Michael Oneka

On Park Design
looking beyond the wars

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On Park Design
looking beyond the wars

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dr. C.M. Karssen,
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Cover Photograph:
By the author in 1984 on top of a hill in the Rabongo region of the Murchison Falls Park, Uganda. This is the highest region of the park. In the background is Igisi hill located just outside the southern bounds of the park. In the picture are ranger guards (with guns) and two senior officers. For various reasons connected to wars probably all people in the picture are no longer with the Uganda National Parks. Cover designed by E. van Cleef.

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PROPOSITIONS
MICHAEL ONEKA
On park design: looking beyond the wars

1. War is like fire, most people it affects have no say in it.
   -This thesis.

2. Unlike Noah's Ark (Genesis 6:9-22 to 8:1-19) parks are not for temporary refuge but are for posterity and their design should take this seriously.
   -This thesis.

3. Many of the *species at risk are completely unknown -their biological* importance a mystery and their potential value to society an open question.
   -Edward C. WOLF (1987) *On the brink of extinction.* Worldwatch Paper 78.

4. The usefulness and also the uselessness of scientific techniques are their structured nature.
   -This thesis.

5. When the only tool you have is a hammer everything begins to look like a nail.
   -Anupam SARAPH (1994) *Toolbox for tomorrow. Exploring and designing sustainable systems*. Ph.D. thesis, University of Groningen, Groningen.

6. The only test of a design is how it works in practice.
   -This thesis.

7. Park design is a puzzle.
   -This thesis.

8. The future of green design will depend on the evolution of appropriate institutions.
   -This thesis.

9. Fire, termites, plants and herbivores in a cause/ effect model exemplify attempts to trim the apparent chaos of nature to fit into fantasies!
   -This thesis.

10. The recovery of *Terminalia* woodland in Murchison Falls Park will require the use rather than the exclusion of fire.
    -This thesis.

11. Our individual roles in the future of green design are comparable to what has been shown by Oldeman (1974) as the roles of individual trees (of the past, of the present or of the future) in forest silvigenesis.
    -This thesis (but see also Roelof A.A. Oldeman (1974) *L'architecture de la forêt Guyanaise.* ORSTOM, Mém. 73, Paris).

12. I wonder what impression I would have of man if I were a snake!

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PREFACE

In 1985 while I worked in the Murchison Falls Park, there was a *coup d'état* in Uganda and we suddenly had to host initially tens but later hundreds of soldiers. The presence of soldiers helped us, the senior members of staff based in the park, to temporarily unite. One of the first challenges we faced was feeding the soldiers who demanded wildlife meat. To avoid chaos in the park we, the park officers, decided to go and kill the animals for the soldiers. I decided to go on one of the first hunting expeditions. In the Te Okuto area of the park there were normally many buffaloes feeding within close distance from the road. On that day there was a lone buffalo standing at some twenty metres from the road. As we approached, it stopped grazing and raised its head to look at us. Suddenly there was a big explosion: the buffalo had been shot around the heart. For a moment I did not know any more why I actually went on this trip. The next moments were rather chaotic. The buffalo fled away at full speed as if it had not been shot. The soldiers on seeing it flee, fired several rounds of ammunition at it until it fell down with broken limbs. This case illustrates the turmoil of the parks in Uganda largely as result of the past years of civil unrest. The case, however, also depicts a worldwide problem. Parks in many countries are being crippled by inappropriate development programmes made worse by chronic wars. The buffalo case symbolises many parks around the world, fatally crippled by the nature of their design. Even though they look healthy and full of life, they are by the nature of their artificial design, like the bullets in the above buffalo, doomed to kill them. The present book raises issues aimed at generating debates on the design of the parks looking beyond the wars.

The book synthesizes studies started in 1983 as part of the Uganda Institute of Ecology research and monitoring programme. The studies have evolved through several violent disruptions, personal tragedies and some unforeseeable institutional changes. Virtually from the beginning of the studies there have been sudden changes in the research schedules, contents, methodologies, logistics, composition of team and/or even institutional framework. What became familiar were such situations as a research station with no serviceable transport but with expectations to regularly sample on sites tens of kilometres away. Or being caught up in one of the waves of insecurity at the hands of undisciplined and murderous army. Or the total collapse of security in a study area as well as the loss of critical research facilities without funds to replace them. Or the sudden death of critical supervisors or staff. Or the sudden loss of institutional support at critical points of the studies. These circumstances have helped to grasp why many parks especially those in poor countries ravaged by wars might not survive. In the nature of their design the park systems do not have the capability to accumulate and to deploy resources necessary for the sustained development of the parks.

There have been many other studies before dealing with park design but this book differs from them in some major aspects. Many previous studies on park design have put emphasis on the design of recreation parks found largely in urban areas, whereas this study focuses on nature reserves. Most of the studies on park design have adopted the approaches which have been widely used in the design of recreation parks, whereas this one considers them inappropriate. This book proposes that park design should be treated as a puzzle with emphasis being given to building institutional capability to deal with the puzzle. Accordingly the emphasis given to the institutional aspects of park design is a break from the past in that such aspects have normally been left out while focusing on the biological quasi-ecological aspects. The issues raised are expected to generate a lot of debates which hopefully should contribute to the evolution of science and its role in sustainable land development.

The book shows that park design requires clear objectives and deep understanding of the dynamics of the park systems. Prevailing instability, poverty, lack of know-how on the dynamics of the park systems, widespread deterioration of environmental conditions, the complex and dynamic nature of the park systems underline the need to innovate appropriate institutions. The nature of the relationships that exist between the park and the above circumstances outside its legal physical boundaries underline the need for a re-definition of the park system. Any design of a park that does not fully incorporate such factors as the socio-economic and political realities in which the park is embedded, as has been common practice so far, provide a basis for the alienation of the park. This broader context of the park is therefore treated in the present book as an equally important component of the park system structure as what is within the legal physical boundaries of the park. Accordingly, an increasingly turbulent socio-economic and/or political environment is considered equally influential as fire, herbivores and other ecological components in the park. Just like in a society where there are invisible but effective regulatory structures (e.g. cultural values) in park systems similar structure ought to be innovated. Such structures (cf. cultures in the human society) need to be innovated with regard to parks because parks have been created by man where they occur. To treat a park as an enclave without sufficient reference to its broader institutional context is therefore naive and in fact tantamount to setting the park on top of a timebomb.

Parks in poor countries especially those ravaged by war are emphasized in the present book because those are the parks where the need for major institutional reform is most apparent. These parks are in countries which can ill-afford development mistakes. Besides, it is more likely that any reform could be incorporated in internationally funded post-war reconstruction and rehabilitation programmes, than it is under the usual development programmes. Cautiously the book also draws attention to the "wars" within and amongst groups of people (especially specialists): wars that undermine collaborations. Whether it is the well-known violent wars or the subtle wars to lock rivals out of a system, the wars are salient features of the park and it is essential that they are treated accordingly in the design of the parks. If the parks are to succeed their design should help build relevant institutional support, flexibility, resilience and other capabilities.

Many persons and organisations have contributed to this book.. The data used in the case studies in the book were collected while I was employed by the Uganda Institute of Ecology to do research for the Uganda National Parks. Initially the studies concentrated on fire effects on *Terminalia* regeneration in the Murchison Falls Park. The fire studies formed part of a collaborative research programme between the Uganda Institute of Ecology and the Fire Science Centre of the University of New Brunswick, Canada. Fieldwork was funded by the Uganda National Parks, the British American

Tobacco (Uganda) Ltd., and the East African Wildlife Society. The first phase of the research in the Netherlands was supported by Wageningen Agricultural University, Department of Terrestrial Ecology and Nature Conservation and the last phase by the Department of Ecological Agriculture. My participation in congresses and study tours to park systems in Kenya and Botswana were made possible by extra funds from the Wageningen Agricultural University Foreign Office. In relation to this I acknowledge the friendly and personal support I got from F. Pepping and C.M. van Heist. To cover the cost of printing photographs in full colour in this book I have obtained grants from the Stichting PRO-Natura and the LEB-Funds. I have also received substantial personal loans to pay for many items used in the preparation of the book but for which no other budgets existed. In this respect I acknowledge the unreserved supports from D. Turk, M. Hoeft, E. Koldenhof, P. Budde, P. Verweij, A. Velazquez, F. Rossingh (Reverend), Robert and Nelly Bwire.

Relevant authorities of the Uganda National Parks and Uganda Institute of Ecology as well as many of their staff members generously facilitated the research work. Besides logistical support I learnt a lot about the way a park system works from my contacts with E.L. Edroma, P.N. Sali, G. Laker-Ojok, P. Oola, S.J.A. Sumba, Y. Evans, A. Labongo, F. Busenene, M. Bitamazire, D. Okech, J. Otekat, E. Akena, E. Muirumubi and C. Mayongo. I was assisted with the field and laboratory work by J. Omona, M. Oneka (Martin) and D. Mugabe. The staff at Paraa workshop and Ranger Guards in the park made it possible to safely reach study sites, despite the desperate conditions of the research vehicles, and also freely made available at my disposal their experiences. I particularly would like to mention the driver-mechanics J. Opiyo, A. Byaruhanga and J. Otim. Probably the most important lesson I learnt from all these people was that without relevant personal support, however good the ideas one has, the park can be a very lonely, frustrating and ruthless place in which to work and/or live.

The studies of fire in the Murchison Falls Park were formulated and executed under the supervision of E.L. Edroma with assistance from Professor P.H. Omara-Ojungu. In the fire research collaboration with the University of New Brunswick I also had a field visit and technical advice from Professor T. Dilworth (from Canada), A. Ogen-Odoi and E. Sabiiti. The animal census was stimulated by the collaboration with Professor D. Pomeroy, J. Tindigarukayo, D. Etori and the other members of staff and graduate students of the Makerere University Wildlife Biology course. Mr T. Katende facilitated access to the Makerere University Herbarium (Botany Department) and also helped to identify the plant specimens.

The studies benefited from the landscape ecology course in ITC, Enschede and linked to this course a field experience in parks of Thailand. I acknowledge the training I got from the staff of the ITC Rural Surveys Department especially Professor I.S. Zonneveld, H. van Gils and Professor W. van Wijngaarden. Various departments and staff members of the Wageningen Agricultural University have directly helped to shape this work. Despite a very brief working contact the late Professor D. Thalen initiated, in the former Department of Nature Conservation, a framework which provided a stable base for much of the groundwork for this book. Both the staff and students in the Department provided an environment in which the ideas in this book grew. The support from C. Geerling, S. de Bie and Professor C. Stortenbeker helped to minimise the effects of the sudden death of Professor Thalen especially with regard to the admission formalities for the Ph.D. programme. The arrival of Professor H.H.T Prins could not have been more timely with most planned work grinding to a halt due to funding constraints. Under his supervision the study programme underwent a preliminary restructuring with the focus on ecological dynamics. The interactions with him and other members of his department contributed immensely to the evolution of this book. In this respect I acknowledge the contributions of P. Ketner, I. Heitkonning, J. Kairu, M. Voeten, A. Heringa and the secretaries. Above all, your encouragements enabled me to fight a little longer than I probably would, especially in some of those difficult moments.

The original Ph.D. programme, though based in the Department of Nature Conservation, was initiated and largely coordinated by Professor R.A.A. Oldeman, chairman of the former Department of Silviculture and Forest Ecology. The programme had a broad base also supported by the Departments of Remote Sensing and Land Survey, Landscape Planning and Landscape Architecture, and the Centre for Geographic Information Processing (CGI). Under Professor M. Vroom and I. Duchhart I prepared for and did my qualifying examinations in Landscape Architecture and Landscape Planning. In subsequent stages the two supervised the landscape planning and landscape architectural aspects of this work. Their inputs were critical in developing the analytical description of the Murchison Falls Park presented in chapter 2. I therefore owe to them much of my understanding of the approaches used by landscape architects in dealing with land development. I got much support from Professor M. Molenaar and J. Stuiver (from Departments of Remote Sensing and Land Survey) and F. Rip, R. van Lammeren, R. Eweg and the other members of staff of CGI. The work with these people helped to lay the technical basis of the views expressed in the present book regarding the possible role of computer-based information systems in parks. I found co-supervising students and participation in workshops with these people particularly revealing partly because many of them, unlike me, were from planning background. Although for various reasons it was impossible to develop this programme in that form beyond initial phases, the experience from it helped to appreciate the realities of implementing truly multi-disciplinary studies.

The unfailing technical and moral support from Professor R.A.A. Oldeman from the initial phases of the Ph.D. work created an institutional niche without which this work could simply have not survived many of the challenges it faced. His introduction of me to the Department of Ecological Agriculture exposed me to the techniques of green design, i.e. the design of living systems, and the potentials therein for sustainable land development. Professor Oldeman supported the work in various forms. He provided the open mind which I needed to freely examine many of the concepts which emerged in the course of this study. I had unrestricted access to his office, computer and massive private collection of reading material (many of which are not published and so would otherwise be virtually impossible to obtain). My discussions with several members of the Department of Ecological Agriculture also helped to build my appreciation of green design over-all. Comments of Professor E.A. Goewie on an earlier draft helped to minimise the communication gap with those not familiar with green design. I am indebted to the following librarians T. Bouwhuis (IBN-DLO Leersum), F. Kampes and colleagues (Dreijenborch), members of staff of the library in the IBN-DLO (Dorschkamp), those in the Department of Agronomy (TEELT) as well as those in the African Study Centre (Leiden).

Many friends and relatives have contributed to this work in various forms. As I grew up my family, peers and friends exposed me to a mine of earth lore which I later have found very useful in my park career. I remember in particular the lessons in our courtyard around fire in the evenings (*wang oo*), herding cattle, hunting and fishing. Some of the memories that linger on include the sleepless nights drumming and making noise to chase elephants away from crops, and the amazement of the gigantic spoors and heaps of faeces full of thorns remaining in their trail. Then the realities of poverty, ill-health and the lack of development all around in the country-side, a situation which has even worsened with time. Growing up submerged in this type of setting has significantly influenced my formal education which together provided a foundation for this book. Many statements made in the book draw on this common knowledge and I cannot identify one authority. I learnt a lot from *babá* Yairo Ojok who was more than a father. I learnt from him many things which I have since seen reported as discoveries by scientists. When I recall what he drew my attention to as I walked through the bush with him the intimate knowledge he had of the plants compares with many described in ecological books. He has helped me to realise that with the loss of people of his generation we are losing the people who have truly grown up in the landscape and through that have unrivalled knowledge of their landscapes.

I also would like to thank some of the people with whom I have had the opportunity to discuss various aspects of this work. Of special importance were M. Hoeft, A. Velazquez, J. van Dam, J. Bos, E. Koldenhof, A.C. Hamilton, N. Rozemeijer, P. Budde, R. Bwire, P. Verweij and A. Jacobs. Your intellectual and moral support helped to broaden the basis of this book. The French translations was controlled by C.K. Traoré, H.Oguli and Professor R.A.A. Oldeman. The Dutch translation was controlled by E. Koldenhof and Professor Oldeman. I acknowledge you, together with many others not named here, that helped provide the context within which this book evolved.

The significance of your contribution to this work is comparable to that of the environment in the growth of a tree in the African savanna: be it like the supply of water, the incidence of fire or the case of pollination. Whether perceived as small or big, the input of each element made the difference in its own ways. To you all, named or not, I give my whole-hearted thanks. To those of you who have not lived to see the final results of what you contributed to I dedicate this book.

Michael Oneka
Wageningen, The Netherlands
28 November 1995

NOTE:

List of figures in full colour

The following figures have been put together on pages 106, 107 and 110.

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CHAPTER 1. INTRODUCTION

1.1 Central concepts

The word park as used in this book refers to category II, *National Park*, as defined in the United Nations List of National Parks and Protected Areas (IUCN 1990). This is land set aside for the primary purpose of conservation of specific features. The features may be some peculiar environment such as the tropical rainforest (Petocz 1984), indigenous wildlife as in many African parks (Ouma 1970; Myers 1972; IUCN 1987), or a cultural practice (Nelson 1982; Meganck & Ramadial 1984). In comparison to the biblical *ark of Noah* (Genesis 6:9-22 to 8:1-19; Myers 1979) the parks are land set aside to preserve what they contain. Unlike the ark, however, parks are not for temporary refuge but are for posterity. In countries ravaged by wars, the aftermath of war offers a chance to review the design of a park to provide a technical basis for programmes to renew it. Hindsight on the Murchison Falls Park, Uganda is drawn upon to highlight some elements of park design. The present book examines how to provide, in the design of a park, for relevant aspects of institutional development so that they are rooted in the true nature of the park systems. As discussed in the present book, the definition of a park system incorporates not only the biotic and abiotic components enclosed within the legal park boundaries but also socio-economic and political components which are functionally part of the park. A human population hostile to a park constitute as important factors as uncontrolled large herbivores in the park's ecological processes. A broad definition of a park system is thus considered essential for its design.

Beside the primary goal of preservation, often parks have to fulfil other important functions. The goals of parks differ per country and in a country from park to park (MacKinnon & MacKinnon 1986; IUCN 1987 & 1990). In poor countries besides their preservation roles, the parks are expected to contribute to the national economy (Myers 1972; IUCN, UNEP & WWF 1991; Kemf 1993). The UNESCO MAB (Man And the Biosphere) programme was initiated to develop and to demonstrate concepts on how to preserve natural resources while using them to promote economic development (UNESCO 1970; IUCN & UNESCO 1979; Batisse 1982 & 1986; Hadley & Schreckenberg 1989; Young & Solbrig 1992). Whereas one of the goals of parks may be to provide recreational opportunities, there is a big contrast between them and the recreation parks found largely in urban areas (Rutledge 1971 & 1985; Simonds 1983; Lynch & Hack 1984; Baljon 1992). In the recreation parks requirements for use by man receive priority over conservation. Since requirements of the various human activities are fairly well-known (see e.g. Rutledge 1971 & 1985; Lynch & Hack 1984), the design of recreation parks is comparable to that of houses, bridges and roads. It is in the design of recreation parks and similar structures that much experience exists. The parks as discussed in this book are living landscapes and their design call for different approaches, an area in which experience remains fragmentary. The present book examines some aspects of park design and makes proposals aimed at strengthening the development processes of the parks.

Park design

The word design, as used in this book refers either to the process through which forms and/or functions are innovated, or to the product of such a process (Simonds 1983; Lynch

& Hack 1984; McCullough 1990; Lucas 1991). Which of these meanings applies depends on the context in which the word is used. Another word widely used in similar context is plan (Friedmann 1973 & 1987; Simonds 1983; Lynch & Hack 1984; Krieger 1987). Whereas both planning and designing deal with the structuring of functional and aesthetic relationships amongst components of a system, as treated in the present book, they are distinguished from each other in the extent of their details. If the ideas expressed exceed basic concepts and tend towards operational details then "design" is suggested. In contrast, if the given information is strategic rather than operational then "plan" is suggested. Planning and designing are two inseparable processes, the design defining the operational structure for the strategic and tactical plans.

Park design as used in this book is *green designing* since its result is the park's "*greenprint*" as termed by Bellamy (ex Oldeman 1990 p.6). This is because the design process covers structures and processes through which programmes (cf. building steps) are ceaselessly innovated to preserve the park as a living system. The design process involves all steps required to define a programme for the park development. These steps usually include the definition of the park objectives, necessary analysis and evaluation of resources and constraints, and the structuring of the functional relationships amongst the park system components. The final product of this process, the park design, should thus be functional: a model or portrait of the park. The design should convincingly show that it can achieve the set park objectives. Whether in terms of the process or the end result, park design is a puzzle! A puzzle because neither is predictable.

Park design is comparable to the design not of a house, but of a home. Although it is possible to sketch at any one moment the structure and functioning of the home, it is impossible to prescribe how it will develop beyond that moment. An architect produces a blueprint (design) for a house and that is as far as he might be able to go to structure and to prescribe the home. His design of the house provides for comfort in it and does not set rules of how it may be developed into a home. That process to become a home is largely the result of the interactions that evolve amongst people who use the house as a space to live in. Whereas the techniques for the design of a house are established, those for a home are not. In fact as Rutledge (1985) shows many objects end up in functions other than those for which they were designed. The design of a park remains a speculative attempt at putting its pieces together. That is, in a park the "house" itself is alive; hence Bellamy's greenprints (ex Oldeman 1990). In a design of a recreation park, for example if the only site available is swampy or marshy, the design may emphasize draining and keeping it dry. This is an example of landscapes resulting from design aimed at meeting the aspirations of man. Up to now it is more easy to find examples of disastrous rather than beneficial changes (McHarg 1969). The evolution of approaches treating landscapes as living systems is thus of interest not only to park design but also to land development as a whole.

Wars

The word war as used in this book covers all forms of conflicts (Ortega y Gasset 1927; Ogot 1972). Two forms of wars are contrasted: largely "non-violent" versus "violent" conflicts. Wars are considered in the present book as symptoms of differences of opinion or conflicts of interests. As such, they are inherent to societies and create volatile and unpredictable circumstances which require stabilizing institutions. In the absence of such institutions wars may result, as is the case in many countries, reported daily in the popular press. As Ortega y Gasset (1927) has shown, the history of the world can be explained in terms of such conflicts. Once wars erupt there is no remedy but to let them burn out. Wars cause many deaths, losses of property and changes in inter-personal relationships. In many such cases the care for parks does not fit in with priorities. Hence, parks suffer from wars: either over territories, political control or, as in many offices, over scarce resources or conflicting views.

The last two examples are typical of what is referred to in the present book as "non-violent" wars. These often originate from conflicting visions of a park, evolved from different ways in which such a park is perceived and/or modelled. In many cases, however, there might also be no fundamental differences in perception. For instance the wars might be due to struggles over scarce resources or to personal reasons outright. As Bonner (1993) and Chase (1987) illustrate, the manners in which these wars are fought can be very sophisticated. According to them such wars permeate the conservation scene in manners that favour "club" formation which often promotes more personal than institutional interests. The implications of this category of wars on park design are immense. Most importantly, as Chase (1987) points out, where one such a club gets entrenched in a park system it may lock out all those with contrary ideas. In this way the design of a park would be deprived of a more pluralistic opinion base: much in the same way as the promotion of a monocultural land-use practice. These situations, in which there is no room for opposing views undermine creativity and independent-mindedness, salient features of any design. Without appropriate institutions, such wars will therefore always hinder park design and development.

Violent wars are more evident and therefore are also more widely reported in the popular press. Some of the main causes of the violent wars in recent years have been either struggles over political control, territories, or resources (see e.g. Ogot 1972). In the course of wars much destruction occurs (Hjort af Ornäs & Mohamed Salih 1989), many lives may be lost (von Orsdol 1979a & b; Cameron 1981; Decter 1981), and as shown from regions where land mines have been widely used, the losses may continue far into post-war periods. The cover picture of the present book shows armed ranger guards in the Murchison Falls Park, Uganda. Ranger guards are the people who combat illegal activities in many parks (see chapter 8). In many respects their work consists of truly military operations. In recent wars and subsequent changes in Uganda, the parks have lost a large proportion of their manpower. Of the people on the cover page, the two senior staff are no longer in the park system, while probably the ranger guards have also left: either killed or forced to flee. The persistent loss of personnel and property hinder the development of a park. Without stable socio-economic and political conditions programmed management, as proposed in the design of many parks, is impossible. As will be shown for Uganda such instability can directly threaten the status of the parks especially where they are not popular amongst local people. In the absence of suitable institutions, a change of government may usher into power people who indeed unlegislate some of the parks. During the Amin era, by presidential decrees some of the protected areas were unlegislated (Uganda Government 1972a & b) while the starting of bush-fire was banned (Uganda Government 1974). The ban of burning in the country-side could help control illegal fires around the parks. Since the Amin era, the embargo on hunting in Uganda has helped create conditions to allow the wildlife populations to recover (Uganda

Government 1980b & 1982). These cases highlight the unpredictability of the conditions and underscore the need to innovate appropriate institutions in park design to deal with such dynamics.

The above conditions created by wars provide a peculiar context engulfing all parks. There are no reports of any park design which incorporates such conditions, understandably so because it is not possible. In such a situation how credible are park designs which do not incorporate such critical features of the parks? Moreover, what about circumstances where only fragmentary insights exist in the dynamics of the park systems? Or what about in circumstances where the definition of the park system does not include over-all socio-economic and/or political factors as part of the park system structure? These are the types of questions that will be tackled in subsequent parts of this book with emphasis being put on institutional aspects of the park design.

Institutions

The word institution as used in the present book refers to structures and mechanisms through which specific functions may be accomplished. Institutions are organisational systems with their own routines for solving specific problems (North 1990). These routines or practices may be in terms of formal operational procedures but may also be purely a set of value systems. Mugabe (1994) compares institutions to organisms and equates routines in institutions to genes in organisms. According to him the evolution of an institution depends on whether its routines adapt to changes in its circumstances. He argues that if the routines do not adapt to enable the organisation to "generate or search, acquire and utilise new information" the organisation might not survive. The present book suggests that indeed a broader perception of institutions would be more appropriate especially with regards to park development. The book considers institutions as living systems. As such, institutions are considered to have complex and dynamic internal structures. Although these internal structures are influenced by their external environment, they are also able to influence it.

The growth and development of an organism is the combined result of processes inside as well as those outside it. In a multi-celled organism the death of a cell does not hinder the normal performance of the organism. Imagine, for an example, an animal that lives in a fire-prone area. When fire prevails the organism knows how to react. In fact, as shown by Ogen-Odoi and Dilworth (1987) and also by Velázquez (1993) predating birds take advantage of the burnt environment in their hunts. In many cases the sight of smoke already attracts them to the site where there is fire as they have learnt to associate it with food. These sketches illustrate in many ways institutions. For instance, when an institution lacks functional components (cf. organs or species) the defects will be reflected in its behaviour and performance. The defects will prevent the normal growth and development of the institution. Similarly, despite a normally functioning internal structure, if an organisation has unfavourable external environment its growth and development will be adversely affected too. For the parks to survive it is imperative that their designs provide them with the constituents needed for them to grow and develop normally. Their designs should help them to develop resistance to or resilience after the impact of wars. Wherever possible the design of parks should enable them to take advantage of the changes in the environment of the parks. The case presented by Chase (1987) of a systematic cover-up of policy failures in the Yellowstone

Park in the United States of America illustrates the damage that can be wrought by power-play in park institutions. In the present book it is suggested that such risks should be amongst items in future research on institutional aspects of park design and their development.

