Working Paper and Preprint 90/7

WORLD MAP OF THE STATUS OF HUMAN-INDUCED SOIL DEGRADATION

An Explanatory Note

L.R. Oldeman
R.T.A. Hakkeling
W.G. Sombroek

Global Assessment of Soil Degradation
GLASOD

ISRIC

in cooperation with
Winand Staring Centre-ISSS-FAO-ITC

UNEP

World Map of the Status of Human-Induced Soil Degradation
An Explanatory Note

FOREWORD

The soil is an important source and sink of both elemental and molecular components of the planet. Life on earth depends very directly on the living soil and aquatic ecosystems. Without fertile soils and the microbial fauna that inhabit it, crops would not grow, dead material would not decay, and nutrients would not be recycled.

Past and present human intervention in the utilization and manipulation of environmental resources are having unanticipated consequences. Brundtland et al. (1987) stated in their report 'Our Common Future': 'There is a growing realization in national and multilateral institutions that not only many forms of economic development erode the environmental resources upon which they are based, but at the same time environmental degradation can undermine economic development'. They indicate that there is a possibility for a new era of economic growth, based on policies that sustain and expand the environmental resource base, but that this hope for the future depends on decisive political action *now* to begin managing environmental resources in such a way that both sustainable human progress and human survival is ensured.

The World Map of the present status of human-induced soil degradation is to be considered as a tool to create awareness among policy-makers and decision-makers on the seriousness of soil degradation in a global perspective. Quantitative acreage estimates on the basis of the present map will be available under a follow-up activity ISRIC-UNEP (to be published early 1991).

INTRODUCTION

Late September 1987 the United Nations Environment Programme (UNEP) concluded an agreement with the International Soil Reference and Information Centre (ISRIC) for the execution of a project, entitled: Global Assessment of Soil Degradation (GLASOD). The three year project involved two separate activities:
- Preparation of a world map on the status of soil degradation at a scale of 1:10 M
- Preparation of a detailed assessment on soil degradation status and risk for a pilot area in Latin America, covering parts of Argentina, Brazil and Uruguay, accompanied by a 1:1M map.

This explanatory note deals with the preparation of the world soil degradation map. In the first section the historical perspective of mapping global soil degradation is reviewed; the major objectives are discussed, and a general overview of the various aspects of the project organization is given. In the second section a more detailed account is given of the methodologies applied to prepare and publish the world soil degradation map within a three year period. The third section of this report gives a detailed explanation of the legend of the world map on human-induced soil degradation. The fourth section deals briefly with possible follow-up activities on the basis of this world soil degradation map.

TABLE OF CONTENTS

I TOWARDS THE PREPARATION OF A WORLD SOIL DEGRADATION ASSESSMENT

1.1 Historical Perspective

The first United Nations Conference on the Human Environment held in Stockholm, 1972, was inspired by the increasing awareness of the continuing deterioration of the renewable environmental resources. As a result of this meeting the United Nations Environment Programme (UNEP) was born.

An expert consultation on soil degradation, convened by FAO and UNEP in Rome, 1979, recommended that a global assessment be made of actual and potential soil degradation in collaboration with UNESCO, WMO and ISSS[1]. This assessment should be based on the compilation of existing data and the interpretation of environmental factors influencing the extent and intensity of soil degradation such as climate, vegetation, soil characteristics, soil management, topography and type of land utilization; the results of this assessment should be compiled as a World Map of Soil Degradation. During the next four years FAO, UNESCO, and UNEP developed a provisional methodology for soil degradation assessment and prepared a first approximation to identify areas of potential degradation hazard for soil erosion by wind and water, and for salinization and sodication. Maps at a scale of 1:5 M covering Africa north of the equator and the Middle East were prepared (FAO, 1979).

As an outgrow within the ISSS of this Society's increasing concern for soil degradation and environmental quality, a sub-commission on Soil Conservation and Environmental Quality was established during the New Delhi ISSS Congress in 1982. In the same year the Governing Council of UNEP adopted a World Soils Policy document aimed at 'conserving this most important of natural resources and using it on a sustainable basis' (UNEP, 1982). One of the elements of the World Soils Policy was, and still is the development of methodologies to monitor global soil and land resources. Methods are required which can reliably detect significant changes in those soil and terrain characteristics which directly or indirectly effect the quantity and quality of the land and its ability to produce food, fibre and timber. An assessment of the status and risk of soil degradation will provide one of the essential data sets for such a global understanding.

In response to these objectives Sombroek (1985) prepared a discussion paper on the Establishment of an International Soil and Land Resources Information Base. This paper formed the base of an international workshop early 1986 at ISRIC[2], Wageningen, to discuss the aims and scope of a possible international programme to establish a digital soil resources map of the world and accompanying soil and terrain databases at a scale of 1:1M (ISSS, 1986). The only available document on the geography of the World's soil resource at that time was the FAO/UNESCO/ISSS Soil Map of the World at 1:5M scale, prepared by conventional cartography and resulting from a major international action programme to aggregate all soil survey information of the past 15 to 20 years. There was a unanimous agreement as to the need and desirability of the proposed 1:1M soil map, and a project proposal for a World Soils and Terrain Digital Database (SOTER) was prepared (Baumgardner, 1986) and endorsed at the ISSS international soil congress in Hamburg, 1986.

Recognizing the importance of the SOTER proposal, UNEP convened an ad-hoc expert meeting at Nairobi in May 1987 to discuss the feasibility of producing a Global Soil Degradation Assessment. SOTER would provide the scientific ingredients - soil and terrain attributes - to make a quantitative assessment of the rate and risk of soil degradation at sufficient detail for national and regional planning. A world coverage of SOTER however is expected to take at least 15 years. This approach does not solve UNEP's desire for a global soil degradation assessment *now*. Even in 1987 the public awareness of the problem of the world's soil degradation did not correspond to the magnitude of the problem. UNEP therefore

---

[1]UNESCO: United Nations Educational Scientific and Cultural Organization
WMO: World Meteorological Organization
ISSS: International Society of Soil Science

[2]ISRIC: International Soil Reference and Information Centre

requested the ad-hoc expert meeting to consider the possibility to produce, on a basis of incomplete knowledge, a scientifically credible global assessment of soil degradation in the shortest possible time. 'Politically it is important to have an assessment of good quality *now* instead of having an assessment of very good quality in 15 or 20 years' (ISSS, 1987). The meeting reached consensus and recommended to UNEP as follows:

- Preparation of a global soil degradation map at a scale of 1:10 M be completed in three years.
- Preparation of a soils and terrain digital database and generation of soil degradation maps at a scale of 1:1 M for five test areas in the framework of SOTER.

On the basis of these recommendations UNEP formulated a project document: Global Assessment of Soil Degradation (GLASOD) and a agreement was concluded in September 1987 with ISRIC for the execution of GLASOD. ISRIC was requested to administer and coordinate all activities related to the accomplishment of

- A world map on the status of human-induced soil degradation at a scale of 1:10 M and
- A detailed assessment on the status and risk of soil degradation for one pilot area in Latin America, covering parts of Argentina, Brazil, and Uruguay, accompanied by a 1:1M map.

The project had a duration of 28 months. ISRIC was assisted in the execution of the activities by many individual members of the ISSS, the Winand Staring Centre-WSC (formerly the Netherlands Soil Survey Institute STIBOKA), FAO, and the International Institute for Aerospace Survey and Earth Sciences-ITC.

1.2 Objectives of GLASOD

As formulated in the project document the immediate objective of GLASOD is: 'Strengthening the awareness of policy-makers and decision-makers on the dangers resulting from inappropriate land and soil management, and leading to a basis for the establishment of priorities for action programmes'.

A realistic understanding of global environmental changes is needed. The often indiscriminate destruction of forests and woodlands, and the spectre of land degradation resulting in decreased productivity with dire social consequences is generally recognized. By some estimates 10% of the land surface of our planet has been transformed by human activities from forest and rangeland into desert and as much as 25% more is at risk (World Resources, 1990). The earth's soils are being washed away, rendered sterile or contaminated with toxic chemicals at a rate that cannot be sustained. The loss of existing agricultural land through erosion is estimated at 6 to 7 million ha. per year with an additional loss of 1.5 million ha. annually as a result of waterlogging, salinization and alkalinization (Brundtland, 1987). Although soil degradation is recognized as a very widespread problem, its geographical distribution and total areas that are affected is only very roughly known. 'Sweeping statements contending that soil erosion is undermining the future prosperity of mankind, while holding an element of truth, do not help planners, who need to know where the problem is serious and where it is not' (Dregne, 1986).

1.3 Project Organization

In order to achieve the ambitious goal to prepare and publish a world map on the status of human-induced soil degradation within a time frame of three years, cooperation from a large group of soil scientists throughout the world was sought. They were asked to give their expert opinion on soil degradation in their particular geographic region.

The use of this 'expert-system' approach implied the need to prepare general guidelines for the assessment of the status of human-induced soil degradation. These guidelines were needed to ensure uniformity in reporting and delineating on maps the seriousness of various soil degradation processes. In order to avoid that maps of different scales and different projections would be used, a simplified geographic base map had to be prepared.

