# The Effects of the Seasonal Flood Regime on the Ecology of Chief's Island and the Adjacent Floodplain Systems

**R. C. BIGGS, University of Pretoria**

The largest island in the Okavango Delta, namely Chief's Island, and parts of the adjacent floodplains of the M'borogha and Boro River system, are scheduled for extension into the existing Moremi Wildlife Reserve. This comprises an area of 1 810 km$^2$ of central Delta, made up, approximately, of 1 100 km$^2$ of island dryland and 710 km$^2$ of wetlands and floodplains. The new unit forms about 11% of the total Delta area, or 21% if Moremi Wildlife Reserve is included.

The flooding patterns of the Delta arise from two sources: the major source is a late autumn to early winter flood arising from rainfall in the catchment areas of the Cuito and Cubango River systems of south-eastern Angola. A possible late summer flood may occur when local rainfall over the Delta is high, viz, in the 1973/74 rainy season.

The vegetation of this unit can be divided into five main types, based on water availability, viz:

- Aquatic vegetation types
- Floodplain vegetation types
- Riverine vegetation types
- Marginal riverine vegetation types
- Dryland vegetation types.

These vegetation types are distributed in a mosaic as a function of water availability, water table level, soil type and frequency and duration of flooding, which, in turn, are all governed by local base levels. Therefore, any factor altering or capable of altering base levels, such as seismicity, termites via establishing termitaria and physical erosion either due to the elements or animal action, is of the utmost importance in this system, as flooding patterns are altered and, thus, vegetation density and distribution can change. This, in turn, can affect mammalian distribution.

These vegetation types will be broadly discussed with regard to plant communities or habitat types found within them and the larger mammalian species associated with these habitat types. I have largely followed Wilson's (1974) definitions for hydrological communities and Tinley's (1966) for dryland communities. Within parts of the mid-Delta areas, fairly large fluctuations in water levels can occur between peak flood and absolute dry conditions, these being in the order of 160 cm.

## AQUATIC VEGETATION TYPES

These communities are dependent on permanent or almost permanent water, or a high water table, in very dry seasons.

### Filter communities

These communities occur only within the northern sectors of the Delta in the vicinity of the M'borogha and Boro River headwaters. Filter communities are, thus, not actually in the study area, but are located marginally on the extreme northern sectors. This community is, however, very important, due to its role in preventing sudd and floating debris arising in the upper channels from entering the major river systems in the study area. Together with restricted take-offs above the study area, the filter communities thus serve to keep the Boro and M'borogha River channels relatively free of these blockage-initiating agents. Where sudd or floating debris originate in the Boro and M'borogha channels themselves, it does still serve as a blockage-initiating agent.

Filter communities are dominated by *Miscanthidium junceum, Cyperus papyrus* and *Phragmites spp.* They are medium- to shallowly-flooded areas which are relatively stable. Water levels fluctuate to a small degree and there is a definite current flow through these areas between adjacent river systems and feeding madiba. Filter communities form relatively important sitatunga *(Tragelaphus spekei)* habitat, and if water levels drop, red lechwe *(Kobus leche)* habitat.

**Middle channel communities**

The M'borogha River is classified under this community in the study area. Middle channels are perennially-flowing watercourses, generally free of floating or emergent aquatic vegetation. The major vegetation components marginally situated are *Cyperus papyrus* and *Miscanthidium junceum*, with other aquatic sedges and grasses, such as *Vossia cuspidata* and *Cladium mariscus*. The ferns *Thelypterus spp.* and twiners *Mikania cordata* and *Vigna luteola* are common. The submerged aquatic component is largely made up of *Ottelia muricata, O. ulvifolia, Ceratophyllum demersum, Lagarosiphon ilicifolius* and *Rotala myriophylloides*.

Middle channels, together with outlet channels and Madiba, form important hippopotamus *(Hippopotamus amphibius)* and otter *(Lutra maculicollis* and *Aonyx capensis)* habitat. When water levels are high, hippopotamuses tend to move out of the middle channels into outlet channels and other freshly-flooded habitats of suitable depth. The reptilian segment of importance here is the Nile crocodile *(Crocodylus niloticus)*.