The park objective to preserve specific features for eternity introduces an important feature, longevity, required of park institutions. As mentioned earlier in comparison to the ark of Noah parks are not for temporary refuge but are for posterity. An organism is conceived, born, matures and dies, but to meet the preservation objectives, a park institution must have everlasting life. How this should be achieved by major park design features is the focus of attention of the present book. By focusing on the evolution of relevant institutions the design of a park is approached from the aspects through which the capacity of the park system to deal with uncertainty can be developed. Unfortunately they are also the aspects of land development in general that have hitherto been the object of little serious analysis. The future of green design and with it sustainable land development will depend on the improved understanding of the dynamics of relevant institutions.

The history of the park idea is filled with various attempts to develop landscapes to meet set conservation goals (see e.g. Willock 1964; Batisse 1982 & 1986; Hannah 1992; Chase 1987; Kemf 1993). A closer examination of the attempts reveals a clearer picture of the park design problems overall. The cases presented by Willock (1964) and Hannah (1992) illustrate these problems rather well. Willock wrote at a time when the general belief was that to develop a park the best way was to *lock man out* of the landscape and to *let nature take its course*. It was also believed that the economic returns from the *"non-destructive"* use of the park by tourists would enable national economic growth and development. The book by Hannah coming three decades later provides an interesting context to view the ideas that dominated the design of parks at the time when Willock wrote. The cases in Hannah (1992) show that by focusing on elements within the *"enormous zoo"* (Willock 1964), the designs of most parks missed out the linkage between social, economic and political processes and the dynamics of the parks.

In the cases presented in Hannah (1992) are attempts in different parks to address the problems of poverty. The focus is squarely on the socio-economic rather than ecological aspects of park development. The issues raised by Hannah (1992) are further illustrated in Kemf (1993) by such examples as the CAMPFIRE programmes in Zimbabwe. In all cases there is a general admission that no one knows the precise manner in which parks can be developed. Indirectly these cases prove that whatever attempts are being made to develop the parks rest simply on trial and error. The Yellowstone National Park being the oldest park (Chase 1987; IUCN 1990) is looked at from other parts of the world as an example. As Chase shows, however, many disastrous errors continue to be made even in the Yellowstone, threatening some species with extinction.

The empirical basis for the cases examined above largely consists of the intimate contact of the authors with the issues discussed. For example, reading the cases in Hannah's or Kemf's book no statistical proof is required to appreciate the plight of an increasingly impoverished people, no longer able to feed or take care of themselves. The images of open hands stretched out for help, the tear-full faces and the cries of naked and starving children leave in the minds of thinking on-lookers un-escapable moving shadows. This is because in many parks some of these images are the only tangible results of park development: proof that the park design puzzles went wrong. Related consequences of these include poaching, encroachments, extinction of species, etc. When Chase (1987) talks of a dying park there is an awareness of the ills besetting the system that only intimate insight can provide. To the advantage of those who come later, the examples prove that when an error is made the results eventually show up. This is interesting because that is what happens in a puzzle: at times the parts fit, more often they do not! In each trial a development approach is either conceived or copied from a similar case. The steps that follow are made as confidently as if that development approach had been tested and would certainly lead to the achievement of the goals, just like a tested medication would in treating a common curable ailment. A development approach, *formula*, that seems to work in one park is rapidly copied in other parks. While the approach is being copied in other parks, it might be on its way out from the park where it originated, having proved that it does not work. It illustrates that the main challenge to the development of parks is not so much a lack of technical insight, as it is the lack of understanding of the context in which such insight is applicable. In the absence of such understanding the evolution of parks to-date can be characterised as attempts at fixing a puzzle, and yet formally dealing with it like any other normal design problem. The range of examples is very diverse.

The above arguments can be illustrated by any aspect of park development as follows. There are debates on if and how man should intervene in ecological processes (Laws 1968, 1970 & 1989; Caughley 1976; Owen-Smith 1983; Chase 1987; Oldeman 1991; Velazquez 1993; Verweij 1995). What should be protected (Myers 1979 & Myers 1988; May 1980; Nilsson 1986; May 1990; Vane-Wright, Humpries & Williams 1991)? What is the place of local people (Parker & Graham 1989; Hannah 1992; Kemf 1993)? In what ways should the parks be used to promote economic development (Bere 1957; Clarke & Mitchell 1968; Ouma 1970; Jahnke 1972; McMaster 1974; Myers 1979; McNeely & Miller 1984; Batisse 1986; Munasinghe & McNeely 1994)? In what ways should the features and/or conservation programmes be evaluated (Taylor & Walker 1978; Margules & Usher 1981; Thresher 1981; Tisdell 1990)? Can the parks be viewed and treated as stable systems (Laws et al. 1975; Caughley 1976; Huntley & Walker 1983; Owen-Smith 1983; Clifford & Specht 1986; Prins 1987; Oldeman 1990; Behnke, Scoones & Kerven 1993; Scoones 1995)? Viewing park design as a puzzle provides a context in which all the above issues and others not cited would fit. In fixing a puzzle the only formula is the formula which fixes the puzzle correctly! Accordingly, subject to the case at hand, any combination of these often mutually exclusive options could constitute the right formula. In practice, it calls for open-mindedness to explore possible formulas to solve the puzzle.

The perception of park design as an attempt at solving a puzzle would be a fundamental step in the evolution of park philosophy and would influence measures taken in response to the above questions, regardless of the situation. This would be so whether the problem is with elephants (Lamprey et al. 1967; Savidge 1969; Croze 1974; Caughley & Goddard 1975; Ross, Field & Harrington 1976; Owen-Smith 1983; van Wijngaarden 1985), or fire (Trapnel 1959; Sinclair & Norton-Griffiths 1979; Pellew 1983; Cowling 1992; Shea 1994), or rural development (Ouma 1970; Lele 1974; Hannah 1992; Kemf 1993), or relevance of zoos (Wayre 1969; Benirschke 1983), or poaching (Leader-Williams, Albon & Berry 1990; Barnes & Kapela 1991); or evaluation of the network of protected areas

(Lamprey 1976; MacKinnon & MacKinnon 1986). Given this context the relevance and the place of detailed research and monitoring in park design would be clearer. They would have to provide the feedback, the results of any approach or assumptions on park development. Such would be the context in which to view new ideas such as ecotourism (Tobias & Mendelsohn 1991) and ecoforestry (Oldeman 1995). The use of computer modelling to test new approaches (Kessel 1979; Starfield & Bleloch 1986; Sol, Takkenberg & de Vries Rhodbe 1987; Huston, DeAngelis & Post 1989; Stuth et al. 1990; Velazquez 1993; Michelmore et al. 1994; Brinkman 1994; Verweij 1995) could become a critical tool in park design. It could help to eliminate some of those field experiments which are very expensive in a cost-benefit perspective.

Park design as a puzzle

Given the above background, with much of the park system patterns and processes unpredictable or simply poorly understood, the present book proposes that a new perception of park design is essential. It is proposed that park design is a puzzle and should be treated as such. Park design is a puzzle, because if the constituent parts are not fitted together correctly, the failure will surely surface. Unlike ordinary puzzles, the pieces are alive and the relationships amongst them are complex. In dealing with a park design one is faced with a puzzle in which the pieces are not only complex and dynamic but also have complex and dynamic relationships amongst themselves. If park design is to succeed, attention should focus on the analysis of the design process itself with a view to developing relevant institutional capabilities. A strong institutional base would provide the appropriate context in which to deepen insight into the park system's objectives, patterns, processes and how they interact.

As a puzzle, the park design process attempts first to see the contours of the pieces making the puzzle of how the park system works and second, to join the pieces together into a development programme. In the design, the programme schedules and logistics are worked out. Even where no formal design exists, as is true for most parks, various forms of programmes exist reflecting some underlying assumptions concerning the structure and dynamics of the parks. Imagine a park landscape in which fire is a salient piece of the puzzle. If fire is considered bad for the park system, by design a large part of the park development programme will be devoted to its control. Until recently, this has been the case in most national parks (Wein & Edroma 1986). In these cases, wherever fire control was effective, the negative perception of fire has had drastic impacts on the park. The resulting situation is typical of what Chase (1987) showed as the perils of man *playing God in nature*. Effective fire control in a fire-prone landscape results in biological communities adapted to fire being replaced by those requiring protection from it. Later when fire occurs in such a landscape it can wipe out the fire-prone community. This can be a major disaster, i.e. proof that the fire puzzle persists and that by adding control pieces the puzzle is wrongly fitted.

The complexity and dynamics of the park systems call for design approaches different from those used for houses, roads and such facilities. Taking the above example of fire, the numerous aspects of the fire problem make it most unlikely that it can be solved once and for all. With regard to park systems in general in the short term a park design may create the false impression that the puzzle has been solved. Just as it seems that all the pieces begin to fit together there comes a drought, a flood, a civil war, or a big lottery win by a key poacher! What is predictable about these types of incidents is their unpredictability. Any one of these types of changes can dramatically alter circumstances in and around the park, which changes trigger waves of new changes that ripple through the park system comparable to *singing in a bottle*. One action triggers other actions and reactions which finally conceal the original cause (*cf.* concept of determinate chaos in Gleick 1987). In dealing with the challenges of how to develop the parks, the seemingly technical nature of the problems caused attention to be turned to scientists, especially to biologists. In the absence of other tools these original largely biological, quasi-ecological foundation, has continued to dominate views shaping the design of many parks. As put by Saraph (1994) "... when the only tool you have is a hammer, every thing begins to look like a nail...". To-date many park development programmes continue to reflect this narrow base. With park systems so complex and dynamic, park design will remain a puzzle especially given the lack of appropriate perceptions and tools.

To make a park design that would work requires an appropriate information base. Much emphasis is currently placed on a multi-disciplinary approach to park design. To get a holistic treatment of the park system, the design team is composed of experts drawn from different professional backgrounds. Analogy is drawn to a cooking *recipe*, in the hands of a mother, used to bring out of disparate ingredients the satisfying feeling of *one strong taste*. It is said amongst many tribes in Uganda that a child believes its mother is the best cook until the child tastes food cooked by someone else (Apoko 1968). Subject to the team of experts selected for the design of a park, it is possible to have a situation comparable to that in the well-known story of a *team of blind men* fighting over the description of an elephant. A team of blind men with no prior knowledge of an elephant was asked to survey an elephant. Each member of the team touched a different part of the elephant. Afterwards when asked to describe the elephant they were intensely at odds with each other. Although they touched complementary parts of the elephant, they lacked a formula to approach "the elephant". In the same way, different professional backgrounds of the experts create new puzzles in the park design process: a park system is more than the sum of its individual elements. As van de Veen and Lardinois (1991) put it, the park like a forest, is greater than the sum of its parts, a point they succinctly expressed as "*tussen de bomen groeit het bos*" (amongst the trees grows the forest). Likewise, a park is the result of the interaction of parts, the complexity and dynamics of which defy the acquisition of holistic insight by attempting to sum up the opinions of a selection of experts. The resulting and persistent lack of insight in park systems reduce park design to speculation even though the designer perceives this differently. Viewed in the long-term, the design of the park indeed remains a puzzle. The main role of the designer should therefore be to innovate formulas that can ease putting the pieces together as the park system evolves. Towards this end it is essential that the design covers the creation of institutions enabling the accumulation and the deployment of experience to ease putting the pieces together as the park system evolves. The accumulation of experience calls for the evolution of a *memory system* with a lifespan exceeding that of man. This is an area in which computer-based information systems are certain to make critical contributions.

The only test of a park design is how it works in practice. Many park designs are confidential documents and so are not open to public scrutiny. Besides, the development of most parks is only marginally influenced by their existing paper designs. This is because the designs and plans lack reality on the ground and even if they try to provide it, their reality is ephemeral, the park not being static. What happens then is, that events in the park are influenced more by factors on the ground than by any existing paper designs. It thus becomes important that those who actually shape the park on the ground are viewed as part of the institutional make-up in the design of the park. In driving, the gears are adjusted to meet the ground conditions. When the wrong gear is used the vehicle begins to wobble and may even grind to a halt or change direction altogether. Getting the gears right together with, among others, a mastery of the traffic rules and knowledge of the direction are therefore essential to reaching a desired destination. Similarly, for park design to succeed it is crucial that it defines the classical patterns and processes in terms of institutional make-up necessary to achieve the set park objectives. With park design viewed in this way the significance of such issues as the evolution of favourable social, cultural, economic and political environments individually are as important as ecological issues.

It is doubtful whether the survival of most parks in many countries will depend merely on improved ecological insight. Park designs that hinge on such improvements are too narrow-based, therefore inappropriate, and potentially most dangerous and wasteful. Reference to cases such as the mysterious disastrous ecological attempts to develop the fisheries of Lake Victoria (Payne 1987; Watson 1989) makes it unnecessary to illustrate the risks in such approaches any further. As Oldeman (pers. comm. 1995) puts it instead of attempts at deriving parks from existing natural patterns and processes to work with, abstract theories and models are developed into which the real park systems are forced to fit. In the Lake Victoria case, the guiding theory was simple and for the time seemed very sensible (Payne 1987; Watson 1989). It was argued that introducing the Nile perch would act as an effective converter of the mass of smaller fish into few, larger piscine individuals. This would of course present the local fishermen with the much simpler and more efficient task of catching one or two large fish instead of literally thousands smaller ones. It was thought that this would optimize the advantages of the very diverse but small-sized fish species in the lake. The Nile perch, large and sometimes exceeding 200 kg as an adult, put in the right place in possible food chains, seemed to fit very well in such a model and got introduced in the lake. To-date the lake has become a major ecological and economic disaster. Most fish species which were of economic importance have been wiped out. A related increase in water weeds has become a major problem negatively affecting even the supply of fresh water from the lake to the neighbouring populations. These types of approaches, in which land development is used as a testing ground for fascinating ecological models, are very dangerous.

The issues discussed above are particularly critical given the relative institutional instability of many park systems. It is virtually impossible to find any park system in which many staff members stay for any considerable length of time. Many parks depend and will continue to rely on internationally available technical personnel. The trends are for parks to be designed by consultants whose contacts with the park systems are often short-term. Mechanisms have yet to evolve that would take advantage of the limited advantages in such circumstances. Realisation that park design is a puzzle would fundamentally change the park development debates. It would provide the kind of contexts in which whatever is done in developing a park is foremost viewed as purely a trial. With this perception, attention would be bound to focus on more stringent scrutiny of past actions and reactions in dealing with the present and in preparing for the future. It implies that in designing a park the emphasis would need to be put on defining institutions that would effectively enable such scrutiny and feedback. Chosen as an example in the present book is the Murchison Falls Park, as from the cover photograph.

1.2 Park design and development

Development of a park involves identifying, selecting, legislating and implementing a site as a park. While site selection spatially delimits the park, legislation specifies the legal framework, i.e. the limits within which it should be developed. All processes that have linkage to a park system influence the potential to achieve the set park goals even if they are not part of any comprehensive park development programme. To implement the park involves all activities that make it possible for the site to *evolve* into the desired *park*. This may include such activities as infrastructure construction, fencing and management (e.g. burning, ranger patrols, and infrastructure maintenance). What the authorities of the park adopt as their *ideal of the park* will determine what they set as their development and management targets (see chapter 3). Coupled to this is how the park system is perceived to work. The perception of the park system dynamics provides the basis upon which programmes are formulated to achieve the *reference image* (the ideal) of the park and will influence relevant development strategies.

Park development processes are determined largely by the interactions amongst their key components: planning, management/ administrative processes, research and monitoring programmes (MacKinnon et al. 1986). Through the planning process an area that needs protection is identified, its development objectives are established, and relevant plans are developed. The plans specify programmes, following which the park development may be achieved. Through the management/ administrative processes the programmes in the plans are executed. An appropriate characterisation of the park system by research and monitoring programmes is crucial to the planning process and aids setting reference standards to evaluate the development programmes. It also aids the planning process by highlighting the strong and the fragile aspects of the park system. The quality of the interactions amongst the planning, management/ administrative, research and monitoring programmes is thus very important in the development of the park. Where insights lack in the park's nature there is the risk of inappropriate design. The park design is then likely to relate poorly to realities of the site. For example, it might require a heavy financial input (e.g. costs of fire management, five star hotels) which in a given context may well be financially unrealistic, and probably is ecologically and aesthetically inappropriate. On the other hand it is possible that existing research and monitoring programmes provide information that is irrelevant with regard to prevailing circumstances of the park system. A park's design can thus be evaluated in terms of how effectively and efficiently it matches these components. In practice this expresses how far the park's planning, management/ administrative, research and monitoring components complement each other.

The various approaches currently in use to design parks fall in two main groups. The first group of approaches is common amongst designers often with no or little formal design background (Lusigi 1978; de Bie 1991; Crossen 1979; Croft 1981; Clarke & Bell 1986; Leader-Williams, Harrison & Green 1990). Here the main beginning points are the studies of the landscape leading to views on its potentials and limitations. Then proposals are made, in a regional context, on what can be achieved with the "resources" and how the constraints can be tackled. These insights become the basis of a design which often incorporates plans for further research and monitoring. The problem with this approach is that the more is known, the more unknowns are exposed, so that it becomes inherently impossible (Gleick 1987) to determine when enough is known to act. The situation in the Uganda National Parks is typical of this. The Uganda National Parks' researchers were predominantly biological scientists whose purpose it was to study the parks and develop the management programmes. Despite major scientific break through of the research and monitoring programmes (Laws & Parker 1968; Eltringham 1969; Beadle 1974; Laws 1989) their impacts on management and park development have remained marginal.

The second group of approaches is common amongst designers with formal design background. Here the beginning point centres on establishing objectives that need to be achieved through the design (Vroom 1973; McHarg 1969; Rutledge 1971). Then emphasis moves to examining the characters of the landscape to identify development possibilities and constraints. Next the design process centres on defining development programmes consisting of various activities the implementation of which could satisfy the set objectives. The major drawback here is often the lack of insight into the landscape patterns and processes. The above linear sequence in both design approaches has been included here purely to highlight the individual components and in general terms to show how they relate amongst themselves in a design process. Even though in practice the design processes are cyclic and are made up of several feedback loops, the placing of emphasis in the beginning affects the focus of the design as a whole.

The above point is particularly critical since the more is known about a feature the more value is likely to be attached to it. As shown by Omara-Ojungu (1992) human perception and existing technical capabilities define what is perceived as resources. Previously viewed largely as rich land suitable for agriculture or purely as a source of hardwood, tropical rainforests were felled to give way to agriculture or to get timber (Myers 1981; Aiken & Leigh 1986; Shukla, Nobre & Sellers 1990). Or as said by some in Indonesia "forest is potential rice" (Michon 1985). These types of perception of resources have had adverse effects worldwide and are largely responsible for the wave of extinction and threat of extinction of many life-forms (Myers 1979, 1985, 1986a; Aiken & Leigh 1985; Wolf 1987; Hoth et al. 1987; Malingreau Tucker 1988). The evolution of fields of studies such as biogeography and conservation biology (May 1975; Soulé & Wilcox 1980; Shaffer 1981; Myers 1983, 1984, 1986b & 1988; Shaffer & Samson 1985; Soulé 1985 & 1986) and landscape ecology (Naveh 1982; Naveh & Lieberman 1984; Küchler & Zonneveld 1988; Zonneveld 1990; Hanson & Angelstam 1991) is transforming the way in which Man perceives and deals with nature. The use of new techniques such as computer-based information systems make it increasingly possible to automatically assess land-use possibilities (Steiner 1991; Brinkman 1994; Eweg 1994). Many parks are one of two extremes in this respect. On the one hand there are those parks which are flooded with different computer packages offered by aggressive prospective system vendors. In many such cases the computer packages are promoted as if they were the unique tools to solve all the puzzles hitherto too complex. On the other hand, there are parks, often in poor countries unattractive to donors, where no attempts are made to try out the new techniques. In the present book a systematic testing of such new techniques is very strongly recommended. Given appropriate understanding, such techniques could help streamline the design process (Lansdown & Roast 1987). A definition of what constitutes an appropriate system for the park systems would therefore be of interest in the design of parks. Important are the places of man and the computers in such a system.

The points raised above are particularly serious in the case of "poor developing" countries heavily dependent on foreign expertise and finance to develop their parks. The lack of expertise often means that little technical insight exists locally into the character of their own parks. Another important feature is the often high level of illiteracy, entailing that, whatever design is developed, the scope for informed debates is limited. The evolution of well-informed population able to participate in the discussion of any design should therefore be an important item in any park design. In this context it is deplorable that many expatriate workers in developing countries only seriously collaborate with other expatriates and rangers who could never replace them when they leave. Besides, many expatriates have the tendency to claim that "we know best", an attitude which does not favour taking seriously whatever contributions from the local people. Working in the Kalahari I was always puzzled by the design of the shelter used by the Bushmen. One night about four o'clock in the morning, camping a few metres from the Bushmen, we were woken up by a storm which nearly blew off our tent. This experience helped me to see the wisdom of shelters of the bushmen which, unlike our tent, allow winds to pass through unhindered. Such an experience cannot be predicted. In fact it is necessary to develop a design that truly capture the spirit of the site (McHarg 1969; Rutledge 1985; Vroom 1973). It is therefore difficult to take seriously experts who fly into an area one day and have a design for it the next. This unfortunately is the way many parks are being designed to-date. Viewing park design as a puzzle, as advocated in the present book, would bring pressure to bear on the designer to define processes instead of focusing on some physical structure or activities such as dates of fire. Such an approach would call for the design of the park to innovate mechanisms through which the abilities of relevant institutions evolve enabling the park system to cope with its evolving circumstances.

During recent wars in Uganda the parks lost virtually all their infrastructure (von Orsdol 1979a & b; Decter 1981; Kayanja & Douglas-Hamilton 1983; Anonymous 1986; UNEP 1988). Under these circumstances effective government control in the parks has been impossible and as a result local people have encroached on the parks (von Orsdol 1986; UNEP 1988; Eltringham & Malpas 1993). In the unrest in Northern Uganda most local people who lived in the fringes of the Murchison Falls Park have been displaced and their settlements were destroyed, so they need rehabilitating. As plans are made to rebuild the park and its surroundings, this study examines the park's design looking beyond the wars (see definition given above). This is a deliberate attempt at converting the war damages into a lesson, enabling us to make a new start, with a development process that this time would be more sustainable. It is hoped that the book will contribute to a true peace process in the park region and help the park, in a sustainable manner, to evolve beyond the ravages of the wars. The cases discussed could be interesting examples to parks in other regions ravaged by wars. In these regions the space to introduce new design ideas has been created by the wars, as a tiny beneficial side-effect from their tremors. On the broader scale, the issues raised affect green design and park design in all places. In that respect the book could be an interesting reading to those involved in land development issues.

1.3 Study approach

The elements of the design of parks as discussed above are illustrated through case studies presented in the following chapters. A park, the Murchison Falls Park in Uganda, was selected for more detailed analysis of key aspects of its development to highlight major design issues. Since its creation, the integrity of the Murchison Falls Park has come under severe stress from poaching, fire and large variations in the densities of herbivores. Fire and herbivore damage (see figure 1.1) transformed most woody vegetation to open tree-less vegetation (see figure 1.2). As management responses to these problems elephant culling and fire control were initiated. Since the 1970s political unrest and related wars in Uganda have disrupted all programmed development. The related increase in poaching has drastically affected the herbivore populations and the fire control has largely been abandoned. Although the regeneration of woody plants appeared widespread, the recovery of woodlands and forests has remained subdued. This mystery is examined in the present study in steps through which attention is also drawn systematically to specific institutional dimensions of the design of a park. The design of Murchison Falls Park is examined in terms of the park's objectives, patterns and processes. Through the case studies the inappropriateness of many techniques that form the foci of the design of many parks are illustrated. Only the barest of necessary technical details are included in the case studies so that the details do not distract attention from the central theme of the book: the design of parks. On purpose, much of the analysis focused on vegetation and fire. The choice of this focus was made in a bid to build an intensive rather than extensive examination of the park development problems and how design could help to address them. This approach is based on the assumption that virtually every problem offers various aspects the study of which can give as much insight as is obtainable from the study of a range of dissimilar problems.

1.4 Outline of the book

The concepts and issues presented in the preceding sections are elaborated in the following chapters. An analytical description of the Murchison Falls Park and its conservation and development circumstances are provided in chapter 2. The chapter shows how the park system has evolved and how this process has been impacted upon by wars.

When the Murchison Falls Park was established, the primary concern was to preserve the wildlife therein for the benefit of posterity. *Wildlife* effectively referred to wild animals and the main perceived threat to their preservation was the part played by humans as illegal hunters and/or starters of fire. These views were translated into a park management strategy primarily oriented by the objective to *keep Man out and let Nature take its course*. Within a decade, drastic changes in the park's landscape led to question this approach and prompted debates on the roles of management interventions in ecological processes. In chapter 3 Pandero woodland is used as an example to put in perspective these vegetation changes, highlighting the link between park management and park development. This woodland, formerly one of the most extensive woody vegetation in the park, declined in surface area by almost 80% between 1956 and 1985.

In chapter 4 the woodland described in chapter 3 is analyzed in more detail to highlight the need for insights into the conservation status and suitable models of park systems in the design of parks. The place and roles of analytical research are examined in chapter 5 whereby deep insight into key park structures and processes are shown as essential to a park's design. In the case study it is argued that the regeneration of plants fulfils an important function in the dynamics of a park. To be able to work properly with such processes an understanding of the processes is crucial to park design. In chapter 6 emphasis is put on the importance of correctly identifying key factors in a park system dynamics. It is shown that in the above vegetation case, despite changes in factors previously considered critical, the recovery of the woodlands has not responded as was speculated. The analysis of the pattern in factors which had hitherto been considered critical is presented in chapter 7. It is shown that the patterns of the factors are fuzzy and relatively chaotic and that the relationships amongst them are complex and dynamic. The last case study focuses on the human control system in the park. An analysis is made of the problems of poaching and mechanisms used to control it in the park. The patterns and issues that emerge are used to highlight the need in the design of a park to view and treat the park system in its broadest sense possible.

