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On the Ecological Vegetation Maps of the Niger Delta

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Introduction

When maps show the geographical distribution of vegetation types in relation to one or more features or attributes of the environment, such maps are known as ecological vegetation maps (Kuchler 1984). The maps rely upon availability of data, regularly updated and stored for easy retrieval. Produced for specific ecosystems, ecological vegetation maps are a useful tool in environmental management which must be consulted, if available, in the processes of environmental auditing, environmental evaluation report and writing of environmental impact statement. Particularly, the maps are useful in bio-diversity conservation aimed at guaranteeing ecologically sustainable policies (Folke *et al* 1993).

Once an ecological vegetation map is produced, its future use as a reference source depends on an efficient information storage, retrieval and distribution system. Such a system would allow the on-site environmental management practitioner to manipulate vast amounts of spatially oriented data to check on the "losses" so far made with respect to the conservation of the particular environment. The Geographic Information System (GIS) meets these requirements. GIS is an information system that allows man to manipulate spatially oriented data e.g. environmental information with a view to determining the most efficient and effective areas to implement management decisions, conservation procedures or to place functions such as water storage, game reserves aqua-culture ponds and forest reserves etc.

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Vegetation

Two items are important in the distribution of swamp communities: (a) tolerance and (b) competition. The ability of plants to tolerate all features of the environment is refereed to as tolerance. Tolerance ranges from a minimum to maximum for each feature. For all features the ranges of tolerance are not the same. The ranges may be wide for one feature and narrow for another feature. Tolerance may also vary according to the seasons. Although tolerance relates to all features of the environment, it takes only one such feature beyond the range of tolerance to limit the spread of a given species or genera (Kuchler, 1967).

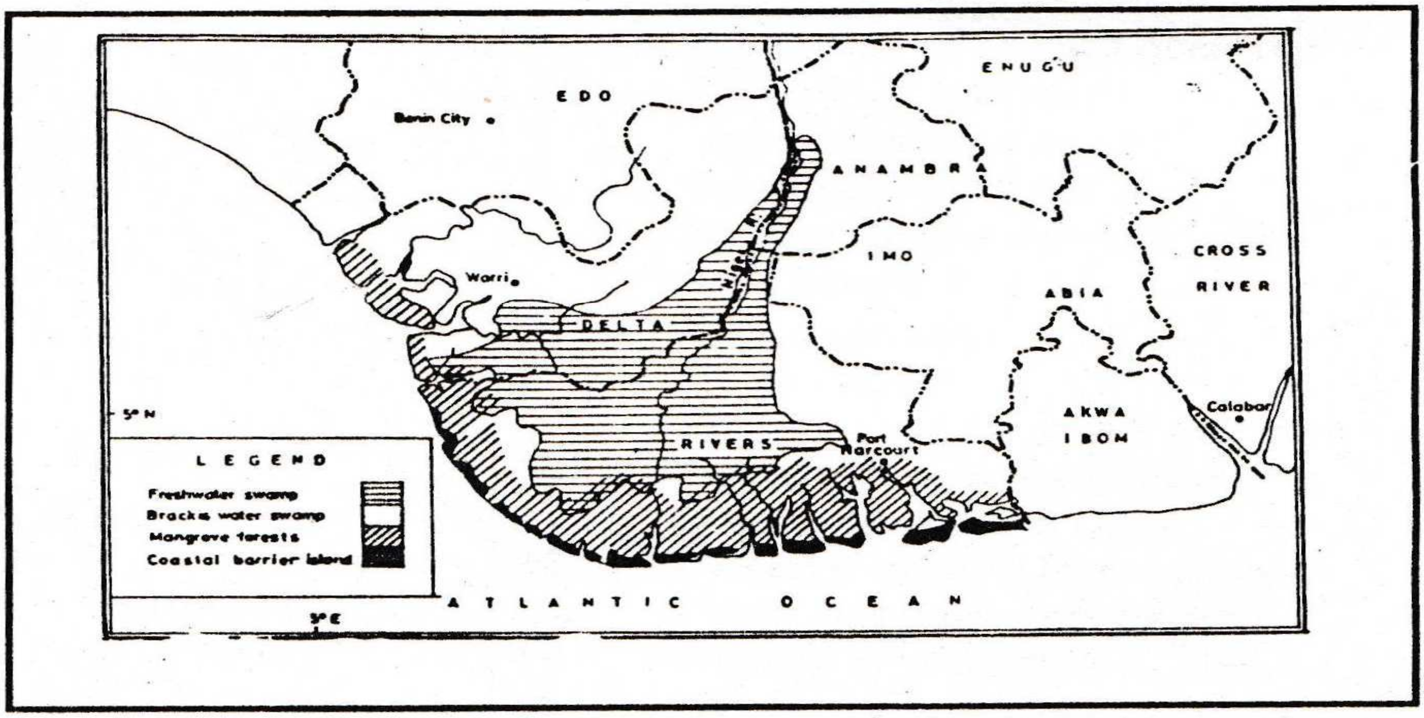

Fig. 1: The ecological zones of the Niger Delta

The ranges of tolerance are reduced by competition. The ecological behaviour of one species is affected by the other species with which it must compete. Therefore species can only grow where tolerance and competition permit. Consequently, species which grow together within the same tolerance and competition limits form plant communities.