Obviously it was not feasible to request soil scientists in all nations of the world to prepare their own soil degradation maps. As soil degradation phenomena transcends national boundaries, the international panel of experts that convened in Nairobi (May 1987) suggested to divide the world in ten geographic regions, and to assign a correlator for each region. Because of logistic, administrative and political considerations the project came up with 21 regions (figure 1). Regional correlators - institutes and/or individual qualified experts - were designated and asked to prepare draft regional soil degradation maps on the supplied geographic base maps following the general guidelines as closely as possible and in consultation with national soil experts in their region. Over 250 soil and environmental scientist have cooperated and their expert opinion has been of invaluable importance (see annex 1). The regional correlators were requested to send their reports on the status of human-induced soil degradation, accompanied with a draft soil degradation map and complementary matrix tables to the project centre within 9 months. The first reports were received in February 1989, while the last regional report was sent in January 1990.

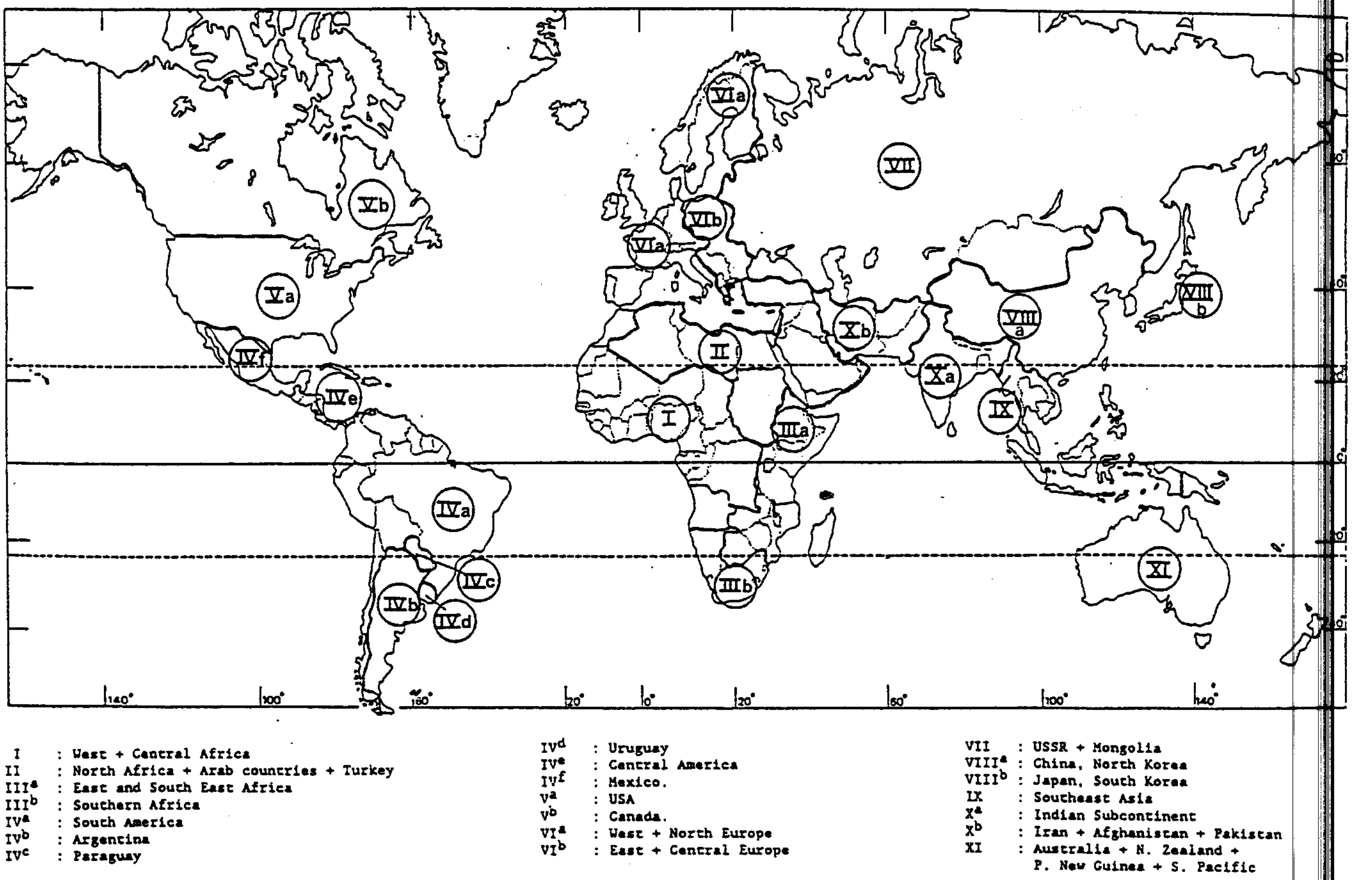

Figure 1: GLASOD Regions

In the mean time, procedures were developed for the final preparation of the GLASOD map. Through a fruitful cooperation with the Winand Staring Centre in Wageningen, guiding principles were developed for the compilation of the 21 regional soil degradation maps. These were tested when the first regional maps arrived, improvements were made and comments of the regional correlators were, whenever possible, incorporated to ensure that the final GLASOD map was the best possible approximation of the global status of soil degradation.

The final draft version of the GLASOD map was then sent to national soils institutions throughout the world for their comments and acceptance. The response from a large cross section of the countries gave the project management sufficient confidence about the quality of the GLASOD map. At that stage the 'green light' was given to the cartographers to prepare the final version of the map.

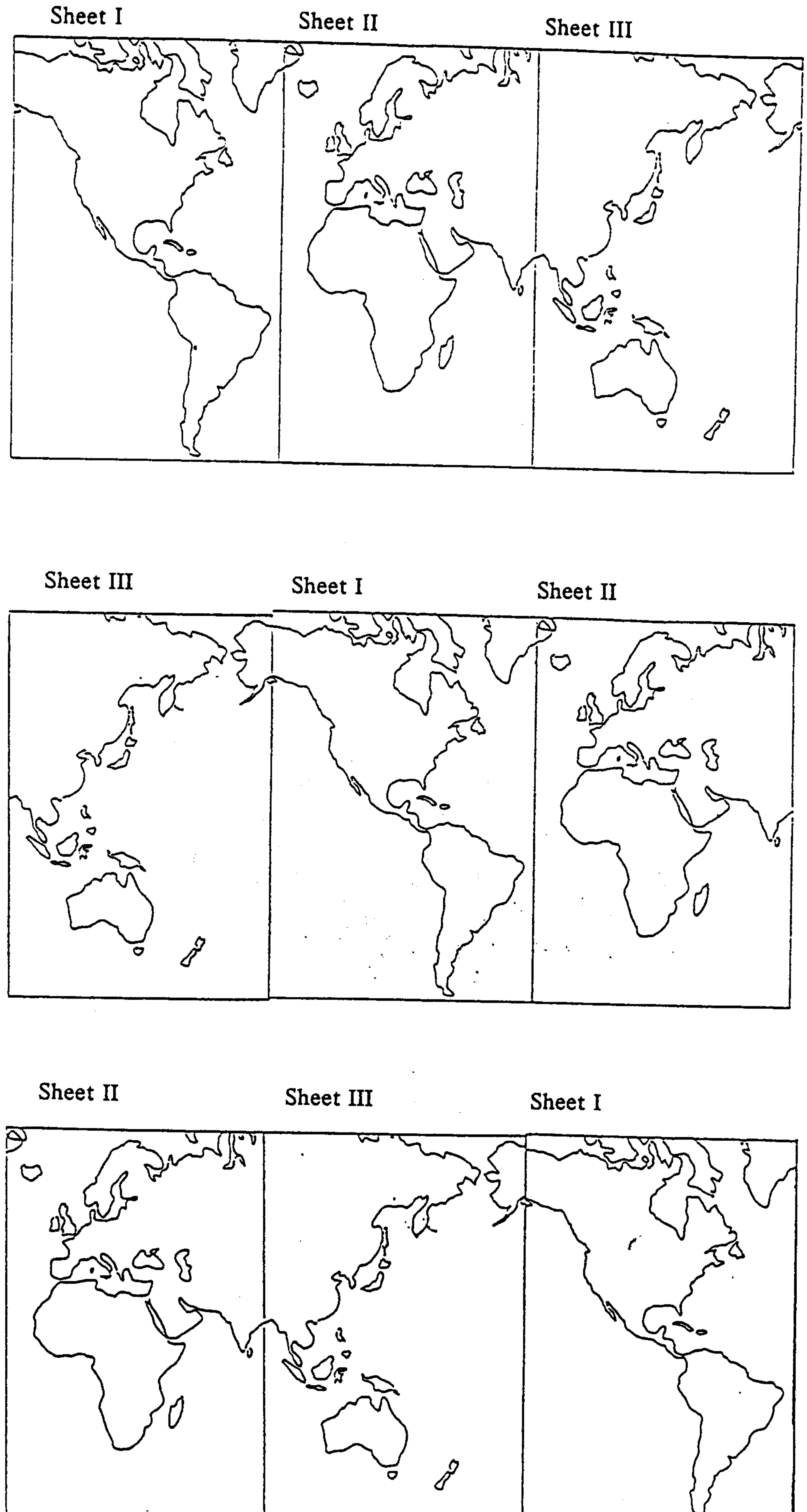

Figure 2: Three possible arrangements of the GLASOD map with Mercator projection

The experience of the Winand Staring Centre in the preparation of a wide variety of different types of soil maps and the excellent facilities of their cartography division, which carried out the final map preparation, made it possible to publish the GLASOD map within three years after the start of the project.