**Outlet channel communities**

The Boro River from below Qo Flats, where it forms part of the new unit's western boundary, and some of the smaller channels of the eastern floodplains, are classified as outlet channel communities. Outlet channels are nearly all perennial watercourses within the study area. Lower down in the Delta they may become annual watercourses. They are very variable in width and depth, and the sandbars often become exposed at low water periods.

*Miscanthidium junceum, Vossia cuspidata, Echinocloa colonum, Oryza longisteminata, Leersia hexandre, Panicum repens,* and the sedges Cyperus asticulatis and *Scirpus spp.* form the dominant marginal vegetation. In the channel, submerged aquatic vegetation comprise mainly *Rotala myriophylloides, Ottelia ulvifolia, Ceratophyllum demersum* and *Lagarosiphon ilicifolius*.

Outlet channels form important hippopotamus habitat when water levels are sufficient. Otters are common in these channels. During the dry seasons in low flood years, this habitat type is the most important for red lechwe, together with marginal shallow backwaters and sumps. Reedbuck *(Redunca arundinum)* and buffalo *(Syncerus caffer)* utilise this habitat under similar conditions.

**Madiba communities**

Madiba occur mainly in the extreme northern and southern areas of the unit. These are old oxbow lakes where water levels fluctuate slightly and water currents are very slow. These madiba are relicts of former watercourses and are largely open water bodies of varying sizes and shapes.





Margins of *Cyperus papyrus* are common, and on the verges submerged, surface-floating and emergent-rooted aquatics occur. Central areas are largely open-water and in some madiba, large thicket clusters of *Ficus verruculosa* occur. These form important nesting colonies for some bird species.

This habitat type is well represented with the new unit and forms important hippopotamus and crocodile habitat. Some madiba have short-island grassland adjacent to, or enclosed by, them and this forms important red lechwe habitat.

**Flat communities**

Flat communities occur on the western margin of the arbitary boundary, viz, Qo Flats. They are characterised by slow-flowing water and shallow depth, dotted with occasional small termitaria islands and medium-sized islands supporting woody vegetation. Very little open-water surface exists and minor channels across flats are kept open only by hippopotamus paths or propellers from outboard engine navigation. Flat communities seem to be relatively stable.

Common-rooted emergent aquatic vegetation is made up of *Eleocharis spp, Cyperus spp.* and *Scirpus spp.* The water-lilies *Nymphoea caerulea* and *Nymphoides indica* are submerged and free-floating aquatic vegetation is common. On larger islands, riverine and marginal riverine woodland are well developed, due to the high water table. Island grassland dominated by *Sporobolus spicatus,* with large quantities of evaporites, occur.

Flat communities are important for sitatunga and hippopotamuses. Sitatunga move to flats and filter communities when the water levels in shallow backwater communities drops. Red lechwe utilise shallower areas in the flat community.

**Shallow backwater communities**

These communities are well represented in the M'borogha floodplains and upper Boro floodplains in the study area. Shallow backwater communities lie either adjacent to major channels or relatively far from them on slightly elevated ground, and remain, on average, flooded for the greater part of the year. No defined drainage takes place with almost stagnant water conditions existing. Numerous small termitarium islands occur, and in the deeper areas, sumps communities are found. The vegetation is made up mainly of aquatic grasses and sedges.

Shallow backwaters form very important habitat for red lechwe in drier times, and for sitatunga when heavily inundated. Buffalo occasionally utilise this habitat.

**Sump communities**

These are similar to small madiba, but are much smaller, and neither have the depth, permanence of flooding or amount of open surface associated with madiba. Sumps lie as a mosaic in the depressed areas of shallow backwater communities, or adjacent to middle or outlet channels.

