AFRICOVER

LAND COVER CLASSIFICATION

Environment and Natural Resources Service
Research, Extension and Training Division
FAO Sustainable Development Department

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INTRODUCTION

This publication aims at presenting the actual status of the land cover classification system of the AFRICOVER project, as adopted by the international working group on "Land cover legend and classification".

The first part is composed of a technical document describing the main concepts and justifications of the basic classification system, as well as a presentation of main definitions used.

The second part is the proceeding of the seminar of Saly, Senegal, where all members of the "Land cover legend and classification" working group met for 3 days.

The third part is a presentation through a series of color plates, of the architecture of the classification system, revised after the recommendations of the Saly seminar.

The proposed scheme is supported by a user-friendly and interactive software which allows any user to define a land cover class, through a logical decision-tree process, completely automated. This software, now under finalization, will soon be published by FAO.

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Working Paper presented at the Saly Meeting

29 - 31 July 1996

1. THE AFRICOVER PROJECT

1.1 Origin and Objectives

For the last two years, FAO has been involved in the organization of the AFRICOVER project, **whose goal is to establish for the whole of Africa, a digital geo-referenced database on land cover and a geographic reference (geodesy, toponomy, roads, hydrography) at a 1:200,000 to 1:250,000 scale (1:100,000 for small countries and specific areas).** This base will also be generalized at a 1:1,000,000 scale, updated, made homogeneous and comparable/compatible from thematic and geographic points of view, for the whole African continent.

A further objective of AFRICOVER is to **reinforce and to build up the national and sub-regional capacities** for the establishment, update and operational use of geographic reference and land cover maps and geo-databases.

This project has been prepared in response to a number of national requests for assistance in the implementation of reliable and geo-referenced information on natural resources at sub-national, national and regional levels.

The analysis of national needs proved that no information system on resources, covering or supporting early warning, forest and rangeland monitoring, land use planning, catchment management, production of statistics, biodiversity or climate change, can do without reliable and homogeneous basic geographic information, showing both usual landmarks (infrastructure, settlement, hydrography) and land cover.

Hence, the purpose of AFRICOVER is to **prepare this basic geographic information common to the information components of actual and future programs on natural resources in African countries.**

1.2 Implementation of AFRICOVER

From a technical point of view, the preparation of AFRICOVER products depends essentially on remote sensing data and geographic information systems (GIS).

The land cover will be mainly derived from visual interpretation of recent high resolution satellite images digitally enhanced. This will be carried out according to a homogenized and hierarchical classification system. The geographic reference will be derived from existing topographic maps and updated from remote sensing documents and ground surveys geo-referenced with GPS points. The geometrical base, which will be used as a reference, will depend on the quality of the geodetic network and on the topographic maps. It may be either the existing topographic maps themselves, or the satellite images geo-coded with GPS measurements and using spatiotriangulation techniques, when possible. In order to maximize the synergy and the scale savings, the cartographic methods will use techniques optimizing the teamwork and allowing task division, such as a multiphase approach.

From an operational point of view, the cartography will be carried out by a national team, with the assistance of specialized international experts, originating, when possible, from other African countries. Several fully compatible approaches could be considered for the implementation of the project in the different countries, depending on countries and sub-regions:

- *A strictly national approach*, in which each country independently joins the project. This approach corresponds to the policies developed by the World Bank and several bilateral cooperating agencies. In this case, the countries themselves will have the responsibility and the control of contracts and of

international expertise. As far as possible, a number of responsibilities of coordination, monitoring and training could also be entrusted to a sub-regional organization.

- *An approach which is both national and regional*, in which countries of a sub-region arrange to implement the project simultaneously. In this case, a sub-regional coordination will be needed, as well as common execution of technical activities.

The final users of AFRICOVER will be technicians and decision-makers involved in natural resource management and monitoring at regional, national and sub-national levels, e.g. ministries (Planning, Rural Development, Environment, Statistics, Agriculture, Forest, Fisheries, Water, etc.), international organizations of development (United Nations, World Bank, European Union, FIDA, etc.), intergovernmental organizations (IGAD, SADC, CILSS, OACT, etc.), bilateral cooperating agencies, non-governmental organizations and national private operators.

The FAO objective is to assist in the preparation (technical, institutional and financial arrangements) and the technical monitoring of AFRICOVER.

Beyond this technical assistance function, FAO offers to act as a **normalization and labeling agency for AFRICOVER**: this role will consist in defining in detail, in the framework of international working groups, the standards to be applied in all African countries in terms of information, tools, analysis methods and utilization procedures. This standardization will greatly integrate the national and sub-regional specific needs and it is absolutely necessary, from a technical point of view, in order to ensure homogenization and a better distribution of final products (databases and maps), as well as important scale savings for production, update and use of geo-referenced data on resources. FAO will guarantee that these standards are respected and will deliver an AFRICOVER label. FAO could **eventually** be involved as **executing (or co-executing) agency** for the project, on request of individual countries and sub-regions.

The budget of each national component of the project ranges between 1 and 2.5 US$/km² depending on the countries and approaches to be used.

The time is estimated between **three and five years.**

1.3 Present State of AFRICOVER

AFRICOVER proposal was approved in principle in July 1994 by an international consultation at the ECA headquarters, Addis Ababa, which was attended by representatives of eight African countries, 8 sub-regional organizations (IGADD, SADC, CILSS, RCSSMRS, OACT, CRTO, CRTEAN, RECTAS), 4 United Nations organizations (UNEP, UNDP, FAO, UNITAR) and 19 international and national organizations.

In parallel, detailed inquiries and studies were conducted within each African country, in order to assess national and regional capacities, the available maps and data, the future and in progress projects/programs which could be linked with AFRICOVER, as well as final users needs.

Today, the East-African sub-region (11 countries of the Nile Basin: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Zaire) is just starting the implementation of the project, due to a financing of 5.4M US$ provided by the Italian government. This execution will follow mainly a regional approach. For this sub-region, FAO will also act as executing agency of the project.

For the other sub-regions and countries, negotiations are in progress between the different African partners and many sponsors or collaborating agencies (French Cooperation, European Union, GTZ, CIDA, World Bank). All approved the principle of AFRICOVER, and intend to participate at the level of the different countries. FAO is also assisting the World Bank with the technical preparation of important environmental information projects, in particular in Ivory Coast and in the Central Africa sub-region (the REIMP project), which would include the AFRICOVER products.

A number of African countries (Côte d'Ivoire, Equatorial Guinea, Guinea, Mali, Mauritania, Mozambique, Namibia, Nigeria, Senegal, Togo, Zimbabwe) have already sent official requests; while other countries have requests under way within the different ministries. Several countries such as Senegal and Tunisia have built-up national AFRICOVER Working Groups which started with the formulation of project documents according to the national approach.

Finally, FAO has established **three international working groups** (1. Legend and Classification, 2. Geometry and Topography, and 3. Technical Methods). The first one of these will be responsible for developing the standardized methodology for definition and classification of land cover for the entire AFRICOVER project and for drawing up specifications for the database to be used. The AFRICOVER project will, therefore, be the first project to use a standardized land cover classification system at continental scale.

1.4 Context of Technical Study on AFRICOVER Land Cover Classification

The AFRICOVER initiative on the definition of a Land Cover Classification was initiated during the expert consultation held in Addis Ababa, in July 1994.

The *Working Group on Classification and Legend* which was set up has the task to define a standardized classification which could be used for mapping land cover in all African countries. This classification should meet the following requirements:

i) the final user needs;
ii) applicable in all environmental conditions;
iii) adapted to be used in mapping exercises which may use means ranging from high resolution satellite imagery to aerial photography;
iv) oriented to the preparation of multi-user databases;
v) compatible with existing classifications/legends in Africa;
vi) practical and adapted to existing African capacities; and
vii) liaise with ongoing initiatives on the classification and definition of land cover and land use (e.g. IGBP, FAO/UNEP/ITE/ITC/WCMC, EU Corine program, etc.).

Since this expert consultation, a user definition study has been held in 27 African countries to evaluate the information requirements and the priority classes to be mapped within the project. The latter survey clearly indicated the importance of cultivated cover types. This survey also included an extensive review of existing maps and databases on land cover and land use existing in Africa. This data is now stored in the geo-metadatabase.

Several papers and preliminary reports (Nègre, Barisano) were prepared in which the existing classification/legends were analyzed, drafts of nomenclatures were submitted and proposals made for the standardized classification.

Many discussion were held between members of the working group to discuss and review the main land cover features which can be seen on high resolution satellite imagery.

Finally, the cooperation between the working group and the FAO/UNEP/ITE/ITC /WCMC initiative should be mentioned. At a meeting in Rome early last year, the approaches of AFRICOVER and FAO/UNEP/ITE/ITC/WCMC, which were developed in parallel, merged into one common approach.

2. DEFINITION LAND COVER AND LAND USE

2.1 Land Cover and Land Use

The distinction between land cover and land use is fundamental. In previous classifications and legends the two were often confused. They are now defined as follow:

Land cover is the observed physical cover, as seen from the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, roads, etc.) which cover the earth's surface. Water, ice, bare rock or sand surfaces count as land cover.

Land use is based upon function, the purpose for which the land is being used. Thus, a land use can be defined as a series of activities undertaken to produce one or more goods or services. A given land use may take place on one, or more than one, piece of land and several land uses may occur on the same piece of land. Definition of land use in this way provides a basis for precise and quantitative economic and environmental impact analysis and permits precise distinctions between land uses, if required.

2.2 Classification and Legend

Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria, the so-called classifiers. SOKAL (1974) defined it as the ordering or arrangement of objects into groups or sets on the basis of their relationships. A classification system describes the names of the classes and the criteria used to distinguish them.

From the above, it follows that a classification should be:

i) *scale independent*; and

ii) *independent of the means* used to collect information (whether satellite imagery, aerial photography or field survey or a combination of them are used).

2.2.1 Classification structure

2.2.1.1 *Hierarchical system*

Classification systems come in two basic formats, i.e., hierarchical or non-hierarchical. A *hierarchical* classification offers more flexibility with the ability to accommodate different levels of information, starting with broad-level classes which are structured to allow further sub-division into more detailed sub-classes.

2.2.1.2 *A-priori and a-posteriori systems*

Classification can be done in two ways, i.e. a-priori and a-posteriori. An *a-priori classification* is based on classes defined before actual data collection takes place. This

means that all possible combinations of classifiers must be dealt with in the classification system. Basically, in the field each sample plot is identified and labeled according to the classification system adopted using a kind of dichotomous key approach. This method is used extensively in plant taxonomy (flora) and soil science. The main advantage of a-priori classification is that classes are standardized independent of the area to be described and the means used.

A-posteriori classification means that classes are defined after clustering similarity or dissimilarity of samples. The Braun-Blanquet method is an example of this approach. The advantage of this type of classification is its flexibility compared to the implicit rigidity of the a-priori classification. On the other hand, because a-posteriori classification depends on the area described it is unable to define standardized classes.

2.2.2 Legend

A legend is the application of a classification in a particular area using a defined mapping scale and a particular data set. Therefore, a legend may contain only a proportion, or sub-set, of all possible classes of the classification. Thus, a legend has the following characteristics:

i) is scale and cartographic representation dependent (e.g., occurrence of mixed classes);

ii) is data and mapping methodology dependent; and

iii) if different legends which do not have a common reference classification system, cannot be compared and correlated.

3. PROPOSED GENERAL CONCEPTS FOR AFRICOVER STANDARDIZED CLASSIFICATION

3.1 General Criteria for a Standard Land Cover Classification

A standard classification should meet the following general criteria:

i) it must be comprehensive;

ii) it should be an a-priori classification system as defined and explained above;

iii) it should be a common reference basis for all derived (and when possible existing) classifications;

iv) it meets the needs of a variety of users (it should not be single project-oriented);

v) it must be arranged in a hierarchical structure to be used at different scales and at different levels of detail allowing cross-reference of local/regional with continental/global maps without loss of information;

vi) it must be able to describe all land cover features as derived from its general definition, e.g., it must be able to describe ice as well as forest;

vii) it must be adaptable to the variety of land cover types and, therefore, all possible combinations of the classifiers should be considered;

viii) a class must be defined by a combination of well-defined diagnostic criteria, the classifiers;

ix) classes must be mutually exclusive and unambiguous;

x) a clear distinction must exist between the type of classifiers used. For example, land cover classifier (structural, physiognomic, etc.) versus environmental classifiers (climate, floristic, etc.);

xi) the diagnostic criteria or classifiers used in the classification must be selected because of easy measurement and permanence (they must be easily recognizable in the field and independent of season);

xii) it should be suitable for mapping and monitoring purposes;

xiii) it must be scientifically sound and practically oriented.

3.2 Current Classifications

Many classification systems are being used throughout the world. However, there is no single internationally accepted land cover classification system. With reference to the factors listed above, the following points can be made:

i) A proportion of the existing classifications are vegetation classifications, e.g., UNESCO and Yangambi. Other land cover features, such as cultivated areas, bare land or ice, are not considered.

ii) Some existing classifications are designed to be used at a specific scale.

iii) Some classifications only or mainly consider classes derived from satellite imagery.

iv) In most of them, there is an unclear or unsystematic description of the classifiers from which the class should be derived.

v) Threshold values for one classifier differ from classification to classification.

vi) In most cases the entire combinations of a set of classifiers are not considered.

vii) No underlying common principle has practically been identified and used to define land cover. Often it is a mixture of different types of classifiers, e.g., land cover and environmental classifiers such as climate, geology and landform. These factors influence land cover, but are not its inherent features. These types of combinations are frequently applied in an irregular way and often do not follow any hierarchy. This leads to confusion in the final nomenclature.

viii) Often one is dealing with a legend in which classes are not defined without a link to a reference classification system.

ix) Some classifications are not designed for mapping and monitoring purposes.

x) Classifications are often not user-oriented.

As a result in some cases there can be a total lack of compatibility, or solely a slight compatibility, between two classifications, or between classification and legend. The practical implications of these facts hamper the possibility of having the classification results used by a wide audience.

3.3 The AFRICOVER Land Cover Classification Scheme

3.3.1 Conceptual basis

The general criteria as explained in paragraph 3.1 are the conceptual basis for the proposed classification system. The main conditions to fulfill are:

i) no emphasis must be put on the name of a class, but on the classifiers defining the class. The main land cover class is then defined by the combination of a set of independent diagnostic attributes (classifiers);

ii) the classifiers must be hierarchically arranged in order to assure at certain levels of the classification (highest levels) a high degree of geographical (i.e., mapping) accuracy of the class considered. (AFRICOVER wants to assert land cover as a geographically precise located feature to which other less well-defined geographical features can refer, e.g., land use, climatic and ecological studies.)

To fulfill these requirements two problems arise:

i) land cover according to its definition is dealing with a heterogeneous set of classes which cannot be defined with the same set of classifiers;

ii) even when classifiers are the same, their hierarchical arrangement may be different.

In addition, the free combination of the whole set of classifiers involved would lead to an enormous number of combinations (which are, in most cases, not present in the field).

The fulfillment of all these requirements, without incurring in the problems mentioned above, is the objective of the proposed method.

3.3.2 Design criteria

The classification is designed according to two main phases:

A dichotomous phase **where a simple sub-division is made in order to define eight major land cover types (see paragraph 3.3.2.1), from which point:**

a so-called *modular-hierarchical phase* starts. In this phase the creation of a land cover class is based on the combination of a set of pre-defined classifiers. These classifiers are tailored to each of the eight major land cover types (see paragraph 3.3.2.2).

The tailoring allows the use of most appropriate classifiers to define land cover classes derived from the major land cover types and at the same time reduces the total number of impractical combinations of classifiers.

This results in a class defined by a Boolean formula showing each classifier used, a unique number for the geographical database, and a name which can be both the provided standard name or user-defined.

3.3.2.1 *Dichotomous phase*

As stated above a dichotomous key is used at the main level of classification to define the major land cover classes.

At the main level a distinction is made between:

A. Vegetated Areas: areas which have a vegetative cover[1] (which may consist of woody, herbaceous, trees, shrubs, forbs, graminoids, mosses/lichens) of at least 4 percent during at least two months of the year. This class is determined by the presence of vegetation and the time factor of vegetation present.

B. Non-Vegetated Areas: areas which have a total vegetative cover of less than 4 percent during at least 10 months of the year. This class is determined by the time factor of absence of vegetation.

At the second level a distinction is made in:

A1. Vegetated Terrestrial: vegetation is influenced by the edaphic substratum which is terrestrial. This class is determined by the vegetation, cover, time factor of vegetation present and edaphic condition.

A2. Aquatic or Regularly Flooded Vegetated Land: the environment is significantly influenced by the presence of water over extensive periods of time, i.e., water is present for more than three months a year and when water is present less than three months a year, it is present 75 percent of the flooding time. This class is determined by vegetation, cover, time factor of vegetation present and edaphic condition.

B1. Terrestrial Non-Vegetated: the cover is influenced by the edaphic condition which is terrestrial. This class is determined by the absence of vegetation, cover, time factor of absence of vegetation and edaphic condition.

B2. Aquatic or Regularly Flooded Non-Vegetated Land: the environment is significantly influenced by the presence of water over extensive periods of time, i.e., water is present for more than three months a year. This class is determined by absence of vegetation, cover, time factor of absence of vegetation and edaphic condition.

These distinctions result at the third level in eight major Land Cover Categories:

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[1] *Cover* is defined as the proportion of a particular area of ground, substrate or water surface covered by a layer of plants considered at the greatest horizontal perimeter level of each plant in the layer (Eiten, 1968)

A11. Cultivated Terrestrial: areas where the natural vegetation has been removed or modified and replaced by different types of vegetative cover resulting from anthropic activities. This vegetation is artificial and requires human activities to be maintained over the long-term. In between the human activities, the surface can be temporarily without vegetative cover. Its seasonal phenological appearance can be regularly modified by humans (e.g., irrigation). All vegetation that is planted or cultivated with the intent to harvest is included in this class (e.g. wheat fields, orchards, rubber and teak plantations). This class is determined by vegetation, cover, time factor of vegetation present, edaphic condition and artificiality of vegetative cover.