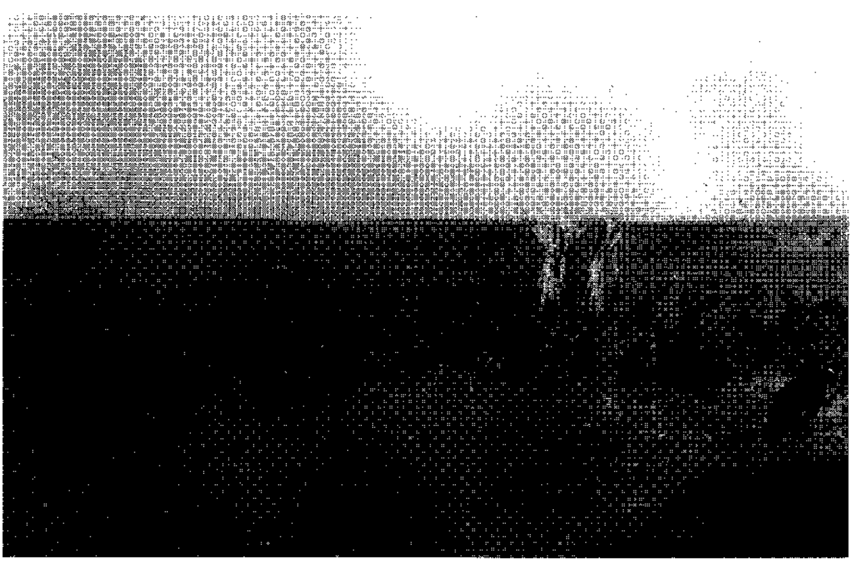

Figure 1.2 A typical open, tree-less landscape of the Murchison Falls Park. In the mid-ground are abdim's storks (migratory species) on a patch of land that had a typical severe (thorough) burn (most plant materials burnt). Photo by the author 1985.

A summary of the issues raised in the present book and suggestions on how to address them in the design of parks are presented in chapter 9. The conclusions highlight the need for the design of a park to innovate and to provide for the development of relevant institutions. It is argued that education and computer-based information systems offer immense potentials which could be exploited in the design of parks. In future research priority should be given to developing appropriate park design models as well as define models of park design.

CHAPTER 2. PARK OBJECTIVES, PATTERNS AND PROCESSES

2.1 General Background

This chapter examines some aspects of the objectives, patterns and processes of Murchison Falls Park. The main purpose of this chapter is to highlight the importance of a good definition of a park system boundaries in its design. It also provides a background against which to examine the objectives and strategies applied in developing the park. The details presented show a lack of critical information on the park system which situation would impair design of the park. It is shown that in such a case it is important that the design of the park define a mechanism through which the lack of information can be systematically addressed as the park evolves.

Murchison Falls Park is located within 1°50' to 2°35'N and 31°22' to 31°16'E in north-western Uganda (Figures 2.1 and 2.2). It was gazetted in 1952 while Uganda was still under the British Protectorate (Uganda Government 1952 & 1953; Willock 1964). Covering about 3860 m^2, it is Uganda's largest protected area. The park is bisected by the Victoria Nile into northern and southern banks (Figure 2.3). The northern bank is subdivided into Paraa and Chobe sectors by the River Ayago (Figure 2.3). It is bound on the west by the Albert Nile, human settlements and Bugungu Game Reserve, the south by Karuma Game Reserve, the north by Aswa-Lolim Controlled Hunting Area, the east and northeast by human settlements (Figure 2.4). Although outside the physical legal boundaries of the park, these surroundings interact with it in manners which make them integrated components of the park's systems dynamics.

Primarily to preserve examples of Uganda's indigenous wildlife and specific scenic landscapes such as the water-falls (see Figure 2.5) several sites have been accorded protection status (Uganda Government 1952; Willock 1964; Ouma 1970; Trustees Uganda National Parks 1971; Howard 1991). The sites accorded the highest protection are those gazetted as national parks (see also section 1.1). Apart from the Murchison Falls there are seven other national parks in Uganda: Bwindi, Kibale Forest, Kidepo Valley, Lake Mburo, Mount Elgon, Queen Elizabeth and Rwenzori Mountains (Figure 2.1). It was hoped that beside conservation, the parks would advance national development interests (Uganda Government 1952; Bere 1957; Willock 1964; Olivier 1990 & 1992). Efforts to develop the park have focused primarily on the animals, and on the other aspects of the landscape in as far as they directly related to the animals. It was expected that the preservation of the wildlife would provide opportunity for tourism based on game viewing through which economic development could be stimulated in the region (Bere 1957; Willock 1964). Vegetation management received attention largely as it furthered the interests in the animals and for aesthetic reasons. Development programmes of the park (Wheater 1968; Olivier 1992) have heavily been influenced by international thinking such as the concept of the biosphere reserves (UNESCO 1970; Forster 1973; IUCN & UNESCO 1979; Batisse 1982).

The main philosophies and strategies through which the park has evolved are as follows:

a. *-No management intervention, let "nature" take its course.*

Active management was generally unacceptable (Buechner & Dawkins 1961; Laws 1968, 1970a & b; Laws et al. 1975). To preserve biological diversity the park was gazetted and "nature" was allowed to take its course (Uganda Government 1952 & 1953). At first the animals were confined to the park by shooting and later man was kept out from the park by force (see chapter 8). The other features that were to be preserved (e.g. the scenic landscapes) were simply protected from significant modifications (Uganda Government 1952 & 1953; Wheater 1968).

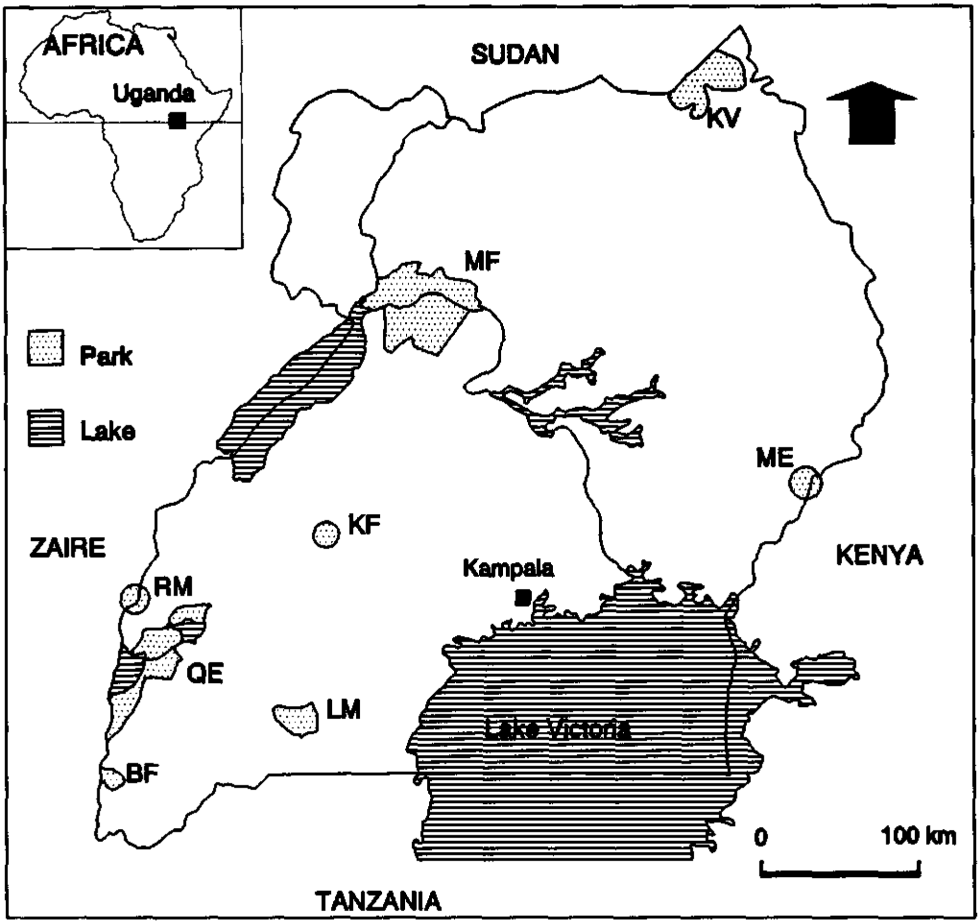

Figure 2.1. Location of the National Parks and some landmarks of Uganda

BF Bwindi Forest **KF** Kibale Forest **KV** Kidepo Valley
LM Lake Mburo **ME** Mount Elgon **MF** Murchison Falls
QE Queen Elizabeth **RM** Rwenzori Mountains

b. *-Encourage non-destructive recreational activities.*

Infrastructure for camping, viewing of game and scenic landscapes s well as for sports (e.g. fishing/angling) were developed (Bere 1957; Willock 1964; Ouma 1970; Trustees Uganda

National Parks 1971; Olivier 1992). Most notable are the roads for game viewing and tourist lodges at Paraa, Chobe and Pakuba in the park (Figure 2.2).

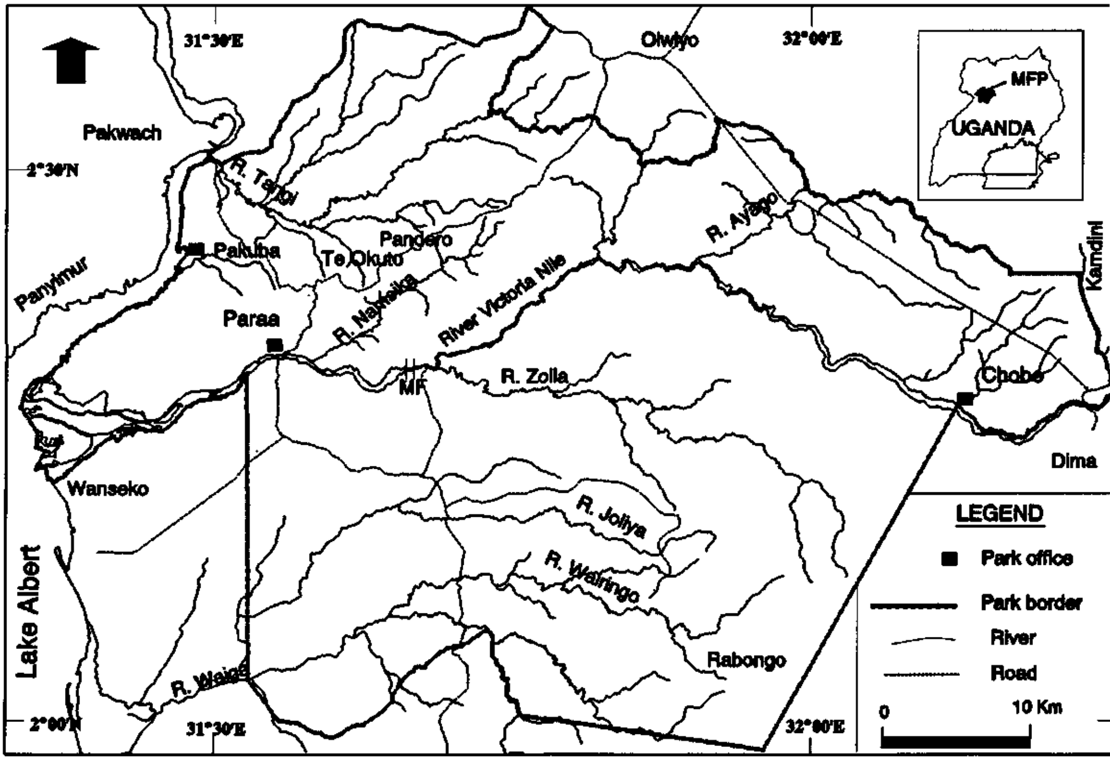

Figure 2.2 Main topographical features in the Murchison Falls Park (MFP) region, Uganda. The location of Murchison Falls is marked with MF on the map.

c. *-International tourism and sale of trophies*

This would promote economic growth and development (Bere 1957; Ouma 1970; Willock 1964; Myers 1971 & 1972; Jahnke 1972; Wheater 1974). A network of tourist infrastructure was developed and the park was opened for tourism based on viewing of game and scenic landscapes. Revenue was raised from the park entry fees, services, and souvenirs. Trophies such as ivory, rhino horn, skins of crocodile and leopard were sold to raise extra income. Local people were employed in the park and their employment benefits hopefully contributed to the development of the region. All revenues raised were transferred to the national treasury and therefore contributed to national economic development. The infrastructure (e.g. transport and communication) built for the tourist industry contributed directly to over-all regional economic growth and development.

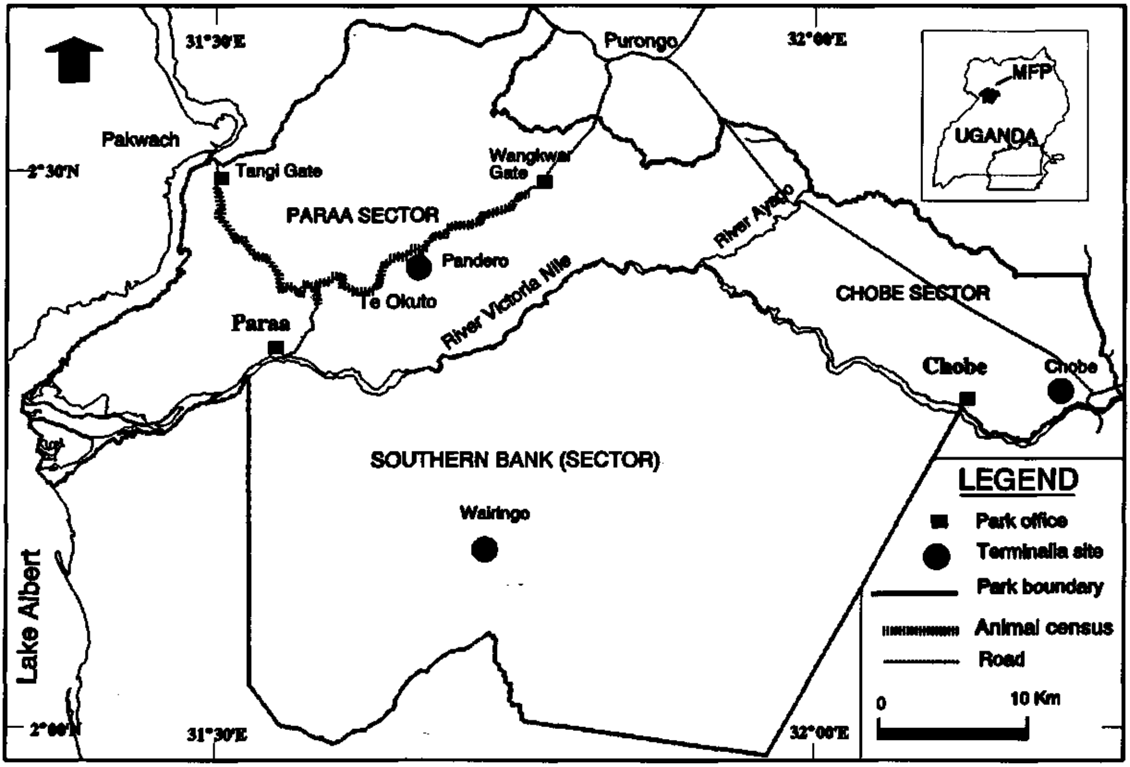

Figure 2.3 Major divisions of the Murchison Falls Park and the main *Terminalia* woodland sites. Animal census was done in the present study along the marked portions of the Paraa to Purongo and Paraa to Pakwach roads.

d. -*Use of cultural attributes in tourism*

This practice would raise cultural appreciation by local people and tourists (Ouma 1970). Traditional dances and skills were incorporated in the tourist industry. Local people were rewarded for dancing or playing music to entertain tourists in the park. The local people were also employed to build some of the houses (vernacular architecture) in the park.

e. -*Field education in the park*

Develop educational facilities to cater for field studies in and encourage visits to the park by education parties.

f. -*Opportunities for research*

Applied research was initiated and was promoted to provide a scientific basis for the management of the parks (Eltringham 1969; Beadle 1974; Laws 1989). The research contributed to the advancement of science and some of the work helped improve natural resource management (Petrides 1975; Petrides & Swank 1965).

These park development philosophies and strategies are reminiscent of a global picture (ole Saibul 1968; Owen 1972; McMaster 1974; Russell 1975; Ratcliffe 1976; Rylands & Mittermeier 1983; Chase 1987).

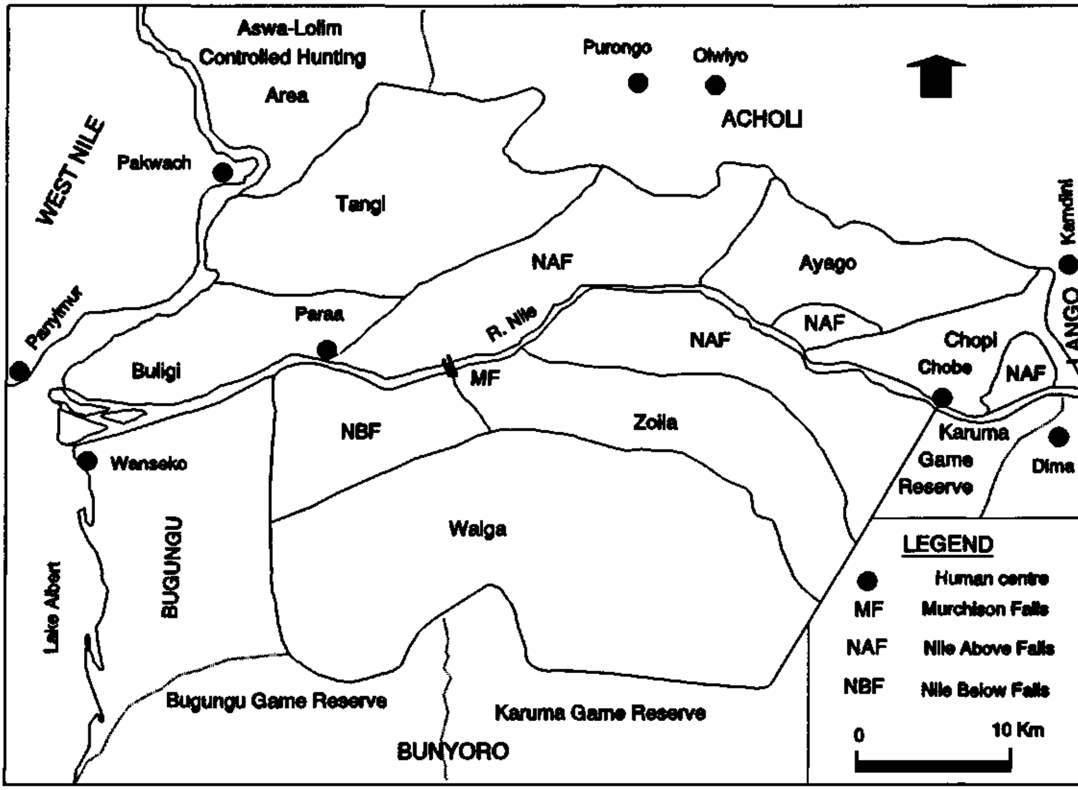

Figure 2.4 Location of major human centres and the main land-use practices in the Murchison Falls Park region (adapted from UNEP 1988). The patrol zones into which the park is divided are based on watersheds of the main drainage systems of the region.

2.2 Historical perspective

The influences of both man and animals in the Murchison Falls Park region pre-date 10,000 BP (Fagan & Lofgren 1966; Posnansky 1971). According to oral tradition and available historical evidence there has been major tribal movements in the region (Beattie 1960; Ogot & Kieran 1973; Atieno-Odhiambo et al. 1986; Sutton 1990). Most of the migrations were prompted by famine, epidemics, or wars (Crazzolara 1937; Webster 1979). The last people to occupy the region were mainly of nilotic origin (Baker 1866; Hodges 1909; Bere 1947; Morris 1963).

It is believed that the Lwo, the main nilotic ethnic group, were forced out of their cradleland in the Barh el Gazhal in southern Sudan by repeated drought and poor harvest

(Crazzolara 1937; Webster 1979; Atieno-Odhiambo et al. 1986). Their migration into the park region was generally along the Nile influenced by a fishing tradition and the need for secure water supply. Although many of these immigrants moved out of what became park (Lowth 1934; Crazzolara 1950; Gray 1937; Nyakatura 1973; Atieno-Odhiambo et al. 1986) many people remained there till the close of the 19th Century (Baker 1866; Churchill 1908). The region attracted the Arabs in search of slaves and ivory and the Europeans for the source of the Nile (Baker 1866; Atieno-Odhiambo et al. 1986; Sutton 1990). Around 1900 the park region became infested with human and bovine trypanosomiasis (Hodges 1909; Morris 1963). The epidemic of sleeping sickness lead the protectorate government to evacuate all people from the area by 1915 (Langlands 1967a). Before this period, cultivation of food crops, cattle rearing and hunting (which also sustained an ivory trade) were widespread (Baker 1866; Churchill 1908). These are land uses still practised amongst local people (Ocitti 1973; pers. observ. 1983/85). In virtually all of them fire is widely used (Bere 1934a; Langlands 1967b). Historical and cultural importance (human occupancy and exploration) of the park region have had only limited interpretation. Unfortunately some of the evidence is now disappearing.

The evacuation of people reduced hunting pressure on wildlife (notably the larger herbivores) and these rapidly increased through birth and immigration from surrounding areas. Outside what became park the British Protectorate administration began to promote economic development through export oriented agriculture (Barber 1965). This development policy required protection of crops from pests and vermin (especially the elephant *Loxodonta africana* Blumenbach). As what became park was unsuitable for human occupancy, it got sanctioned for wildlife and effectively became an elephant sanctuary. Any animals (game) *threatening* people and their property outside this sanctuary were *controlled* through the Game Department by shooting (Uganda Government 1955; Brooks & Buss 1962; Laws et al. 1975; Kinloch 1988). While wildlife decreased outside the sanctuary, inside it increased and supported licensed hunting (Kinloch 1988). A growing awareness of the general decline in wildlife coupled with a growing belief that the wildlife could provide an excellent basis for tourism (Bere 1957; Willock 1964). Changes in the perception of wildlife translated into greater legal protection to the animals (Uganda Government 1952). By 1952 when the area became park, the primary concern was how to retain the abundance and diversity of the wildlife for the benefit of future generations. Central to the park management strategies, from this time, were means to exclude man whose hunting and fires made the area *unnatural*.

During the 1950s and 1960s with growing international fame, the park witnessed an increase in the number of its tourists, a development which called for a range of services and catering facilities (Ouma 1970). By 1971 the park enjoying full political and material support accounted for up to 70% of tourist business, 32% of park employment and 60% of bed capacity for tourists in Uganda (Ouma 1970; Laws et al. 1975). Later in the 1970s, the Amin regime restricted foreign tourists. This move cut down the revenue from the park. Even after Amin the continued political unrest and related insecurity have hindered recovery of the tourist industry. With the Ugandan economy weak, the park has increasingly had to rely on a less readily available political and material support from the government to keep operational. Recent violent political changes have wrecked the park infrastructure and paralysed most management activities leaving the park hardly patrolled and poaching widespread (Oneka 1990). The park staffing is inadequate, ill-equipped, ill-supplied and demoralized (see chapter 8). The net result has been serious poaching and declining animal numbers (Eltringham & Malpas 1976; Malpas 1980; Edroma 1982; see also chapter 7). Design of the park over-emphasized international tourism and a dependency on government support. In the absence of such tourism and under ineffective or unstable government, the park system has come under severe stress. The above situations highlight the need in park design to give attention to the evolution of an institutional setup not only capable of withstanding such instability but also of taking advantage of it.

2.3 Cultural and socio-economic setting

The population density in the park fringes ranges from 25 to 99 persons/km^2 and is increasing by ca. 3% annually (Uganda Government 1980a). Until 1986 local people maintained traditional homestead settlements (pers. observ. 1983/85). A homestead consisted of several huts built around a courtyard within which lived 5-20 closely related persons: parents, children, grand-children plus close relatives(Apoko 1968; Ocitti 1973). The settlements were mainly along communication lines and around trading centres. Traditional rituals such as funeral, marriage and communal hunts reunited relatives and neighbours especially during the dry season (see figure 2.5). Most of the settlements were broken down since 1986 in the civil war and the people were forced into camps. Descriptions given below are of the situation that largely remain in dreams, images of old glory to be recovered through rehabilitation programmes. With the park in mind, as shown in the present book, that setup was already unsustainable. In the park, traditional dances and crafts from local people were used the tourist trade. From north of the park alone came more than seven traditional dances (Bere 1934a) many of which skills are disappearing. Such aspects of the park system will be very difficult to recover since the socio-economic context in which they evolve are also being lost. The points given below are proofs of pieces of the park puzzle not appropriately handled.

Around the park, on land largely communally owned and inherited along family lines, most people subsisted on agriculture (Lands & Surveys Department 1964; Ocitti 1973). This was mainly through growing crops such as millet, cassava, beans, maize, rice, groundnuts, simsim, potatoes, sunflower, cotton, tobacco and cowpeas. Except for the rice, tobacco, cotton and sunflower, the crops were primarily for domestic use. The agricultural products provided money to buy basics such as salt, soap and clothing. A few livestock (cattle, sheep, goats and chicken) were kept mainly for use on special occasions (e.g. marriage, funeral, etc.) or sold to raise money to pay school fees and poll tax. Most agricultural activities took place during the wet seasons which left most local people free during the dry seasons (Bere 1934a & b; Apoko 1968; Ocitti 1973). It was therefore during the dry season that hunting expeditions into the park and associated problems of fire were most serious (Chapter 8). Most people who lived along the western boundary of the park subsisted on fishing and often penetrated deep along the Nile into the park waters (Aerni 1969; Oneka 1990). If park development is to benefit these people as emphasized in *Caring for the Earth* (IUCN, UNEP & WWF 1991) then its design should help mitigate resulting socio-economic problems.