Sumps are characterised by large numbers of sedges, mainly *Eleocharis spp.*, large numbers of rooted, aquatic vegetation with floating leaves and submerged aquatic vegetation, such as *Potamogeton spp., Ottelia spp.* and *Najas pectinata.*

Sump communities, together with the shallow backwater communities and their associated termitaria, form excellent sitatunga and lechwe habitat. As the water levels drop, sitatunga move to lower-lying habitats and red lechwe move into these areas. Termitaria are of two types: either eroded to a flat, circular disc and covered by short, lawn-like grasses of *Cynodon dactylon* and *Sporobolus spicatus,* or less eroded and supporting fairly dense thickets and usually one or more large trees. Red lechwe are associated with the open, old termitarium and sitatunga rest up on the thicket-supporting termitaria in general. Reedbuck and buffalo may be found in these habitat types when they are dry or nearly dry.

## FLOODPLAIN VEGETATION TYPES

These communities are dependent on annual flooding; with lower-lying floodplains receiving an average annual flooding period of eight to ten months, and more elevated floodplains, an average annual flooding period of three months.

### Primary floodplain communities (melapo)

These communities are represented in the middle and lower Boro floodplains within the study area. Primary floodplains are secondary channels characterised by aquatic to semi-aquatic sedges and grasses with very little open-surface water. Rising floodwaters overflow down these channels first. In poor flood seasons they are only inundated for five months, and throughout the year in high flood conditions.

When primary floodplains are inundated they form important red lechwe habitat; red lechwe move into these areas shortly after flooding has occurred. When primary floodplains are excessively flooded, only their verges may be utilised by the red lechwe, which often to move into less-favoured secondary floodplain habitat due to the high water levels. Sitatunga may utilise the primary floodplains at this stage. When primary floodplains are dry (whether burnt or unburnt), they are favoured reedbuck habitat, usually after the red lechwe have moved back with receding water levels.

When dry or nearly dry primary floodplains are very heavily utilised, especially after a burn prior to flooding, or in late spring before the onset of the summer rains. Buffalo, zebra *(Equus burchelli)*, blue wildebeest *(Connochaetes taurinus)*, tsessebe *(Damaliscus lunatus)*, impala *(Aepycerus melampus)*, warthog *(Phachochoerus aethiopicus)*, chacma baboon *(Papio ursinus)* and vervet monkey *(Cercopithecus aethiops)* all utilise the primary floodplain. In dry seasons, after poor summer rains, warthog and baboon still utilise primary floodplains heavily, rooting up for tubers and bulbs, the baboon following up after the warthog. Waterbuck *(Kobus ellipsiprymnus)* were found here occasionally.

### Secondary floodplain communities

These are essentially grasslands, occurring on sandy soils, and are last to receive inundation. In poor flood seasons, viz, 1972/73, secondary floodplains are not inundated at all, but during heavy flood seasons they may be inundated for up to seven months. To prevent vegetation compositional changes and over-utilisation leading to habitat deterioration, these secondary floodplains should be inundated for at least two to three months of the year. Secondary floodplains are well represented in the middle and lower Boro floodplains and the central M'borogha floodplains in the study area.

Secondary floodplains are critical areas, since when insufficiently-flooded termitarium establishment and woody vegetation encroachment can proceed either on the new raised base levels or from the island verges, the latter process may be restored to normal in exceptional flood years.

A series of secondary floodplains exist which varies in flooding frequency and duration. On the more frequently-flooded areas, a high density of grasses per m$^2$ exists, and a taller perennial grassland with few other herbaceous species forms good reedbuck habitat. Secondary floodplains not regularly flooded show, on average, about one-quarter the density of herbaceous plants and a marked percentage increase in annual grasses and other herbaceous plants. Such areas are heavily over-utilised





and receive shorter rest periods, and according to Riney's (1963) field technique for describing status and trends of vegetation, are showing a downgrading tendency. Tsessebe, buffalo, wildebeest and impala utilise these secondary floodplains fairly heavily. Waterbuck and zebra were occasionally encountered making use of them, whilst downgrading secondary floodplains showed heavy use by springhare *(Pedetes capensis)*.

### *Sporobolus spicatus* island grassland communities

Adjacent to most islands or often nearly enclosed by riverine woodland or termitaria, are slightly depressed areas, which, depending on locality and base levels, are only flooded for a short duration in high floods, or are well flooded. These are short grasslands, characterised by *Sporobolus spicatus* with sedges and plenty of evaporites or drier areas of *Sporobolus spicatus* and *Cynodon dactylon* with little or no evaporites present, and a higher proportion of other grasses and herbaceous plants.