A12. Natural and Semi-Natural Vegetation: natural vegetated areas are defined as areas where the vegetative cover is in balance with abiotic and biotic forces of its biotope. Semi-natural vegetation is defined as vegetation not planted by humans but influenced by human actions. These may result from grazing, possibly overgrazing, the natural phytocenoses, or else from practices such as selective logging in a natural forest whereby the floristic composition has been changed, also previously cultivated areas which have been abandoned and where vegetation is regenerating are included. The human disturbance may be deliberate or inadvertent. Semi-natural vegetation thus includes vegetation due to human influences, but which has recovered to such an extent that species composition and environmental and ecological processes are indistinguishable from, or in a process of, achieving, its undisturbed state. The vegetative cover is not artificial in contrast classes A11 and A24 and it does not require human activities to be maintained over the long term. This class is determined by vegetation, cover, time factor of vegetation present, edaphic condition and natural cover.

A23. Cultivated Aquatic: areas where an aquatic crop is purposely planted, cultivated and harvested which is standing in water over extensive periods during its cultivation period (e.g. paddy rice, tidal rice and deep-water rice). In general, it is the emerging part of the plant which is fully or partly harvested. Other plants (e.g., for purification of water) are free-floating. They are not harvested but they are maintained. This class excludes irrigated cultivated areas. This class is determined by vegetation, cover, time factor of vegetation present, edaphic condition and artificiality of vegetative cover.

A24. Natural and Semi-Natural Aquatic Vegetation: areas where the vegetative cover is significantly influenced by water and dependent on flooding (e.g., mangroves, marches, swamps and aquatic bed). Occasionally flooded vegetation within a terrestrial environment is not included in this class. *Natural Vegetated Aquatic* habitats are defined as biotopes where the vegetative cover is in balance with the influence of biotic and abiotic forces. *Semi-Natural Aquatic* vegetation is defined as a vegetation which is not planted by humans, but which is influenced directly by human activities which are undertaken for other unrelated purposes. Human activities (e.g., urbanization, mining, agriculture) may influence abiotic factors (e.g. water quality), which influence the species composition of the vegetation. Further, vegetation is included in this class which developed due to human activities, but which recovered to such an extent that it is indistinguishable from the former state, or, which build up a new biotope which is in balance with the present environmental conditions. A distinction between *Natural* and *Semi-Natural Aquatic Vegetation* is not always possible because human activities far away from the habitat may create chain reactions which ultimately disturb the aquatic

vegetative cover. Human activities may also take place voluntarily to compensate reactions as described above with the aim of keeping a "natural" state. This class is determined by vegetation, cover, time factor of vegetation present, edaphic condition and natural cover.

B15. Built-up and Associated Areas: areas which have an artificial cover which is the result of human activities such as construction (cities, towns, transportation), extraction sites (open mines and quarries) and waste disposal sites. This class is determined by absence of vegetation, cover, time factor of absence of vegetation, edaphic condition and artificiality of cover.

B16. Bare Areas: areas which do not have an artificial cover resulting from human activities. These areas include areas with less than 4 percent vegetative cover. Included in this class are bare rock areas and deserts. This class is determined by cover, time factor of absence of vegetation and edaphic condition.

B27. Artificial Water Bodies: areas which are covered by water due to the construction of artifacts such as reservoirs, canals and artificial lakes. Without these the area would not be covered by water. This class is determined by absence of vegetation, cover, time factor of absence of vegetation and edaphic condition.

B28. Inland Water: in the case of rivers, the lack of vegetation cover is often due to high flow rates and/or steep shores. In the case of lakes, their geological origin affects the life conditions for aquatic vegetation. The following circumstances might cause water surfaces to be without vegetation cover: depth, rocky basins, rocky and/or steep shorelines, infertile washed-in material, hard and coarse substrates. This class is determined by cover, time factor of absence of vegetation and edaphic condition.

3.3.2.2 *Modular-hierarchical phase*

In this phase the creation of the Land Cover Class is given by the combination of a set of pre-defined pure land cover classifiers. This set of classifiers is different for each of the eight main land cover types and this difference is due to the tailoring of the classifiers to their respective type. This type of classifier can be combined with attributes. Two types of attributes are considered:

i) *environmental and/or other* types of attributes; and

ii) *specific technical* attributes, e.g., floristic, crop type and soil type.

The user is obliged to start with the pure land cover classifiers. However, the user can stop at any time depending on the level of detail required and he/she can derive a land cover class. Further definition of this class can be achieved by adding a combination of any of the other types of attributes.

Due to the fact that the classification is designed for mapping purposes (the system gives high priority to mapability), the user needs to follow specific rules:

i) a higher level must be fulfilled before going to a lower level (as the mapability is high at high levels and decreases at lower levels);

ii) within each level there are essential pure land cover classifiers (in the figures in bright green), plus a further subdivision (in the figures of the modular-hierarchical phase in light blue) which defines in greater detail the class. The latter type of classifier is optional and does not need to be fulfilled;

iii) all essential classifiers within one level should be determined before going to a lower level;

iv) at any time within a level the user can stop and a mutually exclusive class is defined;

v) all land cover classes defined in such way are hierarchically arranged;

vi) at any time the user can further define the land cover class using environmental and/or specific technical attributes;

vii) each land cover class is defined by a Boolean formula (combination of classifiers used), a unique code (numerical) and a name (nomenclature);

viii) the land cover class can be combined with environmental and/or specific technical attributes at any level. The attributes will add a second, separate, code to the land cover class.

3.3.3 Examples of the application of the classification

Some examples are given below to illustrate the proposed Land Cover Classification Scheme. The Boolean formula, the classifiers and the nomenclature name is given at each step in the classification. The user can determine at which step of the classification no further information on the next classifier is available and, therefore, one derives the land cover class. Information on classifiers, e.g., collected during field survey, can be added at a later stage.

Three examples are given which illustrate:

i) *The complexity of layered strata in a forest*: various forest types contain more than one tree layer.

ii) *Tree savanna area*: the classification forces the user to start with the dominant or main strata. In the case of a herbaceous layer combined with sparse trees, the derived nomenclature name does not necessarily put emphasis on the main layer, as is the case with tree savanna.

iii) *Cultivated area*: cultivation of two type of crops with a fallow period and additional environmental and specific technical attributes.

EXAMPLE 1

DICHOTOMOUS PHASE:

A Vegetated
A1 Terrestrial
A12 Natural, semi-natural

MODULAR-HIERARCHICAL PHASE:

Classifier	Classifier Type Chosen	Boolean Formula	Nomenclature Name
A Life Form and Cover	trees closed	A3A10 [1]	Forest
B Macropattern	continuous	A3A10B1	Continuous forest
C Height	>30 - 3 m	A3A10B1C2	Continuous high forest
D Leaf Type	broad-leafed	A3A10B1C2D1E1	Broad-leafed high forest [2]
E Leaf Phenology	evergreen	A3A10B1C2D1E1	Broad-leafed evergreen forest
F Other Strata	no other layer	A3A10B1C2D1E1F1	Broad-leafed evergreen forest (single layer)
If a second a/o third layer present:			
FFG Life Form/Cover 2nd Layer + Height	trees closed to open 20-5 m	A3A10B1C2D1E1F2F5F7G2	Multi-layered broad-leafed evergreen high forest (20-5 m high sublayer)
F Other Strata	No third layer	A3A10B1C2D1E1F2F5F7G2F1	Multi-layered broad-leafed evergreen high forest (20-5 m high sublayer), no third layer
FG Life Form/Cover 3rd Layer	Third layer	A3A10B1C2D1E1F2F5F7G2F2F5F10G2	Multi-layered broad-leafed evergreen high forest (20-5 m high sublayer) with emergents

[1] At any level environmental a/o specific technical attributes can be added.
[2] At this level "continuous" disappears from the nomenclature because a forest is continuous unless it is stated that it is a *"fragmented"* forest.

EXAMPLE 2

DICHOTOMOUS PHASE:

A Vegetated
A1 Terrestrial
A12 Natural, semi-natural

MODULAR-HIERARCHICAL PHASE:

Classifier	Classifier Type Chosen	Boolean Formula	Nomenclature Name
A Life Form and Cover	graminoids closed	A6A10	Closed grassland
B Macropattern	continuous	A6A10B1	Closed continuous grassland
C Height	3-1 m	A6A10B1C4C11	Closed tall grassland
F Other Strata	no more layer	A6A10B1C4C11F1	Closed tall grassland (single layer)
If a second layer is present:			
FG Life Form/Cover 2nd Layer + Height	trees sparse	A6A10B1C4C11F2F5F7G2	Closed tall grassland with emergents (savanna)

EXAMPLE 3

DICHOTOMOUS PHASE:

A Vegetated
A1 Terrestrial
A11 Cultivated terrestrial

MODULAR-HIERARCHICAL PHASE:

Classifier	Classifier Type Chosen	Boolean Formula	Nomenclature Name
A Life Form Main Crop	graminoid	A4	Graminoid crop
B Spatial Aspect - Size	small	A4B2	Intercropped graminoids
B Spatial Aspect Distribution	clustered	A4B2B6B7	Small-scale graminoids [3]
C Crop Combination	intercropped graminoids	A4B2B6B7C2C3C7	Small-scale graminoids on clustered fields
D Cult.Practices/Water Supply	rainfed	A4B2B6B7C2C3C7D1	Rainfed small-scale graminoids (clustered fields)
D Cult.Practices/Cult. Time Factor	fallow	A4B2B6B7C2C3C7D1D8	Rainfed small-scale graminoids under fallow system (clustered fields)

The following attributes may be added [4] in addition to the Land Cover code:

l Landform	gently to moderately sloping terrain	L2	Rainfed small-scale graminoids under fallow system (clustered fields), on gently to moderately sloping terrain.
Q Erosion	sheet erosion	L2Q6	Rainfed small-scale graminoids under fallow system (clustered fields), on gently to moderately sloping terrain with sheet erosion
S Crop Type	sorghum and millet	L2Q6S3	Rainfed small-scale sorghum and millet under fallow system (clustered fields), on gently to moderately sloping terrain and with sheet erosion .

[3] At this level *"intercropped"* disappears from the nomenclature because it is implied by the use of the plural "crops".
[4] At any level attributes may be added, in the example it is done after a full land cover class.

3.3.4 Advantages of the adopted method

From a conceptual point of view, the advantages of the proposed classification are:

i) A real *classification system* in the sense that it covers all possible combinations of classifiers. Some combinations are excluded due to some conditions which are elements of the classification system. These conditions are clearly explained.

ii) A given land cover class is *clearly defined* by a set of independent classifiers. The classifiers are clearly differentiated in: pure land cover classifiers, environmental and other classifiers and discipline specific classifiers. This avoids an unclear mixture.

iii) The classification is truly *hierarchical.* The difference between a land cover class and a further sub-division of this class is given through the addition of new classifiers. The more classifiers used, the greater the detail of the defined land cover class.

iv) The classification can be used as *reference classification system.* In fact, the emphasis given to the set of classifiers defining the class allows easy correlation between existing classification/legend and the proposed one.

v) The specific design of the classification allows *incorporation into GIS* and databases. The pure land cover classes can be used in overlay procedures to make combinations with e.g., climate and physiography, to create new classes.

From a practical point of view:

i) The classification is *designed for mapping*. The hierarchical arrangement of classifiers is set up to assure a high level and precise mapping accuracy (clear definition of boundary between two land cover classes).

ii) It facilitates the *integration of different types of data.*

iii) It is highly flexible, *reflecting the information available* or collected in a given area, or for the time and budgetary constraints of a project. This means that within one land cover map mapping units will contain the maximum available information, but this quantity of information may differ between mapping units. This will not affect the homogeneity of the resulting map.

iv) It *rationalizes the field data collection.* As the classes are defined by a combination of classifiers, field surveyors should detect the single classifiers and not deal with the final class name. This means that the field survey can be done independent of, or parallel to, the interpretation process.

v) It facilitates the *standardization of the interpretation process* contributing to its homogeneity. In fact, the interpreter is not dealing with a final class name, but is dealing with one classifier at a time.

vi) It is *multi-user oriented.* As the class is defined by a set of classifiers, every user can make a re-selection based upon the classifier(s) of interest.

vii) It is designed to map at a *variety of scale*, from small- to large-scale.

4. CLASSIFICATION SOFTWARE

Parallel to the development of the classification scheme a prototype classification software has been developed. This software is intended, at this stage, to show the advantages of the conceptual basis adopted, as well as to show it as a useful tool combined with on-screen image interpretation. The purpose of this software is also to demonstrate that the adopted system is flexible and allows the user, at almost any level of the system, to ask for the class name, its code and string of classifiers. It also enables the user to add attributes to the land cover code.

The software begins at the dichotomous phase where one derives the main land cover type. At this phase no classifiers are used. Dependent on the land cover type selected, the user enters the modular-hierarchical phase where the classifiers are defined.

In this phase the selection of one classifier at a high level may have consequences for the options available at a lower level. The system is built up in such a way that automatically choices which are no longer valid in connection with a chosen classifier at a high level become inactive. As the system will be used in several countries by different teams, data consistency needs to be guaranteed. The user can ask for the land cover class at any level and store its Boolean formula, its code and class name in a file named "legend". Any user having derived a certain class will store the same Boolean formula and the same code. The class name can be the given class name or may be user-defined.

For every mapping unit the user goes again through the same sequence of screens to derive the land cover class which is subsequently stored in the "legend". To facilitate the interpretation process, selection of the land cover class for a repeatedly occurring mapping unit can be done directly from the "legend" file.

Together with the Boolean formula and class code, the interpretation level is also stored in the "legend". This has the advantage that the field surveyor can directly comprehend where more field information is needed. This will assist the selection of field sampling. As already explained, the field survey concentrates on defining the class classifier per classifier.

The classifiers of the system are explained in detail in the appendix which follows.

PRELIMINARY GLOSSARY OF LAND COVER CLASSIFIERS USED IN THE PROPOSED AFRICOVER CLASSIFICATION

I. NATURAL AND SEMI-NATURAL VEGETATION (A12)

In the present classification the vegetation is described by its physiognomy (overall appearance of vegetation) and its structure (spatial distribution pattern of life form both vertical and horizontal). This strict rule allows the user to independently add the floristic composition of the vegetation independently. The combined use of structure and floristic composition is scientifically the most precise method of describing and mapping vegetation.

Six big structural vegetation domains exist: forest, woodland, thicket, shrubland, herbaceous communities (savannas and grasslands) and sparse vegetation (any type, tree and/or shrub and/or herbaceous). The belonging of a given population to one of the main types is determined by what is chosen as main layer. Two parameters should be considered:

1. **The first parameter is the *Life Form*.** A broad distinction can be made in:

   1) *Woody*

   2) *Herbaceous*

   A more detailed one can be made between:

   1a) *Trees*: a woody plant which has generally a single main stem and has more or less definite crowns.

   1b) *Shrubs*: a woody plant that generally shows several erect, spreading, or prostrate stems and has a bushy appearance.

   2a) *Forbs*: broad-leaved herbaceous plants such as clover (*Trifolium*), sunflower (*Helianthus*), ferns, etc. (usually all non-graminoids herbaceous plants are included in this class).

   2b) *Graminoids*: which include all herbaceous grasses and grass-like plants such as sedges (*Carex*), rushes (*Juncus*). The bamboos are also grasses but they are excluded because they are woody.

   This separation is mainly done on the physiognomy of the vegetation, but there is also a relation with Height. At this level, the classes of Height are not mutually exclusive; an overlap exists between the lower limit for trees and the maximum height for shrub, and the lower limit of shrub and the higher limit for herbaceous (forbs and graminoids). Thus, the height is not considered as the main diagnostic criteria to determine the Life Form but contributes to its definition by defining a threshold value.

2. **The second parameter is the *Cover*.** It can be considered as the proportion of a particular area of ground, substrate or water surface covered by a layer of plants considered at the greatest horizontal perimeter level of each plant in the layer.

Three main cover types are distinguished:

1. *Closed* cover: more than 70 percent of the perimeter, in case of trees or shrubs the crowns are interlocking.

2. *Open* cover: from 70 to 20 percent of the perimeter, in case of tree and shrub crowns are not usually touching, sub-divided in 20-50 percent and 50-70 percent.

3. *Sparse* cover: less than 20 percent, the perimeters are separated by an average distance of more than twice the average perimeter diameter, sub-divided into 5-10 percent and 10-20 percent.

Definition of the *main layer* is done by combining the two following conditions:

1. Importance of Life Form: going from trees -> shrubs -> herbaceous (forbs and graminoids).

2. Importance of Cover: going from closed -> open -> sparse.

Here below are some examples to clarify the above definition:

- If "trees closed" are present, the main structural domain is forest independently of the presence or absence of other life forms.

- If "trees open" are present, the same accounts, though the structural domain is woodland.

- If "trees sparse" are present, it is different. In this case the trees are only the main strata if other life forms are sparse or absent. If not, "trees sparse" are not the main layer. Then, for example, shrubs or herbaceous, open or closed, can be the main layer. A tree savanna, for example, is formed by the main layer of herbaceous, closed or open, and a second layer of sparse trees. If the cover of the trees would be open, the main layer would subsequently change into the structural domain of woodland.

Other classifiers as *Spatial Distribution, Leaf Type, Leaf Phenology* and *Layering*, will determine hierarchically arranged sub-classes of the above-mentioned main structural domains.

Spatial Distribution/Macropattern

Spatial distribution/Macropattern is the horizontal spatial arrangement of the vegetation. It is subdivided in:

- *Continuous*: when a given cover (open or closed) is without interval or break.

- *Fragmented*: when a given cover (open or closed) is interrupted. Fragmentation can be subdivided according to its form into *striped* (elongated ellipse) and *cellular* (circular-like).

- *Parklike patches*: in this case the distribution is directly related with cover, which is sparse. It signifies that trees and shrubs grow singly or in small groups as in the so-called parks or savannas. In case of herbaceous vegetation it signifies disconnected patches. Two sub-groups can be distinguished, i.e. *dotted* (basically sparse single plants) or *cellular* (small groups of plants).

Leaf Type (only for trees and shrubs)

There are three types:

- *broad-leaved*

- *needle-leaved*

- *aphyllous* = plants without leaves or short-leafed or with leaves reduced to scales or thorns (the plants generally have the chlorophyll in their stems, branches and twigs, which are frequently succulent).

In all the above mentioned cases the leaves play when present a negligible role in the photosynthesis. Aphyllous plants are most common in arid and semi-arid regions.

Leaf Phenology (only for trees and shrubs)

There are two types and two sub-classes:

- *deciduous*: areas where more than 75 percent of vegetation is made up of trees or shrubs that shed their foliage simultaneously in connection with a specific season.

