this rather small area of approx. 7000 ha two vegetation types occur: dry evergreen and dry dipterocarp forest.

In 1967 already a soil map has been produced which will serve as guide.

CASE STUDIES FROM LATIN AMERICA

Area: Mapimí Biosphere Reserve

Country: Mexico (Durango State)

Coordinates: 26°29' - 26°52' N and 103°32' - 103°58' W

Altitude: 1075 to 1680 m

Surface area: 174.000 ha

Background of the study:

The area was recognized as MAB biosphere reserve in 1977.

The reserve was established primarily to protect the desert tortoise (Gopherus flavomarginatus), that was threatened by extinction due to excessive hunting. Scientists from the Institute of Ecology in Mexico City reached an agreement with local "ejidatarios" and ranchers on abandoning the tortoise hunt in exchange for ecological research in the area aimed at the improvement of the forage resources of the area. The existence basis for the cattle raisers living in the reserve can in this way be improved. A soil map was needed for the ecological studies to improve the grasslands of the reserve.

Environment:

climate: Average annual rainfall is about 230 mm, whereby a minimum of 150 mm is highly probable to fall every year. Precipitation is concentrated in the months July to September.

Average annual temperature is 19°C, in January temperature averages 12°C, in June 28°C.

Climatic classification (Köppen): BWh

geology: The dominant rocks occurring in the area are:

Cretaceous limestones (eastern part), Cretaceous sandstone (northern part), Tertiary conglomerates (central and western part), Tertiary volcanic rocks: basalt and acid rocks, Quaternary basalts and Quaternary recent sediments, covering most of the reserve.

vegetation: Mainly open shrubland communities with Larrea divaricata as dominant or subdominant species and shrubby open grasslands dominated by Hilaria mutica or Sporobolus airoides.

land use: The main land use is extensive grazing and breeding of cattle, almost exclusively cows. An important secondary land use is the extraction of "candelilla" (Euphorbia antisyphilitica) for the production of resin. Near the Laguna de Palomas salt is extracted at industrial scale.

Soil studies:

kind of study: Soil survey at scale 1:25.000 through recompilation of existing soil data and additional field work. The final map was produced at scale 1:100.000.

previous work: CETENAL soil maps at scale 1:50.000, using the FAO/Unesco classification system to define mapping units, with some additional phases (four salinity phases, etc.). Maps are produced without survey reports, field and laboratory data are printed at the back of the maps. Some ecological studies are available including some soil data, however without clear indication of sample locations.

progress made: The field soil map at scale 1:25.000 has been finished, as well as the reduced final soil map at scale 1:100.000. This map is now being printed at the ITC (print proof available).
The survey report is in progress.

Land evaluation:

Beside the soil survey a vegetation survey was carried out by Mexican ecologists. It is envisaged that on the basis of both surveys a land evaluation exercise be made for improvement of the forage resources under extensive grazing. The research being carried out by two ORSTOM scientists on the relation between vegetation and soil moisture will be very helpful for this land evaluation.

Problems encountered:

Due to limited time for field work (one month) not all mapping units are described in profile pits, but these units represent mainly the shallow and stony soils.

Area: Pampa de Achala

Country: Argentina (Province of Cordoba)

Coordinates: 31°25' - 31°53' S and 64°40' - 64°54' W

Altitude: 2000-2300 m

Surface area: about 70.000 ha

Background of the study:

The area forms part of the Pachon-Achala project of MAB-6 (mountainous ecosystems). The Pampa de Achala is the highest plateau of the Sierra de Córdoba, that has the function of a catchment area for the rivers feeding the artificial lakes east of the main mountain chain. The accelerated erosion occurring in the area prompted the ecological centre of the National University of Cordoba to make a study into the causes of the erosion, as signs of ecological disequilibrium. For this study a soil map was needed.

Environment:

climate: Average annual rainfall is about 850 mm, concentrated in the summer months November to March.
Average annual temperature is 8°C, average January temperature is 13°C (average maximum 18°C), average July temperature is 4°C (average minimum -2°C).
Climate classification (Köppen) Cw

geology: Almost the entire area consists of a Precambrian granite batholith. Only one small patch of mica-rich gneiss enters the survey area.

vegetation: The climax vegetation is a Deyeuxia hieronymi grassland, associated with Alchemilla pinnata "lawn" (soil-covering vegetation stratum). Wetlands are dominated by Poa stuckertii high grasslands in association with Alchemilla "lawn".

land use: The exclusive land use is cattle grazing on ranches ("estancias") of several thousands of hectares. Aberdeen-Angus is the prevailing cattle type.