II METHODOLOGY FOR THE PREPARATION OF A WORLD MAP OF SOIL DEGRADATION

In this section a brief overview is given on the choice of the topographic map that would serve as base map to delineate soil degradation status; on the elements that should be described and delineated on the map, and on the methodologies to be used by the regional soil degradation correlators to prepare regional assessments of soil degradation.

2.1 The Topographic Base Map

UNEP requested a world soil degradation map at a scale of 1:10 M. The immediate objective of the map was to create awareness of the present status of soil degradation for policy-makers, decision-makers, and the general public at large. This implied that a topographic base map was needed that could be conveniently displayed on an office wall, in conference centres, in classrooms, etc. The project therefore decided to use as topographic base a map on which the various continents would be displayed with as less distortion as possible: a world map with Mercator projection was the obvious choice. An additional advantage of this projection is that the three map sheets - the America's; Europe and Africa; Asia and the Pacific region - could be interchanged at will (figure 2). A disadvantage is the variation in scale. At the equator the scale is smaller than at other longitudes. In fact the topographic base map that was chosen had a scale of 1:15 M at the equator; 1:10 M at 48° longitude; 1:5 M at 70° longitude (figure 3). This scale distortion should be realized when areas displayed on the map are interpreted as actual surface areas. It is however possible to calculate actual surface areas being affected once the map units are digitized and linked to a Geographic Information System, capable of converting Mercator Projection (see section IV) into 'equal area' projection.

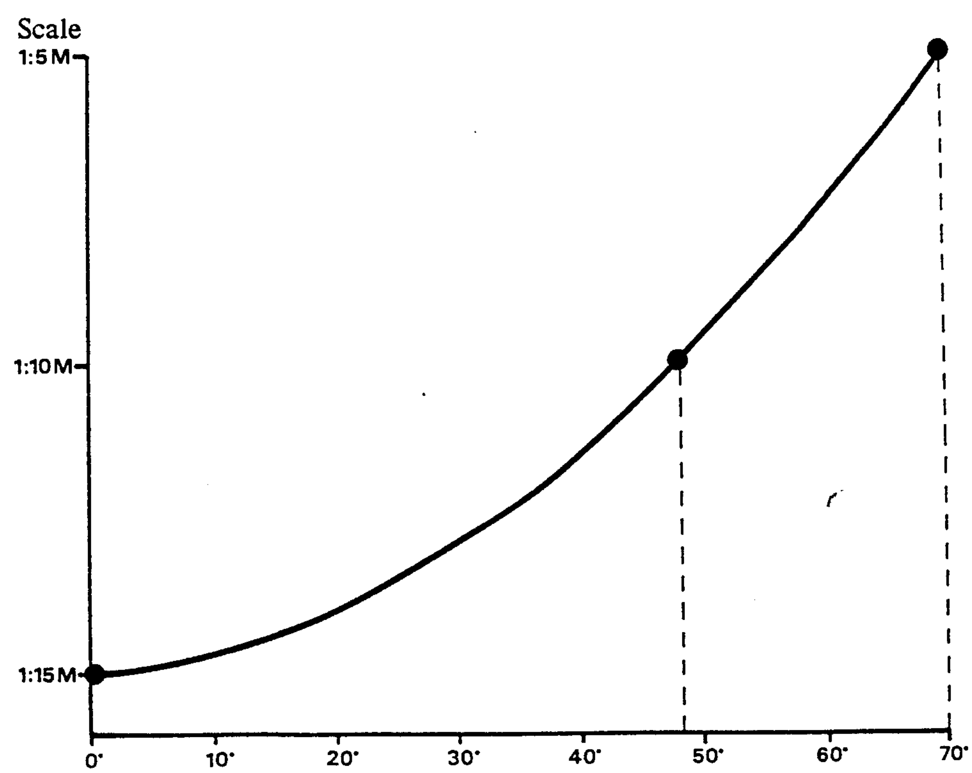

Figure 3: Relationship between scale and latitude as a consequence of Mercator projection.

2.2 Methodologies for Regional Soil Degradation Assessment

An International advisory committee and a large group of soil degradation specialists were consulted in the preparation of 'Guidelines for General Assessment of the Status of Human-induced Soil Degradation'. In its final edited version (ISRIC, 1988), these guidelines were distributed to the regional correlators to ensure uniform application of methodologies for the assessment and mapping of soil degradation. In this section a short description is given on the various elements that were to be mapped by the regional correlators. Then a brief outline is given on the methodology of mapping and reporting.

2.2.1 Types of human-induced soil degradation, its degree, recent-past rate, relative extent and causative factors.

2.2.1.1 Types of degradation processes

Two categories of human-induced soil degradation processes were recognized. The first category deals with soil degradation by displacement of soil material. The two major types of soil degradation in this category are water erosion and wind erosion. Both types can be further subdivided in a) loss of topsoil, defined as a loss by which a uniform part of the topsoil is displaced, and b) terrain deformation, in which case there is an irregular or uneven displacement of soil material. Displacement of topsoil will also lead to off-site effects such as (in case of water erosion) reservoir, harbour, or lake sedimentation; flooding, including riverbed filling, riverbank erosion, excessive siltation of the basin land; coral, shellfish beds and seaweed destruction. In case of wind erosion the off-site effects in the form of dunes, sand sheets etc. can result in encroachment on structures or roads, buildings and/or sand blasting of vegetative cover. These off-site effects were to be indicated on the draft map by 'flagging'.

The second category of soil degradation describes soil degradation types as a result of internal soil degradation. Three possible types of soil degradation are described: chemical deterioration; physical deterioration; and biological deterioration.
Chemical deterioration is subdivided into the following types:
- Loss of nutrients (e.g. accelerated acidification of soils in the humid tropics)
- Salinization, caused by human activities such as irrigation
- Acidification and pollution from (bio)industrial sources
- Discontinuation of flood induced fertility
- Gleysation as a result of waterlogging
- Other chemical problems, such as catclay formation upon drainage of coastal swamps; negative chemical changes and development of toxicities in paddy fields.

Physical deterioration is subdivided in the following types:
- Sealing and crusting of topsoil
- Compaction, caused by heavy machinery on soils with weak structure stability
- Soil structure deterioration due to dispersion of soil material by Na (and Mg) salts in the subsoil
- Waterlogging
- Aridification (caused for instance by lowering of the local base ground water level)
- Subsidence of organic soils (by drainage and oxidation).

Biological deterioration is not further subdivided. It is defined as an imbalance of (micro)biological activity in the topsoil. This can be caused by deforestation in the humid tropics or by overdoses of chemical fertilizers in industrialized countries.

As will be discussed later (3.1 and 3.2.3) not all types listed here were recognized by the regional correlators, or could be mapped at this scale.

2.2.1.2 The degree of soil degradation

Recognition of the degree to which the soil is presently degraded is estimated in relation to changes in agricultural suitability, in relation to declined productivity, and in some cases in relation to its biotic functions. Four levels of degree were to be estimated:

LIGHT: The terrain has somewhat reduced agricultural suitability, but is suitable for use in local farming systems. Restoration to full productivity is possible by modifications of the management system. Original biotic functions are still largely intact.

MODERATE: The terrain has greatly reduced agricultural productivity but is still suitable for use in local farming systems. Major improvements are required to restore productivity. Original biotic functions are partially destroyed.

STRONG: The terrain is unreclaimable at farm level. Major engineering works are required for terrain restoration. Original biotic functions are largely destroyed.

EXTREME: The terrain is unreclaimable and beyond restoration. Original biotic functions are fully destroyed.

2.2.1.3 Recent-past rate of soil degradation

Recognition of the average rate of human-induced soil degradation should be estimated in dependence of changes in local population densities (both human and animal), and/or in relation to intensification of mechanization, agricultural expansion, fertilizer use, industrialization, etc. occurring over the last 5 to 10 years. Instances of soil degradation during critical periods should be totalled and averaged over the last 5 to 10 years in order to define whether the rate is slow, medium or rapid. Reasons for indicating various rates should be explained as detailed as possible in the accompanying report.

2.2.1.4 Relative extent of the degradation type

Correlators were asked to indicate whether the degradation type that was recognized in a mapped unit occurred infrequent (up to 5% of the unit affected); common (6-10% being affected); frequent (11-25% being affected); very frequent (26-50% being affected) or dominant (more than 50% affected). Local knowledge of the areas is very important to estimate the relative frequency of occurrence of soil degradation in delineated mapping units.

2.2.1.5 Causative factors

The word 'soil degradation' is by definition a social problem. Purely environmental processes such as leaching and erosion occur with or without human interference, but for these processes to be described as 'degradation' implies social criteria which relate land to its actual or possible uses (Blaikie and Brookfield, 1987). For this reason the correlators are asked to indicate what kind of physical human intervention has caused the soil to be degraded.

Soil degradation can be caused by exploitation of the original vegetative cover, either through deforestation - burning for clearing the land or logging - or through over-exploitation for domestic uses (as fuel source, fencing material etc.). Soil degradation can also be caused by over-intensive use of the agricultural land (e.g. heavy machinery; intensive fertilizer use; irrigation) or by overgrazing of pasture lands. Finally, soil degradation can be the result of (bio)industrial waste such as contamination of the ground water and acid rain deposition.