- *evergreen*: areas where more than 75 percent of trees or shrubs have leaves all year.

In tropical areas the deciduousness is a difficult feature to map for many reasons:

1. Seasonal variation (in the higher latitude the onset of the cold season, with its shorter days, induces plants to drop their leaves; in the lower latitude it is not the same. The days vary little and the adverse period is usually the dry season, which can vary from place to place.

2. Geographical location (some plant species are deciduous in some areas but evergreen in other).

3. Individuality of plant phenology (some plants may shed their leaves on an individual basis rather than as member of a species); high degree of mixture in tropical forest of deciduous and evergreen plants. For these reasons, three sub-classes are distinguished:

    - *mixed*: when there is a mixture of broad-leaved deciduous and needle-leafed evergreen. Within this combination it is necessary that neither of the two classes has less than 25 percent.

    - *semi-deciduous*: this term applies to a combination of broad-leaved deciduous and broad-leaved evergreen with a dominance of the first one and the second one is more than 25 percent.

    - *semi-evergreen*: a combination of broad-leaved evergreen with broad-leaved deciduous with the first one dominating and the second one more than 25 percent.

These types are particularly important in the tropics and sub-tropics as the broad-leaved evergreen forest of the humid tropics merges gradually with the broad-leaved deciduous forest of the drier regions.

Leaf phenology (only for herbaceous)

- *Perennial*: plant living for several years.
- *Annual*: plant living for one year.

Stratification/Layering

This describes other than the main layer with Life Form, Cover and Height as described for the main layer. The importance for Life Form and Cover is as described above. In addition, the following conditions are applied:

1. Only two sub-layers other than the main layer can be considered.

2. Forbs and graminoids are considered together as herbaceous.

3a. For trees, three main strata, including the main layer, can be considered.

3b. For shrubs, two main strata, including the main strata, can be considered.

3c. For herbaceous, only one strata is considered.

4. If the cover of the main strata is "closed trees" or "closed shrub", herbaceous is not considered in the layering.

5. If in the layering herbaceous is sparse, it is not considered as second layer except when the main layer is sparse trees or sparse shrub.

6. If the main strata is shrub or herbaceous, only one layer of trees can be considered.

7. If the main strata is trees, closed or open, and the second layer is "sparse trees", then these must be higher than the main strata (i.e., emergent); if lower, they are not considered as independent strata.

Specific Technical Attributes for Natural and Semi-Natural Vegetation - Floristic denomination

It is considered at two main levels, if the given name is derived from:

1. A *single plant species*, sub-divided into:

   - dominant species that are dominating for height, cover (or the combination of both);
   - species which are most frequent.

2. A *group of plant species*, sub-divided into:

   - statistically derived plant groups, e.g., the association in the Braun-Blanquet tabular method;
   - plant groups that are derived without statistical methods, e.g. plant groups which have the same ecological significance, the same geographic distribution or the same dynamic significance.

II. NATURAL AND SEMI-NATURAL AQUATIC VEGETATION (A24)

These areas are described by Life Form, Cover, Height, Leaf Type and Phenology and Layering as described above. The classifier Water Persistence is described in addition.

Life Form

Life Form is described as in paragraph I.1, but there is a further subdivision under "Forbs" in *Rooted* and *Free-floating*.

Water Persistence

The endurance of water in the area is sub-divided into:

1. *More than three months a year*: this is further sub-divided into: *persistent for all day* or *with daily variations*, e.g., tidal areas.

2. *Less than three months a year:* in this case the water needs to persist more than 75 percent of the flooding time.

3. *Waterlogged*: soil completely saturated with water.

III. CULTIVATED TERRESTRIAL (A11)

In the classification, the cultivated vegetated areas are described by physionomy, crop combination, spatial aspect and distribution and cultural practices. The crop type can be added separately.

Life Form of the Main Crop

Life Form is described as explained under (semi-)natural vegetation.

Crop Combination

A broad distinction can be made into:

- *monoculture*: the growing of a single crop on a field;

- *intercropping*: the growing of two or more crops simultaneously on the same field. Crop intensification is in both time and space (vertical and horizontal) dimensions. There is an intercrop competition during all or part of crop growth, but the period of overlap is long enough to include the vegetative stages. No horizontal spatial arrangement of the crops, e.g., rows, strips or without any arrangement, is considered.

It can be further sub-divided into *one additional crop* or *more than one additional crop*. They can be specified by Life Form.

Spatial Aspect - Size (of field(s))

The *Spatial Aspect/Size* is described (to be quantified) and sub-divided into:

- *Large*: (to be quantified) further sub-divided into *Very Large* and *Large;*
- *Medium - Small*: (to be quantified) further sub-divided into *Medium, Small*, and *Very Small.*

Spatial Distribution

Spatial Distribution is the horizontal spatial arrangement of the field(s). It is in analogy with (semi-) natural vegetation sub-divided into:

- *continuous*: when a given field pattern is without interval or break;
- *scattered*: when a given field pattern is interrupted.

Two sub-types are distinguished according to the existing grouping of fields, i.e., *clustered* and *isolated* (no grouping).

Spatial Aspect - Form

The *Spatial Aspect/Form* describes the form of the fields. Three types are distinguished:

- *rectangular*
- *cellular*
- *striped*

Cultural Practices - Water Supply

Two main types of agricultural practices are distinguished:

1. *Rainfed*: agricultural cropping system dependent on rain.

2. *Irrigated*: agricultural cropping system with an artificial supply of water, in addition to rain.

This is further sub-divided into (terminology according to FAO Terminology Bulletin No. 34):

2a) *gravity*: irrigation type based on gravity (also called *flow irrigation*);

2b) *furrow*: irrigation type with furrows where the supplied water is led in;

2c) *sprinkler*: irrigation system based on water supplied in droplets, like rain;

2d) *drip*: irrigation type where the water trickles on the soil near the plant(s) at a confined spot (also called *dribble* or *trickle irrigation*).

Cultural Practices - Fallow Period

Four types of growing crops are distinguished:

1. *Shifting*: the growing of crops for a few years on selected and cleared plots alternating with a lengthy period when the soils is rested. The land is cultivated for less than 33 percent of the years (Ruthenberg, 1980).

2. *Fallow*: a sequence of alternation between cropping for several years and a fallow period. The land is cultivated between 33 and 66 percent of the cropping years.

3. *Permanent*: growing of long-term crops in open air, which do not have to be replanted for several years after each harvest, e.g., trees and shrubs. The crop should occupy the land for a minimum of two years. The first harvest normally takes place after one year or later. The land is cultivated for more than 66 percent of the cropping years.

4. *Sequential*: growing of two or more crops in sequence on the same field within one year. The succeeding crop is planted after the preceding one is harvested.

IV. CULTIVATED AQUATIC (A23)

These areas are described by the classifiers: Life Form of the Main Crop, Spatial Aspect (Size, Distribution and Form) and Cultural Practices.

Life Form of the Main Crop

Only *Herbaceous* is considered, which is sub-divided into *Graminoids* and *Other*.

Spatial Aspect - Size (of Field(s))

Two sub-divisions are made:

- *Large*: (to be quantified) further sub-divided into *Very Large* and *Large;*
- *Medium - Small*: (to be quantified) further sub-divided into *Medium, Small* and *Very Small.*

Spatial Distribution

It is the horizontal spatial arrangement of the field(s). It is in analogy with (semi-)natural vegetation sub-divided into:

- *Continuous*: when a given field pattern is without interval or break;
- *Scattered*: when a given field pattern is interrupted. Two sub-types are distinguished according to the existing grouping of fields, i.e., *clustered* and *isolated* (no grouping).

Spatial Aspect - Form

The *Spatial Aspect/Form* describes the form of the fields. Three types are distinguished:

- *rectangular*
- *cellular*
- *striped*

Cultural Practices - Fallow Period

A distinction is made into four types:

1. *Permanent*: Growing long-term crops in open air, which do not have to be replanted for several years after each harvest, e.g., trees and shrubs. The crop should occupy the land for

a minimum of two years. The first harvest normally takes place after one year or later. The land is cultivated for more than 66 percent of the years.

2. *Multiple Cropping*: Growing two or more crops on the same field in a year.

3. *Relay Intercropping*: Growing two or more crops simultaneously during part of each one's cycle. A second crop is planted between the first crop (often between rows), generally 4 to 6 weeks before the harvest of the first crop, but after flowering of the first crop. Relay cropping is an intermediate form of Intercropping and Sequential cropping. An example is: rice/mungbean.

4. *Sequential*: Growing two or more crops in sequence on the same field within one year. The succeeding crop is planted after the preceding one is harvested.

V. BUILT-UP AND ASSOCIATED AREAS (B15)

This major land cover type is described by surface aspect only.

Surface Aspect

This can be divided into two main groups:

1. *Built Up*: can be further sub-divided into *Linear*, e.g. roads, railways and above ground pipelines, and *Non-Linear*, the truly built-up areas. They can be further subdivided into: (1) Industrial or Infrastructure and (2) Urban Area. These two classes can be further defined according to the density of artifacts into: high, medium and low.

2. *Non-Built Up*: can be sub-divided into: (1) Waste Dumps/Deposits and (2) Extraction Sites, e.g., quarries, open mines, etc.

VI. BARE AREAS (B16)

The (semi-)natural non-vegetated terrestrial areas are described using the following classifiers: *surface aspect* and *macropattern*.

Surface Aspect

The bare surfaces are distinguished into two main classes:

1. *bare rock*: rock surfaces and no soil is present. This is further sub-divided into:

   - *rock* and *gravel or stones* (which should cover at least 80 percent of the surface);
   - *rock with a shallow sandy layer, shallow or isolated pockets of soil.*

2. *top soil*: soil surfaces independent of its depth. This is sub-divided into:

   - *sandy* or *other (silty or clayey)* soil;
   - *stony* (less than 80 percent but more than 15 percent).

Macropattern

The Macropattern describes the pattern of a specific type of sandy cover, i.e., dunes. They are defined as mounds or hills of sand which have been deposited by the wind and tend to be associated with specific locations. They vary greatly in size and shape according to the nature of the wind and the amount of sand available. Three forms are distinguished:

1. *Barchans*: crescent-shaped dunes with horns pointing downwind.

2. *Parabols*: elongated dunes with horns pointing upwind.

3. *Longitudinal*: long, narrow, symmetrical dunes running parallel with the prevailing wind direction.

Most dunes are not static features and slowly migrate as wind blows sand up the gently sloping windward side over the crest and down the steep leeward side.

The area where the dunes occur can be either *saturated*, dunes are clustered, or *unsaturated*.

Specific Technical Attributes - Lithology

There are three major lithological groups which, if needed, can be further sub-divided. They are:

1. *Igneous*: a rock formed by the cooling and solidification of magma. Igneous rock may be either intrusive or extrusive in origin. This can be further sub-divided into: granite, diorites, gabbros, porphyrites and other extrusive rocks.

2. *Metamorphic*: rock formed by the application of great heat and pressure to igneous and sedimentary rocks over immense lengths of time, which results in alterations to the original texture, structure and compositions of the rock. This can be further subdivided in: gneiss, serpentines, schists, marbles, quartzites, slates, phyllites and other.

3. *Sedimentary*: rock formed by the lithification of sediment. Stratification occurs due to variations in the nature of the deposition environment and the material being deposited. These can be further sub-divided into: chalks, limestones, dolomites, shells, marls, mustiness, sandstone's, conglomerates, brachia and other rocks which are not consolidated.

VII. INLAND WATER BODIES (B28) AND ARTIFICIAL WATER BODIES (B27)

These areas are described by the classifiers: Physical Status, Flow Regime, Depth and Sediment Load.

Physical Status (only applicable for B28)

- The *Physical Status* describes the status of the water, i.e., *water, snow*, or *ice*.

Flow Regime

The *Flow Regime* is sub-divided into:

- *Perennial*: water, snow or ice cover the surface for more than 9 months/yr.
- *Non Perennial*: water, snow or ice cover the surface for less than 9 months/yr.

Depth (only for water)

The *Depth* is described for water only and it is sub-divided into:

- *deep to medium deep* (to be quantified)
- *shallow* (to be quantified)

Sediment Load (only for water)

Transport of rock fragments and suspension of soil particles in water is described. The following sub-division is made:

- *almost no sediment* (to be quantified)
- *medium sediment load* (to be quantified)
- *high sediment load* (to be quantified)

Specific Technical Attribute - Water Quality

In case of water, the quality is described. It is sub-divided into (according to US Geological Survey):

- *Fresh*: Less than 1,000 PPM of Total Dissolved Solids
- *Slightly saline*: 1,000 - 3,000 TDB
- *Moderately saline*: 3,000 - 10,000 TDB
- *Very saline*: 10,000 - 35,000 TDB
- *Brine*: more than 35,000 TDB (water saturated, or nearly so, with salt)

ENVIRONMENTAL AND OTHER TYPES OF ATTRIBUTES

The environmental and other attributes comprise Land Form, Lithology, Climate, Altitude, Erosion, Water Quality and Soil.

Land Form

Land Form is based on the sub-division of slope percentage in three main classes:

1. *Flat to Almost Flat*: 0-2 percent slope. This is further sub-divided into:

   - *plain;*
   - *depression* (e.g. playas);
   - *floodplain.*

2. *Gently Sloping to Rolling*: 3-20 percent slope. This can be sub-divided into:

   - *gently to moderately sloping* (3-7 percent slope and/or relief height difference of 5-50 m);
   - *undulating* (8-13 percent and/or relief height difference of 25-75 m);
   - *rolling* (14-20 percent with a relief height difference of 50-200 m).

3. *Hilly to Mountainous*: 21-more than 140 percent slope. This is sub-divided into:

   - *hilly to steeply dissected* (21-55 percent slope and relief height difference of 200-500 m); - *mountainous from very steep to extremely steep* (55-more than 140 percent slope and relief height difference of 500 to more than 1000 m).

Lithology

(as described above)

Climate

The Köppen bioclimatic classification has been followed.

Altitude

Ten altitude range classes are proposed:

1. < 300 m
2. 300 - 600 m
3. 600 - 1000 m
4. 1000 - 1500 m
5. 1500 - 2000 m
6. 2000 - 2500 m
7. 2500 - 3000 m
8. 3000 - 3500 m
9. 3500 - 5000 m
10. > 5000 m

Erosion

Erosion describes the human-induced or accelerating erosion phenomena which result from irrational use of land and water resources. The main types are in stable areas, *"No visible evidence of erosion"*, and in unstable areas, *"Visible evidence of erosion"*.

The latter is further sub-divided into:

1. *Water erosion: it is sub-divided into: Sheet, Rill* and *Gully* erosion;

2. *Wind*: no further sub-division is made;

3. *Mass movements*: no further sub-division is made.

Water Quality

(as described above)

Soils

It is proposed to follow the FAO Legend which divides them into 28 major soil groups.

LITERATURE AND INTERNET PAGES CONSULTED

Anderson, J.R., et al., 1976 - A Land Use and Land Cover Classification System for Use with Remote Sensor Data. Geological Survey Prof Pap 964. U.S Govt Print Off, Washington DC, 28 pp.

Ashton, P., M. Ashton , 1975 - The classification and mapping of Southeast Asian ecosystems -Transactions of the 4th Aberdeen-Hull Symposium on Malaysian Ecology - Aberdeen, UK -pp 103.

Baltaxe, R., 1980 - Système Mondial de Surveillance Continue de l'Environnement. Projet pilote Cameroun, Bénin, Togo - FAO - Rome, Italy - pp 84, 75 and 117.

Barisano, E. and S. Braunstein, 1996 - Proposal for a landcover legend for Africa (AFRICOVER).

Bekker, R.P. and P.V. de Wit, 1991 - Contribution to the vegetation classification of Botswana - FAO/UNDP/Rep of Botswana - Gaborone, Botswana - pp 66.

Belward, A., 1994 - The IGBP-DIS global 1Km land-cover data set: A validation strategy proposal. Draft version Oct. 94 - European Commission's Joint Research Centre - Ispra, Italy.

Belward, A.. and T. Loveland, 1995 - The IGBP-DIS 1 Km Land-Cover Project - European Commission's Joint Research Centre - Ispra, Italy.

Blasco, F. and P. Legris, 1989 - Classification and mapping of vegetation types in tropical Asia. FAO - Rome, Italy - pp 169.

Boughey, A.S., 1957 - The physiognomic delineation of West African vegetation types. J. West African Sc. Ass 3: 148-165.

CCAS, 1956 - C.S.A. specialist meeting on phytogeography. Yangambi July 28 - August 8 - C.C.T.A. 22: 1-40.

CCD, 1995 - United Nations Convention to Combat Desertification - published by UNEP Information Unit for Conventions - pp 71.

Centre National des techniques Spatiales, Algérie - Recommandations du séminaire Désertification/Afrique du Nord - Arzew 17-19 Janvier 1993.

CESD Communautaire - Statistical cartography. Land Use. Technical specifications -Luxembourg - pp 32.

Cole, M.M., 1982 - The influence of soils, geomorphology and geology on the distribution of land communities in savanna ecosystems. In: B. J. Huntley and B.H. Walker (eds), Ecology of Tropical Savannas. Springer, Berlin pp 145-175.

de Bie, C.A., J.A. van Leeuwen and P.A. Zuidema, 1996 - The Land Use Database: A Knowledge Based Software Program for Structured Storage and Retrieval of User-Defined Land Use Data Sets. User's Reference. Includes software diskette.

de Leeuw, J. and K. de Bie, 1995 - The land cover data base: concepts and data-model - presented in Moscow, August 95 - pp 14.

Di Gregorio, A., 1991 - Technical Report on Land Cover Mapping of Lebanon. FAO project NECP/LEB/001/SAU. pp 24.

Direction et Contrôle des grands travaux, 1989 - Abidjan: carte des modes d'occupation des sols -MOS Etat 1989 (extraits) - Abidjan, Cote d'Ivoire.

Eiten, G., 1968 - Vegetation Forms - A classification of vegetation based on structure, growth form of the components, and vegetative periodicity. Bol. Inst. Bot. 4. Sao Paulo: 33 pp.

ESRI/The Nature Conservancy, 1994 - NBS/NPS Vegetation Mapping Program. Standardised National Vegetation Classification System. Final draft - USDI - Washington, USA

Euromed, 1993 - Le projet Medgeobase Tunisie - Commission des Communautés Européennes, DG XI - pp. 49.