Island grassland communities are heavily utilised by red lechwe when inundated or dry. When dry, tsessebe, wildebeest and warthog commonly utilise these areas, and to a lesser degree, impala and buffalo. Hippopotamus graze on island grassland nocturnally.

Due to a natural process of termitarium establishment and erosion, some island grasslands receive progressively less inundation. This leads to a process of "island closure" and subsequent vegetation evolution to a marginal or more frequently dryland type.

## RIVERINE VEGETATION TYPES

These vegation types are dependent on close water proximity or a high water table.

### Closed riverine woodland

Riverine woodlands are situated on the margins of islands adjacent to channels or islands in the floodplains, except where base levels are low and allow floodwaters to inundate island grassland, or surface water proximity is too distant and water tables too low. This vegetation type is well represented throughout the study area, but more well developed in the proximity of more permanent waters.

This type prominently comprises a partially-evergreen, closed woodland of *Diospyros mespiliformis, Garcinia livingstonei, Ficus sycomorous, F. burkei* and *Lonchocarpus capassa*. Common, but less prominent, are *Croton megalobotrys, Hyphaene ventricosa, Rhus spp., Euclea spp., Gardenia spathulifolia, Ximenia americana, Vernonia spp., Grewia spp., Acacia spp.* and *Ziziphus mucronata. Syzygium spp., Phoenix reclinata* and *Myrica serrata* occur where the water table is very high. A well-developed sciophyte population with mainly annual grasses occurs in the herbaceous layer.

In high flood conditions, surface water may cover the outer verges, but this does not generally occur. In drier Delta areas, this riverine woodland is less well developed, degrading or absent.

Riverine woodland is utilised by Chobe bushbuck *(Tragelaphus scriptus)*, which are scarce, leopard *(Panthera pardus)*, kudu *(Tragelaphus strepsiceros)*, impala, baboons, monkeys, warthog, genet *(Genetta spp.)* and night apes *(Galago senegalensis)*.

### *Phoenix reclinata — Syzygium sp.* parkland

This parkland exists as a result of limited available high base levels from termitaria above the surrounding floodplains, and occurs in the north-west part of the study area. *Phoenix-Syzygium* parkland is well developed in the upper Delta areas. Sitatunga and red lechwe utilise these small islands for resting on. Buffalo and elephant *(Loxodonta africana)* utilise these areas lightly and baboon when water levels are lower.

## MARGINAL RIVERINE VEGETATION TYPES

Marginal riverine vegetation types are partially dependent on the proximity of water or a fairly high water table. These types are more extensively developed in the lower Delta. In the study area, marginal riverine vegetation occurs adjacent to riverine woodland on slightly elevated ground that is never flooded.

### *Acacia nigrescens - Croton megalobotrys* woodland and savanna woodland

*Acacia nigrescens* and *Croton megalobotrys* are dominant in small stands on some islands or larger communities of this type occur on Chief's Island as a result of previous communities when flooding regimes crossed or penetrated parts of the large island. *Lonchocarpus capassa* is often associated with these woodlands.

Giraffe *(Giraffa camelopardalis)*, buffalo, kudu, impala, bushbuck, warthog, baboon, monkey and night ape utilise these communities.

### *Hyphaene ventricosa - Croton megalobotrys* palm woodland and palm savanna woodland

*Hyphaene ventricosa* is the more dominant tree in these communities, occurring as a single-boled or shrub-like form. These communities are very common on most islands of both floodplain systems. *Kigelia africana, Garcinia livingstonei* and *Ziziphus mucronata* are common within this type of palm savanna woodland.

Elephant utilise these areas fairly heavily, browsing on the palm fronds. Kudu, impala, baboons and monkeys also utilise these woodlands. Fires, common on the islands, seem to stimulate palm seedling generation.

### *Combretum imberbe - Croton megalobotrys* woodland and savanna woodland

*Combretum imberbe - Croton megalobotrys* occur adjacent to riverine woodland in raised, sandier substrate conditions. *Lonchocarpus capassa* forms a sub-dominant. *Acacia tortilis, A. nigrescens, Dichrostachys cinerea* and *Grewia spp.* are present in small numbers. This marginal type is utilised by elephants, giraffe, kudu, impala, baboons and monkeys.