2.2.2 Miscellaneous terrain types: stable terrain and non-used wasteland

While human-induced soil degradation occurs widespread throughout the world, we should also recognize the many effective soil improvement and protection programmes, undertaken by national and international bodies. Large areas are not affected at all by human intervention by the mere fact that population density is very low.

Since we are only interested in human-induced soil degradation, we exclude natural soil degradation phenomena that took place in the distant past as a result of geologic events or under past climatic conditions, such as the rising of mountain chains; volcanic eruptions and the subsequent erosion of fresh lava and ash materials; the melting of glaciers; the rising and subsidence of ocean levels; occurrence of pluvial and interpluvial periods etc. However we will indicate those areas where natural erosion has led to extreme conditions, such as deserts, salt flats, rock outcrops, etc. Deserts could still be a source of danger to the lands around its edges by sand blasting and drift. A salt flat is a source of salt, capable of causing salinization of the terrain around it. Rock outcrops may cause excessive run-on on neighbouring land.

2.2.2.1 Stable terrain

In this category we distinguish between terrain that is stable because of a permanent natural vegetation cover (e.g. tundra, natural forest, marshes/swamps) or a permanent agricultural cover without intended conservation practices as well as terrain that is stabilized by human intervention as a result of conservation practices (e.g. paddy or wetland rice field terraces; conservation practices for rainfed crops or other forms of permanent conservation measures: reforestation, permanent plantation crops; empoldering).

2.2.2.2 Non-used wastelands

This group of mapping units comprises areas which cannot be considered stable, even though they show no signs of human-induced soil degradation. On the map one should recognize active dunes; salt flats; rock outcrops, deserts; ice caps, arid mountain regions.

2.3 Mapping Procedures for Regional Soil Degradation Evaluation

The second part of the guidelines described in detail how the above discussed phenomena should be mapped. The correlators were asked to map the status of soil degradation caused by human intervention as follows:

The first step should involve the delineation of physiographic units on the supplied base map. These units should show certain degree of homogeneity of topography, geology, soils, climate, vegetation and land utilization. Diagnostic criteria could be animal and human population densities. Each delineated unit should get a unique number and the general aspects related to each physiographic unit should be documented on a matrix table (figure 4). The next step involves the evaluation of the degree, relative extent, recent past rate and causative factors for each type of human-induced soil degradation, as it may occur in the delineated physiographic unit. This evaluation process should be carried out in close cooperation with national and/or international experts with local knowledge of the region. The evaluation process results in a list of human-induced soil degradation types per physiographic unit, ranking them in order of importance. These are to be filled out on the supplied matrix table formats. Mapping symbols are given for each soil degradation type.

Obviously not all terrain within a physiographic unit is affected by human-induced soil degradation. The 'rest group' - be it 'stable terrain' or 'miscellaneous terrain types' - should also be indicated in the matrix table. In this case only the relative extent of these terrain types should be indicated.

Finally the correlators were asked to prepare a technical report with a detailed description of human-induced soil degradation for their respective regions, in particular the criteria used for defining the degree and rate of the different processes. All kinds of soil degradation processes that are of local importance - human-induced land slides, solifluction, on-site pollution, mine spoils - should be described as detailed as possible. The report should also contain a complete list of all collaborating scientists and institutes as well as a list of existing materials - maps, reports, etc. - that have been consulted.

GLASOD MATRIX TABLE

Map unit : D25
Country 1 : Kenya
Country 2 :
Country 3 :
Area(km2) : 16900

Physiography : Upland, undulating to rolling (dom)
Plateau, undulating (inc)
Soil : AC , clay, deep (ass)
FR , clay, deep (ass)
Geology : Metamorphic rock
Precipitation (an.mean) : 500-900 mm
Temperature (mean) : 21-23 degr.C
Population density : Medium to high
Land use : Mixed farming
Vegetation : Grassland

General remarks :

DEGRADATION CHARACTERISTICS

Type	Caus	Degr	Rate	Ext	Remarks
Wt	g	3	3	4	Caused by sealing, Pk occurs in same area
Wd	g	3	3	2	On steeper slopes
Pk	g	1	1	1	No Wt yet
SN				5	

GLASOD MATRIX TABLE

Map unit : D26
Country 1 : Kenya
Country 2 : Tanzania
Country 3 :
Area(km2) : 42100

Physiography : Plain, undulating (dom)
Hills, steep (inc)
Soil : FRr, clay, deep (dom)
LPe, shallow (inc)
Geology : Metamorphic rock
Precipitation (an.mean) : 200-700 mm
Temperature (mean) : 23-29 degr.C
Population density : Low to medium
Land use : Pastoralism
Vegetation : Bush/shrubland

General remarks : Large area occupied by Tsavo national park, no degradation. Taita hills: heavy erosion in past, now stabilized by conservation practices

DEGRADATION CHARACTERISTICS

Type	Caus	Degr	Rate	Ext	Remarks
Wd	g	3	1	1	On footslopes around hills, now stabilized
Wt	g	1	1	4	Result of Pc in same area
Eo	g	1	1	3	
SH				2	Taita hills, stabilized by cons. practices (SHc)
SN				4	

Figure 4: Two examples of matrix tables, provided by the regional correlators (from Hakkeling, 1989).

III COMPILATION OF THE WORLD SOIL DEGRADATION MAP

Draft maps on the status of human-induced soil degradation from 21 different regions, prepared by 21 different groups of soil scientists arrived at different times. They were prepared at twice the final scale. Despite the fact that all correlators made use of the same General Guidelines a major job lay ahead to put together all the information reported in the matrix tables and displayed on the maps and to compile the final World Soil Degradation Map. Guiding principles were developed from the compilation, and a generalized soil degradation map for each region prepared and returned to the regional correlators for their comments. These were incorporated and the final draft was then sent to national soil institutions for their remarks and approval. Only then the map was finalized and submitted to the cartography division of the Winand Staring Centre for drawing and printing.

3.1 Development of a Legend for the GLASOD Map

Several concepts were developed for the legend of the GLASOD map, keeping in mind that the map should create awareness on the seriousness of soil degradation in a global perspective among policy-makers and decision-makers and among the general public. At the same time however the map should provide information in sufficient detail on the various aspects of soil degradation, as it was supplied by the regional correlators.

The regional draft maps were prepared at twice the scale of the final map. Reduction in scale was necessary and therefore certain generalizations were unavoidable. Furthermore matrix tables accompanying the map often listed many types of soil degradation occurring within the same mapping unit. It was decided that a maximum of two types of soil degradation would be indicated on the map per mapping unit. After evaluation of the contributions of all regional correlators, it was noted that some of the degradation types listed in the original guidelines had not been not distinguished at all, or were distinguished only very few times. Furthermore, many correlators had added the degradation type acidification (through drainage of acid sulphate soils or through fertilization). Therefore, the original list of degradation types (section 2.2.1.1) had to be adjusted.

Four different colours were selected to represent the four main types of soil degradation (water erosion, wind erosion, chemical deterioration and physical deterioration). The colour of a mapping unit on the map is determined by the dominant degradation type occurring in the unit. Only in rare cases both types of degradation given had the same weight of importance. In these cases a colour mosaic was shown on the map.

A major point of deliberation was in which way the seriousness of a certain soil degradation type could best be represented on the map. The status of soil degradation is indicated by its degree, relative extent in a mapping unit, and recent-past rate. This last element in the assessment was the most difficult one and not always reported, while reasons for giving a degradation type a certain degree and indicating how widespread it occurred in mapping unit was in almost all cases well documented. After careful consideration a decision was made to indicate the seriousness of a type of soil degradation by a combination of the degree and relative extent. Since there are four degrees possible and the relative extent is given in five categories (see 2.2.1.2 and 2.2.1.4) a total of 20 combinations are possible. As it would be impossible to give an individual cartographic representation for these 20 combinations, they are grouped into 4 groups. On the map, each group is representedby different colour shades: light shades refer to low degradation severity, dark shades to very high severity (see Figure 5).

This approach implies that for example a strong degree of degradation occurring infrequently is given the same degradation severity as a light degree of degradation occurring frequently. However the degree and relative extent of the degradation process is always indicated by a number combination on the map. The recent past rate and the type of human intervention that has caused soil degradation - the causative factors - are only indicated as symbols in the mapping unit.

Stable areas and non-used wasteland are given separate colours on the map and are identified only when 100% of the mapping unit belongs to that category of land. It should be kept in mind that the GLASOD map is prepared to create awareness on the seriousness of soil degradation. This implies that a mapping unit with a light degree of soil degradation occurring infrequently (less than 5% of mapping unit affected) has already a light shade of the colour of that particular soil degradation process. However 95% or more - but not 100% - of the mapping unit is in that case not affected by soil degradation as a result of human intervention.