FAO, 1995 - Forest resources assessment 1990 - Global synthesis - FAO Forestry Paper 124 -Rome, Italy - pp 91.

FAO, 1994 - Africover proposal - Working group on land cover classification and legends. Report and Recommendations - Addis Ababa, Ethiopia - pp 7.

FAO, 1994 - Projet AFRICOVER: "Dossier de présentation" - Rome, Italy.

FAO, 1993 - Guidelines for the design of agricultural investment projects - FAO investment centre technical paper 7 - Rome, Italy - pp 177.

FAO, 1993 - Forest resources assessment 1990 - Tropical countries - FAO Forestry Paper 112 -Rome, Italy - pp 102.

FAO, 1991 - Forest resources assessment 1990 project: Monitoring Methodology - FAO Field Document - Rome, Italy - pp 45.

FAO, 1991 - Guidelines Land Evaluation Extensive Grazing. Soils Bull. 58:158 pp.

Fontès, J. and S. Guinko, 1995 - Carte de la végétation et de l'occupation du sol du Burkina Faso -Notice explicative. ICIV. Toulouse, France.

Fuller, R.M. et al., 1995 - Darwin initiative: computers in terrestrial ecology, Sango Bay, Uganda - Final report - ITE - Huntingdon, UK - pp 13 and Appendix A.

Gillison, A.N. and D.J. Anderson, 1981 - Vegetation classification in Australia - proceedings of CSIRO workshop in Canberra, Australia, Oct 1978 - pp 229.

Grunblatt, J. et al., 1989 - A hierarchical approach to vegetation classification in Kenya - in Afr. J. Ecolo. vol 27, pp 45-51.

Howard, J.A. and D. Lantieri, 1987 - Vegetation classification, land systems and mapping using SPOT multispectral data. FAO technical paper - pp 12.

Howard, J.A. and J. Schade, 1982 - Toward a standardised hierarchical classification of vegetation for remote sensing - FAO Remote Sensing Series 11 - Rome, Italy- pp 30.

ITE, 1995 - Letter to J. Latham: Land cover classification bibliography.

ITE/UNEP/FAO - Glossary of Land Cover Attributes - Draft version - 29 June 1995.

ITE/WCMC. Harmonisation of Global Land Nomenclatures (GGNLCLU).

Kennedy, P., 1994 - Designing a system of nomenclature for European forest mapping - Proceedings Joint Research Centre, European Forest Institute - Joensuu, Finland - pp 455.

Kuchler, A.W. and I.S. Zonneveld, 1988 - Vegetation mapping - Handbook of Vegetation Science v. 10. Dordrecht, Netherlands - pp 635.

Lantieri, D., 1990 - Utilisation de la télédétection pour la cartographie des ressources naturelles dans les pays en developpement, papier technique - FAO.

Lantieri, D., 1993 - Remote sensing and its application to investment project identification and preparation, pp 62. FAO publication.

Lantieri, D., 1993 - Use of remote sensing for development projects assisted by the World Food Programme. WFP/FAO publication - pp 16.

Latham, J., 1983 - Utilisation of remote sensing and field data for the production of agricultural statistics on crop acreage (Excerpts) - FAO Remote Sensing Centre - Rome, Italy.

Lund, G., 1994 - Guidelines for the use of digital imagery for vegetation mapping. Draft report -USDA - Washington, USA.

Lund, H., 1995 - FGDC vegetation (classification) standards - Version 31 July 1995 - USDA -Washington, USA - pp 14.

Milligton, A., 1994 - Estimating woody biomass in sub-Saharan Africa (excerpts) - The World Bank - Washington, USA.

Mulder, P. and M. Clabaut, 1993 - STRING: Annexe A, Base de données cartographiques - OSS -pp 64.

NASA, 1995 - Landsat Pathfinder Program - Information from Internet WWW - pp 7.

Negre, T., 1995 - Report of the Preparatory Mission: Outlines for the AFRICOVER Classification System. Draft Document. FAO, Internal Document. pp 47.

Paivinen, R. et al., 1993 - IUFRO international guidelines for forest monitoring - Draft report -pp 37.

Popov, G.B. et al., 1991 - Etude écologique des biotopes du criquet pélerin - PRIFAS Collection Les Acridiens - Montpellier, France - pp 743.

Rosenholm, D., 1993 - Land use and vegetation mapping by satellite: SSC satellitbild experiences 1987-1993 - in ITC journal 1993-3 - pp 251-260.

Schomaker, M., 1995 - Fax including land-cover legends for Nigeria - UNEP - Nairobi, Kenya.

SCOT Conseil et al., 1992 - Etude de mise en place du CNTIG, Madagascar: Annexe 7, Nomenclature de cartes thématiques existantes.

Sims, D., 1995 - Background Note On Ongoing Activities Relating to Land Use and Land Cover Classification. FAO, Internal Document, Rome. pp. 7.

Sokal, R., 1974 - Classification: Purposes, Principles, Progress, Prospects - in Science vol.185, number 4157 - pp 111-1123.

Toe, E., Monitoring and Evaluation of temporary protection of vegetation - Bam province, Burkina Faso - page 20 and 36.

Thompson, M., 1994 - A standard land-cover classification for remote sensing applications in south Africa - CSIR - Pretoria, South Africa - pp 22.

Turner, B.L., R.H. Moss and D.L. Skole (Eds.), 1993 - Relating Land Use and Global Land Cover Change: A Proposal for an IGBP-HDP Core Project. Joint Report of the IGBP, Rep. No. 24 and HDP, Rep. No. 5. Stockholm, Royal Swedish Academy of Sciences. Exerpt on http://www.ciesin.org/docs/002-105/002-105.html.

Turner, B.L., D.L. Skole, D., Sanderson, S. Fischer, G. Fresco, L.O. and R. Leemans (Eds.) 1996, Land Use and Land Cover Change Science/Research Plan. Joint Report of the IGBP, Rep. No. 35 and HDP, Rep. No. 7.http://pathfinder-www.sr.unh.edu/lucc/scienceplan.html.

Ugandan Forestry Department, 1994 - The national biomass study: Evaluation mission - Kampala, Uganda - pp 11-13.

UNEP - Terms of reference for a Corporate Contract between UNEP and ITE: Harmonisation of nomenclature for recording land use and land cover globally.

UNESCO, 1973 - International classification and mapping of vegetation - Paris, France - pp 32.

U.S. Geological Survey, 1996 - Global Change Research Program. Http://geochange.Er.Usgs.Gov/pub/info/html/elements/landchar.html.

U.S. Geological Survey, 1996 - Land Data Directory, Catalog and Inventory Systems Development - Global Land Information System (GLIS). http://geochange.er.usgs.gov/pub/info/html/nmd/glis/html.

van Gils, H.A.M.J., 1989 - Legends of landscape ecological maps, ITC Journal 89/1: 41-48.

van Gils, H. et al., 1991 - The evolution of the ITC system of rural use and land cover classification (LUCC) in ITC Journal 1991-3 - pp 163-167.

van Gils, H., 1993 - Vegetation classification: a review for harmonisation of maps - presented at Charlottesville, USA - pp 29.

Walter, H., 1985 - Vegetation of the Earth - Third edition - Heidelberg Science Library - Berlin, Germany - pp 318.

Webb, L.T., 1959 - Physiognomic classification of Australian rain forest - Ecology 47: 55-70.

White, F., 1983 - The vegetation of Africa - A descriptive memoir to accompany the UNESCO/ EATFAT/ UNSO vegetation map of Africa - UNESCO - Paris, France - pp 356.

Wyatt, B. et al., 1994 - Comparisons of Land Cover definitions - Final report - ITE project TO2071b1.

Wyatt, B. et al., 1990 - Comparison of Land-Cover definitions - Countryside 1990 series - vol. 3 -ITE, Department of the Environment - UK - pp 131 - includes diskette.

Young, 1994 - Towards international classification systems for land use and land cover - A preliminary proposal prepared for UNEP and FAO - FAO - Rome, Italy - pp 45.

PART II

PROCEEDINGS OF THE SEMINAR

ON LAND COVER LEGEND AND CLASSIFICATION

held at the Saly Meeting
29 - 31 July 1996

1. GENERAL INTRODUCTION

From 29 to 31 July 1996, FAO organized the first AFRICOVER seminar for the international working group on legend and land cover classification at Saly (Mbour, Senegal).

1.1 Historical Background and Context

Analysis of the physical and human resources information in African countries has revealed the insufficiency and difficulty for use because of the following reasons:

- basic information on environment and natural resources is missing;
- quality of existing information is extremely variable and the way it is often presented does not support decision-making;
- topographical maps are obsolete and thematic maps, when available, are heterogeneous;
- information provided by the various institutions is often redundant within the same country;
- it is extremely difficult and often impossible to integrate or compare the existing information made available by departments and organizations.

Decision-makers at local, national or sub-regional, public or non governmental levels are now realizing the necessity to have access to reliable geo-referenced information systems on natural resources.

Technically, the production and the rational and harmonized use of these information systems should necessarily go through the establishment of a geo-referenced and standardized thematic base which meets the common needs of natural resources information producers and users.

To meet such a demand, FAO has proposed to set up the AFRICOVER project in collaboration with the relevant technical organizations in Africa.

The purpose of the AFRICOVER project is to give African countries a standardized geo-referenced numerical database on the vegetation and land cover and a topographic geographic reference system (toponymy, roads, hydrography) at scales 1:250,000 or 1:200,000 that are thematically homogeneous and comparable over the African continent.

For some restricted areas and small countries of less than 30,000 km², the database will be prepared at scale 1:100,000. The techniques used will be mainly based on geomatics (remote sensing, GIS, GPS) and cartography.

The AFRICOVER project has another important main objective, which is to reinforce and level out national and sub-regional capabilities in Africa with a view to establish and regularly update vegetation and land cover maps, and to follow up changes in land cover on the African continent. The seminar of Saly, held on 29-31 July 1996, has been organized in that framework.

1.2 Specific Objectives and Results Expected from the Seminar

1.2.1 International working groups

In order to define an homogeneous methodology which is standardized and adapted to all African countries, and following the recommendations from the experts mission organized by FAO at the Headquarters of the Economic Commission for Africa in July 1995, three international working groups were set up:

- Group 1: Legend and Land Cover Classification
- Group 2: Geometry and Geodesy
- Group 3: Technical Methods and Quality Control

Each group includes, on average, 15 to 25 high level international experts among which two thirds from African countries, a Chairman selected among the African experts and a Co-chairman. The Chairman is also assisted by two to three international consultants in charge of writing the technical reports discussed by working group members. The working groups operate according to the main following steps:

- preparation of a preliminary technical report;
- collection of comments from group members;
- finalization of the technical report;
- meeting of working group members in an African country;
- realization of pilot projects to test and validate the groups recommendations;
- finalization of recommendations and diffusion of the AFRICOVER standard.

The joint organization of this meeting, as well as the joint preparation and publication of the seminar minutes, is subcontracted to an African organization, which is leading in this technical area.

1.2.2 The seminar of Saly

The seminar, organized from 29 to 31 July 1996 at Saly in the Senegalese region of Thies, is a key step in the normalization process started by Working Group 1 "Legend and Classification."

This working group is made up of a team of African and non-African scientists selected among the finest experts dealing with issues related to legend and land cover classification and nomenclature.

The Environment and Natural Resources Service of FAO's Sustainable Development Department, which initiated and prepared the AFRICOVER project, handed over the organization of this seminar to the Center for Environmental Monitoring (CSE) which has good experience in this field.

The scope of the seminar is to establish the discussion within this working group with regard to adoption of a standardized land cover classification system.

The following terms of reference for the working group were proposed:

- identification of users' needs, for thematic information on natural resources;
- analysis of main legends and classifications used in Africa (Yangambi, UNESCO, those of projects, etc.) and elsewhere (IGBP, ITC, ICV);
- identify the parameters required for the classification (classifiers and attributes);
- architecture of the classification system: hierarchy of classes with subdivisions including climatic zones found in Africa (e.g., mild, tropical dry, tropical humid);
- prepare description of every thematic class;
- formulate recommendations and conclusions for the field projects on the preparation of legends and mapping techniques;
- provide technical advice on legends to be applied in the field projects.

2. SEMINAR MINUTES

2.1 Opening of the Seminar and Presentation of the Basic Document

The Director-General of the Center for Environmental Monitoring (Centre de suivi écologique: CSE), Mr. Amadou Moctar Niang, during the opening of the workshop on legend and classification, declared firmly the importance of this technical meeting, the first organized by one of the AFRICOVER working groups, following the recommendations of Addis Ababa meeting.

The meeting then proceeded with the adoption of the program and elected the following people to conduct the seminar:

Chairman	Mamadou Fofana	CNTIG
Vice Chairman	Dominique Lantieri	FAO
Francophone rapporteur	Mohamed Talbi	IRA
Anglophone rapporteur	Luka Isavwa	RCSSMRS

Two CSE staff, Messrs Aboubacar Camara and Djibril N'Diaye were designated to support the rapporteur.

Following the official opening by the CSE Director-General, the AFRICOVER Coordinator in Senegal, Mr. Aboubacar Camara, recalled the seminar's objectives.

Mr. Dominique Lantieri, coordinator of the AFRICOVER working groups at FAO and AFRICOVER program officer for West, Central and Southern Africa, then presented the AFRICOVER project putting emphasis on:

- the general and specific objectives, the historical background, output products, implementation phases (preparation and execution), the role of FAO and that of the other partners. He reminded that FAO's role is, first of all, one of normalization, labeling and quality control and, when requested by countries, one of executing agency;

- the way the project will be executed, which consists of regional and national approaches;

- the project's progress according to countries and regions.

He also presented the objectives, the way the three working groups are functioning and the respective roles of members (consultants and associated organizations), the work schedule for organizing the working groups and pilot projects.

Mr. Lantieri was asked to give some clarification on data availability, starting dates of pilot projects, mapping scales used, various implementation conditions (at national and sub-regional levels), the prices for data acquisition and standardization concepts.

2.2 Plenary Session on Land Cover Classification

2.2.1 Preliminary presentations

Presentations were made by several FAO officers and by the consultants recruited to study the AFRICOVER classification and nomenclature.

Mr. John Latham, in charge of the backstopping of the East African module at FAO, elaborated some aspects related to the East African module and, in particular, the geometrical data correction, countries'

institutional state and signee status, and image acquisition. He also mentioned the negotiation underway for the provision of Landsat data at reduced prices for the AFRICOVER project, possible after a recent American regulation.

Ms. Louisa Jansen, FAO Expert in the Land and Water Development Division, proposed some definitions on land cover and land use, (a-priori and a-posteriori) classification and legend concepts and different classification criteria.

Mr. Antonio Di Gregorio, main consultant of the Land Cover Legend and Classification Working Group, developed the basic concepts which structure the classification proposed for discussions by the working group. He also described the historical context and listed the definitions of the a-priori and a-posteriori classification. He gave a detailed presentation of the proposed classification structure and the advantages envisioned in both the dichotomous and modular phases.

He then described the proposed classification using a preliminary version of the software for illustration, which FAO developed with ACCESS. Thanks to this user friendly software, the different land cover classes may be defined according to a decision-tree reviewing classification parameters in compliance with pre-established thresholds and a pre-determined hierarchical order. Classes are automatically generated. Each class defined by the user, is given a compound name translating classification hierarchy and selected values or threshold. Also, each class is given one digital code only. It is automatically registered in a module called "legend" which is organized in a tabular form. This module allows to file the classes generated by the user according to a methodical legend that can be commented or illustrated by the user, if necessary.

2.2.2 Presentation of countries' experiences in the field of land cover mapping

Several countries and programs represented at the seminar introduced their experiences in the field of land cover mapping and the possibilities to work together with the AFRICOVER program. The following experiences were presented:

- program on Environmental Information Systems (EIS) in Sub-Saharian Africa, by Mr. Koffi Kouakou, World Bank;

- activities of the AGRHYMET Center under the natural resources management program, by Mr. Mamadou Diouf, CILSS/AGRHYMET;

- the SADC vegetation regional mapping project and the South Africa national land cover mapping project by Mr. Mark Thompson, CSIR, South Africa;

- the land cover mapping project of the arid zones of Tunisia, by Mr. Hammad Talbi, IRA;

- land cover mapping programs and digital database for decision makers in Côte d'Ivoire, by Mr. Dramane Touré, CNTIG, Côte d'Ivoire;

- land cover mapping project in Mozambique, by Mr. Sylvain Braunstein, IGN, France;

- mapping activities on land cover and land use in Senegal, by the national AFRICOVER project group;

- vegetation mapping project in northern Cameroon using LANDSAT TM images, by Mr. Djoda Mabi, CETELCAF;

- U.S. Federal Geographic Data Committee activities on geographical data related to vegetation and land cover, by Mr. Gyde Lund, USDA.

2.2.3 Discussions

The general discussion held after the presentations listed above stressed the following points:

- necessity to clarify terms and definitions used and to prepare both a French and English glossary;
- necessity to define methods and constraints related to a-priori and a-posteriori classifications;
- links between classification and legend and the necessity to develop a more comprehensive legend structure;
- the compatibility of the proposed software with existing softwares, in particular with GIS;
- precision level required for standardization;
- classification use: for which type of thematic maps? Does it meet users' needs?
- methods to test classification accuracy;
- reference classifications and legends used to set up the proposed AFRICOVER classification;
- problems of homogenization of classes in border areas;
- the building of mixed land cover classes;
- is the AFRICOVER classification specific for the African continent?
- at which scale is the classification system applicable? Does it meet detailed scales?
- FAO's role in mapping codification for Africa;
- correlation and translation between legends and classifications used in African countries.

The FAO AFRICOVER team provided detailed answers and gave the following clarifications:

- The AFRICOVER product contains the basic data for the information systems on resources and environment in Africa.
- Some questions would have to be discussed in detail during meetings scheduled to take place with sub-working groups 1 and 2 (agricultural areas and natural and semi-natural areas).

2.3 Abstracts of Conclusions and Recommendations from Working Groups

At the end of the general discussion, four sub-working groups were set up and given respectively the mandate to reflect on:

- cultivated and associated areas,
- natural and semi-natural areas,
- terms of reference of pilot projects,
- classification and nomenclature.