## DRYLAND VEGETATION TYPES

Dryland vegetation types are not dependent on floodwaters, but are affected by flooding when they have colonised old channels or floodplains that may become inundated as a result of heavy floods or altered drainage patterns. Years of exceptionally heavy local rainfall may also cause surface flooding, due to impeded drainage. Numerous old watercourses were not flooded during the exceptionally-heavy 1973/74 local rainy season.

### *Acacia tortilis* savanna woodland

On compact, silty alluvium, well-developed stands of *Acacia tortilis* savanna woodland occur. In the study area these are located in the upper eastern and western margins of Chief's Island adjacent to the present floodplain and on ancient floodplain. On some large islands in the M'borogha floodplain, *Acacia tortilis* stands are present on ancient floodplains. On higher ground, *Acacia nigrescens* replaces *A. tortilis*, whilst under sandier substrate conditions *A. erioloba* replaces *A. tortilis*.

These areas are among the most heavily utilised of all the communites. The herbaceous layer is kept in a short, cropped state. Giraffe, buffalo, tsessebe, wildebeest, zebra, kudu, impala, warthog and baboons utilise these areas heavily, as do elephant, which cause damage to *Acacia tortilis* trees by pushing them over, stripping bark and browsing on the exposed roots.

*Acacia tortilis* savanna woodland areas became inundated under exceptionally





heavy local rainfall and flood conditions, and red lechwe are then forced to move on to these areas by abnormally high water levels in their more favoured habitat. Under average hydrological conditions, red lechwe will not be found in this habitat type. Predators are common here, due to the high herbivore biomass.

### *Acacia hebeclada* thickets

*Acacia hebeclada* does not occur as fairly large communities as found lower down in the Delta, but rather as localised, isolated thickets around pans in *Acacia tortilis* savanna woodland, *Colophospermum mopane* woodland, or on some islands. *Acacia hebeclada* occurs more commonly in multiple-stemmed, decumbent form, with its typical hollow of shade utilised by carnivores and warthog as lying-up areas. Giraffe, kudu and impala browse lightly off these thickets.

### *Acacia erioloba* woodland and savanna woodland

*Acacia erioloba* occurs on sandy alluvium or on firmer, more compact Kalahari sands. *Acacia erioloba* forms a widespread community, following old drainage courses and on some old, sandy floodplain on Chief's Island. Distribution is from the south of Chief's Island, mainly up the western margin of the large island, and then alternating and forming a mosaic with *Acacia tortilis* savanna woodland, *A. nigrescens - Crotan megalobotrys* woodland and *Terminalia sericea - Combretum collinum* woodland depending on substrate conditions; but as a function of the original sand deposition and subsequent water action and silt deposition on it.

*Acacia erioloba* is very dominant (80% or more) with small amounts of *A. fleckii, Terminalia sericea* and *Grewia spp. Brachiaria brizantha* is the dominant grass. *Acacia erioloba* woodland is well utilised by elephant, giraffe, buffalo, kudu and impala, but not to the same extent as *A. tortilis* savanna woodland.

### *Grewia spp. - Croton megalobotrys* shrub savanna

On medium to large sandy islands, the central core is often sparsely covered by tall, woody vegetation; but the bulk is formed of a *Grewia spp.* shrub savanna with *Croton megalobotrys* often associated. *Grewia flavescens* (27%), *G. schinzii* (20%) and *G. retinervis* (11%) with *Croton megalobotrys* (19%) forming the bulk of this community. *Urochloa brachyura* was the most important grass.

This community was relatively well utilised by giraffe, kudu, impala, warthog and baboons, and to a lesser degree, by hippopotamus and springhare. Elephant, wildebeest and tsessebe were rarely encountered in this area.

### *Terminalia sericea - Combretum collinum* savanna woodland and shrub savanna

On Chief's Island and on medium- to large-sized islands, *Terminalia sericea - Combretum collinum* savanna woodlands or shrub savanna is established on loose, pallid Kalahari sands.