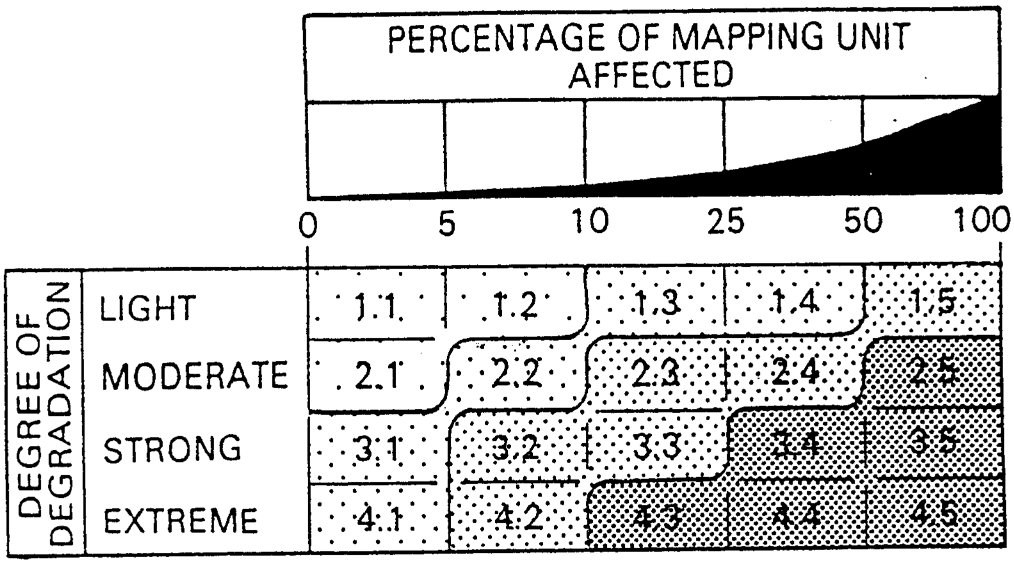

Figure 5. Severity classes of human-induced soil degradation.

3.2 Explanation of the Legend of the GLASOD Map

Mapping units represented on the GLASOD map are characterized by a colour and by a symbol. The colours indicate the main degradation type; the shading of the colour indicates the severity of the degradation taking place in a mapping unit. Each mapping unit has also a symbol giving a more detailed description of this type of degradation (see Figure 5).

3.2.1 Key to the colours

Twelve different soil degradation types are recognized on the map. These types are discussed in detail in section 3.2.3. They are grouped into four main types, each being represented by different colours: blue for water erosion, brown for wind erosion, red for chemical degradation and pink for physical degradation. Within each colour group different shades of that colour are used to indicate the severity of the degradation process: light colours refer to low degradation severity; dark colours refer to high degradation severity. Stable terrain is indicated by a light grey colour, while non-used wasteland has a dark grey colour. Reddish dots in a dark grey background indicate desert areas with scattered degraded oases.

3.2.2 *Key to the symbols*

EXAMPLE OF A SYMBOL:

Wt2.3 g ↑ ∿∿∿

In this example Wt refers to the soil degradation type (W for water); in this case loss of topsoil through water erosion (t for topsoil).
The number 2 refers to the degree of soil degradation. In this case a moderate degree.
Then number 3 refers to the frequency of occurrence of the soil degradation type in the mapping unit: in this case 10-25% is affected. The combination of these two numbers indicates the severity of soil degradation. In this case 2.3 indicates a high degradation severity (see figure 5).
The symbol g refers to the causative factor: in this case overgrazing.
The symbol ↑ refers to the recent past rate: in this case medium.
The symbol ∿∿∿ refers to the off-site effect: in this case uncontrolled human-induced flooding. The different symbols for soil degradation types, the degree, relative extent, causative factors, and recent-past rate are explained in the following paragraphs.

3.2.2.1 Soil degradation types

Not all degradation types that were indicated in the general guidelines were distinguished by the regional correlators. Some degradation types occurred only infrequently and/or in relatively few mapping units. In the final compilation a total of 12 types are recognized and mapped.

W : **Water Erosion**
Wt : Loss of topsoil
Loss of topsoil through water erosion is the most common type of soil degradation. It is generally known as surface wash or sheet erosion. It occurs in almost every country, under a great variety of climatic and physical conditions and land use. As the topsoil is normally rich in nutrients, a relatively large amount of nutrients is lost together with the topsoil. This process may lead to an impoverishment of the soil. Loss of topsoil itself is often preceded by compaction and/or crusting, causing a decrease in infiltration capacity of the soil, and leading to accelerated runoff and soil erosion. On very steep slopes, natural loss of topsoil may occur frequently. This 'geologic erosion' is not indicated on the degradation map, unless it is accelerated by human intervention.
Wd: Terrain deformation/mass movement
The most common phenomena of the degradation type terrain deformation are rill and gully formation. Rapid incision of gullies, eating away valuable soil is well known and dramatic in many countries. Control of active gullies is very difficult and total reclamation is almost impossible. Other phenomena of this degradation type are riverbank destruction and mass movement (land slides).

E : **Wind Erosion**
Et : Loss of topsoil
This degradation type is defined as the uniform displacement of topsoil by wind action. It is a widespread phenomenon in arid and semi-arid climates, but it also occurs under more humid conditions. In generally, coarse-textured soils are more susceptible to wind erosion than fine-textured soils. Wind erosion is nearly always caused by a decrease of the vegetational cover of the soil, either due to overgrazing or to removal of vegetation for domestic use or for agricultural purposes. In (semi-)arid climates natural wind erosion is often difficult to distinguish from human-induced wind erosion, but natural wind erosion is often aggravated by human activities.
Ed : Terrain deformation
Terrain deformation by wind erosion is a much less widespread type of degradation than loss of topsoil. It is defined as the uneven displacement of soil material by wind

action and leads to deflation hollows and dunes. It can be considered as an extreme form of loss of topsoil, with which it usually occurs in combination.

Eo : Overblowing
Overblowing, which is defined as the coverage of the land surface by wind-carried particles, is an off-site effect of the wind erosion types mentioned above. Overblowing may occur in the same mapping unit as those other types, or in adjacent units. It may influence structures like roads, buildings and waterways but it can also cause damage to agricultural land.

C : Chemical Deterioration

Cn : Loss of nutrients and/or organic matter
Loss of nutrients and/or organic matter occurs if agriculture is practised on poorly or moderately fertile soils, without sufficient application of manure or fertilizer. It causes a general depletion of the soils and leads to decreased production. Loss of nutrients is a widespread phenomenon in countries where low-input agriculture is practised. The rapid loss of organic matter after clearing of the natural vegetation is also included in this type of soil degradation. The loss of nutrients by erosion of fertile topsoil is considered to be a side-effect of erosion, and not distinguished separately.

Cs : Salinization
Human-induced salinization can be the result of three causes. Firstly, it can be the result of poor management of irrigation schemes. A high salt content of the irrigation water or too little attention for the drainage of irrigated fields can easily lead to a rapid salinization of the soils. This type of salinization mainly occurs under (semi-)arid conditions and covers small areas. Secondly, salinization will occur if seawater or fossil saline groundwater bodies intrudes the groundwater reserves of good quality. This sometimes happens in coastal regions with an excessive use of groundwater but can also occur in (closed) basins with aquifers of different salt contents. A third type of salinization occurs where human activities lead to an increase in evapo(transpi)ration of soil moisture in soils on salt-containing parent material or with saline ground water.

Ca : Acidification
Two different types of acidification occur. The first may occur in coastal regions, upon drainage of pyrite-containing soils. As a result, pyrite will oxidize to, among others, sulphuric acid, which strongly reduces the agricultural potential of the soils because of extremently low pH values. The second type of acidification is caused by over-application of acidifying fertilizer, which may also lead to strong acidification and reduced agricultural potential.

Cp : Pollution
Many types of pollution can be recognized, best known of which is probably industrial or urban waste accumulation. Other types of pollution are the excessive use of pesticides, acidification by airborne pollutants, excessive manuring, oil spills, etc. Degree and distribution of these individual types vary strongly.

P : Physical Deterioration

Pc : Compaction, sealing and crusting
Compaction, sealing and crusting occur on all continents, under nearly all climatic and physical conditions. Compaction is usually caused by the use of heavy machinery on soils with a low structure stability. Sealing and crusting of the topsoil occurs in particular if the soil cover does not provide sufficient protection to the impact of raindrops. Low-humic soils with poorly sorted sand fractions and appreciable amounts of silt are particularly vulnerable. Both compaction and crusting can be caused by cattle trampling. Compaction and crusting will make tillage more costly, impede or delay seedling emergence, and lead to a decrease in water infiltration capacity, causing in its turn a higher surface runoff, which may lead to significant water erosion.

Pw : Waterlogging
Waterlogging includes flooding by river water and submergence by rain water caused by human intervention in natural drainage systems. The construction of paddy fields is not included, as this is considered to be an improvement rather than a degradation of the soil.

Ps : Subsidence of organic soils
Subsidence of organic soils, as caused by drainage and/or oxidation, is only recognized if the agricultural potential of the land is negatively affected. In many cases however,

drainage of organic soils will lead to an increase in agricultural potential, in which case it is not mentioned on the map.

Two types of chemical deterioration - discontinuation of flood induced fertility, and gleysation - and two types of physical deterioration - soil structure deterioration due to dispersion of soil material by Na (and Mg) salts in the subsoil, and aridification - are not indicated on the map. Although these processes occur in many areas, they are generally only of local importance and could not be mapped in a global perspective.

3.2.2.2 Mapping Units without human-induced soil degradation

S : **Stable terrain**

SN : Stable terrain under natural conditions
Areas which are stable under natural conditions show little or no agricultural practices, and usually very little other human activities. This absence of human activities is in general due to the fact that the type of land concerned is not very suitable for agricultural practices. Large areas of stable terrain under natural conditions are found in Canada, Scandinavia and the Soviet Union, where mean summer temperatures are too low for large scale agriculture. Low temperatures and steep slopes account for the absence of agriculture in large parts of the Himalayas and the Andes. The extensive rainforests of South America and Africa also comprise some stable, virtually uninhabited areas. Other reasons for the absence of human activities are highly unfavourable soil conditions, semi-desertic conditions and inaccessibility due to, for instance, poor drainage. Nature or wildlife reserves also fall in this class, but are often too small to be mapped at the GLASOD scale.