The plant community e.g. the mangrove community or the freshwater swamp community is an aggregation of plants that can tolerate all conditions of the site on which they occur. Such plants can successfully compete with one another. A combination of the members of the plant community is a reflection of the character of the environment on which they occur.

The species attributes that may be used to analyse tolerance and competition within the communities are listed in table 1. The attributes of the vegetation or plant communities should be monitored over time and the variation compared for updating an existing ecological base map. Such analyses of vegetation change resulting from tolerance and competition are better made in permanent sample plots (Swaine and Greig - Smith, 1980), or in forest reserves (Ubom, 1993). Air photographs are essential for demarcating species and community boundaries in a general sense

Table 1: Plant Species Attributes

1.	Frequency of species occurrence.
2.	Number of species per stand.
3.	Index of stand similarly.
4.	Index of stand diversity.
5.	Species density per unit area
6.	Tree height.
7.	Tree basal area.
8.	Crown cover.
9.	Density of saplings per unit area
10.	Density of pneumatophores.
11.	Basal area of dead tress.
12.	Cover of ground layer species.
13.	Cover of under storey species.
14.	Density of ground layer stems.
15.	Density of under storey stems

Environment

Everything that affects a plant community is included in the term environment (Mason and Langenhem 1957). Therefore the environment is very complex. However most ecologists limit their consideration of the environment to climate and soil. Table 2 is a typical environmental diagram for mangrove freshwater ecosystem. Although an environmental list can be quite comprehensive, the main issue is how the plant community can be related to the variables.

The environmental conditions are more meaningful if they are compared with conditions existing in another place such that the performance of both vegetation communities can also be compared.

The environmental values must also be obtained under standard conditions (although such conditions cannot be defined for the communities for which the measurements are made). As more information becomes available, the environment also becomes more complex.

Table 2: Environmental Diagram for Mangrove Ecosystem

1.	Mean monthly temperature for every month.
2.	Mean annual temperature.
3.	Mean daily temperature of the coldest month.
4.	Absolute temperature minimum.
5.	Mean daily maximum temperature of warmest month.
6.	Absolute temperature maximum.
7.	Mean daily temperature variations.
8.	Mean monthly rainfall for every month.
9.	Mean annual rainfall.
10.	Relative humid season.
11.	Swamp elevation above sea level.
12.	Swamp accretion rates.
13.	Channel sedimentation rates
14.	Particle-size composition of mud.
15.	Moisture content of mud.
16.	Bulk density of mud/soil
17.	Moisture at saturation of soil.
18.	Water holding capacity.
19.	Mean monthly salinity values (soil and soil water).
20.	Mean monthly salinity values (soil and soil water)
21.	Mean daily salinity values (soil and soil water)
22.	Concentration of exchangeable bases (Ca, Mg, Na, K, in soil and soil water)
23.	Phosphorus, nitrogen, iron, manganese, copper, zinc, sulphate, aluminium in soil and soil water.
24.	pH levels
25.	Organic content of soils.
26.	Frequency of tides.
27.	Height of lowest annual tides.
28.	Height of highest annual tides.
29.	Mean tide level.
30.	Water table height at low tides.
31.	Height of forest floor above mean low water.
32.	Height of obstruction to tidal inundation.

Ecological Vegetation Maps

The complexity of the environment is therefore condensed into a living space, by giving it an ecological order through mapping the vegetation. The vegetation then faithfully portrays the character of that environment. However, if vague ecological terms are used on the maps e.g. partly flooded area, swampy area, low-lying area, densely vegetated etc. (Schantz and Zon 1923) the maps are not always enlightening. On the other hand, if ecological information appears only in a few legend items then such maps are only partially ecological (Kuchler 1977). For a specific area, local terms may be employed as a matter of convenience to aid local readers (Richard 1978), but if no precise ecological information is introduced, then the map is only partly useful.

When every type of vegetation shown on the map is related to every environmental feature indicated on the legend, then the approach becomes systematic. Two types of systematically prepared ecological vegetation maps are of relevance to the Niger Delta area:

Single-quality maps: Quite often, an environmental feature is glaringly significant in the management of a vegetation community. For example, salinity variation (not salinity) has been established to account for mangrove ecosystem productivity in the Niger Delta area (Ukpong 1991, 1992). The relationship of the mangrove genera and freshwater genera to salinity variation has also been mapped (Ukpong, 1997). According to Ozenda and Pautou (1980)

> "whenever a correlation between a given vegetation unit and a given environmental phenomenon can be established and verified statistically, the spatial distribution of the phenomenon....its seasonal development can be deduced from that of the vegetation and ...the representation on maps: that is the principle of ecological cartography...."

The correlation between plant communities and salinity variation in freshwater or brackish and saline deltaic-estuarine wetlands is so close that statements concerning environmental quality can be made with a high degree of accuracy. Seasonal fluctuations in the water table, particularly in the freshwater swamps may also be important but this has not been statistically tested.