This community occurs as a mosaic with *Colophospermum mopane* or other dryland types on Chief's Island and centrally on most of the larger islands where suitable substrata exists.

*Terminalia sericea - Combretum* communities are relatively well utilised by elephant, giraffe, kudu and impala, with wildebeest, tsessebe, waterbuck and warthog occasionally encountered within it.

### *Colophospermum mopane* woodland and pyrophytic scrub savanna

*Colophospermum mopane* occurs on grey, clayey pan soils of Chief's Island, mainly from the southern tip, extending up the south-eastern side, roughly half-way up the large island, or centrally on some of the large islands or on isolated termitaria on islands or in the floodplain. Rainpans are common within this community.

Greatest utilisation of *Colophospermum mopane* woodland occurs during the local rainy season when grasses flash and drinking water is obtainable. Elephant, giraffe, buffalo, kudu and impala utilise this community heavily then, and wildebeest, tsessebe, zebra, warthog and baboons occasionally. Elephant may utilise this habitat throughout the year and when rainpans are exceptionally full, hippopotamuses have been recorded in the mopane woodland. Occasional steenbok *(Raphicerus campestris)* were located in this community, but no black rhinoceros *(Diceros bicornis)*, as recorded by Smithers (1971) were found.

REFERENCES

Riney, T. 1963. A rapid field technique and its application in describing conservation status and trends in semi-arid pastoral areas. *African Soils*, 159-257.

Smithers, R. H. N. 1971. The mammals of Botswana. *Museum Memoir No. 4*, The Trustees of the National Museum of Rhodesia, Salisbury.

Tinley, K. L. 1966. An ecological reconnaissance of the Moremi Wildlife Reserve, Northern Okavango Swamps, Botswana. Okavango Wildlife Society, Cape Town.

Wilson, B. H. 1973. Some natural and man-made changes in the channels of the Okavango Delta. *Botswana Notes and Records*, Vol. V, Gaborone.





# General Discussion

Major issues which arose during the first session of the Symposium, dealing with an analysis of the primary and secondary productivity of the Okavango ecosystem, can be summarised as follows:

1. What role should the ecologist, or researcher in general, play with regard to the study, development and management of the Okavango Delta? That is, to what degree does the scientist have a right and a responsibility in guiding the direction of future use? Should he simply provide data to the politician and decision-maker, or should he, himself, be active in the decision-making process?
2. Are the techniques and procedures currently being used by environmental scientists adequate? Should and can the systems analysis and simulation modelling approach be incorporated or expanded at this time to maximise the usefulness of the data being gathered?
3. All of the speakers indicated that various development schemes (e.g., flooding, draining, expanded agriculture) will definitely affect the plant communities in the Delta, and, in turn, those organisms dependent upon them. Is it possible to predict more precisely what impact these development programmes will have on the ecosystem?
4. Various speakers suggested that researchers, Government and the Symposium itself may be floundering, due to a lack of a more sophisticated approach to problem-solving — one that systematically considers
   (a) an analysis of the problem, including a detailed inventory of the resources,
   (b) a specification of alternative objectives, ranging from major developments to a preservation of the *status quo*, and
   (c) the drafting and implementation of procedures through which to achieve the chosen objectives.

As indicated by the following report of comments made by various participants, opinions on many of these issues were highly divergent — but then the objective of the Symposium was, as stated by Vice-President, Dr Masire, in his opening speech, "not to reach agreement, but understanding."

During his presentation, **Dr Worthington** emphasised the importance of predicting the effects of various developments through the use of ecosystems analysis and modelling. **Mr Reavell** noted that a lack of funds has greatly limited the amount of grass-root research on the Okavango Delta, and that this research was essential if wise decisions were to be made concerning its development. **Dr Worthington** replied that he was, to the contrary, quite impressed with the abundance of information which had been accumulated for the Symposium — in spite of the "shortage of funds."

**Mr Stark** asked Dr Worthington to further clarify his statements concerning the complementary aspects of cattle and wildlands management. **Dr Worthington** replied that it was important to assess the carrying capacity of the land and to limit the total populations of both cattle and wildlife so as not to exceed the carrying capacity. He cited the land utilisation programme operating in the Masai area of Kenya as one which, presumably, has worked well (i.e., the utilisation of both cattle and wildlife in the same areas has been viewed as beneficial by the residents).