SA : Stable terrain with permanent agriculture.
If agricultural land is well managed, no soil degradation of any kind will occur and productivity levels will not decrease.

SH : Terrain stabilized by human intervention
As the awareness of the dangers of soil degradation grows, so do the efforts concerning conservation programmes. Increasingly, regions do show positive effects of conservation practices. In general, these practices are rather recent, but locally they may originate from centuries ago. Examples of conservation practices are reforestation, terracing, gully control, water management, etc.

Non-Used Wastelands

This group of mapping units comprises areas which, even though they show no signs of human-induced soil degradation, can not be considered stable. Historic or recent natural processes have turned these lands in non-used wastelands, without agricultural potential.

D : active dunes
Z : salt flats
R : rock outcrops
A : deserts
I : ice caps
M : arid mountain regions

3.2.2.3 Degradation status

As discussed in the introductory paragraph of this section (3.1) the status of human-induced soil degradation is expressed as the severity of the soil degradation, which is a combination of the degree of soil degradation and the percentage of the mapping unit affected. The 20 possible combinations are grouped into four classes ranging from low to very high degradation severity. For the qualitative descriptions of the four degrees of soil degradation (1=light; 2=moderate; 3=strong; and 4=extreme) reference is made to section 2.2.1.2. For the quantitative expressions of the percentage of the mapping unit affected by soil degradation in five groups (1=infrequent; 2=common; 3=frequent; 4=very frequent; and 5=dominant) reference is made to section 2.2.1.4.

3.2.2.4 Causative factors

Under causative factors is meant the kind of human intervention that has caused the soil to degrade to a lower rank. For each mapping unit with some form of degradation, one or two of the following causative factors are given.

f : Deforestation and removal of the natural vegetation
This causative factor is defined as more or less complete removal of the natural vegetation (usually forest) of stretches of land. Reason for this clearing may be the reclamation of land for agricultural purposes (cropping or cattle raising), large scale commercial forestry, road construction, etc.

g : Overgrazing
Besides the actual overgrazing of the vegetation by livestock, this causative factor also includes other effects of livestock, such as trampling. Overgrazing usually leads to a decrease of the soil cover, which increases the water and wind erosion hazard. Trampling may cause compaction of the soil.
A widespread effect of overgrazing is the encroachment of unfavourable (inpalatable or noxious) shrub species. Although this phenomenon certainly influences grazing potential, it is not distinguished as soil degradation, as the soil itself is not affected.

a : Agricultural activities
This causative factor is defined as improper management of agricultural land. It includes a wide variety of practices, such as insufficient or excessive use of fertilizers, use of poor quality irrigation water, absence of anti-erosion measures, improperly timed use of heavy machinery, etc.

e : Overexploitation of vegetation for consumptive use
This causative factor deals with the use of the vegetation for fuelwood, fencing, etc. Contrary to deforestation and removal of the natural vegetation, it usually does not lead to complete removal of all vegetation. However, the remaining vegetation does not anymore provide sufficient protection to soil erosion.

i : (Bio)industrial activities
This causative factor usually leads to degradation type 'Cp: pollution'.

Note:

If two causative factors are shown on the map, the sequence of appearance does not indicate a sequence in importance, nor does it necessarily coincide with the sequence of degradation types given for the same mapping unit.

3.2.2.5 Recent-past rate

No strict definition exists for recent past rate. This item is included in the map symbol to distinguish rapidly developing phenomena from, for example, slowly developing or nearly stabilized phenomena. Since recent past rate is not strictly defined, the reliability is rather limited. If the recent past rate is slow, no indication is given on the map.

↑ : medium
⇞ : rapid

3.2.2.6 Off-site effect

The general guidelines proposed several off-site effects as a result of water erosion (see 2.2.1.1). However only one form of off-site effects was reported by the regional correlators: uncontrolled flooding (symbol∿∿), occurring as a result of human intervention in upstream areas like deforestation. This does not imply that other off-site effects do not occur, but as the regional correlators did not indicate them in their reports, they do not appear in the final map.

IV CONCLUDING REMARKS

The compiled world map of the status of human-induced soil degradation is a joint effort of a wide section of the international soil science community. Some aspects of soil degradation that were considered of importance when the general guidelines were drafted are not represented on the map, either because these aspects appeared to be of only minor importance, or because the requested information could not be provided with sufficient detail to be included.

A case in point was our suggestion to indicate human-induced soil degradation that occurred in the past. This aspect could not be mapped with precision because of lack of information. The general guidelines specified three historic periods:

a : Early civilization occurring in the ancient past up to 250 years ago.
b : Era of European expansion in the America's, Australia, Asia and Africa, 50-250 years ago.
c : Post second world war period, very much related to the human population explosion, particularly taking place in the third world countries.

Dregne (1986) elaborated on the occurrence of human-induced soil degradation in the past. Water erosion caused by human intervention occurred 1000 to 3000 years ago in the uplands of the Mediterranean area and the loessial highlands of China, where 'gully erosion has made the Yellow River the most silt-laden river in the world'.

Hallsworth (written comm. 1988) stated with respect to the second historic period, that much of the rangelands of Australia (the 60% of Australia that is too dry for agriculture or improved pastures, and without permanent rivers) has eroded seriously this century, after cattle and sheep were introduced, but much of it has now become stable again. Another era of accelerated erosion started in the second quarter of the 20th century. It is a phenomenon associated with wind erosion in developed countries (Australia, U.S.A., U.S.S.R.) and with water and wind erosion in developing countries. The basic causes of this round of accelerated soil degradation are social and economic factors such as exploitative philosophy; ignorance of the seriousness of erosion or what to do about it; lack of short-term economic benefits; or government policies which promote the cultivation of fragile lands (Dregne, 1986). While the concern of continuing soil degradation is gradually growing and Soil Conservation Policies are implemented by governments in various countries throughout the world since the 1930's, soil degradation is still going on today as examplified on the present map. The principles of soil conservation have been known for centuries, but because soils and landscapes differ per agroclimatic zone the actual design of conservation practices to control soil degradation are site specific. A detailed knowledge of soils and terrain attributes at sufficient detail is needed for an appropriate and effective programme to combat human-induced soil degradation.

The World Map on the Status of Human-Induced Soil Degradation is the first of its kind that shows the severity of the problem of soil degradation in a global perspective. The information on the map in terms of areas being affected by various types of soil degradation, its degree of severity and the kinds of human intervention that is causing soil degradation should be further quantified. In a joint follow-up activity between UNEP and ISRIC, the mapping units of the GLASOD map will be digitized and the legend entries will be computerized in a GLASOD database. It will then be possible to estimate for any selected region the actual acreage of terrain being affected, by type, degree, and causative factor. A tentative assessment for the soil degradation status in South America - done by manual calculation - revealed that about 14% of the total land areas of South America was affected by human-induced soil degradation. The subdivision of this land area by type and degree of soil degradation is illustrated in table 1.

Once the digitized mapping units are linked with the computerized legend database through a Geographic Information System more precise and more accurate estimates can be made.

Other follow-up activities include a more detailed assessment of human-induced soil degradation for the African continent (at a scale of 1:7.5 M, Mercator projection). Various countries (USSR, Cuba, Mexico, Uruguay) are using the guidelines for national level applications at large scale.

Table 1: Relative extent of human-induced soil degradation in South America (Total area affected is approximately 14% of total land area of South America).

	Degree			
Type	Slight	Moderate	Severe	Total
Water erosion	14 %	29 %	4 %	47 %
Nutrient Decline	12	17	5	34
Wind erosion	9	6	-	15
Salinization	1	+	-	1
Waterlogging	3	+		3
Total	39	52	9	100

The GLASOD map and the complimentary statistical information that can be derived from the map will hopefully serve as a guide to policy-makers and decision-makers to pinpoint regions of immediate concern; it may assist agencies concerned with the improvement of our natural resource data base to concentrate their financial resources where it is most needed. This global map will not however in itself solve the problem of soil degradation. Once areas of concern are determined there is a need for more detailed information on quantitative soil and terrain attributes. The SOTER project - a World Soils and Terrain Digital Database at 1:1 M or larger scale - can contribute towards that ultimate objective of an analysis of human-induced soil degradation: to combat and reverse the trend of declining food productivity by conserving and restoring our natural resources.

V REFERENCES

Blaikie P., and H. Brookfield, 1987. Land Degradation and Society. Methuen, London and New York. 296p.

Brundtland, G.H., M. Khalid, a.o. 1987. Our Common Future. Report of World Commission on Environment and Development presented to the chairman of Intergovernmental Intersessional Preparatory Committee, UNEP Governing Council. Oxford Univ. Press, Oxford.

Dregne H.E., 1986. Soil and Water Conservation: A Global Perspective. In Interciencia, Vol.II, nº4, pp 166-172.

FAO, UNEP, UNESCO, 1979. A provisional Methodology for Soil Degradation Assessment. FAO, Rome. 73p. incl. 6 maps.