In the main human centres bordering the park (Figure 2.4) are local authorities, offices, churches, primary schools, medical services, shops, eating and drinking places.

These centres are in their nature typically halfway between the rural and urban areas. Until the Amin era these were small trading centres. Their rapid growth came about as the Ugandan economy began to decline while the roads passing through the centres grew in importance for transport of Zaïrean imports. The centres became important over-night stops for long-distance trailers which resulted in an increase in the commercial activities of the centres. The business opportunities attracted more local people hard-pressed by a worsening economic situation. Many of the people who lived in these centres were poor and somehow got involved in trade in game meat and the sale of trophies illegally procured from the park (see also chapter 8). The lack of economic development and related poverty are important pieces of the park development puzzle. As shown, the socio-economic and political situations are rather dynamic and complex.

Initial estimates of the contributions of the park to economic development in the region painted a very positive picture (Ouma 1970; Myers 1971; Jahnke 1972; Wheater 1974). The impression created by the poverty and the lack of development in the park region, however, point to the contrary. The contrast illustrates what is peculiar to the park design puzzle overall. While the furore lasts about an approach to solve the puzzle, in this case tourism and development, the resulting evaluations are invariably positive. These positive evaluations make it less easy to realise and to remember that whatever was done was just an attempt to solve the puzzle. The persistence of poverty and lack of development are signs that the attempt to solve the puzzle was unsuccessful. This issue also highlights the need for a definition of reference standards to evaluate economic development.

2.4 Conservation and development circumstances

Since the 1970s national political unrest has resulted in the virtual collapse of all socio-economic infrastructure in the region (pers. observ. 1986). The ensuing civil wars caused thousands of deaths and tens of thousands of displaced people. Observations in other parts of Uganda which has undergone similar turmoil do suggest a recurrence of previous socio-economic and cultural landscape patterns. When peace returns to the park region, the socio-economic infrastructure (homes, roads, schools, dispensaries, etc.) will have to be rebuilt. Similarly, within the park, facilities for tourists, education, research and administration have to be rehabilitated. Even before the civil unrest the lack of gainful employment in the region had resulted in a net exodus of people to urban areas (Ocitti 1973; Uganda Government 1980a). Apart from agricultural possibilities the park has been and remains one of the most important development avenues. The present situation in the region offers a rather unique but challenging opportunity to rethink the park development policies and strategies to make it contribute more effectively to the development of the region. Looking beyond the wars it should be possible to do this better given the hindsight and improved understanding that now exist on the landscape dynamics, and the funds ear-marked for rehabilitation. Attention should focus on identifying in which ways the park development puzzle could be better handled for benefits from the park to be enhanced and made more sustainable.

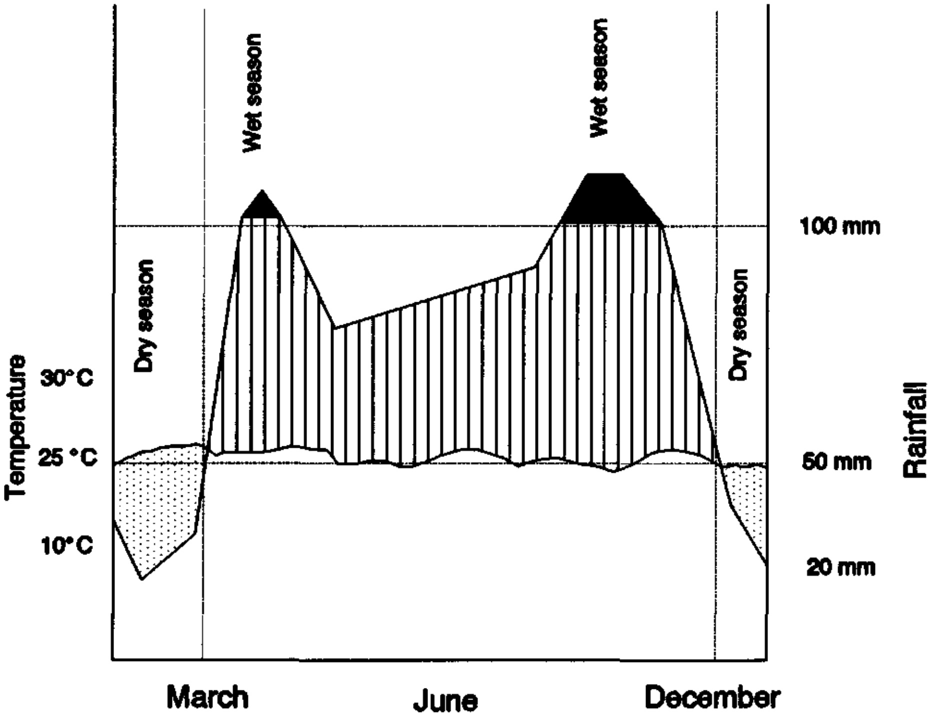

Figure 2.5 Ombrothermic diagram of Paraa, Murchison Falls Park, based on data obtained from Paraa Meteorological station and calculated using Walter's (1979) formula. Similar seasonal patterns apply to the whole park region.

In the past there were interventions from government and non-government organizations (NGOs) to alleviate the regional development problems. Government development policy has been to promote export-oriented agriculture by raising prices for key products (cotton, tobacco, maize and beans). There were also provisions for subsidised production inputs such as seeds, insecticides and hoes. Galloping national inflation, inefficient government controlled marketing systems undermined this strategy. Church-based rural development programmes have focused on activities such as cultivation of locally non-traditional cash crops (e.g. sunflower and rice) and imparting skills such as woodwork and sewing. Other NGOs also promoted skills such as metal-work (producing ox-ploughs, hoes, etc.), manufacture of fishing canoes and nets. Despite the civil unrest interventions by NGOs have been largely successful. These interventions reflect different perceptions of the ways in which the development puzzle can be fixed.

The civil unrest disrupted many ecological processes (pers. observ. 1985). The country-side abandoned by fleeing people saw the recovery of woody vegetation and of land increasingly menaced by soil erosion due to sustained use. Woody vegetation had been declining under a growing need for forest products (firewood and building poles). The declining vegetation cover was aggravating seasonality in the quality and quantity of water supply (Hamilton 1984). Agricultural activities accelerated soil erosion which was silting swamps. The wider cultivation of rice also affected the swamps, critical habitats for species such as the crown cranes. Increase in bushes has also resulted in wider spread of tsetse flies and wild animals. From the 1970s the conservation areas bordering the park (Figure 2.2) became meaningless as they lost their animal populations. The civil unrest was not part of any programmed process of the park system. As shown above, however, it has had major impacts on the park and general regional development. The case illustrates how complex and dynamic the park circumstances can be. Looking beyond the war, there is now an opportunity to rethink the park design and how to develop the region.

As mentioned already the park contributed to regional development through "non-destructive" uses such as tourism based on game viewing, yielding revenue from employment, park entry fees, and sale of trophies (Ouma 1970; Jahnke 1972). Local people were employed in the park and were paid for cultural shows to entertain the tourists. In the 1960s when some hippopotami and elephants were cropped (Laws et al. 1975), local people gained cheap meat. Since the Amin era the park has had to rely on international support to remain operational. In the meantime numbers of the larger herbivores have drastically declined. The tourist industry based almost exclusively on wildlife has virtually disappeared (pers. observ. 1983/85). Due to the park's marginal contribution to regional development and with only little wildlife left, it is getting more difficult to justify the park's presence. A serious on-going debate is whether to develop the hydro-electric potential of the Nile in the park to stimulate industrial development in the region (Anonymous 1970; Katete 1980). It is argued that the cheap electricity would boost industrial activities necessary for economic development.

Maintaining the integrity of the park has faced many problems. As already indicated, initial increase in numbers of the large herbivores accelerated drastic landscape changes such as the loss of wooded habitats, increased soil erosion, a net loss of landscape aesthetic diversity. The rhinos may have become extinct (Edroma 1982) and the elephant became threatened with extinction (Eltringham & Malpas 1976 & 1980; Malpas 1980). These changes are visible proof of failure of the park authorities to meet the established objectives. The specific failures can largely be attributed to flaws in the park design where many important management actions have been and remain crises-driven. For instance the importance of ecological research and long-term monitoring in the park has largely been prompted by the drastic landscape changes under excessive herbivore numbers (Laws et al. 1975). The departure of the expatriates and persistent civil unrest has undermined the development of the initial research activities into comprehensive scientific programmes to support the park management and development activities. Besides, in the civil wars significant proportions of the research facilities have been lost. The insecurity has made normal field-work impossible in large parts of the park. These situations call for park design to provide for the evolution of appropriate institutional mechanisms to overcome such instabilities.

2.5 Geology, geomorphology and soils

The geology of the park region results from climatic an' ˛eological events that affected the whole of eastern Africa. These Plio-Pleistocene even' were the peak of earth movements which started during the pre-Cambrian period (Wayland 1921; Bishop 1961 & 1965; McConnell 1967; Hamilton 1982). The Plio-Pleistocene tectonism drastically transformed the regional landscape structures and processes. While some regions were down-warped, others were up-warped with the emergence of major faults (Wayland 1921; Bishop 1961 & 1965; White 1990). Some of the down-warped regions form the Rift Valley and some of the up-warped regions form block mountains (e.g. the Rwenzori Mountains). The fault lines became and remain major lines of weakness through which volcanic eruptions have occurred e.g. in south-western Uganda. The earth movements created mountains, depressions, rejuvenated some rivers and reversed or even dammed others (Bishop 1961 & 1965). Together with the volcanic eruptions new geomorphological structures and processes were initiated with immense impacts. The new mountains aligned across major rain bearing winds resulted in more rain, higher altitudes meant lower temperatures, and water accumulating in the depressions recharged the winds with moisture (Beadle 1981). The Plio-Pleistocene period was also a relatively wet climatic phase (Wayland 1935; Bishop 1961 & 1965; Beadle 1981). A wet climatic phase ensured that the depressions were filled with water. Although East Africa remains, over-all, seismically active, as is evident from earth-quakes and hot springs (Bisset 1946; Jacobs & Fleay 1952), the geological structures have been relatively stable since 10 000 BP (Bishop 1965; Ouma 1970; Hamilton 1982; Hamilton & Taylor 1991). This was how the landscapes were formed and such are the forces that could again drastically transform them. These are significant realities of the park but they are patterns and processes which cannot be programmed in the design of a park.

With respect to the Murchison Falls Park, the Plio-Pleistocene tectonism resulted in the Western Rift Valley and lakes that influence the park. There are two main geological regions in the park area: the Rift Valley, and the Gneiss Complex (Figure 2.6). Within the Rift Valley is found lacustrine and alluvial sediments from the past lake Kaiso-Kisegi (Bishop 1965; Hamilton 1982). The Gneiss Complex are of pre-Cambrian origin (Lands & Surveys Department 1964; Ollier 1959; Harrop 1960; Bishop 1965). In the Gneiss Complex, the rock formations are wholly granitized or of medium to high metamorphic grade. Most of the rocks are of acidic or intermediate granulite. Some basic granulite do occur but these are not widespread. The old age and acidic nature of the rocks help explain the relative nutrient poverty of the soils and flatness of the region.

The down-warping of most of the south-western quarter of the park to about 700 m asl lead to the formation of the rift valley which left the northern and eastern regions of the park much higher, generally above 850 m asl (Lands & Surveys Department 1964). Changes in the relief have rejuvenated and re-directed the drainage systems and accelerated erosion processes. Along the escarpments there is significant gully erosion with sediments deposited into the Rift Valley. Within the Rift Valley, clay layers underlie a thick sandy sediments. Here the combination of high intensity rainfalls, sandy soils with high rates of water infiltration and a relatively impervious underlying clay layer has made the Rift Valley region very prone to soil erosion. This has resulted in serious gully erosion in the western half of the park, a situation exacerbated in the past by high numbers of large herbivores.

The erosion has dissected and converted about 30% of the otherwise monotonous undulating terrain into a more diverse one (pers. observ. 1985). Whether continuing erosion, evident from gulleys eating into infrastructure, remains justifiable on these grounds is a subject of debate for the design of the park. Considering the muddy water seen in the park when it rains the erosion process is definitely undermining productivity of the landscapes. It remains to be determined whether or not it is a factor in the siltation of some of the wallows and swamps in the park.

The Nile river is one of the most important features of the Murchison Falls Park. Its main reservoirs are Lakes Victoria and Kyoga both of which owe their origin and dependability to the Plio-Pleistocene tectonism and climatic changes. The Nile river crosses the rift faults through a gorge seven metres wide and here it forms an impressive scene, the *Murchison Falls* (Figures 2.2) from which the park got its name (Willock 1964). The falls were *"discovered"* in 1864 by the explorers Samuel Baker and his wife who named it after the then president of the National Geographic Society (Baker 1866). While Amin ruled Uganda the falls were renamed Kabalega Falls after the King of the Bunyoro Kingdom in which the southern half of the park lies. This name reverted to Murchison Falls after the Amin era largely because that was the name by which it was internationally better known. Local people call it *Acucu* (falls) or *Wang-jok* (place of the spirits). The word *acucu* is also used for all other major water falls such as the falls at Karuma and Ayago (Figure 2.2). The word *Wang-jok* has a spiritual/religious connotation and is used only to refer to the Murchison Falls and similarly dangerous sites. There have been debates over the fate of the falls: to preserve them; or to develop the huge hydro-electricity power potential (ca. 600 MW). Besides their spectacular aesthetic qualities, the falls also constitute an important ecological barrier to migration of aquatic species between the Nile-Albert and the Nile-Victoria water systems. The evolution and the distribution of aquatic species in the park have also been influenced by the geological and climatic events discussed above. Whereas the water of the Victoria-Kyoga system is fresh, that of Lake Albert is salty. Several species occur only above or below the Murchison Falls (Rhodes 1971; Beadle 1981). There are many smaller falls and rapids along the Nile but they do not constitute serious barriers to distribution of species. Any unpredictable changes in the geological or geomorphological processes as pointed out above could trigger new chains of limnological and/ or ecological processes that cannot be programmed in a park design.

Many streams draining the region originate from the highest regions of the park in the vicinity of the Rabongo hills (Figures 2.2 and 2.7). Some of the streams are the only reliable sources of water for the local people. Rivers draining west from these hills contribute fresh water to Lake Albert, an important fishery resource for Uganda and Zaïre. The fresh water input to Lake Albert (saline waters) helps sustain a limnological situation responsible for the presence of at least six endemic fish species in the Lake Albert system (Beadle 1981). Most of the northern half of the park is drained by streams that originate outside the park where government policies have been to intensify agricultural production. This has involved bush clearing to ease ploughing with a tractor, eradication of wild animals to combat animal diseases, and the use of biocides (Pers. observ. 1983/85). The indiscriminate removal of vegetation and the compacting of land by heavy machinery reduced water infiltration and so accelerated soil erosion in the agricultural surroundings of the park (Hamilton 1984). Much of the rain water in the region ends up as surface run-off causing much soil erosion.

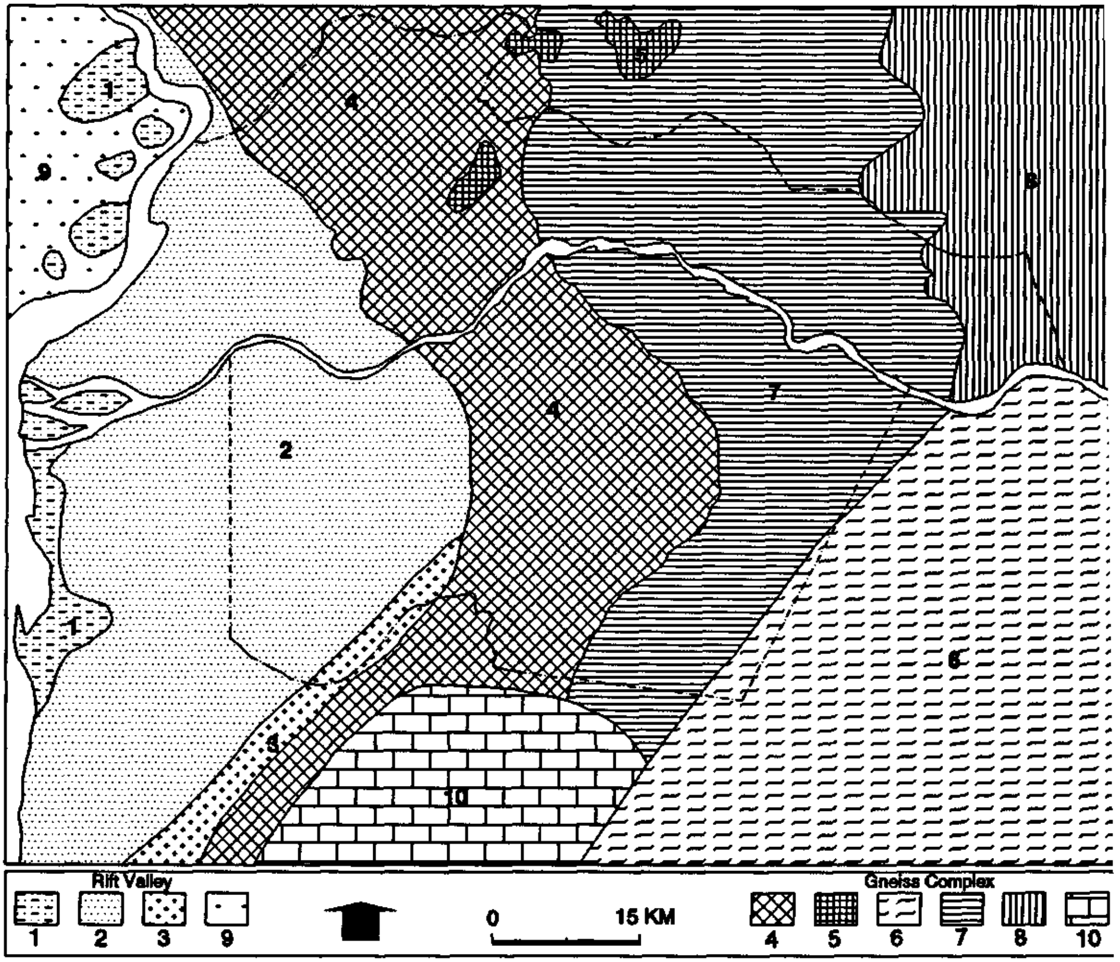

Figure 2.6 Geology and soils of the Murchison Falls Park region. The geological division was derived from the Uganda Atlas (Lands & Surveys Department 1964) and the soil zones have been adapted from Ollier (1959) and Harrop (1960). Major geological zones are the Rift Valley, and Undifferentiated Gneiss Complex. The Rift Valley covers the area west of soil unit 4 and from 4 eastward fall under Gneis complex. Major zones and features of the soils:

1 Weiga Complex- illuvial, water-logged
2 Paraa series- sandy /sandy loam
3 Bugangari- shallow sandy loams and loams
4 Palabek Complex- shallow loams developed on old alluvium
5 Pajule series- sandy loams over clay or lateritic layer (at shallow depth)
6 Kigumba- sandy clay loams
7 Anaka Complex- sandy soils often over lateritic concretion
8 Buruli Catena- sandy clay loams over lateritic (often at great depth)
9 Ora Series- Calcareous clays
10 Rukiri Complex- shallow sandy loams

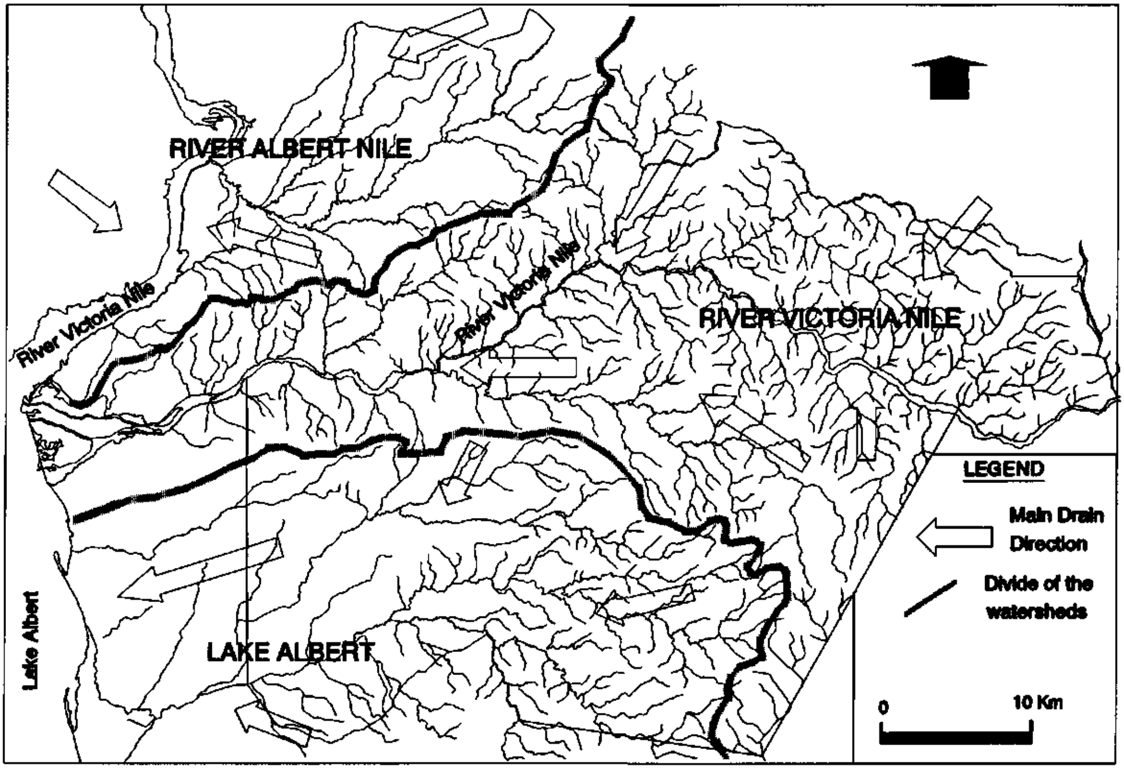

Figure 2.7 The main surface drainage regions of the Murchison Falls Park interpreted from the park's official topographical map (Lands and Surveys Department 1971). All surface drainage in the park are either into Lake Albert, or the Victoria Nile, or the Albert Nile. For more information on direction of Rift Valley faults see figure 2.4.

The quality of water in the streams has been increasingly seasonal: muddy floods during the rainy season and trickles during the dry season (Hamilton 1984; see also Figure 2.8). Some of the eroded material is deposited in swamps through which the streams pass. A lot, however, reaches the park and deposes sediments in the already limited swampy habitats. The growing use of biocides in the agricultural practices worsened the plight of the wetland. Most of the water draining from northern bank of the park passes through the Victoria Nile Delta which therefore is assumed to trap significant proportions of the erosion load and chemicals in the Nile water. The swamps are breeding sites for some of the fish species of economic importance, e.g. *Alestes* spp. (Margach 1948; Rhodes 1971). Any design of the park confined to the park alone would therefore be excluding factors and processes that are part of the park system dynamics.

As shown above, the drainage system can help to treat a regional landscape as a functional whole. In a study in the Netherlands, van Buuren (1991) demonstrated how the knowledge of hydrological network in landscape design provided a framework that can aid treating the landscape as a functional system. Unlike the area covered in their study, very little is known of hydrological systems in the Murchison Falls or in most parks. Besides, even where much information exists on the hydrological systems, e.g. in the Kalahari, experiences suggest that the patterns in ground water system can vary considerably from the surface drainage patterns (Mazor et al. 1977; Foster et al. 1982; Mazor 1982; Silitshena & Osafo-Gyimah 1992). Such variation in the drainage system can invalidate a landscape design based on this approach alone. It is therefore important when designing a park to pay attention to the unravelling of how the hydrological system of the park functions. In the above cases disruption of hydrological cycles in the southern hills of the park, e.g. elephant destruction of arboreal vegetation, affect water supply for people in the park neighbourhood, threaten endemic species in Lake Albert, and undermine the dependent agricultural and fishing economies of the region. Similarly, ecologically destructive agricultural development strategies, as described above, undermine sustainable regional development. The activities at the head-waters of major streams in the northern bank of the park will eliminate wildlife outside the park and also deprive local people of reliable water supply. Besides they degrade soil potentials, destroy most of the swamps and could contribute to the elimination of fish species of economic importance.

Figure 2.8 The confluence of the Namsika and the Nile rivers. The trunk of a tree fallen across the dry river bed in the left fore-ground must have been brought there in the flush-floods typical of many of the rivers in the park after rainstorms. Photo by the author 1984.

Also of importance is the lack of management control within the park. There are many wallows (see Figure 2.9) which contain water throughout the year and therefore are vital sources of water for animals in the dry season. The wallows are associated with sites with impeded drainage and most are small (<500 m^2). Seasonal concentration of herbivores at the wallows destroys vegetation around them by over-grazing and trampling (Figure 2.9) which together with siltation and high nutrient input are causing their eutrophication. In the Queen Elizabeth Park, excessive densities of hippopotamus (*Hippopotamus amphibius* L.), caused rapid ecological succession in several wallows (hippo pools) which disappeared (Edroma 1973a). No such demise of wallows has been recorded in the Murchison Falls Park, probably due to their lesser prominence than in Queen Elizabeth Park. Reader and Croze (1977) described: "...wallows are *animal furniture*... result from their activities, used for comfort, and are as inoffensive to the habitat as an easy chair is to our living-room". As Reader and Croze point out the wallows may be initiated by actions of animals, are used by a succession of animals and eventually are only detectable by lush grass growing on sites where they were. Animals still use it but for different purposes. This case illustrates the presence of ecological processes that are central to the park systems but for which park design can hardly program any management activities. The animals effectively perform as ecosystem engineers (Jones, Lawton & Shachak 1994) which the design of the park should facilitate. In the above case on wallows it is possible to try controlling the animals by shooting some, as was done in the Queen Elizabeth Park (Bere 1959; Thornton 1971; Eltringham 1974), or to try preventing fire (Wheater 1972; Laws et al. 1975). It would be futile, however, to control for instance the schedule of animals that use the wallow or to stop the hippopotami from leaving their faeces in it. These are typical examples of ecological process over which park design cannot program.