Sub-groups discussions focused on the report produced by FAO on the land cover classification. As a whole, **participants recognized and adopted the original structure of the classification proposed by FAO.**

They considered that it could represent a real conceptual improvement, able to propose a standard applicable in the various environmental conditions found in Africa. Advantage recognized for the classification are: **its neutrality, its independence vis-à-vis the mapping scale and the mapping tools used, its applicability for the whole continent and its possibilities to translate most existing legends and classifications used in African countries.**

Recommendations made by the participants can be summarized as follows:

i) For cultivated and associated areas (sub-group 1):

The sub-group confirmed its agreement and satisfaction on the architecture of the proposed classification. They also requested that the software should become a more feasible version which could incorporate further changes.

It was also requested:

- the detailed implementation of the seminar results by the countries;
- with regard to farm sizes, the introduction of a quantitative variable in the "spatial aspect" classifier and addition of a "percentage of vegetation cover" sub-class with appropriate thresholds;
- the selection of two "single-cropping" and "combined cropping" classes and their connection to a database characterizing the "crop type" attribute;
- the linkage of a base of attributes on different irrigation types, to the "farming practices" classifier at the irrigation sub-class level; the introduction of an additional classifier called "drop in level-farming".

ii) For natural and semi-natural areas (sub-group 2):

The sub-group has confirmed the classification as presented by FAO. Also, it recommended:

- 5 percent vegetation cover threshold, in the dichotomous phase, to mark the transition between a vegetated area and non-vegetated area;
- for the modular-hierarchical phase, some changes were made on the classifiers and FAO was requested to propose a final classification integrating more appropriate terminologies.

iii) Concerning terms of reference of the pilot projects (sub-group 3):

Eight sites between 3,000 to 4,000 km² will have to be selected to verify technical criteria obtained from classification; they should be distributed as follows:

- one in North Africa
- two in Sahel (continental and coastal)
- two in East Africa
- one in Central Africa
- two in Southern Africa.

It was also recommended to:

- present results as maps and reports;
- acquire remote sensing data with a resolution of 10, 20, 30 and 100 m;
- start activities end 1996 for nine months with a budget amounting to US$ 280,000 for eight sites;
- subcontract pilot projects with national agencies either from the private or from public sectors;
- request FAO assistance to harmonize work achieved in pilot projects.

iv) Classification and nomenclature (sub-group 4):

Recognize the compatibility of AFRICOVER classification with other classification systems, such as land cover of IGN France, of South Africa, of FGDC/USA and look into a possible extension of the classification system and its eventual generalization at global level.

2.4 Closure of Seminar

Mr. Niang, Managing Director of CSE, thanked the working group for their intense contribution in producing good quality results for the classification and legend. He also thanked for having selected CSE to host the meeting. He also extended his thanks to all participants and wished them a safe return to their respective countries.

Also Mr. Fofana, Chairman of the session, thanked all guests and reporters from the various groups, as well as FAO for having organized this meeting on classification and legend.

3. RECOMMENDATIONS/FUTURE PROSPECTS

3.1 Recommendations

The classification software has been widely recognized, but one should await the finalization of its current version before giving it wider distribution. For this reason, it is recommended that:

- countries represented at the seminar will endeavor to consolidate the comments on the classification;
- countries are expected to make special efforts in mobilizing funding for the implementation of the pilot project and, to that effect, applying countries will have to make a formal request in order to start the procedure. FAO will coordinate the various steps;
- FAO keeps providing the excellent quality of work carried out so far, in order to maintain the momentum needed for a successful edification of the AFRICOVER project;
- FAO will reinforce its collaboration with African organizations having the mandate for the development of cartography and mapping in Africa, such as the OACT.

The seminar emphasized that an effort should be made toward donors to finance activities such as pilot projects, meetings of future working groups, finalization of software after validation of the classification.

3.2 Plan of Action for the Future

In order to continue the post-seminar work and the AFRICOVER program, the priority actions to be carried out by the end of 1997 are listed below:

- finalization and distribution of seminar documents to all countries represented within the months following the working group meeting. These documents will also propose a new version of the African classification system, which would include the comments received from the Saly seminar as well as the technical complements made by the FAO AFRICOVER team. A particular effort will be made to propose a revised classification scheme ready for use in field projects (see part 3 of this publication);

- collection and analysis of countries' comments on the classification document;

- organization of future AFRICOVER working groups meetings;

- gathering of funds to execute pilot projects;

- execution of pilot projects during the first quarter of 1997 and their evaluation in July/August 1997;

- organization of a synthesis meeting for working groups 1, 2, 3 between August and October 1997;

- publication and dissemination of the AFRICOVER standards after validation by African countries and organizations.

ANNEX 1

REPORT OF SUB-WORKING GROUP N° 1: "CULTIVATED AND ASSOCIATED AREAS"

- The Sub-Working Group N°1 on cultivated and associated areas adopted unanimously the *dichotomous phase* which subdivides the category "cultivated and associated areas" into the following four sub-categories:

  - cultivated terrestrial;
  - cultivated aquatic (water or regular flooded environments);
  - built up and associated areas;
  - artificial water bodies.

- In the ***modular hierarchical phase***, minor changes were brought at all levels of classification parameters.

1. Cultivated terrestrial

The classifiers which have been considered are in the following hierarchical order:

- level 1: life form of main crop;
- level 2: spatial aspect;
- level 3: crop combination (3.1);
- level 4: cultural practices (3.2).

2. Cultivated aquatic

The classification proposed was partly accepted. With regard to fallow periods, it was recommended to suppress level 3 as irrelevant to the class. It was recommended the creation of a sub-class on improved farming techniques that would include "terraces" and might be completed later on.

3. Built and associated areas

Four classes were selected:

- linear built up areas;
- non-linear built up areas;
- waste dump areas;
- open mines.

The sub-classes of linear elements will be: land communication networks and infrastructures (roads and railways); telecommunication lines (telephone) and high-voltage lines (electricity).

The proposed sub-classes for non-linear elements were: for infrastructures: industries, airports, harbors and others; and for lodging: cities and villages.

4. Artificial water bodies

In this chapter, two classifiers whose thresholds must be defined were selected:

- physical state;
- persistency.

The other descriptive elements of artificial lakes necessarily require land surveys and must be considered as attributes. Their definition will be given by experts in the different fields concerned. The descriptions proposed in the present classification must be verified according to conditions prevailing in Africa.

5. General recommendations

The sub-group N°2 recognized the great amount of valuable work which had been done for the classification proposed at the seminar, but made the following observations:

- efforts should be made to introduce possible changes in the classification and the next software version should be conceived in a more flexible way to allow modifications;

- considering the limited time devoted to study the proposed classification tool during the seminar, the document should be analyzed by each country and a synthesis of the results made within the next months.

6. Specific recommendations

For the "spatial aspect" classifier, it has been requested to introduce a quantitative variable relating to the size of farms. The variable could be vary according to the environmental context.

In order to avoid redundancies, it has been recommended, for the "crop combination" classifier, to select two (2) sub-classes called "single-crop" and "multiple crop" connected to a database characterizing the "crop type" attribute.

For the "cultural practices" classifier, at irrigation methods level, it has been recommended to link a base of attributes on the different types of irrigation with the sub-class "irrigation". A third classifier called "post flooding farming" was added (cropping in areas having been flooded, but after the withdrawal of waters). Always at farming techniques level, two questions which did not meet general agreement were raised:

- can the "seasonal rotation" be considered as a "cultural period" classifier or an "annual crop" attribute?

- is "greenhouse farming" part of the "cultivation" or "built up areas" class as observed on satellite images?

ANNEX 2

REPORT OF SUB-WORKING GROUP N°2: "NATURAL AND SEMI-NATURAL AREAS"

The Sub-Working Group N° 2 focused its work on the theme "natural and semi-natural areas" and considered, first of all, a working methodology that consisted in asking Mr. Di Gregorio to present and comment the proposed classification. Various interventions followed as contributions, clarifications, suggestions or amendments were made to the presentation.

1. Structuring classification in the dichotomous and modular phases

The dichotomous phase was accepted according to the new land cover classification scheme based on the two main sections listed below:

A: Vegetated areas
B: Non-vegetated areas

On this point, the sub-group N°2 proposed and set the critical limit of vegetation cover at 5% to differentiate a vegetated area from a non-vegetated area. The modular phase did not undergo any notable changes but classification attributes or parameters were modified.

2. Classification parameters or classifiers

2.1 Terminology

The first point of discussion was the table showing the main classification structure. To replace the inappropriately terms used, the following terms, more global and structured, were proposed and selected:

- instead of the big category "forest", consider "closed tree cover";
- instead of "woodland", "open tree cover";
- instead of "thicket", "closed shrub cover";
- instead of "shrubland", "open shrub cover";
- instead of a unique great category "grassland savanna", substitute it with two classes, "closed grass cover" and "open grass cover";
- instead of "sparse vegetation", substitute it with three different categories, "sparse tree cover", "sparse shrub cover" and "sparse herbaceous cover" (steppe).

It was agreed that FAO will propose a final classification and will check the French with regard to the terminology. Concerning the discussions on classification parameters, the group proceeded according to each of the four sub-classes in the scheme dichotomous phase.

2.2 Natural vegetation/semi-natural land

2.2.1 *Classifiers*

The sub-group accepted the hierarchic parameters proposed with the following amendments:

- *percentage cover class.* The new classes selected are: [5 to 20%], [21 to 70%] and [71% and more].

- *height of trees.* Concerning shrubs, it has been proposed [0.3 to 5 m] instead of [1 to 5 m]. This class will include 3 sub-classes, that is [0.3 to 1 m]; [1 to 3 m] and [3 to 5 m]. With regard to creeping plants, it was proposed to class them among the Euphoria.

2.2.2 *Environmental parameters*

- *the lithology* has raised a problem of terminology. In that sense, "ignited rocks" could be replaced by "magmatic rocks";

- *the altitude.* It has been agreed to maintain the proposed altitude classes, but to divide [0 to 300 m] into three sub-classes: [0 to 50 m], [50 to 100 m] and [100 to 300 m]. In any case, the total should not exceed ten classes;

- *the relief.* "landform and slopes" must be replaced by "landform". For slopes measurement, next to percentages, it would be useful to indicate equivalences in degree;

- *degradation.* Finally, it would be convenient to add "level of erosion of vegetated areas" in the natural vegetation classification parameters.

2.3 Natural and semi-natural vegetation in aquatic or regularly flooded lands

Content, names and hierarchy of all classifiers have been accepted.

2.4 Bare soils classification

It has been agreed that:

- the "Macropattern" class should be enriched (ant-hill...);
- in erosion classes, insert a "coastal erosion" class.

2.5 Inland waters

There were no disagreements. Two points were considered by the sub-group:

- include a *"flood fluctuation area"* class in "permanent stagnant waters";
- in "water quality", *"brine"* could be replaced by *"hyper salinity"*.

2.6 Other considerations

i) After long discussions, forestry plantations have been defined as follows:

"Are considered as forestry plantations, any area systematically planted and whose forest resources are managed by man. Forest resources are mainly made up of exotic species. This category includes both young plantations and old plantations which have been planted for the purpose of producing building wood, seeds, windbreak, etc. Any plantation not meant for forestry, such as sisal plantations, orchards and other gardens of fruit trees such as lemon trees, hazel trees, etc. ... are excluded".

Taking into consideration the presence of man and, consequently, of human activity, the sub-group proposed and adopted the integration of forestry plantations in "cultivated areas" as a new classifier. The "forestry plantations" class will include two sub-classes: one open sub-class and one closed sub-class. The two sub-classes should be defined in the classification according to numbers of trees per hectare.

ii) Concerning the proposed classification system, the great flexibility of the system, as far as the number of intervals and class threshold are concerned, was pointed out. In general, the system allows the addition of sub-classes from main classes. Thresholds and intervals of sub-classes were discussed during the seminar.

iii) AFRICOVER is a land cover mapping project and does not concern seas and oceans. On the other hand, delta's, islands and others will be studied case-by-case with a particular emphasis on interface areas, and coastlines.

iv) All classification systems used, like the UNESCO and Yangambi systems, must be explicitly cited in this document. The ways classification charts and parameters are presented could seem complex to read for users. If possible, they should be improved and made more readable and accessible.

ANNEX 3

REPORT OF SUB-WORKING GROUP N°3: "TERMS OF REFERENCE OF THE PILOT PROJECTS"

The sub-group's mandate is to define the content and phasing of pilot projects.

1. Objectives

The purpose of pilot projects is to test the applicability of the AFRICOVER land cover classification system on an operational basis in main African sub-regions.

Thus, eight sites distributed as follows were selected;

- one in North Africa
- two in Sahel (continental and coastal)
- two in East Africa
- one in Central Africa
- two in Southern Africa

Each site will have a size ranging from 3,000 to 4,000 km² and will be studied at 1:250,000 and/or 1:200,000 scales for a sub-area of about 500 km² at a more detailed scale such as 1:50,000 and 1:100,000.

2. Expected results

2.1 Reports and Maps

The project should validate AFRICOVER products specifications by establishing a geo-referenced database showing land cover classes in compliance with classification systems and including both digital and analog data.

2.2 Discussions Over Land Cover Classification and Legend

The technical report should include:

- a detailed and comprehensive description of the methodology used;
- a precise evaluation of mapped classes;
- an analysis of problems encountered and, if necessary, suggestions on changes in the classification system;
- a detailed description of the legend and the nomenclature proposed, while stressing the possibilities for the users of the classification system to develop the legend in a user friendly way. A synthesis will be made on the quantitative thresholds of the different classifiers that vary according to the place;
- a comment on the efficiency or adaptability of attributes to the classification scheme proposed;
- a preliminary proposal on the selection of the attributes and the thresholds.

Results and database will be implemented and presented in conformity with the recommendations of the international AFRICOVER sub-working group N°3 on technical methods and quality control.

2.3 Use of Data

Remote sensing data that will be used and compared will have a 10, 20, 30 and 100 m spatial resolution. These will concern mainly:

- Landsat TM
- Spot PA & XS
- Radar (if necessary) (ERS, Radarsat)
- NOAA IGBP for multi-seasonal analyses
- Russian space photography
- Resurs-01

Other ancillary data like maps, reports, aerial photography, etc. will also be used.

2.4 Data Acquisition

Imagery should be acquired by the AFRICOVER project but operators should be involved in the order of the imagery.

2.5 Work Plan

Activities	Duration
Data acquisition	2-3 months
Pre-processing 1 month	
Preliminary interpretation	0.5 month
Collection of field data	1 month
Final interpretation	1 month
Evaluation	0.5 month
Preparation of final products and reporting	2 months
TOTAL	**8-9 months**

2.6 Budget Proposed (per site)

Activities	(US$)
Data acquisition	10,000
Ancillary data	1,000
Personnel 10 h/m professional 10 h/m technical	10,000
International consultant	10,000
Field data collection	2,000
Expenses for mapping and printing	2,000
TOTAL BY SITE	**35,000**
TOTAL FOR THE EIGHT SITES	**280,000**

2.7 Operators/Project Managers

- Pilot projects will be sub-contracted to national agencies belonging to the public and private sector. A letter of agreement will be signed between FAO and the agencies and, in certain cases, the agreement could be signed between FAO and a regional Center.

- Assistance will also be provided by FAO to ensure the harmonization of the implementation of the pilot projects and to provide technical assistance, if necessary.

International consultation will be provided according to individual agencies needs. In order to facilitate this support, there will be discussions with each agency at the beginning of the pilot project. A consultant will also be contracted to analyze, evaluate and synthesize the reports prepared on each pilot study.

ANNEX 4

REPORT OF SUB-WORKING GROUP N°4: "NOMENCLATURE AND CLASSIFICATION"

This sub-group's objective was to test the feasibility of the proposed classification from the analysis of existing legends or nomenclatures used in some of the countries represented at the seminar, such as the nomenclature of:

- Mozambique
- South Africa
- Senegal.

Mr. Braunstein, representative of IGN France, gave a presentation on his Organization's experience and on the methods used in the field of land cover mapping based on visual interpretation of satellite images. He briefly presented a nomenclature based on the Corinne Land Cover methodology and which will probably be used in a recently approved land cover project in Mozambique. He stated that the classification proposed by AFRICOVER was perfectly compatible with the nomenclature of Mozambique and suggested the possibility for the AFRICOVER project to study an AFRICOVER label of this nomenclature.

Mr. Mark Thompson, in charge of the land cover mapping of South Africa, also confirmed that the classification proposed by AFRICOVER was perfectly compatible with the legend developed in South Africa. Furthermore, he recognized the very positive technical and scientific value represented by this classification in the translation and comparison with different legends and classification systems developed in African countries. The capacity of the AFRICOVER project to describe the different classes of legends according to a series of classifiers perfectly defined, simple, independent and hierarchical, represents a scientific and technical breakthrough. According to Mr. Thompson, the AFRICOVER classification should be adopted by African countries, including South Africa.

Mr. Gyde Lund, US representative, was pleased about the proposed AFRICOVER classification and agreed that it harmonizes and incorporates current FGDC normalization works. He proposed the global generalization of the AFRICOVER classification.