Hakkeling, R.T.A., 1989. Global Assessment of Soil Degradation - Eastern and Southern Africa. Volume 1: Main Report, Volume 2: Matrix Tables/Mapping Unit Descriptions. Rep. nr. 2082, Netherlands Soil Survey Institute (STIBOKA), Wageningen.

Hallsworth E.G., 1988. Review of Second Draft of GLASOD guidelines (written comm.).

ISRIC, 1988. Guidelines for General Assessment of the Status of Human-Induced Soil Degradation. Ed. by L.R. Oldeman. Working Paper & Preprint 88/4, ISRIC, Wageningen, 11 p. (in english and french).

ISSS, 1986A. Proceedings of an International Workshop on the Structure of a Digital International Soil Resource Map annex Data Base (20-24 January 1986, ISRIC, Wageningen). Ed. by M.F. Baumgardner and L.R. Oldeman. SOTER Report 1. ISSS, Wageningen. 138p.

ISSS, 1986B. Project Proposal 'World Soils and Terrain Digital Database at a scale of 1:1M (SOTER)'. Ed. by M.F. Baumgardner, ISSS, Wageningen, 23p.

ISSS, 1987. Proceedings of the Second International Workshop on a Global Soils and Terrain Digital Database (18-22 May 1987, UNEP, Nairobi). Ed. by R.F. van de Weg. SOTER Report 2. ISSS, Wageningen. 27 p.

Sombroek W.G., 1985. Establishment of an International Soil and Land Resources Information Base. Discussion Paper for the ISSS Working Group on Digital Mapping of Global Soil Resources, ISRIC, Wageningen. 12p.

UNEP, 1982. A World Soils Policy, UNEP, Nairobi.

World Resources Institute, 1990. World Resources 1990-1991: A Guide to the Global Environment. World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme. Oxford Univ. Press, New York, Oxford. 383p.

ANNEX 1: LIST OF COOPERATORS

Abdul Hamid, W., Iraq
Abu Arabi, G., Jordan
Achouri, M., Tunis, Tunisia
Adalsteinsson, Reykjavik, Iceland
Aguirre, L., Montevideo, Uruguay
Ahmad, N., St. Augustine, Trinidad and Tobago
Al Tai, F., Iraq
Aleksa, A., Buenos Aires, Argentina
Allaglo, A.K., Lomé, Togo
Allaglo, L.K., Lomé, Togo
Alonso, P., San Lorenzo, Paraguay
Alphen, J.G. van, Wageningen, The Netherlands
Alvarez, C., Santiago, Chile
Alvarez, C., Montevideo, Uruguay
Alvim, P. de T., Bahia, Brasil
Amano, Y., Tokyo, Japan
Amson, F.W. van, Paramaribo, Surinam
Andriesse, W., Wageningen, The Netherlands
Apostolakis, C.G., Ag. Parasevi, Greece
Arduino, E., Turin, Italy
Aru, A., Cagliari, Italy
Asiamay, R.D., Kumasi, Ghana
Aubrun, A., Paris, France
Bandy, D.E., Lima, Peru
Bao, R, Lima, Peru
Barber, R., Santa Cruz, Bolivia
Barneveld, G.W. van, Amersfoort, The Netherlands
Barreto Rodriguez e Silva, F., Recife, Brasil
Bazan, R., Brasilia, Brasil
Beemster J.G.R., Wageningen, The Netherlands
Bellon, F., St. Paul-Trois Châteaux, France
Berasaluce J.P., Santiago, Chile
Bergsma, E., Enschede, The Nether lands
Bernus, E., Paris, France
Bindzi Tsala, J., Yaoundé, Cameroon
Blanco, F., La Paz, Bolivia
Blasco, F., Toulouse, France
Blum, W.E.H., Wien, Austria
Boko, A., Cotonou, Benin
Boudouresque, E., France
Boulet, J., Paris, France
Boulet, R., Cayenne, French Guiana
Boulvert, Y., Bangui, Central Afri can Republic
Bousquet, B., Montpellier, France
Bouwman, A.F., Wageningen, The Netherlands
Brabant, P., Bondy, France
Brammer, H., Hove, United Kingdom
Brandeau, E., Paris, France
Breuning Madsen, H., Copenhagen, Denmark
Broekhuis, J.F., 's Gravenhage, The Netherlands
Brouwers, M., Montpellier, France
Bruggeman, H.Y., Wageningen, The Netherlands
Buckmire, G.E., Georgetown, Guyana
Caillie, X. van, Ohain, Belgium
Calero, E., Quito, Ecuador
Camara, M., Conakry, Guinea
Campen, W. Van, Koutiala, Mali
Casas, R., Buenos Aires, Argentina
Cassi, F., Florence, Italy
Celik, O., Turkey
Chanduvi, F., Santiago, Chile
Chase, R., Samoa
Citeaux, R., Dakar, Senegal
Cochrane, T.T. La Paz, Bolivia
Cock, J., Cali, Colombia
Commerma, J., Maracay, Venezuela
Coote, D.R., Ottawa, Canada
Cordova Rincon, S., Chapingo, Mexico
Cruz, R.V., Quito, Ecuador
D'Hiriart, A., Buenos Aires, Argentina
Da Costa Silva, A., Bissau, Giunea Bissau
Dazzi, C., Palermo, Italy
De La Cruz, S.J.M., Chapingo, Mexico
De Ploey, J., Leuven, Belgium
De Vries, W., Wageningen, The Netherlands
Delgado, M.E., Cape Verde
Demir, N., Turkey
Dent, F.J., Bangkok, Thailand
Derksen, P.M., Turrialba, Costa Rica
Desire Rellum, P., Paramaribo, Surinam
Di Giacomo, R.M., Buenos Aires, Argentina
Diamond, S., Wexford, Ireland
Diepen, C.A. van, Wageningen, The Netherlands
Dilkova, R., Sofia, Bulgaria
Dimantha, S., Colombo, Sri Lanka
Dimitrov, D., Sofia, Bulgaria
Dogan, O., Turkey
Donadieu, Versailles, France
Dourojeanni, A.C., Santiago, Chile
Drummond, M.A., Petrolina, Brasil.
Du Plessis, H.M., South Africa
Egue, K., Lomé, Togo
Einarsson, T., Reykjavik, Iceland
El Qodat, B., Jordan
Elgala, A.M., Cairo, Egypt
Engelen, V. van, Wageningen, The Netherlands
Eppink, L.A.A.J., Wageningen, The Netherlands
Esu, I.E., Zaria, Nigeria
Fairbairn, J., Cali, Colombia
Falco, L., Montevideo, Uruguay
Farshad, A., Enschede, The Netherands
Favi, E., Tuscany, Italy
Fereira Silva, C.E., Cape Verde
Fierotti, G., Palermo, Italy
Figuerda Sandoval, B., Chapingo, Mexico
Filippi, N., Bologna, Italy
Fournier, F., Paris, France
Garduño, M.A., Chapingo, Mexico
Gavaud, M., Paris, France
Giordano, A., Turin, Italy
Glinski, J., Lublin, Poland
Godagnone, R., Buenos Aires, Argentina
Goedert, W., Planaltina, Brasil
Gomes Cordeiro, G., Petrolina, Brasil.
Gomes de Sousa, D.M., Planaltina, Brasil
Gomes, J.F.M., Brasilia, Brasil
Gondim Reis, J., Recife, Brasil
Gonzalez Meraz, J., Chapingo, Mexico
Granger, M.A., Mon Repos, Guyana
Grivas, G.C., Nicosia, Cyprus
Grof, B., Planaltina, Brasil
Grouzis, M., Dakar, Senegal
Gudbergsson, G., Reykjavik, Iceland
Gudbergsson, G.M., Reykjavik, Iceland
Guero, Y., Niamey, Niger
Gutierrez, R., Lima, Peru
Håkansson, I., Uppsala, Sweden
Hallsworth, E.G., Mitcham, Australia