Descriptions of soils of the park region (Figure 2.6) have been derived from Ollier (1959) and Harrop (1960). Most of the western half of the park region is within the Rift Valley and has soils of the Paraa series with pockets of the Weiga complex. Soils of the Paraa series are fairly deep, reddish-brown and sandy and those of the Weiga complex are illuvial and waterlogged. Soils in the eastern half of the park are derived from Gneiss Complex rocks of Pre-Cambrian origin. According to the reports of Ollier (1959) and Harrop (1960) the main soil groups are the Anaka Complex (sandy, often underlain by laterites), Buruli Catena (sandy-clay-loam soils, underlain by lateritic concretions), and the Palabek Complex (shallow, brown loams). The shallow rocky Bugangari soils are found on the escarpment. All these soils are acidic and low in nutrients, especially phosphorus. These are very broad categories, the units provide general information on the soil needed for landuse planning. Whether a tree grows on a site is not determined by the general but by the actual site conditions of the soils. When a tree has grown on a site, however, its impacts stretch beyond the site as it develops (Oldeman 1989, 1990, 1994; Weltzin & Coughenour 1990; Lucas 1991; Belsky & Amundson 1992; Jackson & Caldwell 1993).

The characteristics of the Murchison Falls Park soils (Ollier 1959; Harrop 1960) explain some of the major landscape patterns. The soil origin (lacustrine sediments), texture and structure (friable, porous sandy structure underlain by clayey layers) explain the undulating terrain of the landscape with Paraa soil series. Serious erosion on soils of the Paraa series has dissected its undulating terrain and created diversity with the introduction of wooded/ bushed ravines in an otherwise monotonous grassy landscape (pers. observ. 1983/85; see also chapter 3). The low water-holding capacity of the sandy soils has resulted in low vegetation cover (grass and bushed savannas) indicative of dry conditions. In the eastern regions of the park where the soils are loamy and/or deeper there is less erosion and also higher vegetation cover. Serious erosion, e.g. along the river Nile, might also be due to steep slopes and/or to a history of high herbivore numbers (Laws 1968; Laws et al. 1975). Low vegetation cover on some sites may be due to shallow soils underlain by lateritic concretions or to impeded drainage (Langdale-Brown 1960; Langdale-Brown et al. 1964). Since the whole park region has a quite similar seasonality of rainfall (Figure 2.5; cf. Lands & Surveys Department 1964), soil-related spatial variations in moisture availability could explain existing vegetation patterns. The vegetation patterns that result from these and other factors influence forage and shelter availability as well as regimes of fire in the region. These variations in the landscape may be localised but the resulting landscape mosaics impact on the functioning of the park, for instance through forage availability, resulting distribution of herbivores and dependent predators. Spatial variation in the soil also affects fire behaviour and its effects. For instance, under similar conditions, plants on sandy soils dry up earlier than those on less sandy soils. The resulting patchy drying of the plants may lead to a patchy burn where a thorough burn is desirable (cf. chapters 6 and 7). These are therefore further examples of complex, unpredictable landscape patterns and processes, and yet are aspects on which information should be available in the design of a park.

2.6 Climatic patterns

A weather station existed in the park at Paraa until the beginning of 1985. Until that year, rainfall, temperature, solar radiation, wind speed and wind direction were recorded. Due to civil unrest records since 1978 have been discontinuous. Climatic data from Paraa and towns in the region show a relationship between the climate and the regional geomorphology (Lands & Surveys Department 1964). There is a west-east rainfall gradient with annual totals increasing from below 760 mm in the Rift Valley to above 1200 mm in the Rabongo Hills (Figure 2.10). Although some of the stations had fairly long-term climatic records, continuity of records from all the stations has been affected by the wars. Because of the large size of the area the few meteorological stations means that the over-all coverage by the stations is very low. Just as mentioned in the case with information on the soils, the lack of such information critically hinder any design of the park. The growth or death of trees and grasses are not determined by the average rainfall but by the actual moisture available to individual plants. Availability of the moisture is the result of a combination of such factors such as rainfall, soil and slope characteristics and potential evapotranspiration.

From what is known to date (Wayland 1935; Hemderson 1949; Lands & Surveys Department 1964; Ojany & Ogendo 1973; White 1990) the climate of the region is dominated by a bimodal rainfall pattern with three to five dry months (Figure 2.5). March to May and August to November are the wettest months and are also periods during which lightning and thunder-storms are common. The months June, July and December to March may be completely dry. This rainfall pattern (Figure 2.5) is the result of the Inter-Tropical Convergence Zone (ITCZ). Associated with the ITCZ are two prevailing trade winds: the North-East (September to March) and the South-East (April to August). The mean wind speeds are about 4 km/h (Figure 2.11), getting strongest during the December to March dry season (Figure 2.5). Peaks of the dry season correspond to the solstices (also anti-climaxes of ITCZ over the park) and that of the wet season to the equinoxes (climaxes of ITCZ over the park). The wettest period in the region (April and May) corresponds to a period when the South-East Trade winds dominate. During this time, the winds are maximally recharged by the Victoria and Kyoga water bodies. During the August to November wet season the dominant North-East Trade winds are similarly recharged by the water bodies (sudd and swamps) in southern Sudan. The Murchison Falls Park climate is thus influenced by the major wetland of the region. As mentioned in the beginning of this chapter, the physical background to these processes were largely initiated by the Plio-Pleistocene cataclysms. In the event of another cataclysm the structures and processes might well drastically change.

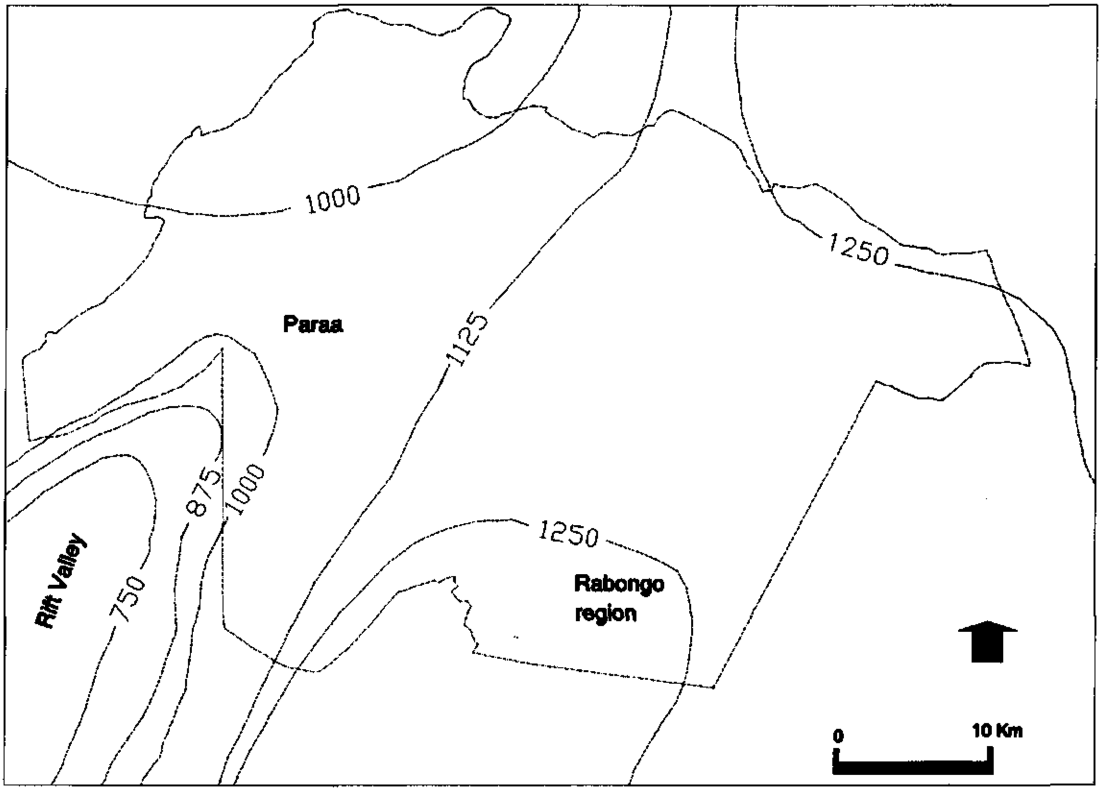

Figure 2.10 The distribution of mean annual rainfall in the Murchison Falls Park region, adapted from the Uganda Atlas (Lands and Surveys Department 1964). It shows a West-East gradient of increasing annual totals from the Rift Valley.

The temperatures vary between a mean minimum of 18°C and a maximum of 33°C being highest in the December/ March dry season (Figure 2.11) and hottest in the Rift Valley. In the higher eastern regions such as around the Rabongo Hills (about 300 m higher) the temperatures are considerably lower. The solar radiation reaches its peak in December and March (Figure 2.11). Smoke from bush-fire (common in the region during January/

February) and cloud cover (May to October) reduce the solar radiation. The high solar radiation contributes to high primary productivity levels (see also chapter 7) and also explains the growing use of solar energy in the local communities. During the dry season (Figure 2.5) the combination of high temperatures, strong winds and little rainfall result in very low relative humidity and very high evapo-transpiration. Plants dry up and bush-fire becomes widespread. Seasonally high temperatures force animals to crowd under trees (see chapter 7). For a given area, whether or not the environmental conditions will be extreme are largely unpredictable and so are the related distribution of the animals and their impacts.

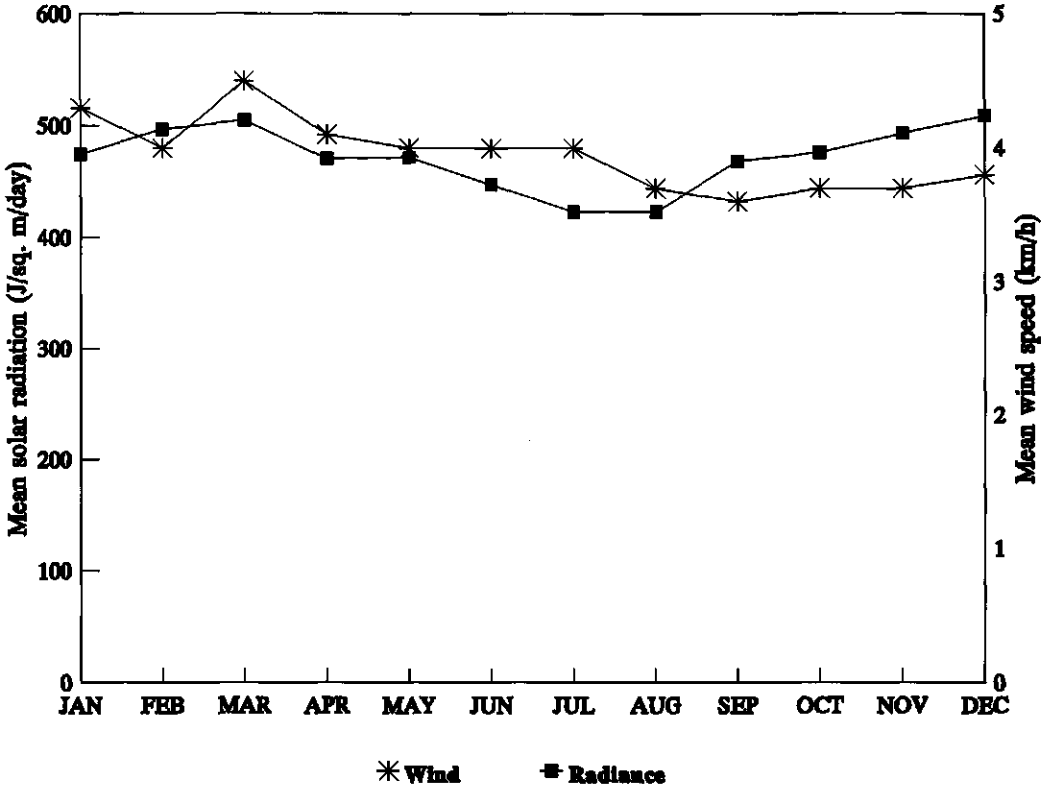

Figure 2.11 Mean wind speed and mean solar radiation of Paraa, Murchison Falls Park (data from Paraa Meteorological station). Similar temporal patterns apply to the whole park region.

2.7 Fire history and ecology

Fire is a very important landscape maker in the park region (Buechner & Dawkins 1961; Wheater 1972). One of the most important pieces of information on fire is detail of its regimes (Komarek 1965; Daubenmire 1968; Davis 1976; Friessell 1973; Kessel 1979; van Wilgen 1987). Of interest here are information on burning patterns: the frequency, intensity, severity and timing of the fires. Nearly all parts of the Murchison Falls Park burn at least once every two years (Buechner & Dawkins 1961; Wheater 1972). Most of the fires occur during the December to March dry season when it is dry and windy.

Without major barriers, when a fire starts it might burn for days (see chapter 7). As the dry season advances the fires become more intense and extensive, some exceeding 200 sq. km. Most of the fires are started by man and reasons for doing so are diverse (Buechner & Dawkins 1961; Wheater 1972; Laws et al. 1975) e.g. to drive and encircle wild animals to ease hunting (Bere 1934b). Early in the long dry season local people burn some of areas fringing the park to stimulate forage regrowth and to lure herbivores out of the park. Often such fires burn into the park. Inside the park, the authorities burn the vegetation to stimulate forage regrowth, control bush encroachment or for more visibility in game viewing and in anti-poaching patrols. To control these fires fire-breaks (including the road network) have been maintained until about 1977. Even when these controls existed, cases of uncontrolled burning were common, a situation worsened by the poor state of the roads used as fire-breaks (see chapter 7). Besides, the lack of insight into the dynamics of the fires and their effects mean that any programmed control of fire is unlikely to be practical and in fact could be counter-productive (see e.g. chapters 5 & 6).

Fire has been and remains one of the most important ecological factors in the park (Buechner & Dawkins 1961; Wheater 1972; Laws et al. 1975). It influences the patterns and processes of a landscape, among others by excluding fire-susceptible species or by effects on herbivores (Buechner & Dawkins 1961; Daubenmire 1968; Glover 1968; Komarek 1965; Gill 1974; V de Booysen & Tainton 1984; Wein & Edroma 1986; van Wilgen et al. 1994). Fire effects on the park vegetation received much attention but probably have been exaggerated in the presence of a multitude of factors. Laws et al. (1975), for instance, showed that in Budongo Forest (south of the park region) where elephant pressure was minimal the forest expanded despite regular burning. Even so, it has been generally agreed that the loss of woody cover results in greater herbage production, leading to bigger fires that also penetrate deeper into wooded and forested areas (Laws 1968 & 1970a; van Wijngaarden 1985; but see chapter 7). Although there has been much scientific appreciation of fire in the Uganda National Parks (Buechner & Dawkins 1961; Ross & Harrington 1969; Spence & Angus 1971; Eltringham 1976; Sabiiti 1985; Wein & Edroma 1986), most of the experiences have still to be brought together to form the basis of comprehensive fire management programmes. As more is known about the fires, the more apparent it becomes that its ecological importance is very complex (see chapter 7). There are simply too many unknowns to seriously talk of any programmed fire control, leave alone its management in the design of a park.

2.8 Vegetation and animal life

The patterns of vegetation described below have been adapted from Langdale-Brown et al. (1964) and updated with field observations in 1983/85 (chapter 3 & 4). The classification of the vegetation used here follows Pratt, Greenway and Gwynne (1966). Ten main vegetation communities were identified in the park region (Figure 2.12) with patterns that reflect influences of the soils, climate, man, large herbivores and fire. As discussed with regard to the soils (section 2.5) a general description of the vegetation might omit details crucial to park design. This is even more important when (see chapter 3) changes in the vegetation are looked at to evaluate the state of the parks (Vessey-Fitzgerald 1974; Laws et al. 1975; Caughley 1976; Hommel 1987; Rebelo & Siegfried 1990; Owen-Smith 1983; Lewis 1991).

Almost 75 % of the park is under various types of grasslands (Figure 2.12). The main grassland types are: **F, H, K, N, Q, W** and **Z**. The **Q** grasslands are mainly on dry sites while the **W** grasslands are on sites with impeded drainage. The other grasslands are on sites formerly under woodlands (**H, K, N** and **Z**) and forests (**F**). Most of the grasslands are tall (2-3 m high) and dominated by *Hypparrhenia* spp. The tall grasslands are common on sites with loamy soils and receiving rainfall above 760 mm. Areas of short grasslands (less than 1 m high) are found especially in the western half of the park also on sandy loam soils but where mean annual rainfall is under 760 mm or on sites with impeded drainage (**W**). The short grasslands are dotted with *Balanites aethiopica* and *Crataeva adansonii* trees. *Acacia* wooded grassland exists in the Chobe region and a grassland with groves of *Borassus aethiopum* in the north-western quarter of the park, i.e. Tangi valley (Figure 2.2). Under reduced herbivore numbers the tree cover in the grasslands has increased (Malpas 1980; see also chapters 3 & 4).

Undifferentiated thickets and bushes (**V, N/V** and **Q/V**) exist especially in seriously eroded sites close to the Nile near Paraa on soils of the Paraa series (Figure 2.12). The thickets (**V**) contain *Combretum aculeatum, Teclea nobilis, Acacia senegal, Tamarindus indicus, Balanites aegyptiaca* and *Securinega virosa*.

The only extensive swamps (**X**) are found in the Nile Delta at Buligi (Figure 2.12). These swamps are dominated by papyrus (*Cyperus papyrus*) and are important breeding grounds for some of the commercially important fish species (e.g. *Alestes* sp.). The swamps form the separation between the fresh water in the Victoria Nile and salty water in Lake Albert (Beadle 1981). Smaller and rather seasonal swamps exist along the Nile and some of the streams.

In the Rabongo region (Figure 2.12) are found fragments of high tropical rainforest (**D**). The canopies of these forests are dominated by *Cynometra alexandri*. Some gallery forests dominated by *Khaya* spp. are also found on river banks where the slopes are steep enough to deter elephants. According to Hamilton (1981) the forests in the Rabongo region represent the northernmost extension of such lowland forests. Where forest has been lost the high rainfall totals in the south-western quarter of the park explain the mosaic of elephant grass *(Pennisetum purpureum)* and forests (**F**) testifying to the extent of former forests (Figure 2.12).

Small woodlands (**N**) remain in the park in Pandero and in Chobe region (Figures 2.3 & 2.12; chapters 3 & 4). The woodlands are associated with sandy loam soils and are dominated by combretaceous species. Patches of woodland are also found in the tall grasslands (**H** and **K**). The vegetation patterns shown by the communities **N, H** and **K** which together cover more than 70% of the park region illustrate the interplay amongst the physical, biotic and human factors. In all three communities *Terminalia* spp. are prominent and in some cases the species constitute woodland almost in pure stand (see Figure 1.1; Langdale-Brown et al. 1964). The *Terminalia* woodlands, though remarkable, are not extensive wherever they occur, even outside the park. They are either earlier succession stages of forests (**H**; -Eggeling 1947; Dawkins 1949) or are fire induced climaxes (**K** and **N**) on the drier sites or sites with shallow soils (Langdale-Brown et al. 1964; see chapter 5).

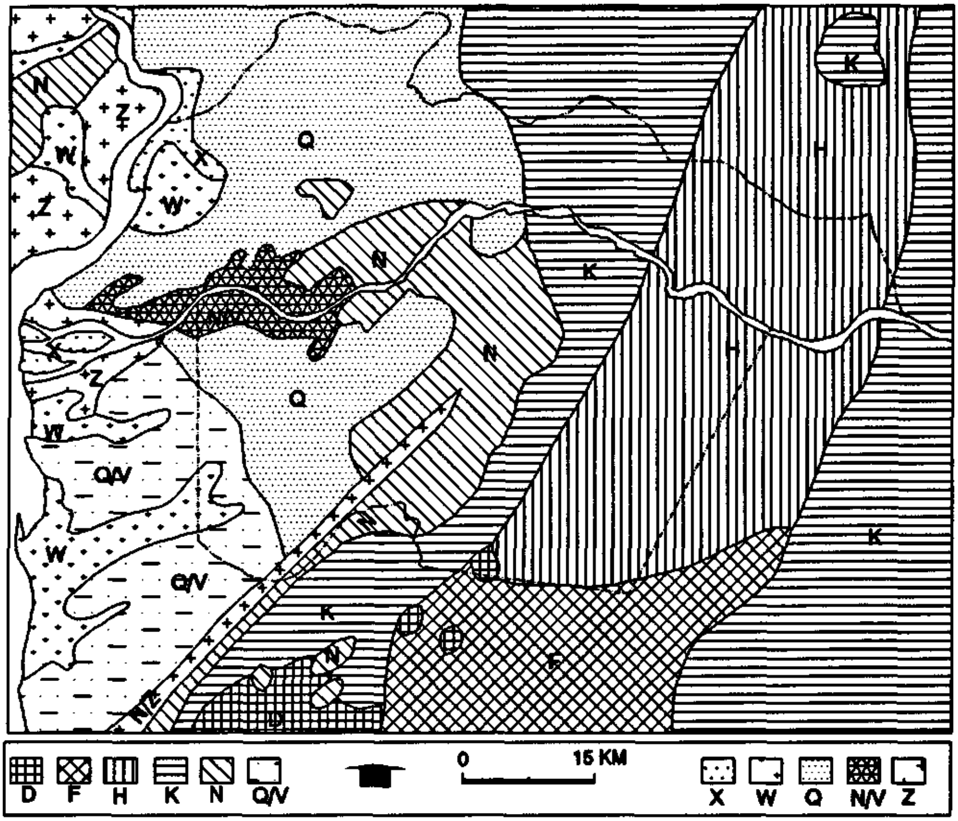

Figure 2.12 Vegetation types of the Murchison Falls Park region adapted from Langdale-Brown et al. (1964) original codes of which are shown in brackets. The generalisation has been based on field observation during 1983 to end of 1985.

D Tropical forest (D: *Cynometra-Celtis* high forest)

F Forest savanna mosaics

H Tall grassland with remnants of woodlands containing *Terminalia*

K Moist savanna (J: *Acacia* or K: *Combretum*)

N Dry savanna (N: *Combretum* or P: *Acacia*)

Q *Hyparrhenia* grass savanna

V Dry undifferentiated deciduous thicket

W Short grass savanna dominated by *Acacia* and *Setaria*

X Swamp dominated by *Cyperus papyrus*

Z Post-cultivation communities dominated by *Cymbopogon-Imperata*

As mentioned above, the absence of comparable, detailed vegetation descriptions of the region from the past makes it difficult to determine how much of plant communities in the region are represented in the park. This lack of details also hinder the evaluation of the apparent vegetation changes in the region. Hamilton (1984) argues that whatever changes took place in such situations do not seem to have endangered any plant species in particular. In preceding sections it has been shown that the vegetation changes, although might not necessarily lead to extinction of plant species, threaten the over-all regional landscape structure and functioning (chapter 3 & 4). As earlier hinted, increased soil erosion is possibly destroying the swamps, which actually directly threatens papyrus and swampy plant communities, but also indirectly threatens habitats for species such as the crested crane and *Alestes* spp.

Available records, show conclusively that the vegetation of the region has changed very significantly in the past century (Shantz & Turner 1958; Buechner & Dawkins 1961). Most of the changes are the result of damage under past excessive elephant numbers combined with regular fire. Langdale-Brown et al. (1964) indicate that in the absence of such disturbances the regional vegetation climax would probably be some form of woody vegetation (dry forest or woodlands). According to Buechner & Dawkins (1961) there was almost 50% reduction of woody vegetation in the period between 1930 and 1960 alone. This decline in woody vegetation continued until the 1970s (chapters 3 & 4; Spence & Angus 1971; Laws et al. 1975). The loss of woody cover was caused by fire killing trees weakened by elephant debarking. Prior to confinement to the park, the elephants migrated extensively allowing time for recovery of the vegetation. In the absence of such extensive range, damage to trees by the elephants became more continuous and also more apparent (Buechner & Dawkins 1961; Brooks & Buss 1962). The decline in the tree cover following the protection of the area was an early sign of defects in the design of its conservation programmes (Brooks & Buss 1962; Kinloch 1988).

The loss of tree cover reduced protective cover of watersheds (e.g. forests in the important Rabongo water-catchments), loss of habitat for forest species such as the chimpanzees *Pan troglodytes* Blumenbach (Reynolds 1963), deprived the giraffe *Giraffa camelopardalis rothschildi* Lydekker of significant browse (Brahmachary 1972; Field & Ross 1976; Pellew 1983), and reduced shaded areas. The decline in tree cover, however, meant an expansion of habitats for the grassland species such as the kob *Adenota kob thomasii* (Sclater), the oribi *Ourebia ourebi aequatoria* (Zimmermann) and the hartebeest *Alcelaphus buselaphus jacksoni* (Pallas) (Bere 1971; Laws et al. 1975). With fewer trees there are also less barriers to winds, making the latter stronger and more desiccating (Meroney 1968; Shaw 1977; Massman 1987; McNaughton 1989). This has serious implications for fire management (Daubenmire 1968; Davis 1976; Chandler et al. 1983; Trollope 1984). Fires are more likely and also more difficult to control under such conditions. The loss of trees undermined the aesthetic diversity of the park landscape and has aggravated what was already a monotonous tree-less savanna (Buechner & Dawkins 1961; Vroom 1973; Lucas 1991). Also there has been an increase of the area of seriously eroded sites (Buechner & Dawkins 1961; Laws 1968; Laws et al. 1975), especially along the Victoria Nile in which thickets have developed. The gulleys have introduced more landscape variation and extended habitats for such species as the leopard, the bushbuck *Tragelaphus scriptus* (Pallas) and the hyenas *Crocuta* (Erxleben).