Soil studies:

kind of study: Detailed soil survey at scale 1:5.000 of two pilot areas, where vegetation mapping was concentrated. A soil survey at scale 1:20.000 was made of the whole area, with final map production at scale 1:50.000.

previous work: A short report of Zamora and Pachecoy, 1980(?), describes the soils of three small areas of the pampa, with six profile descriptions plus analytical data.

progress made: two detailed soil maps at scale 1:5.000 plus the overall map at scale 1:50.000 have been completed. The survey report is in progress but still awaits the analytical data of the soil profiles.

Land evaluation:

It is envisaged to carry out a land evaluation for cattle grazing, including the vegetation data collected by the Argentine ecologists. Erosion hazard rating will form part of the land evaluation.

Problems encountered:

Work started and advanced slowly in Cordoba due to retarded availability of air photos and limited time for field work. Summer is too wet, winter too cold for field work.

The arrangements made with a soil laboratory for the analysis of samples did not work out well and no analytical data are available from the profiles yet.

Area: experimental site near Los Andes, some 90 km north of Santiago

Country: Chile (Fifth Region)

Coordinates: 32°52' S and 70°35' W

Altitude: about 800 m

Surface area: -

Background of the study:

As a follow-up of ecological research carried out in the framework of the UNEP/Unesco Andean Project, a two-year erosion measurement project was funded by Unesco. The Ecological Laboratory of the Catholic University of Chile is carrying out the project, that started in 1982. The project design was made in collaboration with Unesco scientists, testing out some new simple methods of slope processes evaluation.

Environment:

climate: Average annual rainfall is 230-300 mm, concentrated in the winter months May to August.
Average annual temperature is 15°C, average temperatures are 20°C in January and 11°C in July.
Climate classification (Köppen): Csb

geology: At the site mixed igneous and metamorphic intermediate rocks are cropping out, belonging to the "Cordón de Chacabuco".

vegetation: The dominant vegetation of the mountain slopes is a shrubland of Flourencia sp., Acacia sp. and Cactaceae, with different degrees of degradation to open shrubby grasslands with low vegetation cover percentages. The vegetation cover differs considerably from site to site.

land use: While irrigated agriculture is practised in the flat valley bottoms, the steep mountain slopes are used exclusively for goat grazing.

Soil studies:

kind of study: Erosion measurement project, using different measuring techniques.
Three methods were tested simultaneously during the first year:

1. liquid and solid runoff interception (V-shaped bars with drum);
2. microrelief measurement (five pairs of metal bars vertically in the soil);
3. stone displacement (stones of different size classes put in horizontal lines).

These methods were used on four sites, differing in slope gradient and vegetation.

previous work: A two-year erosion measurement experiment had been carried out on a 30° slope near Santiago, showing that the grass cover is most important in limiting soil losses, while the shrub cover did not have much influence on the measured sheet erosion.

progress made: The results of the first year confirmed the results previously obtained, that the grass cover of the soil is the main protection against erosion. The soil loss differences were in accordance with slope gradient and vegetation cover differences and methods 1 and 2 both indicated the same trends. Method 2 did not give statistically significant differences in one year, but should be used for several consecutive years at least to yield some valuable data. Method 3 indicated more displacement on steeper slopes and fewer but farther displacement of bigger stones.
The second year work is concentrated on one site (the most degraded one), installing three big fenced areas with different goat management: 1. no goats grazing; 2. early goat grazing; 3. late goat grazing.
It is expected that early grazing or browsing (at beginning of rainy season) causes more erosion then late browsing.
The author's contribution consisted of advising on the project's set up and in describing and sampling soil profiles at each measurement site.

Problems encountered:

It was difficult to find a suitable experiment design that would yield valuable data without consuming excessive amounts of capital and manpower.

Area: San Carlos de Rio Negro research site

Country: Venezuela (Amazon Federal Territory)

Coordinates: 02°55' N and 67°03' W

Altitude: 100-150 m

Surface area: -

Background of the study:

In 1974 an international research project started in San Carlos de Rio Negro, under the supervision of the Ecology Centre of IVIC (Venezuelan Institute of Scientific Research).

Ecological research was carried out into the structure and functioning of the tropical lowland forest, with emphasis on nutrient cycling.

A short visit was paid to the area to evaluate the needs for and possibilities of soil survey. During the visit a transect was studied more in detail.

Environment:

climate: Weakly seasonal equatorial climate with mean annual temperatures of 26°C and a mean annual rainfall of 3600 mm, whereas monthly rainfall never falls below 100 mm.