Hanegreefs, P., Butare, Rwanda
Hansen, L., Copenhagen, Denmark
Harindranath, C.S., Nagpur, India
Harrop, J., Bradford on Avon, United Kingdom
Heusch, B., Grenoble, France
Himyari, K., Iraq
Hla Aye, Rangoon, Burma
Hollis, J., Silsoe, United Kingdom
Hrasko, J., Bratislava, Czechoslovakia
Hurni, H., Bern, Switserland
Ilaiwi, M., Damascus, Syria
Irurtia, C., Buenos Aires, Argentina
Jamagne, M., Olivet, France
Janabi, K., Iraq
Jensen, N., Copenhagen, Denmark
Jones, P.G., Cali, Colombia
Jones, P.G., Cali, Colombia
Kahn, Z., Mon Repos, Guyana
Kazuki Takamiya, Santiago, Chile
Kemper, Hannover, German Federal Republic
Khafaci, A., Iraq
Khalifa, R., Iraq
Kilinc, M., Ankara, Turkey
Klaij, M.C. Niamey, Niger
Kraayenhagen, J., Mohale's Hoek, Lesotho
Krammer, F., Cali, Colombia
Kuhlman, H., Copenhagen, Denmark
Kulnes, A., Santiago, Chile
Labrousse, P., Paris, France
Lagos, M., Santiago, Chile
Laker, M.C., Pretoria, South Africa
Lal, R., Ohio, USA
Larach, J.O.I., Rio de Janeiro, Brasil
Leao, A.C., Bahia, Brasil
Lee, T.R., Santiago, Chile
Leite, O., Bahia, Brasil
Leon, L.A., Cali, Colombia
Leprun, J.C., Paris, France
Lobato, E., Planaltina, Brasil
Lopez, O., Lima, Peru
Lozi, S., Jordan
Lui Liang-wu, Nanking, Peoples Republic of China
Magno, C., Planaltina, Brasil
Mainguet, M., Reims, France
Maître Mille, G., Paris, France
Malagon, D., Bogota, Colombia
Mapangui, A., Brazzaville, Congo
Marelli, H., Buenos Aires, Argentina
Marius, C., Paris, France
Marquez Rodiles, F., Chapingo, Mexico
Martens, P., Florence, Italy
Mathieu, C., Bangui, Central African Republic
Meijnen, H.G., Wageningen, The Netherlands
Mejia, L., Quito, Ecuador
Mensvoort, M.E.F. van, Wageningen, The Netherlands
Merwe, A.J. van der, South Africa
Michelina, R., Buenos Aires, Argentina
Mietton, M.,Chambery, France
Molvino, J., Montevideo, Uruguay
Mon, R., Buenos Aires, Argentina
Mondjalis-Poto, M.P., Kisangani, Zaire
Morais, J.T., Cape Verde
Morel, A., Grenoble, France
Morote, O., Lima, Peru
Moscatelli, G., Buenos Aires, Argentina
Moutsinga, J.B., Libreville, Gabon
Mulder, P.J.M. Wageningen, The Netherlands
Murray, D.B., Port-of Spain, Trinidad and Tobago
Musto, J.C., Buenos Aires, Argentina
Mutwewingabo, B., Butare, Rwanda
Nani, L., Buenos Aires, Argentina
Ngouanze, F., Bangui, Central African Republic
Niemeyer, J.K.W., Managua, Nicaragua
Nikilov, V., Sofia, Bulgaria
Noordam, D., Paramaribo, Surinam
Nyborg, A., Ås, Norway
Okazaki, H., Tokyo, Japan
Oldeman, R.L., Wageningen, The Netherlands
Oliveiro de Mello, A.A., Bahia, Brasil
Olivry, J.C., Paris, France
Ordogan, S., Turkey
Oros, R., Oruro, Bolivia
Ortiz Solorio C.A., Chapingo, Mexico
Osman, A., Damascus, Syria
Oster, R., Bamako, Mali
Overbo, E., Ås, Norway
P. Silva, C.E., Cape Verde
Palmieri, F., Rio de Janeiro, Brasil
Papanicolau, E.P., Ag. Parasevi, Greece
Paris, S., Lilongwe, Malawi
Paz, J.G., Lisboa, Portugal
Peña Zubiate, C., Buenos Aires, Argentina
Peralta-Peralta, M., Santiago, Chile
Pereira Bareto, S., Dakar, Senegal
Peters, W.L., Maracaibo, Venezuela
Petrie, R.A., Hastings, New Zealand
Peyer, K., Zürich, Switserland
Phommasack Ty, Vientiane, Lao PDR
Pieterse, P.A., Pretoria, South Africa
Pittaluga, A., Buenos Aires, Argentina
Pla-Sentis, Maracai, Venezuela
Poesen, J., Leuven, Belgium
Pofali, R.M., Nagpur, India
Poncet, Y., Paris, France
Porto, E.R., Petrolina, Brasil.
Poss, R., Paris, France
Purnell, M.F., Rome, Italy
Quirgo, S., Tarija, Bolivia
Ranzani, G., Brasilia, Brasil
Rauta, C., Bucurest, Romania
Reid, J.B., Hastings, New Zealand
Remmelzwaal, A., Gaborone, Botswana
Rethman, N.G.F., Pretoria, South Africa
Ribamar Pereira, J., Petrolina, Brasil.
Rickson, J., Silsoe, United Kindom
Rihani, A., Jordan
Riquier, J., Villeneuve-Loubet, France
Robain, H., Cayenne, French Guiana
Rofic, M., Iraq
Rojo, L., Madrid, Spain
Roman, R., Buenos Aires, Argentina
Roose, E., Paris, France
Rossi, R., Toscany, Italy
Ruinard, J., Paramaribo, Surinam
Saif, T., Iraq
Sainz, A., La Paz, Bolivia
Sakuma, T., Sapporo, Japan
Salazar, J.C., Buenos Aires, Argentina
Sanchez, A., Maracay, Venezuela
Sanchez Guerra, M., Chapingo, Mexico
Sartaoui, W., Jordan
Saxena, R.K., Nagpur, India
Schaub, D., Zurich, Switserland
Schmidt, R., Eberswalde-Finow, GDR
Schobbenhaus Filho, C., Brasilia, Brasil
Scoppa, C.O., Buenos Aires, Argentina

Scotta, E., Buenos Aires, Argentina
Seghieri, J., Switserland
Sehgal J.L., Nagpur, India
Shaker, S., Iraq
Shamout, R., Jordan
Shaxton, T.F., Maseru, Lesotho
Shrestha, D.P., Enschede, The Netherlands
Sims, D., Rome, Italy
Singh, A.M.P., Nagpur, India
Sippola, J., Jokioinen, Finnland
Smaling, E.M.A., Wageningen, The Netherlands
Smallwood, B.F., Washington DC, U.S.A
Solbakken, E., Ås, Norway
Sonneveld, B.G.J.S., Turrialba, Costa Rica
Soriza Silva, A. de, Petrolina, Brasil.
Sourabie, F., Ouagadougou, Burkina Fasso
Spain, J.M., Planaltina, Brasil
Spanga, J.C., Montevideo, Uruguay
Springett, J.A., Hastings, New Zealand
Spurway, J.K.R., Causeway, Zimbabwe
Sticher, H., Zürich, Switzerland
Stitou, M., Rabat, Morocco
Stolbovoj, V., Moscow, Soviet-Union
Stoner, E., Planaltina, Brasil
Stoorvogel, J., Wageningen, The Netherlands
Suleyman, Turkey
Tchemi, T.T., Lomé, Togo
Thomas, D., Cali, Colombia
Thorsteinsson, I., Reykjavik, Iceland
Toledo, J.M., Cali, Colombia
Torres, F., Cali, Colombia
Torres Torres, R., Chapingo, Mexico
Torrico, A., Cochabamba, Bolivia
Touber, L., Wageningen, The Netherlands
Troedsson, T., Uppsala, Sweden
Turski, R., Lublin, Poland
Ubierra-Costa, A.A., Santo Domingo, Dominican Republic
Uribe, C.A., Lima, Peru
Urvas, L., Jokioinen, Finnland
Valentin, C., Paris, France
Valev, V., Moscow, Soviet-Union
Varallyay, G., Budapest, Hungary
Vargas Gil, J.R., Buenos Aires, Argentina
Velazquez Loera, A., Chapingo, Mexico
Venema, J.H., Lilongwe, Malawi
Villegas Delagado, R., La Habana, Cuba
Villeneuve, M., Dakar, Senegal
Vlaanderen, A., Rome, Italy
Voortman, R., Egmond, The Netherlands
Vos, J., Wageningen, The Netherlands
Wagner, E., Brasilia, Brasil
Walmsley, D., St. Augustine, Trinidad and Tobago
Waveren, E. van, Gaborone, Botswana
Wen Ting-Tiang, Lusaka, Zambia
Wenzel, W.W., Wien, Austria
Wielemaker, W.G., Turrialba, Costa Rica
Yaalon, D., Jerusalem, Israel
Yolevski, M., Sofia, Bulgaria
Yoro Gballou, Abidjan, Côte d'Ivoire
Zhao Qi-guo, Nanking, Peoples Republic of China
Zyl, J. van, South Africa

THE FOLLOWING PEOPLE CONTRIBUTED TO THE 'GUIDELINES FOR GENERAL ASSESSMENT OF THE HUMAN-INDUCED SOIL DEGRADATION'

Abrol, J.P., New Delhi, India
Aubert, Bondy, France
Ayoub, A., Nairobi, Kenia
Baren, J.H.V. van, Wageningen, The Netherlands
Baumgardner, M.F., West Lafayette, U.S.A.
Bergsma, E., Enschede, The Netherlands
Brinkman, A., Rome, Italy
Cochrane, T.T. La Paz, Bolivia
Coote, D.R., Ottawa, Canada
Dent, F.J., Bangkok, Thailand
Dregne, H.E., Lubbock, U.S.A.
Garduño, M.A., Chapingo, Mexico
Hallsworth, E.G., Mitcham, Australia
Oldeman, L.R., Wageningen, The Netherlands
Peters, W.M., Maracaibo, Venezuela
Pla-Sentis, I., Maracai, Venezuela
Purnell, M.F., Rome, Italy
Reybold, W., Washington DC, U.S.A
Riquier, J., Villeneuve-Loubet, France
Rozanov, B.G. Moscow, Soviet Union
Sanders, D., Rome, Italy
Sims, D., Rome, Italy
Sombroek, W.G., Wageningen, The Netherlands
Szabolcs, I., Budapest, Hungary
Szögi, A., Montevideo, Uruguay
Valenzuela, C.R., Enschede, The Netherlands
Weg, R.F. van de, Wageningen, The Netherlands

CARTOGRAPHY

Betuw, T.J.W. van, Wageningen, The Netherlands
Onderstal, J., Wageningen, The Netherlands