In terms of species, there are at least 400 birds, 50 reptiles and 50 mammals (Bere 1961, 1962 & 1971; Laws et al. 1975). From fossil remains it is known that some species have become extinct here during the early Pleistocene (Bishop 1965). The park fauna includes such rare or endangered species as chimpanzee and crocodile *Crocodilus niloticus* (L.), elephant, leopard *Panthera pardus* (L.) and peregrine falcon *Falco peregrinus*. The park also contains buffalo *Syncerus caffer radcliffei* (Sparrman), giraffe, hippopotamus, Jackson's hartebeest, Uganda kob, warthog *Phacochoerus aethiopicus* (Pallas), bushbuck *Tragelaphus scriptus* (Pallas), oribi, waterbuck *Kobus defassa* (Ruppel), baboon *Papio anubis* (F. Cuvier), aardvark *Orycteroppus afer* (Pallas), lion *Panthera leo* (L.), hyaena. Numbers of most of the large herbivores have declined since the 1970s. The elephant numbers fell from a peak in excess of 14,000 (Laws et al. 1975; Eltringham & Malpas 1980) to below 2,000 animals (Douglas-Hamilton et al. 1980; Malpas 1980). Chapter 7 provides more details on the population trends of the larger herbivores.

The distribution of the animal species is largely influenced by the vegetation (Bere 1961, 1962 & 1971; Laws et al. 1975). The species are ecologically separated from each other by their feeding habits and water requirements (Lamprey 1963; Vesey-Fitzgerald 1965; Reader & Croze 1977; McNaughton 1989; de Bie 1991) and other specialised habitat requirements such as open or enclosed habitat. The kob, oribi, hartebeest and warthog are grazers which prefer rather open grassland landscapes. The buffalo, elephant and bushbuck occur both in the wooded grasslands and more wooded habitats. The browser giraffe is found only in the northern sector of the park, probably due to the barrier of the Nile. High dependence on water confine the water-bucks to swampy sites and near water supply. Similarly amphibious life-style and grazing habits restrict the hippopotamus to the vicinity of permanent water (e.g. the Nile) and to short grasslands. Crocodiles are similarly confined to the rivers. Both the hippopotamus and the crocodile have been eliminated from most waters in Uganda to protect fishermen. Poaching has reduced animal numbers, especially along the park borders, and also forced some species into a few large groups (Malpas 1980).

2.9 Human pressure

The main human pressure on the Murchison Falls Park is poaching, mainly by hunting and fishing. This has been examined in more details in the context of human control networks of the park in chapter 8. Poaching has been and remains one of the most serious management problem in the park (Aerni 1969; Oneka 1990). It has exterminated the rhino population in the park and also threatened the elephant population with extinction (Edroma 1982; Malpas 1980; Eltringham & Malpas 1980; Douglas-Hamilton 1987 & 1988; Oneka 1990). It is also responsible for a significant proportion of fires in the park. As shown in chapter 8 most of the animals dying in the park were killed by poachers. Although virtually all animal species were poached, there was a preference for the hippopotamus, buffalo, warthog and kob. Most of the poachers come from the park surroundings and the main strategies to control them has been a para-military fight using park rangers (anti-poaching) patrols. Hunting and fishing in the region pre-date the park (Willock 1964; Aerni 1969) but got worse due to political instability, civil wars, decline in law and order, and an increase in guns amongst local people (Douglas-Hamilton 1987 & 1988; Oneka 1990). These observations prove the need to incorporate these elements as components of the park system structure and dynamics.

CHAPTER 3. PARK MANAGEMENT AND DEVELOPMENT[1]

3.1 Abstract

As shown in chapter 2 when the Murchison Falls Park was established the primary concern was to preserve the wildlife therein for posterity. *Wildlife* effectively referred to wild animals and the main perceived threat to their preservation was hunting and fire caused by man in the landscape. This was expressed in a park management strategy primarily directed to *keep man out* and to *let nature take its course*. Within the first decade, drastic changes in the park's vegetation underlined the need for broader views on park goals and for discussions on the role of management interventions in the park's ecological processes. This chapter examines implications of changes in the vegetation cover of Pandero over a period of nearly 30 years.

Information on the Pandero vegetation in the past has been compiled and this has been compared with the situation in 1985. The surface area of the woodland in Pandero has declined by almost 80%. Although the physiognomic structure of the remaining woodland is virtually unchanged, i.e. an open orchard-like structure, its floristic composition did change. The original vegetation structure, dominated by *Terminalia glaucescens* Planch. ex Benth. (Combretaceae) and *Prosopis africana* Taub. (Mimosoideae), was an important aspect of the aesthetic and ecological integrity of the park landscapes. Given the increased floristic diversity of the immature trees increased tree recruitment could lead to changes in the vegetation structure. The risk of *Terminalia* woodland being replaced by another woodland type highlights the importance of specifying *reference standards* in the design of a park. The study shows the dangers of management by objectives especially in the relative absence of relevant expertise, a weak philosophical framework and limited understanding of the park system's dynamics. The key questions are: what are the main long term objects (development goals), what are being done towards getting that (management) and what are their results? Are the set objects being approached or not? Park design is called on to help define *reference standards*, relevant institutions and modes to develop them.

3.2 General background

It has been shown in chapter 2 that the national parks in Uganda were set up primarily to preserve indigenous wildlife. Since the 1950s when the first Ugandan parks were created, the park authorities have had to deal with the consequences of major changes in the landscapes. In the Queen Elizabeth Park, grazing under high hippopotamus densities reduced herbaceous cover which eliminated fire and accelerated soil erosion (Bere 1959; Laws 1968; Lock 1972). The lack of fire led to the spread of thickets but this was curbed by elephants. After recent declines in elephant numbers in the park, large areas of the park's open grasslands have been invaded by thickets and woody vegetation (Lock 1985 & 1993; Sabiiti 1985). This spread of thickets and woody vegetation has affected sites which are important

[1] A part of this chapter has been accepted for publication under the title "Implications of changes in vegetation in Pandero, Murchison Falls Park, Uganda" in the proceedings of the XIVth Congress of AETFAT (Association for the Taxonomic studies of the Flora of Tropical Africa) held in Wageningen, August 1994.

for grazing by antelopes (Field & Laws 1976). In the Ishasha sector of the park *Acacia* trees have encroached upon grasslands, thereby drastically reducing the open landscape being the habitat of the topi, *Damaliscus lunatus jimela* Matchie (Yoaciel & von Orsdol 1981). On the Mweya Peninsula of the park, the spread of thickets (Lock 1985 & 1993) has reduced the grazing area and has altered the aesthetic character of the landscape (pers. observ. 1986). In the Kidepo Valley Park a combination of fire and elephant damage critically reduced the population of large trees browsed by the giraffe, *Giraffa camelopardalis rothschildi* (Harrington & Ross 1974; Field & Ross 1976).

Changes in vegetation have been even more apparent in the Murchison Falls Park where regular burning and high numbers of the elephant replaced most of the park's wooded plant cover by tree-less vegetation (Buechner & Dawkins 1961; Laws et al. 1975). As discussed in section 2.8, overall the process involves elephants debarking mature trees (see Figures 3.1 and 3.3) which become defenceless when fire prevails and so are killed (see Figures 3.2) leading to a retreat of the woody vegetation (Figure 3.3). Hitherto, the general assumption has been that the loss of tree cover results in a greater accumulation of herbaceous fuel which would lead to more severe fire (Buechner & Dawkins 1961; Laws et al 1975; van Wijngaarden 1985; but see chapter 7). A more severe fire has been assumed to be the cause of the lack of recovery of wooded vegetation where this had been destroyed.

Like in the Queen Elizabeth Park, here also there have been drastic declines in herbivore numbers (Edroma 1982; Eltringham & Malpas 1980; Malpas 1980). The resulting low herbivore numbers were expected to favour recovery of the wooded vegetation in the park (Spence & Angus 1971; Buechner & Dawkins 1961; Laws et al. 1975; Wheater 1972). Although there has been increased cover of woody plants in the park, the much desired recovery of the *Terminalia* woodland has remained subdued (Smart, Hatton & Spence 1985; Lock 1977; Malpas 1980). Even prior to recent changes in the animal numbers notable growth in tree cover occurred already where animal densities were low, especially along the park borders (Laws et al. 1975). The park's grasslands in the Tangi Valley have had major increases in palm groves (*Borassus aethiopum* Mart) and *Acacia* trees (Figure 2.12), which are eating away the grazing area and also begin to impair game viewing (pers. observ. 1985).

The creation of the Murchison Falls Park in 1952 indeed provided sanctuary to the wildlife displaced and harassed by people. However, the influx, confinement and natural increase in herbivore numbers increased tree mortality due to fire. Decline of woody vegetation subsequent to this process resulted in significant habitat and landscape changes in the park (Buechner & Dawkins 1961; Laws et al. 1975). These changes, in their turn, caused species composition and density to change among the herbivores. This is comparable to what has been described in chapter 1 as singing in the bottle. Justifiably there were serious debates on whether to blame fire or the elephant for the vegetation and landscape changes (Buechner & Dawkins 1961; Buss 1961 & 1977; Laws et al. 1975). The park authority attaches great value to preserving examples of indigenous vegetation. Since the 1970s, reduced herbivore populations (Eltringham & Malpas 1980) favoured regeneration of woody plants in the park (Smart et al. 1985). The major question is which is the right combination of communities?

Figure 3.1 *Prosopis africana* tree recovering from previous debarking in Pandero. All living *P. africana* trees observed in Pandero had similar scars at various stages of healing. Most big *T. glaucescens* trees also had scars but these were often more fully recovered so were less visible. Picture from 1985 by the author.

Vegetation in park management context is more than the green mantle over the landscapes. The spatial and temporal variations in the vegetation largely determine the availability of food, shelter and general context for life of other organisms. Together with the abiotic and other biotic elements, plants define the aesthetic and ecological identity, and characterize the *integrity* of the park's landscapes. In which way the park's integrity is evaluated depends, again, on the state of the park used as *reference standard.* Such a reference standard could be a state in some specific time in the past, the present or some dream state.

Management activities should help a park to grow towards this standard. In the design of a park these standards should therefore be defined to facilitate evaluation of the management programmes. Existing scientific consensus is that the loss of woody vegetation was a negative development for Murchison Falls Park, where woody vegetation occurred only to a limited extent (Buechner & Dawkins 1961; Wheater 1972; Laws et al. 1975). The most extensive of the woody vegetation was *Terminalia* woodland a patch of which remains in Pandero (Figure 2.12). The restoration and the perpetuation of this community is an important management priority of the park.

Terminalia woodland was an essential component of the park landscape, habitat diversity (Buechner & Dawkins 1961; Laws 1970a; Willock 1964) and because of its water-catchments protection (Laws et al. 1975). In this park it also represented a plant association sparingly distributed in Uganda (Eggeling & Dale 1951; Langdale-Brown, Osmaston & Wilson 1964; Osmaston 1968) and elsewhere in its entire geographical range (Keay 1959; Jones 1963; Lind & Morrison 1974; White 1983). This study hence was initiated to provide information on the status and regeneration potential of the *Terminalia* woodland and to suggest how site factors, particularly fire, may be managed to restore and to preserve the community.

Figure 3.2 A dead *Prosopis africana* in Pandero showing the scars and the charring marks (black patches) proving past damage. *Prosopis* wood is very hard and resistant to decay so the tree in the foreground probably died many years ago. Photograph by the author 1984.

3.3 *Terminalia* woodland

Terminalia woodland is a deciduous woody vegetation up to 18 m tall, with an open canopy (tree cover 20-50%) dominated by *Terminalia* in almost pure stands (Langdale-Brown et al. 1964; Pratt, Greenway & Gwynne 1966). The term "woodland" equates the "forêt claire" of Aubréville (1965). The ground cover is dominated by herbaceous plants which result in regular incidence of fire in the vegetation. The woodlands in the Murchison Falls Park were dominated by *Terminalia glaucescens* Planch. ex. Benth.

Terminalia is a pantropical combretaceous genus with up to 200 tree and shrub species (Jones 1963; Liben 1968; Coode 1973; Letouzey 1976; Uzoechina 1978). These woody plants are found in rain forests, woodlands, grasslands and bushlands. *T. glaucescens* is widespread in Africa north of the equator on well drained soils, between 800-1800 m asl notably where the mean annual rainfall is 760-1500 mm and with two to three dry months (Jones 1963; Hopkins 1965 & 1968; White 1983). It has been recorded in West Africa from the Republics of Guinea to Cameroon and Zaire (Hutchinson & Dalziel 1954; Keay 1965; Letouzey 1976; Uzoechina 1978; Geerling 1987), in eastern Africa from Sudan and Ethiopia to Uganda and Tanzania (White 1983). In East Africa Lind & Morrison (1974) have suggested that the species was only widespread in Uganda where Eggeling and Dale (1951) shows *T. glaucescens* occurs in about half the country, i.e. the northern, eastern and parts of western regions.

Although the species is distributed over such a wide geographical range, true *Terminalia* woodland is only sparingly distributed, often as patches within grasslands or at forest fringes (Langdale-Brown 1960; Jones 1963; Langdale-Brown et al. 1964; Osmaston

1968; Lind & Morrison 1974). Dawkins (1949) suggested that *Terminalia* woodland was a sere in succession to deciduous/ semi-deciduous forest communities. In agreement with Eggeling (1947) he proposed that the succession was from grassland, through *Terminalia* woodland (here also referred to as "true" *Terminalia* woodland), then *Phyllanthus-Terminalia-Albizia*, to finally reach mixed forest. In each successive sere, fire was less severe resulting in a simultaneous decrease in-fire-adapted species and increase in fire prone-species. The direction and rate of the changes were influenced by the severity of herbivory, the prevailing fire regime and impacts of man. Langdale-Brown et al. (1964) have shown, however, that *Terminalia* woodland could also be a climatic climax or a climax induced by fire. Oldeman (1990) suggest that it is both a "climax" in rougher biotopes and a "pioneer" formation in more hospitable bio-environments. This corresponds to Budowski's rule (ex Oldeman 1990) that any plant which plays a pioneering role in hospitable environments shows a biogeographical range which includes less hospitable environments. This study therefore provides elements of proof of Budowski's rule hitherto insufficiently supported.

All the seres mentioned above that contain *Terminalia* have been recorded in parts of Uganda, but true *Terminalia* woodland has been mapped only in the north, indeed, rougher climate. Examples of it were also represented in the Murchison Falls Park (Langdale-Brown et al. 1964; Osmaston 1968 & 1971). In the areas where the woodland existed, fire prevails regularly, which makes it likely that it is a fire-induced community.

Within Murchison Falls Park *Terminalia* woodland existed only in Chobe, Pandero and Wairingo (Figure 2.3; Osmaston 1968 & 1971). The floristic composition, the main ecological factors and the conservation status of the two main *Terminalia* woodlands in the park, in Pandero and Wairingo, were described by Buechner & Dawkins (1961) and Laws et al. (1975). As earlier predicted, fire and herbivore damage eliminated the Wairingo woodland and has significantly reduced the woodland in Pandero (Buechner & Dawkins 1961; Laws et al. 1975).

Outside the park the growing need for charcoal, firewood, building material and land to cultivate have resulted in rapid decline in *Terminalia* woodland. The tobacco growers in Northern Uganda relied on such woodlands for more than half of their firewood requirements in flue-curing their tobacco leaves (pers. observ.). According to Ruyoka and Olaka (1982) in the former Lango district *T. glaucescens* may constitute up to 50% of firewood used for this purpose. The species is also highly valued for charcoal in most of northern Uganda. Remaining woodlands continue to be cleared to obtain land for the cultivation of simsim, millet, sunflower, cotton and maize. *Terminalia* woodland has therefore steadily declined, also outside protected areas, and it is imperative that examples of it are re-established and preserved within the park.

3.4 The woodland in Pandero

Pandero is located north of the Murchison Falls (Figure 2.2). It undulates about 800 m asl. The soils are shallow, sandy loam, acidic and low in nutrients especially phosphates (Figure 2.6; Ollier 1959). For the patterns of climate in the area see figures 2.5, 2.10 and 2.11. Most of the mean annual 1000 mm rain falls during April and May, and August to November. The mean daily temperatures range from 18°C to 32°C. Potential evapotranspiration in the area exceeds precipitation during December to March, June and July making these the dry seasons. Some of the prominent herbivores in Pandero are the elephant (*Loxodonta africana* Blumenbach), the buffalo (*Syncerus cafer* Sparrman) and the hartebeest (*Alcelaphus buselaphus* Pallas). For a discussion of the patterns in the herbivore populations see section 2.8. and chapter 7.

The vegetation of Pandero in 1956 has been reconstructed using aerial photographs (Lands & Surveys 1956) and the reports of Buechner and Dawkins (1961). This has been compared with our own 1985 field records on the vegetation (Figures 3.4 & 3.5). As shown in figure 3.5 the woodland surface area declined by ca. 80% between 1958 and 1985. The extent of woody vegetation decreased in a pattern that corresponds to past distribution of elephants and their damage to trees, i.e. from the outside to the centre (Buechner & Dawkins 1961; Laws et al. 1975; see also Figures 3.3, 3.4 and chapter 4). Although the floristic composition of the small trees changed with increases in the density and the number of species the woodland has retained its open, orchard-like structure (Figure 1.1; chapter 4). This structure is dominated by *T. glaucescens* Planch. ex Benth. (Combretaceae) and *Prosopis africana* Taub. (Mimosoideae) and is a salient feature of the aesthetic and ecological integrity of the park landscape and habitat diversity (Buechner & Dawkins 1961; Osmaston 1971; Laws et al. 1975). Although dead trees abounded in all three woodland sites (Figure 2.3) the abundance of standing dead trees in Chobe and Pandero was most striking. In Chobe most of the dead trees belonged to the genera *Acacia* and *Terminalia*. The *Terminalia* trees in Chobe appeared to have died in the 1970s whereas most of the *Acacia* trees seen there died during the 1980 to 1983 period (Malpas 1980). In Pandero most of the dead trees belonged to the genus *Prosopis*.

Figure 3.4 Oblique aerial view on the woodland in Pandero showing its extent and that the boundary between the woodland and grassland is gradual. The big trees that remain in the grassland prove that past tree destruction was selective. Photograph by the author 1983.

3.5 Development strategies

The illustration made in chapter 1 with driving a vehicle is quite appropriate here. When the combination (package) of factors necessary to reach the set goals are not correct there will be a lot of wastage of resources in trying to reach the set goals. A good definition of this package of factors, strategy, is therefore the main challenge of the design of a park. With regard to the vegetation conservation problem in Pandero, there are two main alternative development approaches. In the first approach management is by objectives. Following this approach, attempts are made to base management activities on set objectives. Once the long-term goals of the park have been established, attention focuses on the achievement of these goals. For example, let us assume the goal set to be the restoration of past woodland vegetation. The management activities are geared to controlling incidence of fire, culling herbivores, or fencing degraded sites. The advantage of this approach is that management resources are often efficiently directed at concrete goals. Progress of the park development is usually easy to evaluate and management decisions are fairly straightforward. The drawbacks are that it depends too heavily on the objectives being set right. This is critical, considering the very complex and dynamic nature of the systems being managed. To fairly treat the ecosystem, one often lacks sufficient basic insight. For most parks, hardly any reliable information is available. Besides, even where information does exist, it is too risky to project such understanding far into the future. This means one can but only really plan with some degree of certainty over very limited time spans into the future. Management by objectives therefore opens itself to the risk of committing the park development on a course to dead ends. Treated as a puzzle, park design would on the contrary focus on developing feedback loops through which the objectives and relevant management activities could be continuously updated.

Following the second approach, management activities are woven into the landscape processes. Right from the beginning emphasis is placed on identifying the key processes and strengthening them through management (Oldeman 1990; Steiner 1991). This is not a new idea. Already in the first half of the twentieth century attempts were made to identify the processes that underlie vegetation succession. Attempts were then made to incorporate this knowledge in management to speed up attainment of set goals. For example, it was believed that *Terminalia* woodland was a successional sere on the way to a forest climax (Eggeling 1947). To short-cut the successional processes and increase the commercial value of the woodlands, timber species were introduced in the *Terminalia* woodlands in northern Uganda and their management was accordingly adopted (Dawkins 1949; Butt 1965). This, however, was proved incorrect by the real events.

As illustrated by the latter example, when relevant understanding of the system processes is weak, management based on processes is indeed equivalent to puzzling. In fact, a misunderstanding of the processes mixed with inappropriate objectives probably form the most powerful ingredient of park design failures. A good example of this comes from Botswana, where wildlife populations were devastated in severe droughts in recent years because of fencing (Silitshena & Osafo-Gyimah 1992). Because the system processes were ill-understood major wildlife migratory routes were blocked by fencing, on the basis of what turned out to be a wrong assertion, that it protected livestock from diseases carried by the wildlife. This case illustrates that designs have powerful impacts whichever way they are expressed. Botswana has survived many of this types of mistakes and it is best that attention is directed at developing institutions to mitigate them. For a park in a war ravaged country, e.g. in Uganda, it is important that such circumstances are transformed into chances for review of its design.

In practice the two main approaches discussed above are often combined. First the objectives are set, then the key processes are identified and finally attempts are made to apply management activities that guide or stimulate the processes. As shown by our case studies, where insights in the park system dynamics are lacking the risks are that the objectives set will be wrong. Moreover, because the processes are driven by dynamic, complex and partly unpredictable interactions, the risks of a design leading to disaster are further enhanced. A good example is the Lake Victoria problems created by the introduction the Nile Perch (see section 1.1). In parks and other land-use systems such mistakes can take the form of either the introduction or the elimination of species. It is necessary that future research examine alternative approaches to test both the park objectives and the models of the processes.

3.6 Policy options

The above changes in the park vegetation architecture, structure and composition indeed upset its ecological and aesthetic integrity. Hence they need to be understood, brought under control and monitored. As a consequence, any management intervention will require a definition of priorities for vegetation conservation. There are in this respect three main options: preserving either the highest number of plant species, or the vegetation types showing the highest species diversity, or emphasizing vegetation architecture with a view to niche diversification. Whichever of these aspects are selected as priority for conservation can then be used to define the reference standards for the vegetation conservation programmes.

Vegetation architecture and floristic composition are linked to each other (Küchler & Zonneveld 1989; Oldeman 1990). Giving priority to one of the aspects does not necessarily go at the cost of the other. The floristic composition of a plant community determines how its architecture is built. On the other hand, prevailing ecosystem architecture co-determines the floristic composition of the community. In the Pandero case, the predominance of two species (*T. glaucescens* and *P. africana*) created the peculiar open canopy. The greater diversity of the small trees, however, shows a significant potential for change in the composition of woodland in the area. A woodland with a more diverse tree composition is unlikely to remain open, a salient feature of the former *Terminalia* landscape (Figure 1.1).

Although plant species tend to be widespread, spatial variations in their distribution make associations which they characterise less common. As noted above, *Terminalia* species are widespread but associations in which they are prominent are not common. Under selective pressure, significant changes occur in the floristic composition and architecture of the vegetation. Under such pressure, plant species can be exterminated locally. In the Pandero case, the preservation of *P. africana* is being adversely affected in this way. The species is not widespread and its regeneration in the park is subdued. Outside the park, tree cutting is eliminating the species. This case stresses the need to identify in park design, as early as possible, any and all plant species that may need to be accorded special attention in developing monitoring, research and management programmes.

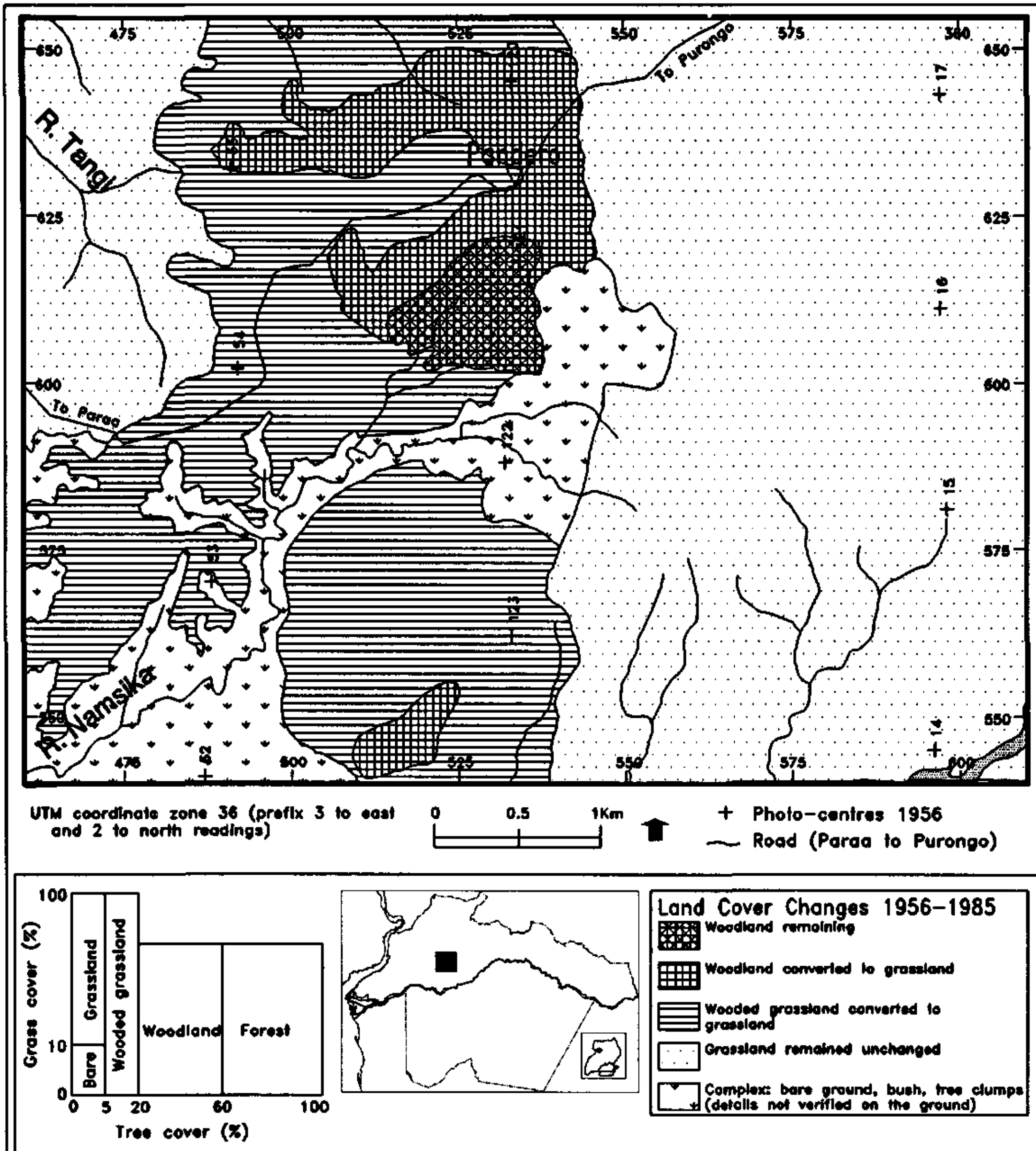

Figure 3.5 Changes in the land cover in Pandero, Murchison Falls Park, between 1956 and 1985. Information on the past situation was derived from aerial photographs (Lands and Surveys Department 1956) and that on 1985 is based on field observations by the author. Land cover classification adapted from van Gils & van Wijngaarden (1984).