ANNEX 5

COMPOSITION AND TERMS OF REFERENCE OF THE SUB-WORKING GROUPS

Composition of Sub-Working Group N°1: Cultivated and Associated Areas

Mamadou Diouf	Niger	Chairman
Dramane Touré	Côte d'Ivoire	Rapporteur
Mohamed Talbi	Tunisia	Member
Kadialiou Touré	Senegal	Member
Assize Touré Senegal		Member
Amadou Diop	Senegal	Member
Louisa Jansen	Rome	Member
Dominique Lantieri	Rome	Member
John Latham	Rome	Member

Composition of Sub-Working Group N°2: Natural and Semi-Natural Areas

El Hadji Salif Diop	Senegal	Chairman
Djoda Mabi	Cameroon	Rapporteur
Degelo Sendebo	Ethiopia	Member
Vincent Ngarambe	Rwanda	Member
Assane Goudiaby	Senegal	Member
Samba Ndao	Senegal	Member
Antonio Di Gregorio	Rome	Member
Sylvain Braunstein	France	Member
Gyde Lund	USA	Member
Mark Thompson	South Africa	Member

Composition of Sub-Working Group N°3: Terms of Reference of the Pilot Projects

Peter Gondo	Zimbabwe	Chairman
Japhet Matiko Weremo	Tanzania	Member
Mohamed Benchekroun	Morocco	Member
Mamadou Siné Camara	Burkina Faso	Member
Dominique Lantieri	Rome	Member

Composition of Sub-Working Group N°4: Nomenclature and Classification

Youssou Ndong	Senegal	Chairman
Sylvain Braunstein	France	Member
Antonio Di Gregorio	Rome	Member
Gyde Lund	USA	Member
Mark Thompson	South Africa	Member

TERMS OF REFERENCE OF SUB-WORKING GROUPS N° 1 AND 2

The first two sub-groups created were Sub-Group N°1: "Cultivated and Associated Areas" and Sub-Group N°2: "Natural and Semi-Natural Areas". Their main points of discussion were:

1. the design classification according to two main phases:
   - dichotomous phase
   - modular-hierarchical phase
2. the selection of classifiers
3. the threshold used for the classes
4. the hierarchical arrangement of classifiers
5. the selection of attributes and thresholds
6. the grouping of the categories of the legend
7. the forest plantations

ANNEX 6

AGENDA OF THE SEMINAR

Monday, 29 July

Morning:

09:00 hrs	Opening of the Seminar Welcome address by CSE - Presentation of objectives - Presentation of the agenda and implementation of the bureau
09:30 hrs	Presentation of the project AFRICOVER and of the working groups
10:00 hrs	Coffee Break
10:30 hrs	Presentation of the preliminary technical report - historical background and context - basic definitions - general criteria for a standard land cover classification - review of existing systems - conceptual basis of the adopted standard land cover classification systems - presentation of the land cover classification organization (dichotomous and modular- hierarchical phases): general presentation of the software
13:00 hrs	Lunch Break

Afternoon

15:00 hrs	Presentation of various experiences (countries and programs)
16:30 hrs	Coffee Break
17:00 hours	General discussion
18:00 hrs	Sub-working groups: composition and terms of reference - Sub-Group N°1: Cultivated and Associated Areas Sub-Group N°2: Natural and Semi-Natural Areas
18:30 hrs	End of Session

Tuesday, 30 July

Morning:

09:00 hrs	Sub-working groups (1, 2) - discussions
10:30 hrs	Coffee Break
11:00 hrs	Sub-working groups (1, 2) - discussions
13:00 hrs	Lunch Break

Afternoon

15:00 hrs	Sub-working groups (1, 2) - discussions
16:30 hrs	Coffee Break
17:00 hrs	Sub-working groups (1, 2) - discussions
18:00 hrs	End of Session

Wednesday, 31 July

Morning

09:00 hrs	- Sub-Working Group N°1: Cultivated and Associated Areas - Sub-Working Group N°2: Natural and Semi-Natural Areas - Sub-Working Group N°3: Terms of Reference of the Pilot Projects - Sub-Working Group N°4: Nomenclature and Classification
10:30 hrs	Coffee Break
11:00 hrs	Presentation of the results and discussion
13:00 hrs	Lunch Break

Afternoon

15:00 hrs	Conclusions and recommendations of the Seminar
17:00 hrs	Closure of the Seminar

ANNEX 7

LIST OF PARTICIPANTS

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ANNEX 8

WELCOMING ADDRESS BY THE DIRECTOR-GENERAL OF CSE

Lady and gentlemen,
Dear colleagues,

Our meeting will not have a protocol ceremony. This decision has been deliberately taken in order to give our work a prevailing technical character and to the necessity of reaching quickly the essential points. The most important is to make further progress in the objective , initiated nearly two years ago, of setting up the AFRICOVER program which should be, after completion, a powerful African integration vector. In fact, it is aimed at establishing a geo-referenced digital database of the land cover at different scales and preparing a digital database for all the countries of the continent.

However, you will allow me to express my feeling of gratitude, in the name of the Ecological Monitoring Center, to all members of the working groups and to the responsible officers of FAO for the confidence that you have given us in organizing this session.

I am expressing the satisfaction of our authorities who have seen in this choice an honorary mark for the country and for the whole population of Senegal. These authorities are conscious of the importance of our work and have well understood our closed sessions and have asked me to wish you a warm welcome in Senegal.

As far as we are concerned, our sincere hope is that you feel at home and that all our objectives are reached.

I wish the meeting full success and thank you for your attention.

PART III

AFRICOVER LAND COVER CLASSIFICATION SCHEME

Version finalized after incorporation of the recommendations
of the Saly Meeting

29-31 July 1996

EXAMPLES OF CULTIVATED TERRESTRIAL

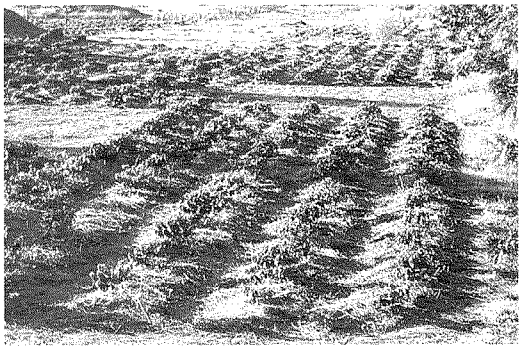


Fig. 1: Young Coffee Plantation, Malawi
Monoculture of continuous large to medium sized field(s) of shrub crops (beverage: coffee)
A2B15C1-S0802

Fig. 2: Hedgerow intercropping of maize & Leucaena leucocephala, Ghana
Rainfed graminoid crops (one additional non-graminoid with simultaneous period).
1st crop: cereals-maize (Zea mays L.)
2nd crop: other - Leucaena leucocephala
A4B1B5C2D1-C3C8C17

Fig. 3: Potato field in state factory, Cape Verde
Surface irrigated non-graminoid crops
Crops: roots & tubers - potatoes
(Solarum tuberosum L.)
A6-S0999

Fig. 4: Rubber (Fontumnia sp.) plantation, Uganda
Forest plantation (industrial crops - other industrial crops, rubber) (Fortumnia spp.)
A6-S0999

EXAMPLES OF NATURAL/SEMI-NATURAL TERRESTRIAL VEGETATION

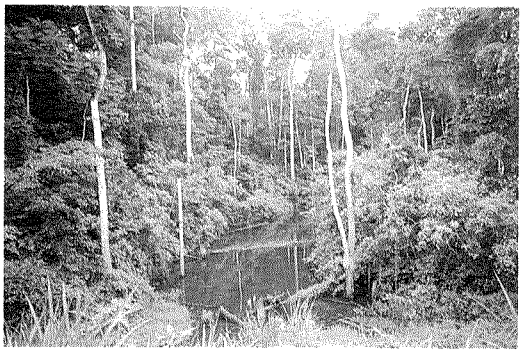


Fig. 5: Rainforest in West Uganda
Multi-layered broad-leaved evergreen high forest (with second layer of low trees)
Climate: Megathermal - tropical wet
A3A10B2C1D1E1F2F5F7G2-B5F8G7

Fig. 6: Acacia spp. Shrubland, Senegal
Broad-leaved deciduous shrubland with open herbaceous
Floristic dominant species: Acacia spp.
A4A11B3C1D1E2F2F4F7G4-F9

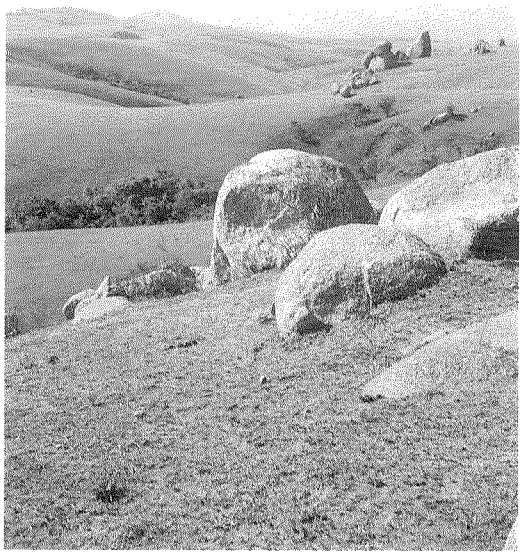


Fig.: 7: Communal grazing area in Highveld, Swaziland
Continuous closed short grassland. Landform sloping to moderately steep undulating to rolling terrain.
Altitude: 1,000 - 1,500 m
A6A10B4C1-B13

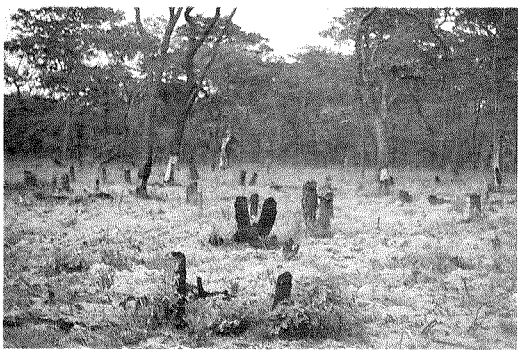


Fig. 8: Area where slash and burn technique have been used, in background original forest, Zambia
Fragmented woodland with open herbaceous layer/continuous closed forest.
A3A11B2C2XXF2F4F7G4-B6F9/A3A10B2C1

EXAMPLES OF NON-VEGETATED AREAS

Fig. 9: Town in Eritrea
Urban area(s). Topographic name: town in Eritrea. A4-A13

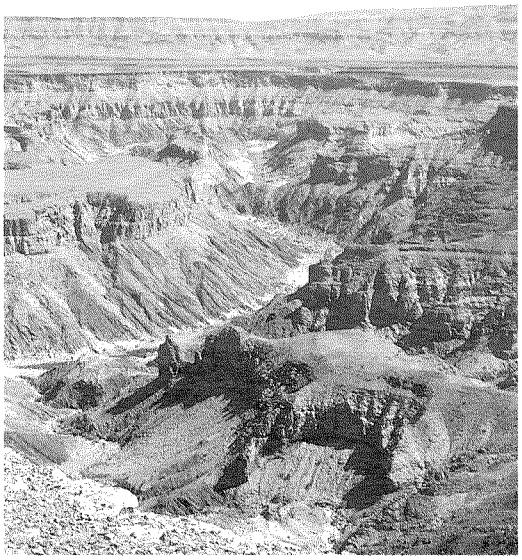


Fig. 10: Fish River Canyon, southern Namibia
Bare rock(s). Land form: extremely steep terrain; steeply dissected hilly and mountainous terrain. Climate: xerotermal. A3-A7

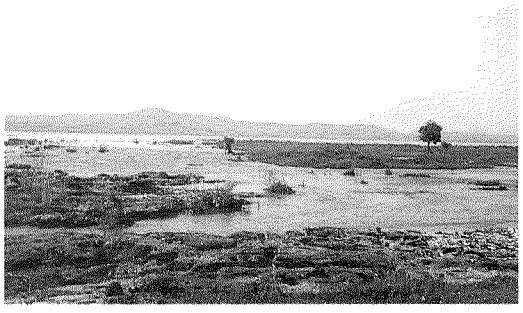
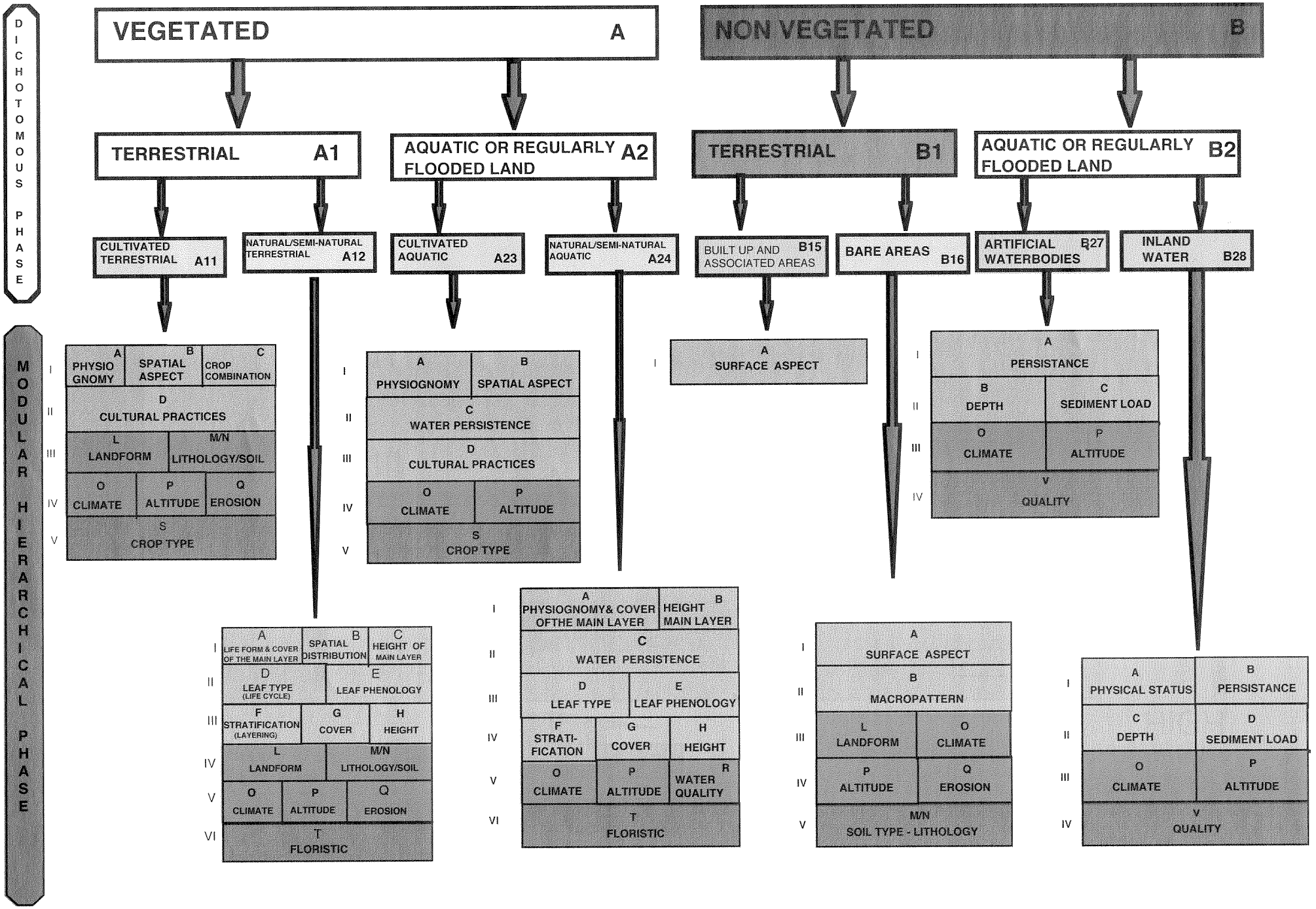
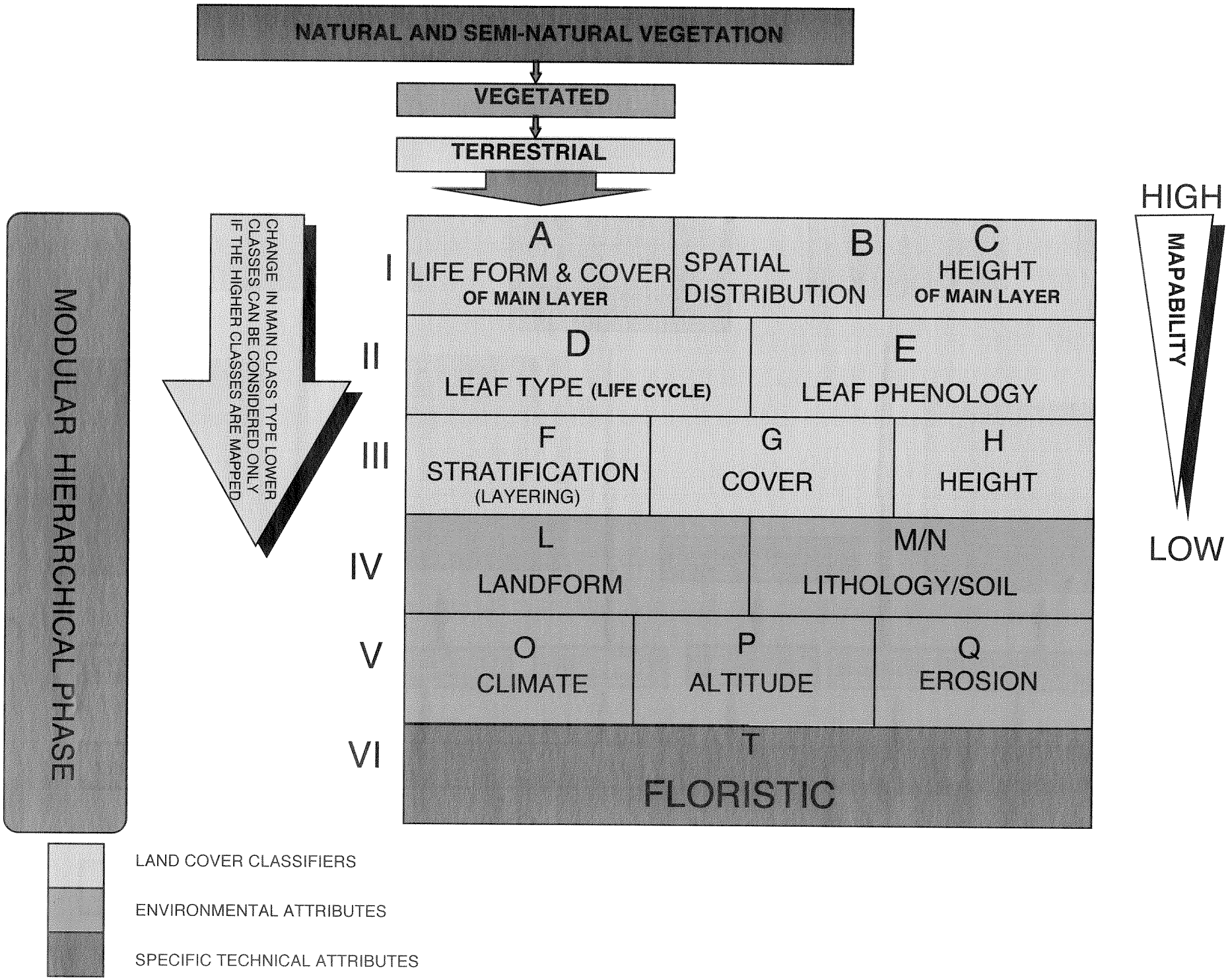
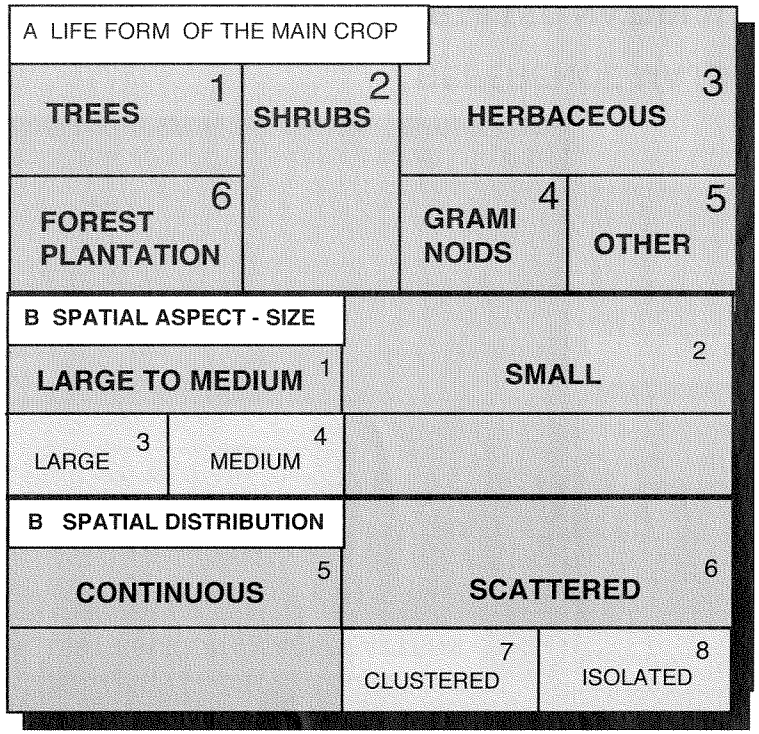