The correlation of plant communities with a single environmental feature e.g. salinity allows for an accurate calibration which is particularly useful in various management considerations, for instance in land-use planning.

Multi-quality maps: These maps seek to portray the ecological conditions of an area. The most comprehensive of these maps tilt towards vegetation-climate relations (Walter 1979) and are more applicable on a world-wide scale than specific cases. Bailey (1976), however, created a regional ecosystem and correlated them directly with the vegetation. But the components of the ecosystem are so complex that map makers must select the components which means that the number of possibilities and their combination could be almost infinite. Consequently, a large variety of multi-quality ecological vegetation maps exist. The modest maps relate the vegetation to three or four environmental features while the more comprehensive maps include as many features as possible.

The following features are suggested for the Niger Delta area:

- Salinity, cation concentrations (in water and soil) soil depth classes, soil series, soil texture and colour, topography, geology, sea level rise, soil types, slope, permeability, drainage, topography, lithology, site types (habitat classes), superficial deposits, annual precipitation, land forms and pH.

If the multi-quality maps must contain features resulting from human activities, the following are suggested:

- Contents of heavy metal (in water and soil), petroleum hydrocarbons (in water and soil), industrial effluents, domestic effluents, water temperature etc.

The legend of a useful multi-quality ecological map should include the physical and chemical nature of each site or soil type or habitat. Then every plant community should be given a floristic analysis (possibly stratified) and related directly to the site components or soil as classified in the legend. Only then would it be possible to divide the whole vegetation into zones with an indication of biomass and productivity.

Interpretation and Ecological Significance of the Maps

If the ecological vegetation maps are interpreted correctly then the maps are of value. According to Seibert (1980) "the goal of ecological interpretation is to determine in what manner ecosystems can serve to maintain and to improve environmental qualities for the physical and spiritual well-being of man, his domestic plants and animals and his institutions" Considering this anthropocentric approach, the significance of ecological vegetation maps of the Niger Delta would be enhanced, and made more interpretable with the inclusion of environmental issues as additional features influencing the vegetation communities. The following issues are suggested:

- Agricultural land degradation, erosion, flooding, fisheries (depletion within the habitats), habitat degradation, deforestation, forest degradation, bio-diversity loss, oil pollution, gas flaring, industrial pollution, fertiliser pollution, toxic and hazardous substances, solid waste and sewage etc.

These issues can be quantified through the use of suitable indices and included in the legend of the ecological vegetation maps. With these, it will not be possible to overlook the true cause and effect relations between vegetation and environment. Because the ecosystem and its components are so complex, map makers must be selective on the combination of features, depending on the focus to the mapping.

As the ecological vegetation map of the Niger Delta must be interpreted for a given purpose e.g. conserving bio-diversity, then clearly defined habitats would facilitate the process. According to Kuchler (1984) the best definition of a habitat should be based on the structure and floristic composition of the vegetation. Both measures are needed because only one measure may change in response to a change in the habitat.

The GIS and Ecological Vegetation Maps

Considering the enormity of variables, the complex nature of the environment and the multiple uses to which the maps are required, a higher level of information technology is needed, much more than the average cartographer can produce on the drawing table; computer-aided cartography is required as an important input into the mapping process.

As environmental management becomes more complex, the field practitioner needs to answer more questions which can only be obtained through a combination of data transformations and retrieval systems. Hence a computer system capable of efficient handling of environmental data is required. Besides, as the spatial units of vegetation and environmental data may be different for different vegetation communities, the conventional methods of mapping may have difficulty in coping with the complex of data set. Data linkage and integration is significant (Rhind, 1984). The facilities to effect the linkage are provided by the GIS. Since the data in GIS represent a model of the real world (Boville 1978), they can be manipulated and updated and manipulated for studying environmental processes and analysing trends for management decisions (Barrough, 1986).

The GIS software however depend upon data from existing maps. Therefore few of these systems can be applied to ecological mapping for environmental conservation, with the probable exception of the Map Analysis Package (Tomline 1980) and the Comprehensive Inventory and Evaluation Systems (CRIES), which is a raster-based computerised GIS (Weir 1987). These software can be used to store environmental information or features and vegetation data, then cartographic and statistical manipulation of these information would enable their ecological implications to be assessed.

Conclusion

An efficient ecological vegetation map must attempt to give answers to the following environmental issues:

- Is the carrying capacity of the available land being exceeded?
- Can the maximum yield be obtained from the available land?
- What is the prevailing erosion type under the present management technique?
- What are the chances of fire/pollution control under different types of management?
- What would be the productivity (biomass/unit area) under different types of management?
- What would be the cost efficiency of management with respect to the different types of vegetation?
- What methods should be adopted for conserving bio-diversity and renewable resources?
- Which pollutants are the most toxic in cumulative effect?

- Which are the most abundant pollutants?
- Where should a monitored vegetation reserve be located for minimum disturbance?
- Is the ecological vegetation map of practical significance?

The ecological vegetation maps are supposed to answer all these questions. With the GIS, it is hoped that the maps will become more sophisticated and consequently more useful. Considering the urgent need to preserve the Niger Delta environment, multi-quality ecological vegetation maps are the basic tools for assessment.

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