If priority is to preserve plant associations and existing ecosystem architecture the likelihood of succession necessitates deciding *a priori* what to focus on. The *Terminalia* woodland is probably a stage in succession to a more closed woodland in the specific biotopes of Pandero. It is likely, however, that prevailing fire and herbivore impacts could maintain the present open structure. If significant changes were to occur in the main ecological factors, fire and herbivores, the vegetation would change. In park design, provision should be made for the analysis and the monitoring of all other implications (management economics, aesthetic and ecological concerns) of the vegetation management alternatives, so as to regularly update the policies, objectives and strategies in operational plans.

Very little is known of the relative importance of different vegetation types on the park system's dynamics (Vroom 1973) From the studies of Janzen (1970) it is known that trees acting as perching sites may become centres from where frugivores (Lamprey 1987) deposit seeds of new plants which lead to further diversification of the vegetation. The emergence and development of trees and bushes in open grasslands also exert their influence on the micro- and meso-climate of the landscapes. This aspect is certainly as important in the dynamics of the park system as it is in traditional selection silviculture. In the Murchison Falls Park, for instance, herbivores tend to congregate under the few lone trees in the grasslands when it is hot. The presence of trees may also be crucial by impairing visibility in game viewing as well as in anti-poaching patrols. There is therefore a need for deep understanding of the relative importance of the vegetation types and how to combine and manage them in the design of a park.

As shown earlier, the conservation status of the plant communities were at stake not only inside the park but also outside it. It has been mentioned that both through selective and indiscriminate felling most woody vegetation was being eliminated. Possible impacts of these on processes inside the park necessitate incorporating in plans to deal with them in relevant programmes to preserve communities as stated in the objectives of the park. Apart from improvements in silvicultural insight as to the vegetation, attention will need to be drawn to better understanding of possible underlying socio-economic, cultural and political processes.

The above issues again highlight the often emphasized need for sound understanding of the biogeography and ecology of the plants and plant communities as a basis for their conservation programme. This is also true of the other aspects of the park system e.g. the animals, the landscape processes, etc. However, the specifications for park design require new knowledge profiles, in which are vast lacunae as described above. Because such a new way of understanding does not exist as yet, it is advisable that park design provides an appropriate context for comprehensive management-oriented research and monitoring programmes. It is important that these are developed as integrated parts of the conservation programmes as early as possible. Research and monitoring programmes are essential permanent tools to develop and regularly update the appropriate understanding on which to base conservation policies and strategies to meet the conservation needs. But the research plans have to be appropriately tailored to meet the needs of the park.

CHAPTER 4. CONSERVATION STATUS AND SUITABLE MODELS[2]

4.1 Abstract

This chapter examines in more detail changes in the Pandero vegetation outlined in chapter 3. It shows the need for a good model base in park design. Earlier studies on the Murchison Falls Park reported large areas of arboreal vegetation being replaced by grassland under the combined influences of fire and high herbivore numbers. As thus conceived, changes in these factors were expected to lead to a recovery of the woody vegetation. The present study examines the composition of tree population in Pandero (chapter 3). The woody plants in the remaining woodland and those in surrounding derived grassland were surveyed. The results show that the woodland in Pandero has a density of large trees and a tree population structure similar to that in the past. The mean density of natural coppice stools has decreased by nearly 80% in the derived grassland but increased by over 790% in the woodland. Composition of both the coppice and the large tree populations changed substantially. Although the remaining woodland retains the original open orchard-like architecture, changes in the species composition of its coppice stools could affect this. The large trees are recovering because of a recent decline in elephant numbers, but the coppice shoots remain suppressed. It is hinted here that damage from both fire and herbivores are responsible for the lack of recovery of the woody vegetation. Apparently chaotic, complex, fuzzy and dynamic interactions are involved amongst the landscape factors. The results of the interactions are subject to such factors as the regimes of fire and herbivore impacts i.e. which combination of herbivores impacts, fire intensity, frequency and thoroughness. To model these require new less reductionist approaches.

4.2 Introduction

As has been shown in the preceding chapters Murchison Falls Park has witnessed conspicuous replacement of woodland and forests by almost tree-less grasslands (Buechner & Dawkins 1961; Laws et al. 1975). These changes in vegetation and landscape prompted speculations as to their causes and debates on the role of management interventions to preserve the integrity of the park (Buechner & Dawkins 1961; Buss 1961; Laws 1970a; Wing & Buss 1970; Laws et al. 1975). The loss of woody vegetation has been attributed to tree damage by high densities of the large herbivores (notably the elephant, *Loxodonta africana* Blumenbach) and frequent fire (Buechner & Dawkins 1961; Laws 1970a; Laws et al. 1975). The woody vegetation steadily shrunk as fire killed trees weakened by elephant damage. This process eliminated the woodland in Wairingo and has seriously reduced the woodland in Pandero as had indeed been predicted (Buechner & Dawkins 1961; Laws et al. 1975). As shown in chapters 2 and 3, the most extensive wooded vegetation in the park was of associations dominated by *Terminalia* dwindling both inside and outside protected areas. This underscores the need to restore and to preserve them.

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[2] A version of this chapter has been submitted for publication as "*Terminalia* woodland in Pandero, Murchison Falls Park, Uganda, since 1956" in the *African Journal of Ecology.*

Figure 4.1 Picture taken by the author while standing on the ground in Pandero, 1984. It shows the huge amount of herbaceous material (standing crop) accumulating every year, fuelling fires in the region. The tall grass conceals small trees in the area. The circle in the picture indicates a reference point used in later pictures.

Figure 4.2 Picture taken by the author from approximately the same viewpoint in Pandero as in 4.1 but while standing at the door of the Suzuki (in Figure 3.3), i.e. from a position about 0.5 m higher than in figure 4.1. The many small trees in the area are now visible. In the middle distance, note a young *Borassus* palm. The circle in the picture is a reference point used in figure 4.1.

Figure 4.4 Pandero in 1985 after a fire, viewed from some tens of metres in front of the positions used to take the photographs 4.1 and 4.2. fire having cleared the view, the termite hill and the young palms in the middle distance have become more readily visible than in figures 4.1 and 4.2. The open understorey in the background is a major feature of the woodland. Photograph by author.

Since the 1970s, increased poaching has devastated populations of the park's large herbivores, reducing the elephant numbers from above 12,000 to below 2,000 (Bere 1958; Brooks & Buss 1962; Laws et al. 1975; Eltringham & Malpas 1980; Malpas 1980; Edroma 1982). Recent studies (Spence & Angus 1971; Smart, Hatton & Spence 1985; Sabiiti & Wein 1988) showed that with low densities of large herbivores the woody component can develop, even in the presence of fire. Hence, the park authorities have expected a recovery of the *Terminalia* woodlands as a result of the recent decline in herbivore numbers (Spence & Angus 1971; Wheater 1972; Laws et al. 1975). Recent reports, though indicating an increase in woody plants, suggested a rather subdued recovery of the *Terminalia* woodlands (Smart et al. 1985). The present study was therefore undertaken to evaluate changes in the tree population in Pandero since the 1950s to help clarify this situation.

4.3 Study area

The present study was done in Pandero (Figures 2.3 & 3.5) south of the Paraa-Purongo road at UTM coordinates 354262 (Lands & Surveys Department 1960a). This was the *Terminalia-Prosopis* site documented by Buechner and Dawkins (1961) and was discussed in chapter 3. As shown in chapters 2 and 3, Pandero vegetation contains a woodland co-dominated by *Terminalia* and *Prosopis*, a remnant of the woodland of the 1950s (Figures 3.4 & 3.5). This is surrounded by grassland, derived from the conversion of woodland (Figures 3.4 & 3.5). Pandero tree population was composed of two distinct categories: coppice/small woody shoots on stumps, and large trees (see Figures 4.1, 4.2, 4.3 and 4.4). Trees in each of the categories appeared even-sized (Figure 4.2). All the large trees were >3 m tall and had girth >100 cm. For coppice, these values were <3 m tall and girth <50 cm. The coppice was ecologically equivalent to immature trees (Figures 4.2 and 4.3) the growth of which was checked by fire and herbivores (Buechner & Dawkins 1961). The term coppice originates from farmers' forestry, where it indicates a field of managed tree stumps ("stools") bearing thin, woody reiterated shoots (James 1989; Oldeman 1990). The biological status of burnt stumps bearing shoots is the same.

4.4 Study methods

The size class distribution and the species composition of trees in the two habitats, woodland and grassland (Figure 3.5) were recorded. The two tree size categories (coppice and large trees) were evaluated separately to ease assessing the regeneration prospects. Using the point-centred-quarter (PCQ) plotless sampling technique (Cottam & Curtis 1956; Krebs 1989) the relative density of large trees and their species composition were determined. At intervals of 25 m, a total of 42 points were sampled along six transects randomly located within the woodland. Within each quarter, the nearest tree was located and its species name, girth, vigour (dead/alive) and distance from the centre of the cross were recorded. The girths were measured at 1.5 m above ground (cf. Hallé, Oldeman & Tomlinson 1978).

In twenty plots, ten in each habitat, laid out randomly, all the coppice stools were counted to determine their relative density and species composition. The plots in the grassland were 50 m x 20 m (cf. Buechner & Dawkins 1961) and those in the woodland were smaller, i.e. 10 m x 20 m (smaller) due to a high density of coppice stools. In both habitats the plots were scanned for coppice stools in 5 m strips. The tree densities, girth sizes and species composition were compared with corresponding records of the area from 1958 (Buechner & Dawkins 1961). Changes in the densities and species composition were evaluated using the Wilcoxon's paired-samples test (Zar 1984).

4.5 Results

In the woodland there were 56.6 $\pm$11.0 large trees ha^{-1} in 1985 compared to 51 trees ha^{-1} in 1958 (Figure 4.5). The mere density of trees recorded in 1985 showed no significant changes having occurred in the number of large trees in the woodland since 1958 ($p=0.05$, $n=88$). However, the species composition of the large trees had changed. While *Terminalia* increased by about 33% there was about 21% decrease in *Prosopis* (Figure 4.5). Almost all the large trees had scars (Figures 3.1 and 3.2) and nearly 5% were dead, but less than 1% of the scars were fresh. Of the 31 dead trees ha^{-1} more than 70% were *Prosopis* many of which, according to some long-serving park employees, died as early as the 1960s. All the dead trees had scars from past fire and elephant damage (Figure 3.2) which might have killed them.

The girth size distribution (Figure 4.6) shows that differences between coppice and large tree have increased. While the large trees became larger, the coppice remained small. This resulted in the persistence and widening of the recruitment gap (Figure 4.6).

Besides their physiognomic contrast, woodland and grassland (1985) differed in density and species composition of their coppice stools ($Z=3.4724$, $p<0.001$, $n=25$). Having been one woodland in 1958, composition of the coppice stools changed both in the derived 1985 woodland ($Z=2.3188$, $p=0.02$, $n=27$) and in the derived 1985 grassland ($Z=2.2234$, $0.02<p<0.05$, $n=30$). Within the grassland, the number of coppice stools decreased by more than 78% whereas in the woodland it increased by more than 790%.

Four patterns were detected in the relative species composition of the coppice stools (Table 4.1). First, some species decreased in grassland while increasing in woodland. For instance, *T. glaucescens* coppice stools decreased by over 55% in grassland but increased by over 5900% in woodland. There were similar but less substantial changes in the numbers of *Albizia zygia, Bridelia scleroneura, Combretum molle, Gardenia jovis-tonantis, Grewia mollis, Lonchocarpus laxiflora, Piliostigma thonningii, Stereospermum kunthianum* and *Strychnos innocua*. Second, species such as *Acacia sieberana, Kigelia africana, Prosopis africana, Pterocarpus abyssinicus* and Spp. *indet.* newly appeared or increased in both vegetation types. Invariably species in this group increased more in woodland than in grassland. Third, the species *Annona senegalensis, Crataeva adansonii, Pseudocedrela kotschyi, Securidaca longipedunculata* and *Securinega virosa* persisted only in grassland. Fourth, species such as *Acacia hockii, Albizia coriaria, Harrisonia abyssinica, Hymenocardia acida* and *Maytenus senegalensis* have diminished everywhere. *Borassus aethiopum* and *Ficus glumosa* fall under the fourth category above (Table 4.1) but were also seen in woodland, although not in the sample plots. It was also noted that both density and sizes of palms increased with distance from woodland.

4.6 Discussion

Relative shifts in the composition of the large trees favouring *Terminalia* (Figure 4.4) support earlier predictions of the effects of selective tree destruction by elephants (Buechner & Dawkins 1961). It also reflects differences in the degree of damage the large trees had undergone as well as the tenacity with which the species can recover. The net increase in *T. glaucescens* and the net decrease in *P. africana* (Figure 4.5) prove that some recruitment in excess of mortality occurred in the former and not in the latter. These facts are consistent with previous observations that *P. africana* had undergone more severe pressure than *T. glaucescens* (Buechner & Dawkins 1961). Widespread dead *P. africana* trees and many barely surviving ones testify to both. The predominance *P. africana* of the dead trees, however, could also be explained by the relative resistance of the species to decay. The local name, *Kijing*, is an onomatopoeia, communicating the hardness of its wood. If many trees of other species had died recently, it would have been reflected in the composition of the dead trees.

Figure 4.6. shows that the recruitment gap in the tree population structure was not only apparent but was also real. The lack of trees in the girth size classes above 150 cm in 1958 relates to net loss of the larger trees, attributed to the selective damage by elephants (Buechner & Dawkins 1961). Relative increase in the number of large trees observed in 1985 proves that some recruitment occurred. However, any recruitment must have been limited in number and duration, considering the widening of the recruitment gap (Figure 4.6). The increase and the emergence of trees in larger girth size classes (>150 cm) in 1985 are proof of a recovery and continued growth of the large trees. This can be explained in terms of reduced elephant pressure evident in the conspicuous lack of dying or recently dead trees and the lack of new scars on the living trees.

Table 4.1 Density and species composition of small trees in Pandero, Murchison Falls Park, based on 1985 field records by the author and the 1958 records on Table III of Buechner & Dawkins (1961). PG = Pandero grassland, PW = Pandero woodland; figure in parenthesis is percentage equivalent of the total.

Species	Number of coppice stools per ha		
	1958 PW	1985 PG	1985 PW
Acacia hockii De Wild.	8 (0.70)	0 (0.00)	0 (0.00)
Acacia sieberana DC	0 (0.00)	5 (0.99)	40 (0.19)
Albizia coriaria Welw. ex Oliv.	7 (0.00)	0 (0.00)	0 (0.00)
Albizia zygia DC	15 (0.64)	5 (0.99)	45 (0.21)
Annona senegalensis Pers.	9 (0.38)	2 (0.40)	0 (0.00)
Borassus aethiopum Mart.	0 (0.00)	7 (1.39)	0 (0.00)
Bridelia scleroneuroides Muell. Arg.	38 (1.68)	0 (0.00)	85 (0.40)
Combretum binderianum Kotschy	430(18.22)	39 (7.74)	60 (0.28)
Combretum molle G. Don.	57 (2.42)	56(11.11)	590 (2.80)
Crataeva adansonii (DC) MacBride	0 (0.00)	1 (0.20)	0 (0.00)
Ficus glumosa Del.	7 (0.30)	1 (0.20)	0 (0.00)
Gardenia jovis-tonantis (Welw.) Hiern.	9 (0.38)	4 (0.79)	10 (0.05)
Grewia mollis Juss.	105 (4.45)	27 (5.36)	230 (1.09)
Harrisonia abyssinica Oliv.	10 (0.42)	0 (0.00)	0 (0.00)
Hymenocardia acida Tul.	31 (1.31)	0 (0.00)	0 (0.00)
Kigelia africana (Lam.) Benth.	0 (0.00)	4 (0.79)	25 (0.10)
Lonchocarpus laxiflora Guill. & Perr.	69 (2.92)	51(10.12)	95 (0.45)
Maytenus senegalensis (Lam.) Exell	7 (0.30)	0 (0.00)	0 (0.00)
Piliostigma thonningii (Schumach.) Milne-Redhead	9 (0.38)	3 (0.60)	10 (0.05)
Prosopis africana (Guill. & Perr.) Taub.	3 (0.13)	54(10.71)	280 (1.33)
Pseudocedrela kotschyi (Schweinf.) Harms	11 (0.47)	7 (1.39)	0 (0.00)
Pterocarpus abyssinicus	0 (0.00)	4 (0.79)	60 (0.28)
Securidaca longipedunculata Fresen	0 (0.00)	8 (1.59)	0 (0.00)
Securinega virosa (Wild.) Baill.	2 (0.08)	1 (0.20)	0 (0.00)
Stereospermum kunthianum Cham.	13 (0.55)	11 (2.18)	25 (0.12)
Strychnos innocua Del.	1300(55.08)	42 (8.33)	5995(28.46)
Terminalia glaucescens Planch. ex Benth.	220(9.32)	98(19.44)	13295(63.11)
Sp. *indet.* 1	0 (0.00)	69(13.69)	150 (0.71)
Sp. *indet.* 2	0 (0.00)	1 (0.20)	50 (0.24)
Sp. *indet.* 3	0 (0.00)	4 (0.79)	20 (0.09)
Total number of coppice stools	2360	504	21065

In contrast, the persistence and expansion of the recruitment gap (Figure 4.6) prove that the coppice shoots of all species is still suppressed. Changes in the large tree species (Figure 4.5) show no correlation with the relative composition of the 1958 coppice stools (Buechner &

Dawkins 1961). Which tree species will dominate any future vegetation in the area will depend primarily on how well their coppice shoots cope with factors currently suppressing them. It remains to be seen, therefore, whether changes in the species composition of the coppice stools will effectively result in a completely new type of woody vegetation.

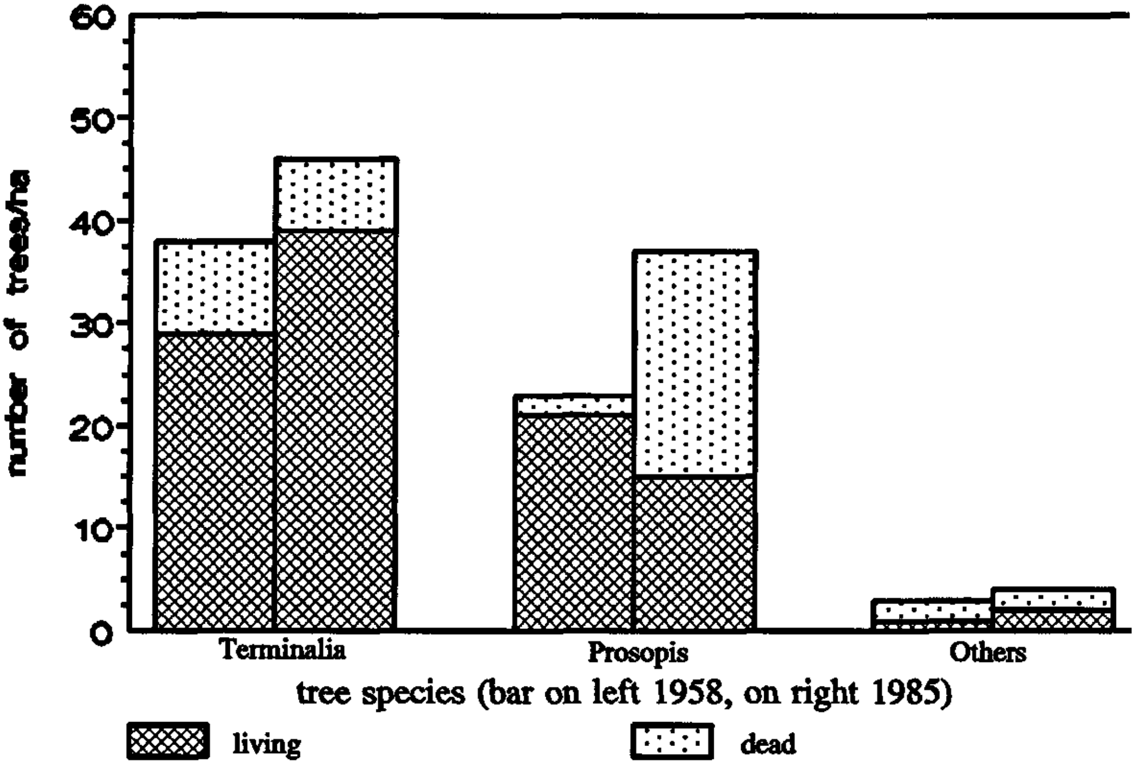

Figure 4.5 Relative density and species composition of large trees in Pandero. Major changes occurred in the composition of the woodland between 1958 and 1985.

Previous studies (Buechner & Dawkins 1961; Laws et al. 1975) showed fire and elephants as the key factors that killed large trees and suppressed coppice shoots. Improvement of the vitality of the large trees following decline in the elephant numbers proves that the role of fire in the death of large trees in the past was secondary to elephant damage. The continued lack of recruitment, however, shows that rather than high elephant numbers, other factors were primarily responsible for suppressing the coppice shoots. It is unlikely that fire alone would prevent tree recruitment (Spence & Angus 1971; Lock 1977; Pellew 1983; Smart et al. 1985; Sabiiti & Wein 1988). The continued suppression of the coppice shoots, therefore, is probably the result of some *interaction* of factors so far not perceived (Oldeman 1990). More precise insight into the underlying processes will require more detailed study of possible interacting influences of fire and herbivores in the vegetation dynamics (but see chapters 6 & 7).

Differences between density of coppice stools in the woodland and in the grassland point to significant ecological changes in the landscape after the loss of the woodland (Oldeman 1990; Oneka 1991). Decline of coppice stools in grassland suggests that conversion of woodland to grassland vegetation was more than the mere loss of large trees. The vegetation changes altered other ecological processes which influenced tree regeneration. This can be due to reduced supply of seeds and reduced establishment of seedlings. Both can be caused by a changed fire regime after the loss of large trees.

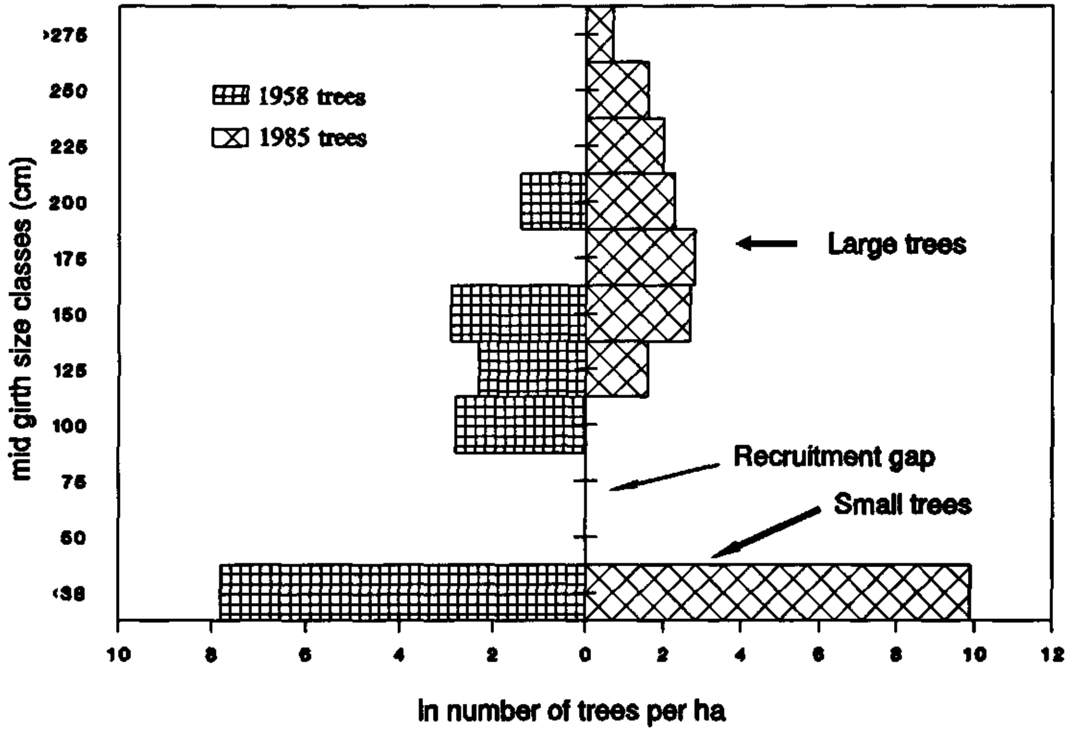

Figure 4.6 Relative density and population structure of trees in Pandero demonstrating a lack of recruitment of small into large trees.