Fig. 11: Niger river near Bamako, Mali
Perennial inland water. Topographic name: Niger river. A1-B1

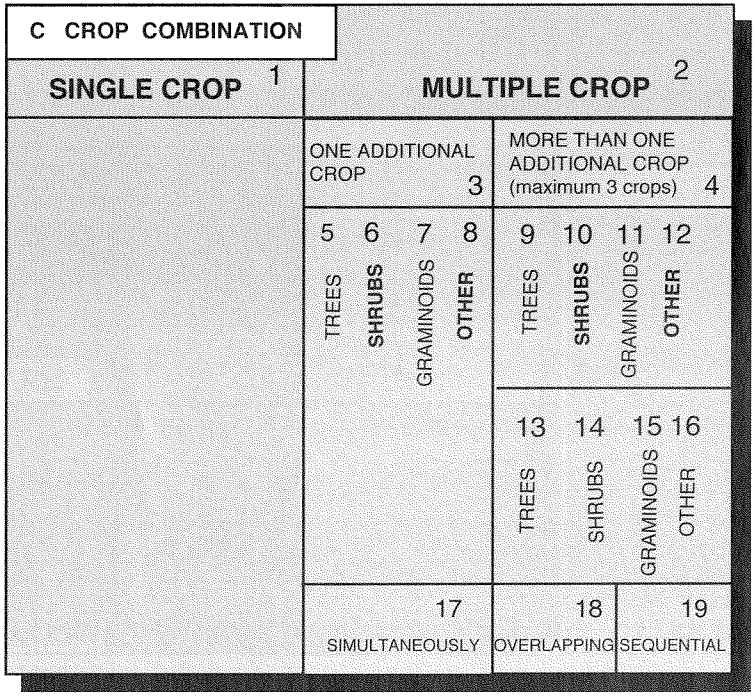
LAND COVER CLASSIFICATION SCHEME




NATURAL AND SEMI-NATURAL VEGETATION
VEGETATED
TERRESTRIAL
MODULAR HIERARCHICAL PHASE
CHANGE IN MAIN CLASS TYPE LOWER CLASSES CAN BE CONSIDERED ONLY IF THE HIGHER CLASSES ARE MAPPED
I
II
III
IV
V
VI
A
LIFE FORM & COVER
OF MAIN LAYER
B
SPATIAL DISTRIBUTION
C
HEIGHT
OF MAIN LAYER
D
LEAF TYPE (LIFE CYCLE)
E
LEAF PHENOLOGY
F
STRATIFICATION
(LAYERING)
G
COVER
H
HEIGHT
L
LANDFORM
M/N
LITHOLOGY/SOIL
O
CLIMATE
P
ALTITUDE
Q
EROSION
T
FLORISTIC
HIGH
MAPABILITY
LOW
LAND COVER CLASSIFIERS
ENVIRONMENTAL ATTRIBUTES
SPECIFIC TECHNICAL ATTRIBUTES

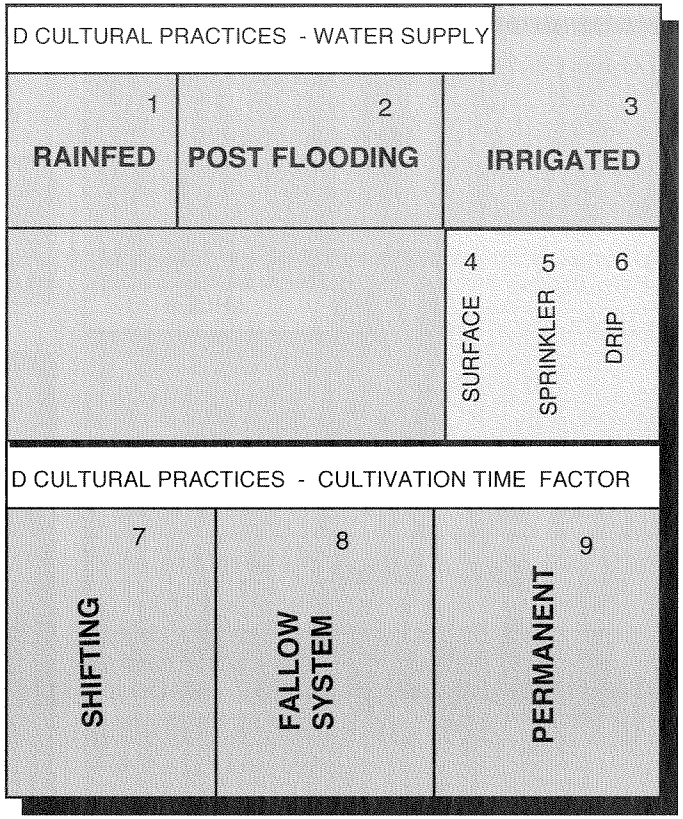


LEVEL I

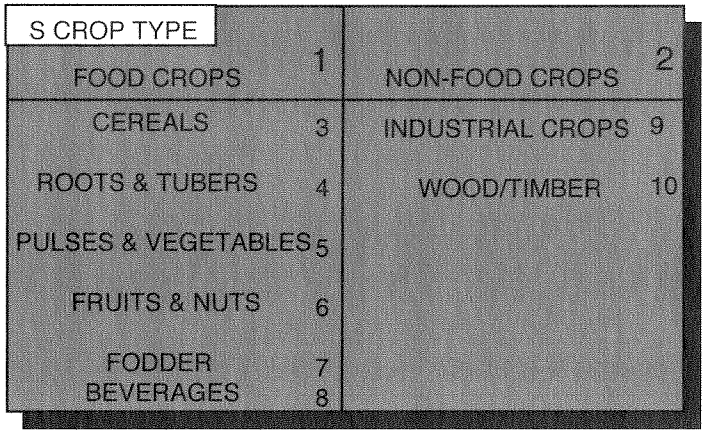


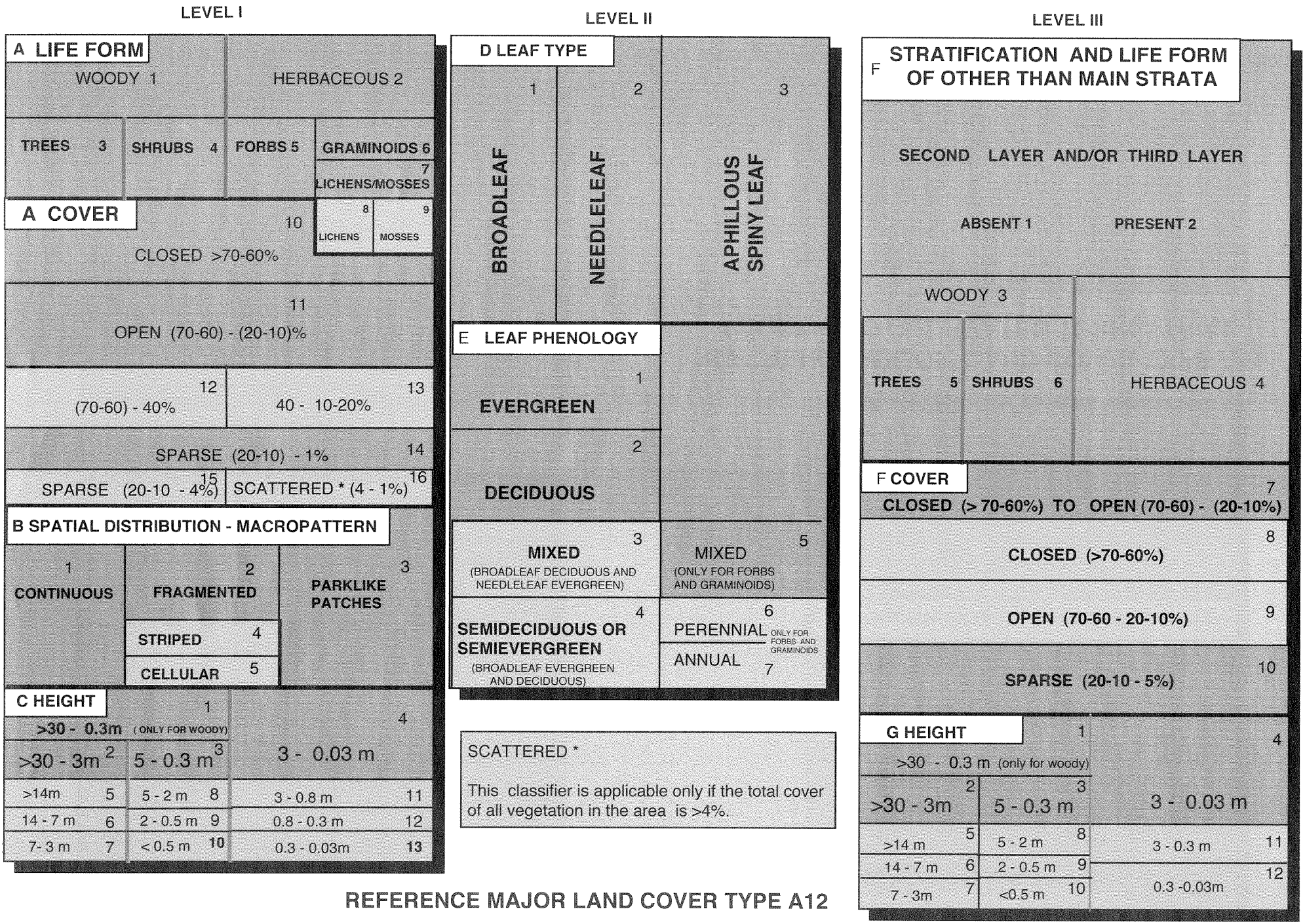
LEVEL II

LEVEL III



REFERENCE MAJOR LAND COVER TYPE A11 VEGETATED CULTIVATED TERRESTRIAL

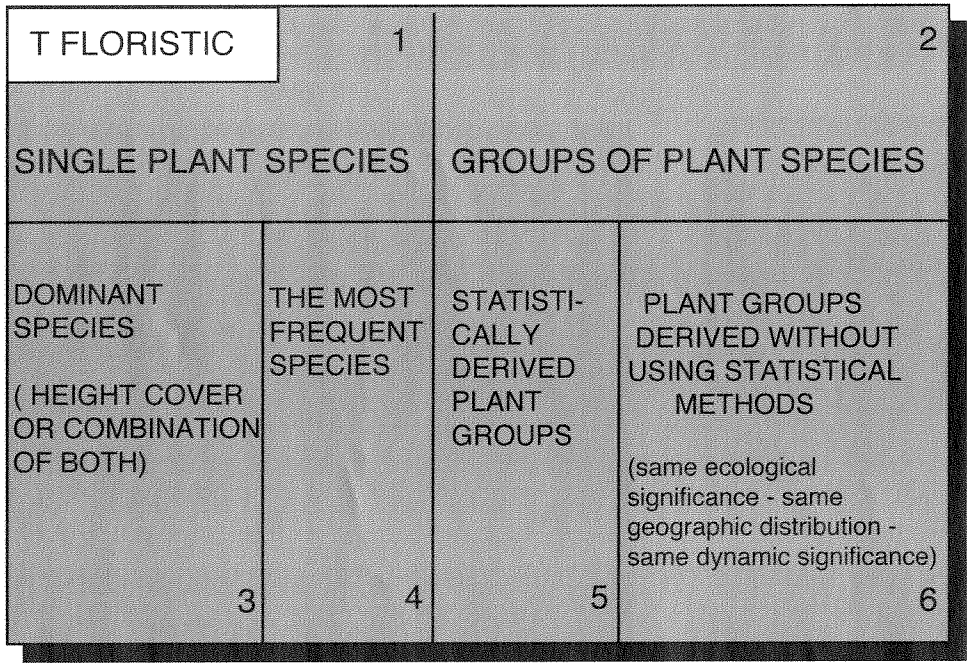




REFERENCE MAJOR LAND COVER TYPE A12

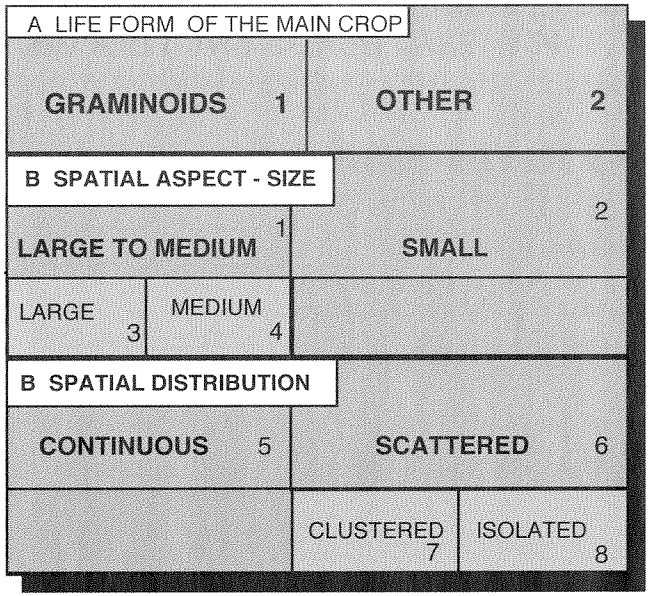
VEGETATED NATURAL/SEMI-NATURAL TERRESTRIAL

LEVEL VI



REFERENCE MAJOR LAND COVER TYPE A12
VEGETATED NATURAL/SEMI-NATURAL TERRESTRIAL

LEVEL I



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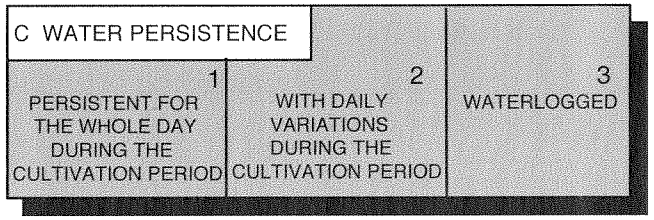
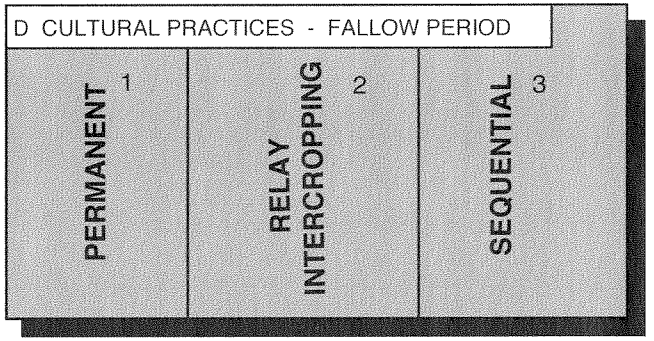
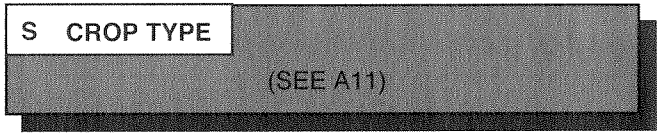