Following Mr Astle's presentation, which briefly described his and Mr Graham's work in assessing the vegetation and major wildlife species of the Okavango Delta, Dr Thompson asked whether the data that had been collected could be synthesised through the use of models. **Mr Graham** stated that they were currently developing limited simulation models for buffalo and other species of major economic importance. **Mr Graham** also mentioned that the entire research programme which has been developed during the UNDP project would be turned over to the Department of Wildlife, National Parks and Tourism at the end of the project. In this way the Department would be able to continue to assess and monitor the Okavango ecosystem and, hopefully, predict the impact of proposed development and utilisation programmes.

**Mr Graham** opened the panel discussion by asking whether the data was available to make the kind of predictions which Dr Thompson called for during his presentation. Pointing to the lack of knowledge concerning the factors which, for example, influence the population size and distribution of hippopotami, **Mr Graham** suggested that much more work is required before accurate and precise predictions become a reality. **Dr Worthington** stated that the information available on the area, and that extrapolated from other areas, may allow one to make rather general predictions. These could then be refined as additional information becomes available. **Dr Thompson**, in replying to Graham's enquiry, stated that he did not say that the making of sweeping estimates was possible, but instead that there was a need to synthesise data on such topics as nutrients, primary productivity and secondary productivity. To accomplish this, **Dr Thompson** suggested that models, which can vary in size and complexity, should be designed. In its basic form, a model amounts to a flow diagram illustrating the various components of the ecosystems and how they fit together. By completing the model, one would discover what information was already available and what data needed to be collected in order to make predictions about such things as, for example, factors limiting the distribution of the hippopotami.

**Dr Worthington** supported Mr Thompson's plea for a systems analysis approach by stating that the International Biological Programme (IBP) collected a great amount of useless data prior to the time that an ecosystem analysis and modelling approach was implemented. Regarding the need for a more systematic and co-ordinated research effort, **Mr Reavell** cited the need for a few ecologists who could co-ordinate the existing studies on the Okavango and synthesise their findings.

By asking "what questions will be answered by the modelling approach?", Mr Stark further stimulated the discussion concerning (a) the need for a more systematic approach to problem-solving and (b) the role of the environmental scientist in the decision-making process. Following Mr Stark's question, **Mr Astle** stated that he thought the programme to investigate the Okavango might have gone astray if a sophisticated modelling approach had been used. He further stressed the need to clearly outline the objectives before implementing a programme of analysis and development. Pointing to an earlier comment by **Mr Biggs** concerning the desirability or redistributing water in the Delta, Mr Astle commented that he believed the proper role of the environmental scientist was to gather data (which might be used by politicians and managers) and that the making of decisions concerning the use of the resource was the domain of politicians and resource managers.

Concerning the relationship between researchers, resource managers and politicians, **Dr Worthington** cited, as essential, three steps required of all management plans:

(a) inventorying of the resources,
(b) stating of the objectives, ranging from major development to the preservation of the *status quo*, and
(c) designing and implementing of the procedures to achieve the objectives.

**He** further stated that since one of the objectives of an ecologist should be to promote wise management decisions, it is impossible for an ecologist to completely





divorce himself from the proposed management plans. **Dr Thompson** supported Dr Worthington's views by stating that an ecologist must not "just collect data," but that it is also the responsibility of an ecologist to provide politicians and resource managers with that data which was essential for rational decision-making. Mr Thompson repeated a previous suggestion by stating that the use of flow diagrams and models could serve a useful function by indicating what information was critically needed.

Regarding the use of objectives, **Prof. Midgley** stated that although objectives change from time to time, it was still important that one's objectives be clearly stated; he also felt that models could be highly useful in the process of defining one's objectives. Regarding the role of the ecologist, **Prof. Midgley** stated that it was important to realise that various professions approach problems from different perspectives. For this reason, he suggested that it was important that an interdisciplinary team approach be used to obtain information which would provide the basis for making wise land-use decisions.