Climatic classification (Köppen): Af.

geology: The area forms part of the Precambrian basement of the Guiana shield, consisting of rocks in which a granitic component and a metamorphic component are intimately mixed: granites, gneisses, granodiorites and schists mainly.

vegetation: Evergreen tropical lowland forest, with local variations related to soil type and water regime.

laterite hills ("tierra firme"): mixed forest

sandy valleys: so-called Amazon Caatinga forest, with three variants: Yaguácana (Eperua leucantha) forest on low-lying sites, Conuri (Micrandra spruceana) vegetation on intermediate slightly higher terrain and the locally called "Bana" open heath-like vegetation on the highest positions. Hill sides are occupied by Yévaro (Eperua purpurea) forest.

land use: subsistence farming on upper hill sides (yellow acrisols), semi permanent cultivation and shifting cultivation.

Soil studies:

kind of study: Study of a 2.5 km transect along a major road, including soil profile descriptions and correlation with vegetation types.

previous work: Apart from the many ecological research reports produced by the project ecologists, a study was published by Dubroeucq and Sanchez (1981) about soil and environmental characteristics of the San Carlos area.

progress made: a cross-section has been produced of the study with ten soil profiles and a schematic cross-section, which includes all major vegetation types and their relation to soil types. This transect will be used in the book that is being edited on the San Carlos project results.

Problems encountered:

During discussions on a possible soil survey around the project site, it was not clear on what scale this mapping should be done, as the reported differences occur at short distances and cannot be surveyed other than in a complex at scales smaller than about 1:50.000. Small scale mapping does not seem to have much sense in this area.

Selected Miscellaneous Activities

R.F. Breimer

Papers presented (in Spanish)

- Ecological Aspects of Erosion, speech held at Erosion Meeting, Bogotá, Colombia, 1981.
- Selected Papers presented at Erosion Meeting, Bogotá, Colombia (editing work), 1981.
- The Role of Soil Science in Rural Development, paper prepared for the First Latin American Seminar on Science and Technology for Rural Development, Lima, Peru, 1982.
- Soil Conservation in an Ecological Context, paper presented at Environmental Conference, Salto, Uruguay, 1982.
- Ecology and Human Settlements in Arid Zones, sppeck held at Autofagasta Seminar, Chile, 1983.

Meetings attended

Soil Science meetings

- Seminar on Soil Deterioration and Conservation, Buenos Aires, Argentina, 1980.
- Experts' Meeting on Erosion Processes in the Northern Andes, Bogotá, Colombia, 1981.
- 12th International Congress of Soil Science Society, New Delhi, India, 1982.

Other meetings

- Latin American Regional Conference of the International Geographical Union, Rio de Janeiro, Brazil, 1982.
- Conference on the Environment of the Uruguay River Basin, Salto, Uruguay, 1982.
- Seminar on Environmental and Human Settlements in Arid Zones, Autofagasta, Chile, 1983.

Missions (other than in connection with field work)

- Orientation mission to Argentina, Chile, Peru, Colombia and Mexico, 1981.
- Advisory missions for erosion project Chile, 1982 and 1983.

- Orientation mission to Venezuela, 1982.
- Idem, to Paraguay, 1982.
- Collection of soil monolith in eastern Uruguay, 1982.
- Orientation mission to San Guillermo Biosphere Reserve, Argentina, 1983.

Other activities

- Writing of articles and short notes for bulletin of regional office.
- Editing issues of regional office bulletin.

Future soil studies in Latin America

Mexico

Mapimí Biosphere Reserve

Completion of the survey report writing and execution of a land evaluation exercise for extensive grazing.

La Michilía Biosphere Reserve

Possibly a soil survey of this area if Mexican ecologists still insist in the desirability of such a survey, as 1:50.000 CETENAL soil maps are available from the area.

Chile

Los Andes research site

Continuation of the erosion measurements and evaluation of the results obtained. It will be advised to continue the measurements in the future to obtain more reliable data.

Argentina

Pampa de Achala area

Completion of the survey writing.

San Guillermo Biosphere Reserve

A soil survey of the hydromorphic valleys of the reserve has been requested by Argentine scientists involved in population studies of the Camelid communities protected in this area. No final arrangements have been made yet.

General: Soil monoliths will be collected from the Argentine pampa region for the ISM. Some profiles out of a transect from the humid pampa to the semi-arid south or west was envisaged.

Venezuela

San Carlos de Rio Negro research site

A proposal for a soil survey of the area around the research site has been made, including adjacent areas of Colombia and Brazil. But it is not clear at what scale a mapping effort should be done, as soil differences often occur at small distances (see previous paper).

Paraguay

Paraguayan officials have requested Unesco to cooperate in a soil conservation and mapping project, to be carried out by the FAO. Unesco's role could exist in compiling a reconnaissance map of eastern Paraguay out of existing soil surveys and additional data produced by the FAO project. This would, however, be a great task that cannot be entrusted to one soil specialist only. No concrete action has been undertaken so far.

Uruguay

Several soil monoliths will be collected for the ISM in close cooperation with the local soil survey organization. Emphasis will be laid on phaeozems and vertisols.