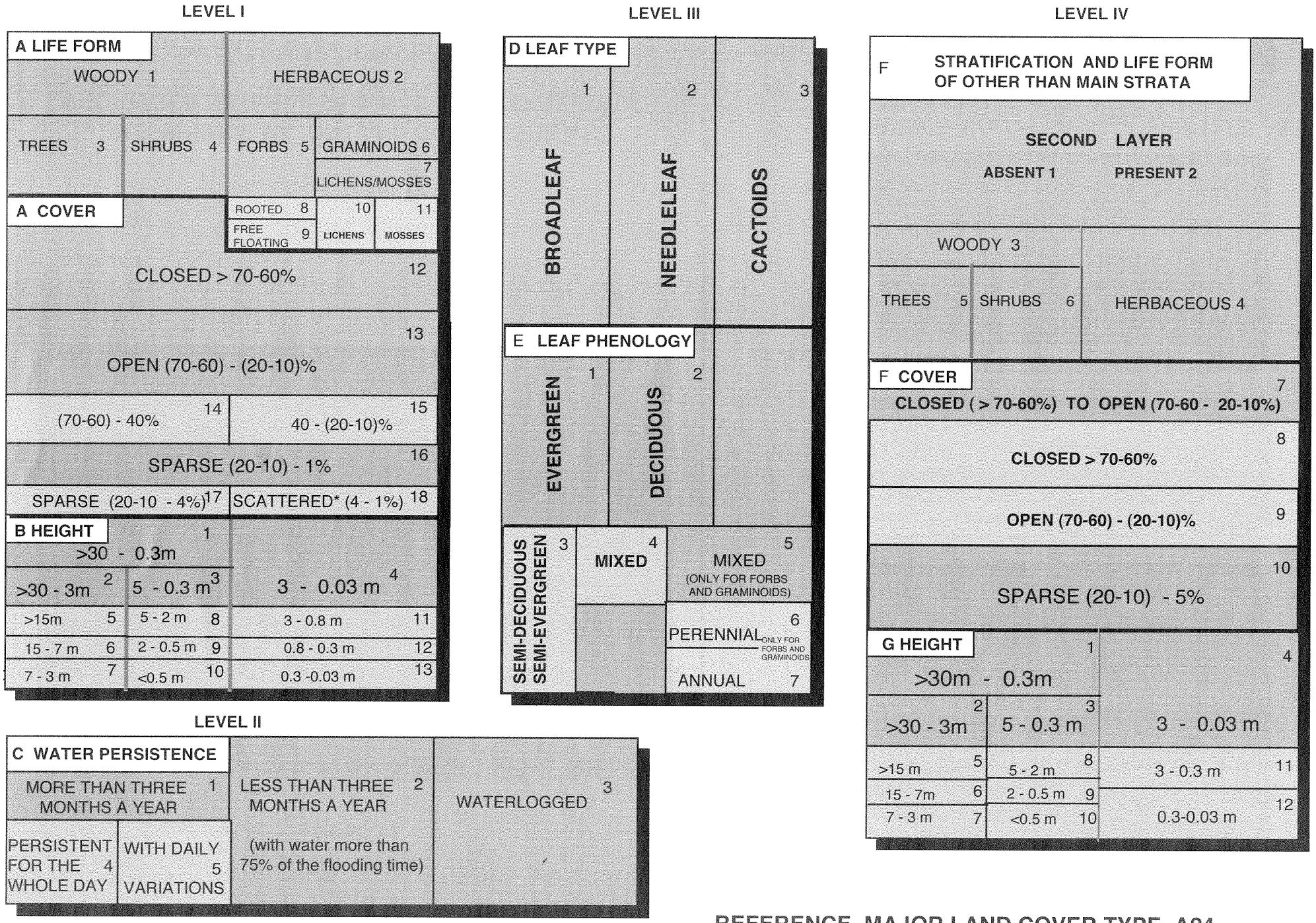
LEVEL III



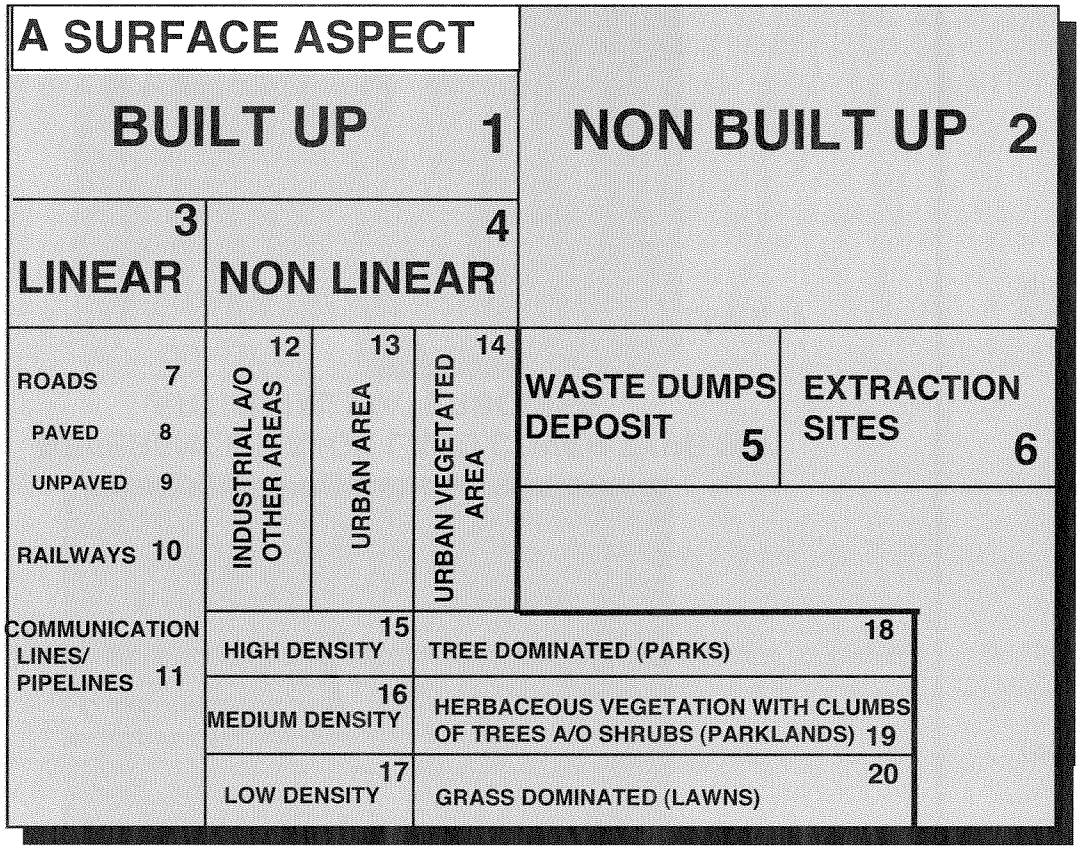
REFERENCE MAJOR LAND COVER TYPE A23
VEGETATED CULTIVATED AQUATIC

LEVEL V





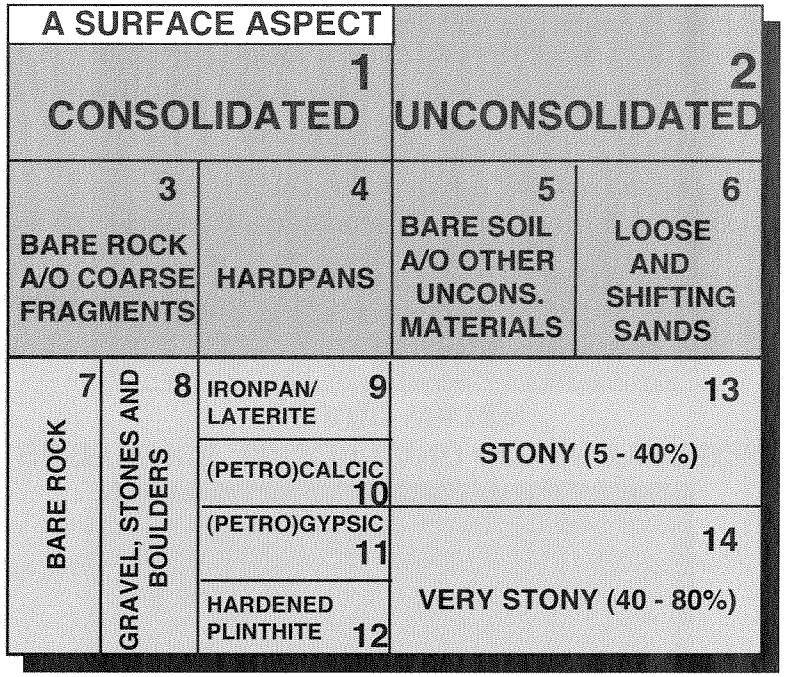
REFERENCE MAJOR LAND COVER TYPE A24
VEGETATED NATURAL/SEMI-NATURAL AQUATIC OR REGULARLY FLOODED



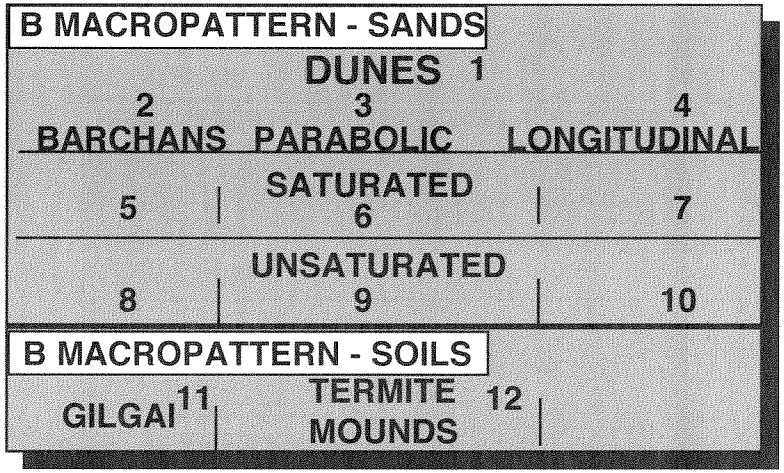
LEVEL I

REFERENCE MAJOR LAND COVER TYPE B15
BUILT UP AND ASSOCIATED AREAS

LEVEL I



LEVEL II



REFERENCE MAJOR LAND COVER TYPE B16
BARE AREAS

LEVEL I

A PERSISTANCE		
PERENNIAL (>9 MONTHS) 1		
NON-PERENNIAL (<9 MONTHS) 2		
3 BARE ROCK	4 BARE SOIL	5 SAND

LEVEL II

B DEPTH	
1 DEEP TO MEDIUM	2 SHALLOW
C SEDIMENT LOAD	
1 ALMOST NO SEDIMENT	2 SEDIMENT

REFERENCE MAJOR LAND COVER TYPE B27
ARTIFICIAL WATERBODIES

LEVEL IV

W QUALITY	
FRESH <1,000 ppm of TDS (TOTAL DISSOLVED SOLIDS)	1
SLIGHTLY SALINE	2
MODERATELY SALINE	3
VERY SALINE	4
BRINE	5

LEVEL I

A PHYSICAL STATUS		
1 WATER	2 SNOW	3 ICE
B PERSISTANCE		1
PERENNIAL (> 9 MONTHS)		
NON-PERENNIAL (< 9 MONTHS)		2
TIDAL AREA		3
4 BARE ROCK	5 BARE SOIL	6 SAND

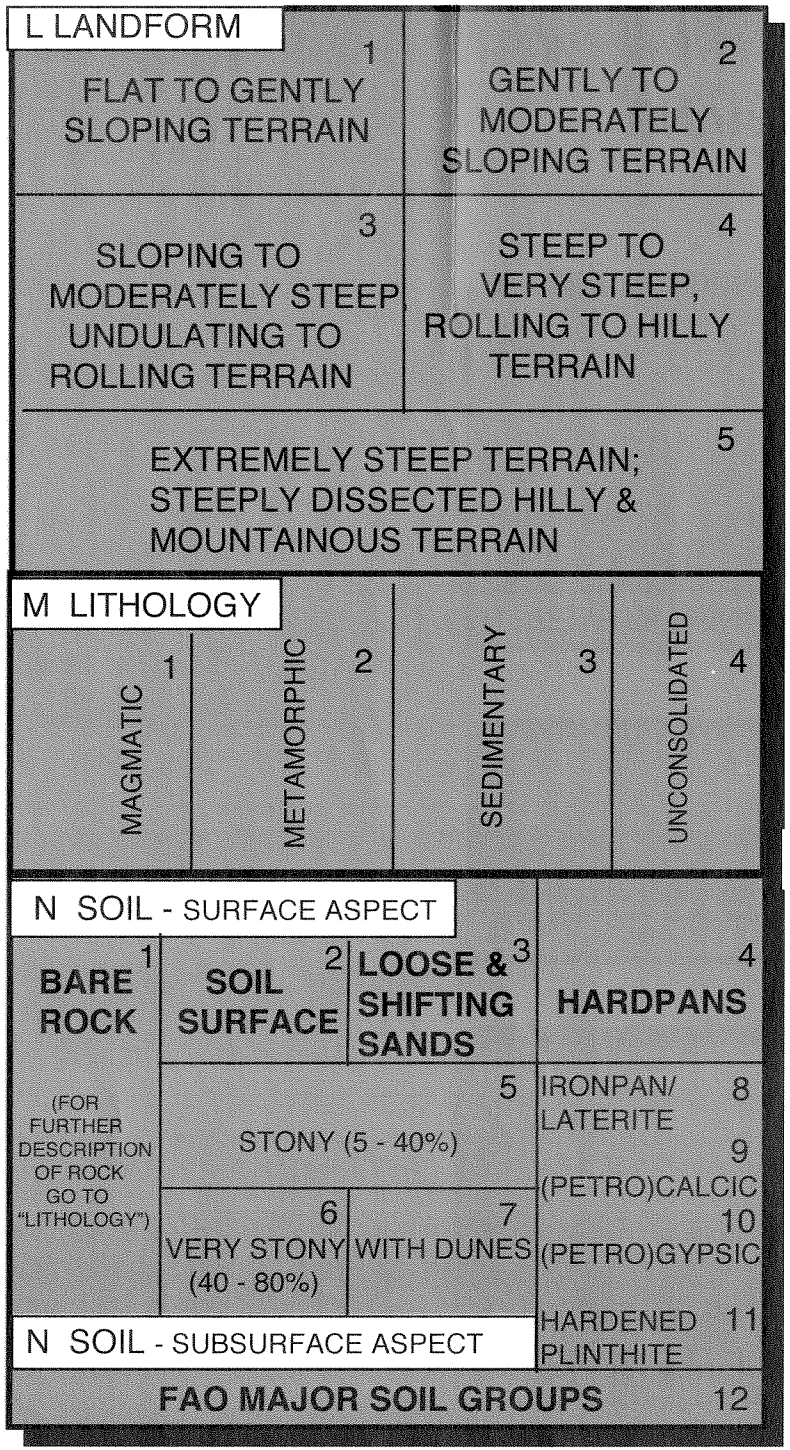
LEVEL II (only for water)

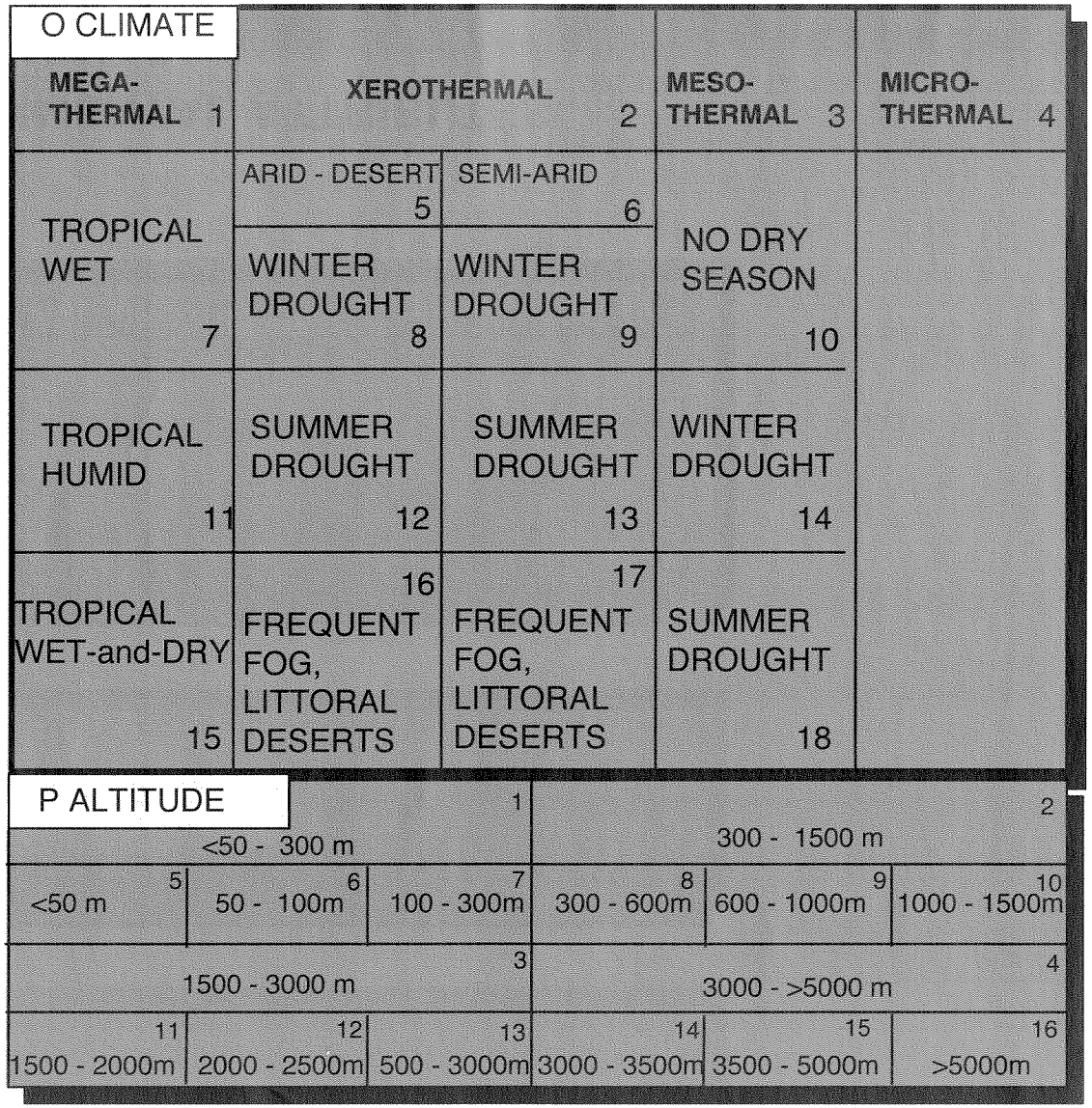
C DEPTH	
1 DEEP TO MEDIUM	2 SHALLOW
D SEDIMENT LOAD	
1 ALMOST NO SEDIMENT	2 SEDIMENT

REFERENCE MAJOR LAND COVER TYPE B28
INLAND WATER

LEVEL IV (only for water)

W QUALITY	
FRESH <1,000 ppm of TDS (TOTAL DISSOLVED SOLIDS)	1
SLIGHTLY SALINE	2
MODERATELY SALINE	3
VERY SALINE	4
BRINE	5





ENVIRONMENTAL ATTRIBUTES

Q EROSION			
NO VISIBLE EROSION 1	VISIBLE EVIDENCE OF EROSION 2		
	WATER 3	WIND 4	MASS MOVEMENT 5
	SHEET 6 RILL 7 GULLY 8		

R WATER QUALITY		
FRESH 1	BRACKISH 2	SALINE 3

U VEGETATION				
SCATTERED VEGETATION PRESENT 1				
WOODY 2	HERBACEOUS 3		LICHENS/MOSSES 4	
	FORBS 5	GRAMINOIDS 6	LICHENS 7	MOSSES 8

ENVIRONMENTAL ATTRIBUTES