Causes of the changes in the species composition of the coppice stools can only be speculated upon as none of the possible explanatory factors have been monitored over long periods. The factors that could help explain some of the changes include possible changes in the fire regime due to changes in the tree cover. It is possible that changes such as increases in frequency of *A. sieberana, K. africana, P. africana* and *P. abyssinicus* were caused by the germination of their seed in the soil, prompted by an occasional severe fire (Roberts 1981; Romme 1982; Sabiiti & Wein 1987 & 1988; Oldeman 1990). Greater increase of these species in woodland than in grassland could be due to possible differences in sizes of relevant soil seed-banks and to seedling establishment factors (Sabiiti & Wein 1987 & 1988; Munyanziza 1994).

Trees recorded only in grassland (e.g. *A. senegalensis, C. adansonii, P. kotschyi* and *S. virosa*) indeed belong to open vegetation (Eggeling & Dale 1951; Geerling 1987). In other cases, however, the higher abundance of some of the species in grassland than in woodland (Table 4.1) can be related to their dispersal mode. For instance, the elephant is an important agent of *B. aethiopum* dispersal in the park region (pers. observ. 1984). Elephants swallow and disperse fruits of the *B. aethiopum* palm and the *C. adansonii* tree along their trails. While destroying large trees the elephants also introduce species by sowing them. The presence of bigger palms at increasing distance from the woodland proves this. It also proves that elephant damage proceeded from the periphery of the woodland inward (Buechner & Dawkins 1961).

Prevailing trends in the tree population in Pandero warned of major changes in the tree species composition and size structure. As shown in chapter 3, the new composition could result in a landscape of different aesthetic and ecological values. Increased recruitment could lead to a higher tree density and fill out and close the peculiar open woodland architecture (Oldeman 1990). On the other hand, subject to other factors, a woodland with a more diverse tree species composition might contribute more to species conservation. Two options are open to the park authority: either a new woodland with more diverse woody plants, or another, less diverse but open, orchard-like woodland architecture, as characteristic of the former *Terminalia* woodlands. The significance of these options as to their ulterior consequences necessitates a finer definition of the vegetation conservation policies and objectives. Clearer objectives in vegetation conservation will facilitate developing appropriate management programmes. Regardless of the particular choice which is made, restoration and conservation of woody vegetation in the park will require changes in the management of both fire and herbivores.

In conclusion, this chapter shows that in dealing with living systems such as the park the interplay of factors defies simplistic modelling of processes. For park design to succeed, its model bases have to be broader and more comprehensive than has hitherto been the case. A more reliable evaluation of the conservation status of the woodland requires no less than the evolution of comprehensive long-term research and monitoring programmes. Other kind of research is needed so as to define relevant institutional make-up, techniques, and conceptual models of the park systems. Towards these ends computer-based information systems offer possibilities that could be exploited. Research methods become essential in this context. The next chapter explores the part to be played by analytical methods.

CHAPTER 5. THE PLACE AND ROLE OF ANALYTICAL RESEARCH

5.1 Abstract

This chapter examines some finer studies of the regeneration of the woodland in Pandero described in chapter 4. It shows the importance of in-depth analysis of key park structures and processes in the design of a park. Regeneration of plants constitutes an important component process of the park's vegetation and landscape dynamics. Aspects of *Terminalia glaucescens* regeneration ecology examined show that fire management policy strongly affects its fruit dispersal, germination and seedling establishment. It is argued that these aspects constitute some of the mechanisms which make fire into a tool to influence the vegetation and landscape patterns. Incorporation of such insight in park design would lead to more effective park programmes. The lack of such insight means many parks are "failures by design". It underlines the need for park design to define the over-all context and profile of relevant research.

5.2 Introduction

Changes in vegetation cover has remained a major concern in the Murchison Falls Park. Already in the park's early years, as shown in preceding chapters, the steady loss of its wooded landscapes threatened to wreck the park system (Buechner & Dawkins 1961; Laws, Parker & Johnstone 1975). The decline in area of wooded landscapes made more open an already monotonous open grassland. This process threatened the park's ecological and aesthetic integrity (chapter 3). Since these problems became apparent, management priority has been to find means to control the underlying processes so as to restore the original park landscapes (Wheater 1972; Laws et al. 1975). The present study examines natural regeneration of *T. glaucescens*. This important pioneer species once dominated the regional wooded landscapes (Eggeling 1947; Dawkins 1949; Langdale-Brown 1960; Osmaston 1968). The earliest reports on the park vegetation blamed fire and large herbivores for the decline of wooded landscapes (Buechner & Dawkins 1961; Wheater 1972). Since the 1970s, the numbers of large herbivores have fallen, making it likely that the subdued recovery of wooded landscapes was being caused by fire. Results from different fire management strategies tested showed that excluding fire enabled some recovery of wooded vegetation in the park (Spence & Angus 1971; Lock 1977). Further studies, however, have shown that where fire was excluded *T. glaucescens* declined (Smart, Hatton & Spence 1985; Oneka 1991). The present study therefore examines the mechanisms of fire influencing *T. glaucescens* regeneration.

Insight into the life cycle of *T. glaucescens* is important in the design of the park considering the species to be an important fore-runner to wooded vegetation in the region (Eggeling 1947; Dawkins 1949; Langdale-Brown 1960). Insight into this life cycle clarifies what makes the species an important pioneer plant. *Terminalia* fruit dispersal, germination and seedling establishment enable wooded landscapes to expand. The expansion of wooded landscapes is an important ecological process, critical to be understood for an effective design of this park.

In northern Uganda *T. glaucescens* fruits ripen and dry up by the onset of the dry season about the beginning of December (pers. observ. 1983/85). The *Terminalia glaucescens* dispersal unit is a two-winged, wind-dispersed, indehiscent fruit, notched or emarginate at its apex, ca. 6.2 cm long and 2 cm wide, somewhat rectangular at the base (Eggeling & Dale 1951; Uzoechina 1978). Fruit dispersal covers the spread of fruits from the parent trees (van der Pijl 1969; Howe & Smallwood 1982). By seed dispersal, plants migrate, colonise new sites (Harper 1977; Fenner 1985) and intermingle, allowing for gene flow in the population (van der Pijl 1969; Hamrick & Loveless 1986; Govindaraju 1988; Silvertown & Doust 1993). In some species it minimises intra-specific competition and seedling mortality near parent plants (Janzen 1970; Fenner 1978; Augspurger 1983, 1984a & b; Becker & Wong 1985; Condit, Hubbell & Foster 1992). In these respects, little is known of *T. glaucescens,* but in some *Terminalia* species they are critical. For example, in the drier regions of southern Africa *Terminalia spinosa* dispersal reduces intraspecific competition for moisture (Ernst 1990). As shown by Augspurger (1984b), in *T. oblonga* fungus-induced seedling mortality was highest in the shade. Therefore dispersal of fruits away from the shade would benefit the species. Yasman (1995) has shown that in shaded sites limited light restricts photosynthesis which can starve seedlings unless this situation is mitigated by mychorrhiza formation. In pioneer trees many of which are *Terminalia* species (Eggeling 1947; Dawkins 1949; Keay 1957; Geerling 1987), dispersal therefore is a critical regeneration factor. It is thus important to determine the main patterns of *T. glaucescens* fruit dispersal and how they relate to the incidence of fire. It is also important to determine in what ways prevailing fire management practices are impacting on *T. glaucescens* regeneration through its dispersal mechanism.

Terminalia glaucescens seeds exhibit epigeal germination (Lamb & Ntima 1971). First, two conspicuous cotyledon pegs appear above soil level, later the cotyledons follow. In an experimental study in West Africa, Uzoechina (1978) reported that seeds of the species germinated without scarification. Preliminary observations in the present study, however, suggest that the fresh seeds have an innate primary dormancy. As shown by Baskin and Baskin (1972 & 1985) and by Miller (1987) dormancy helps relate the time of germination to favourable environmental circumstances. The study of Silvertown (1981) substantiates this and once more proves the old forestry rule that the timing of germination is crucial in the establishment of the seedlings. With fire a salient feature of the *Terminalia* landscapes, does it influence the timing of *T. glaucescens* germination?

A seedling is established when it has taken root, has effectively become independent of its seed reserves (Howe & Smallwood 1982) and can survive adverse conditions such as shade and drought (Augspurger 1984a & b; Fenner 1985; Sabiiti 1985; Silvertown 1987). By reducing plant cover (Daubenmire 1968; Ogen-Odoi & Dilworth 1987), fire creates new conditions which may or may not favour seedling establishment. As Augspurger (1984a & b) showed, shading significantly affects seedling establishment. It is possible that the change of plant cover by fire plays a role in the seedling establishment. The performance of *T. glaucescens* seedlings under contrasting cover-types was monitored to find out whether their establishment under shade differed from that in the sun. Effects of the modifications of plant cover by fire on chances for seedling establishment were also examined.

5.3 Study area

The study was conducted in the wooded site about 1 km from the Chobe Park gate and South of the Paraa-Purongo road in Pandero (Figure 2.3 and 3.5). The Chobe site was described in chapter 2 and the Pandero site in chapter 3. The vegetation of the Chobe study site consisted of a mixture of broad-leaved trees dominated by *T. glaucescens* and *Combretum* spp. (see section 2.8). Although both sites were dominated by *T. glaucescens*, overall tree cover was higher and species composition of the large trees was more diverse in Chobe than in Pandero. Fire is an important feature of both landscapes. During the study, all the fires in Pandero were patchy varying from severe burn here to no burn there (see also Chapter 7). In severely burnt patches, all herbaceous and most shrub material were burnt to ground level whereas completely unburnt patches characterised the other extreme of the scale. In patches under moderate burn some herbaceous and most shrub material remained unburnt. The categories severe, moderate, and not burnt were used to classify the sites in relationship to burning in the present study.

5.4 Study methods

Under mature *T. glaucescens* trees several fruits from previous year were found in both Chobe and Pandero. Some of these *T. glaucescens* fruits were collected in December 1983, checked for any defects and tested for viability using tetrazolium bromide, so as to assess the possible importance of fruits from preceding fruiting seasons as propagule reserves (cf. Thompson 1974; Sabiiti & Wein 1987; Oldeman 1990; Tybirk, Schmidt & Hauser 1992).

The dispersal potential of *T. glaucescens* fruits was equated to their wing-loading (**Ka**) which was estimated using the formula **Ka**= **A/g** where **A** was the fruit surface area (cm^2) and **g** its weight (grammes). These fruits were collected, weighed and their surface areas measured in September and in January. From various studies it has been shown that the larger the surface area of the fruits, the larger is the wing-loading which increases the resistance of the air-borne fruits to gravitational pull (van der Pijl 1969; Burrows 1973; Cremer 1977; Green 1980; Augspurger 1986; Ernst, Decelle & Tolsma 1990). Fruits with large wing-loading would therefore be expected to be dispersed over longer distances from the parent plants. The *effective fruit dispersal* (**ED**), *that is actual fruit dispersal under field* conditions, has been based on the number of fruits found on the ground with increasing distance from the parent trees. In December 1983, 15 large *T. glaucescens* trees, a minimum of 30 m from each other were selected. Eight of the trees were in Chobe and seven in Pandero. Under each selected tree four line transects were sampled each 20 m long and each oriented along the cardinal directions. This was repeated with ten *T. glaucescens* trees in Pandero during February 1984. Five of the trees were in early burnt sites, and the other five in unburnt ones. Dispersal direction and distance in Chobe and Pandero, and effects of the fire treatments on fruit dispersal effectiveness (**ED**) were analyzed.

Fruits collected from Pandero at the start of the dry season (December 1983) and towards the end of the dry season (March 1984) underwent contrasting heat treatments. Batches, each of 25 fruits, were either: i) not exposed to high temperature (control); ii) dipped in boiling water; or iii) exposed to fire fuelled by 25 g of dry grass. Fifty fruits collected in February 1985 from lone *T. glaucescens* trees outside the park received comparable treatment with boiling water. The lone trees from which fruits were collected were, at a minimum, 500 m distant from the nearest known fruiting *T. glaucescens* trees. In all the experiments the fruits were sown ca. 1 cm depth, the seed bed was covered with dry grass and watered regularly. The number of seedlings emerging were monitored and differences in the germination rates amongst the treatments were evaluated.

During a period from May to September 1985, the number of seedlings of *T. glaucescens* was monitored in twenty 1 m^2 quadrat in Pandero. Ten of the quadrat were in severely burnt sites and the remaining 10 in moderately burnt sites. Another 18 pairs of 1 m^2 quadrat, each one including one weeded and the other unweeded, were also monitored in Pandero. Nine of the pairs were in the grassland and the remaining nine in the woodland. In weeded quadrat all other plants were clipped at ground level and removed to expose the *T. glaucescens* seedlings. Difference in seedling survival amongst the contrasting conditions: severe/moderate burns, weeded/ unweeded, and grassland/ woodland, were assessed. Because of the ordinal nature of these and preceding data, the Kolmogorov-Smirnov's test (Zar 1984) was used to test the statistical significance of the observations.

5.5 Results

All old *T. glaucescens* fruits collected from Chobe and Pandero were dead and most of them had holes which indicated damage from *Bruchid* beetles.

The dispersal potential of *T. glaucescens* fruits increased more than two-fold between September 1984 and January 1985, the peak of the dry season. As the fruits matured the surface of their wings increased while their weight fell due to loss of moisture. The fruits curled as they dried and were dispersed from the parent tree spiralling on the wind over a distance.

Fruits from lone parent trees were smaller, shrivelled and defective. Although by the end of the dry season many *Terminalia* fruits were found kilometres away from the nearest known potential parent trees, most of the fruits fell under the parent trees (Figures 5.1). Although fruit dispersal was more distant in Pandero than in Chobe (Figure 5.1) it was more directional in Chobe (Figure 5.2). As shown in figure 5.1, the observed effective dispersal distance in Chobe was only 12 m whereas in Pandero it exceeded 16 m.

The dispersal distance (Figure 5.1) was significantly greater and more directional (Figure 5.3) on early-burnt than on late or no-burnt sites. Trees on early-burnt sites lost most of their leaves early and their fruits became exposed. Many of the fruits were scorched and destroyed by fire on late-burn sites while fruits on early-burn sites lay uncovered on the ground. These uncovered fruits were attacked by termites which nibbled off their wings and buried them.

The relationship between seedling survival and burning severity changed over the year. Although more seedlings survived on moderately- than on severely-burnt sites between May and July, after July this seedlings survival pattern was reversed (Figure 5.5). Seedling survival was significantly higher on weeded quadrat in the woodland than in the grassland between May and July but this pattern was also reversed after July (Figure 5.5). Before July most seedlings died of drought whereas thereafter most died of fungal infections.

New seedlings were found both in the grassland and the woodland in Pandero. Fresh fruits, collected in the beginning of the dry season, required pre-treatment to germinate while older fruits, collected at the end of the dry season, did not (Figure 5.4). Also invariably more fruits germinated after treatments with hot water than with fire. All fruits from lone *T. glaucescens* parents were defective, most were infested by beetles and none germinated.

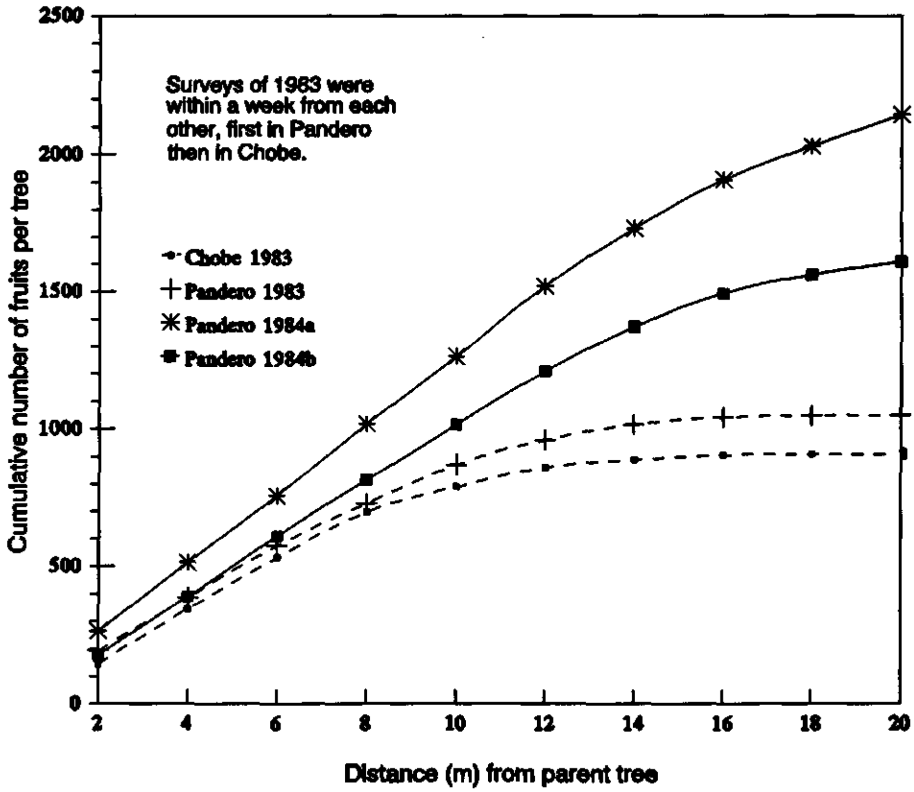

Figure 5.1 Fruit dispersal distance under two different conditions. The tree cover in Chobe was higher and floristically more diverse than in Pandero. The figure shows the number of fruits estimated from line transects parting from the *Terminalia* parent trees.

5.6 Discussion

Under field conditions *T. glaucescens* fruits had a short life-span. The loss of viability in most of the cases observed was caused by beetle damage. The species therefore can barely regenerate from a propagule bank left from past seasons. Prevalence of *T. glaucescens* after land clearance (cf. Geerling 1987) should thus be explained by fruits recently dispersed, not originating from soil seed reserves as is the case in other species (Auld 1986 & 1987; Kemp 1989; Sabiiti & Wein 1987 & 1988; Oldeman 1990; Tybirk et al. 1992). The observed damage of fruits by beetles compares with beetle damage of seeds of other species (Lamprey, Halevy & Makacha 1974; Sabiiti 1985; Munyanziza 1994; Mucunguzi 1995) or to herbivore impacts (Ernst, Decelle & Tolsma 1990). The annual number of fruits produced is a relatively high seed rain, a phenomenon common in *r* strategy species in which the survival chances of the species are enhanced by the high seed numbers (Gadgil & Solbrig 1972; Oldeman 1990).

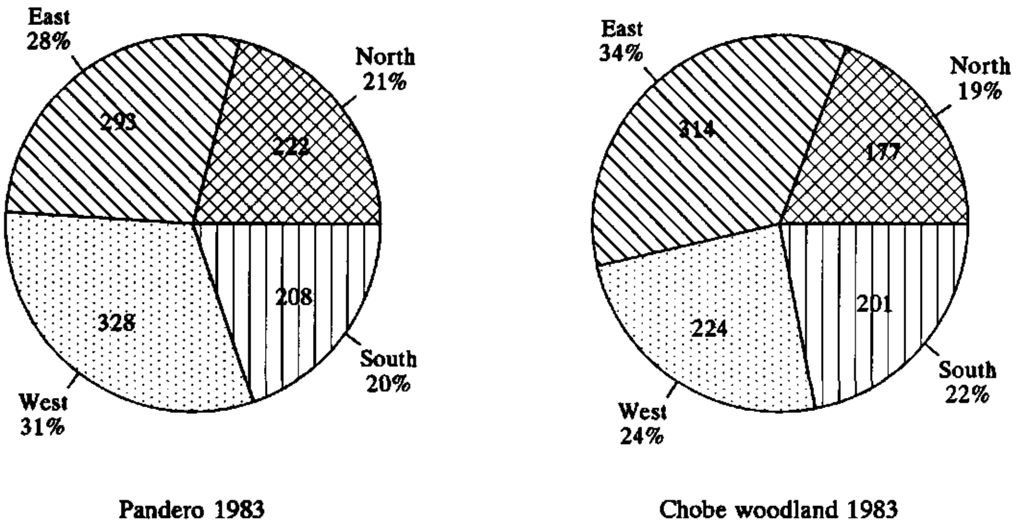

Figure 5.2 Direction of *T. glaucescens* fruit dispersal under different conditions as described in figure 5.1. The figure shows the number of fruits as assessed by using line transects along cardinal directions from the parent trees.

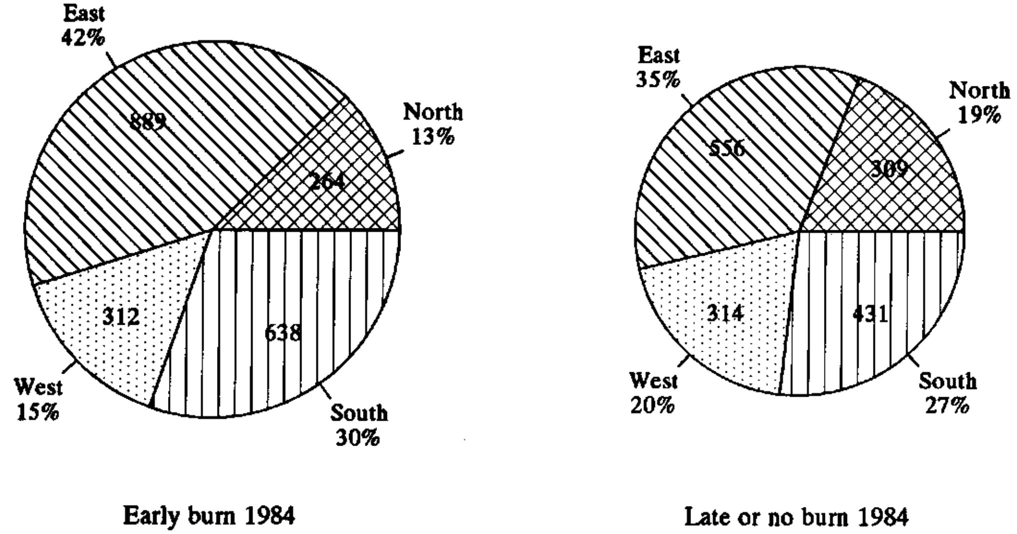

Figure 5.3 Fire effects on *T. glaucescens* fruit dispersal direction in Pandero. The figure shows the number of fruits as assessed by using line transects along cardinal directions from the parent trees.

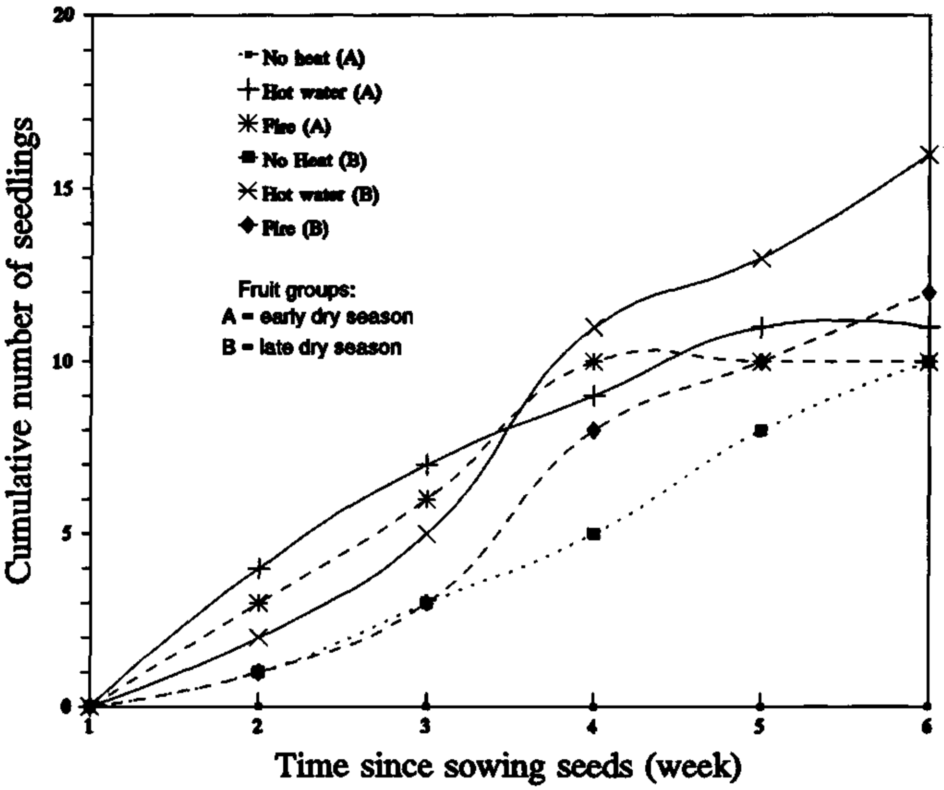

Figure 5.4 Effects of heat on germination rate of *T. glaucescens* fruits. Two sets of fruits were used, the one collected at the beginning of the dry season and the other at the end of the dry season. The treatments were boiling water, fire and control. Laboratory experiment at Paraa.

Temporal increase in dispersability of the fruits was caused by changes in the climatic conditions. The fruits of *T. glaucescens* in the region matured at the onset of the dry season when it was hot, dry, windy (Figures 2.5 & 2.11) and many tree species shed their leaves. Similar phenological pattern also were observed in other plant communities in which wind-dispersed tree species are common (Keay 1957; Exell & Stace 1972; Ernst 1990; Fleming & Williams 1990; de Bie 1991). Under these conditions the fruits are no longer sheltered by leaves, so the dispersal powers of the wind in the tree canopy are at their strongest (Meroney 1968; Shaw 1977; Grace 1977; Jacobs 1983; Jacobs & Wartena 1987). The temporal synchrony between climatic conditions that favour wind dispersal and the phenology of *T. glaucescens* proves that the species is geared to wind-dispersal.

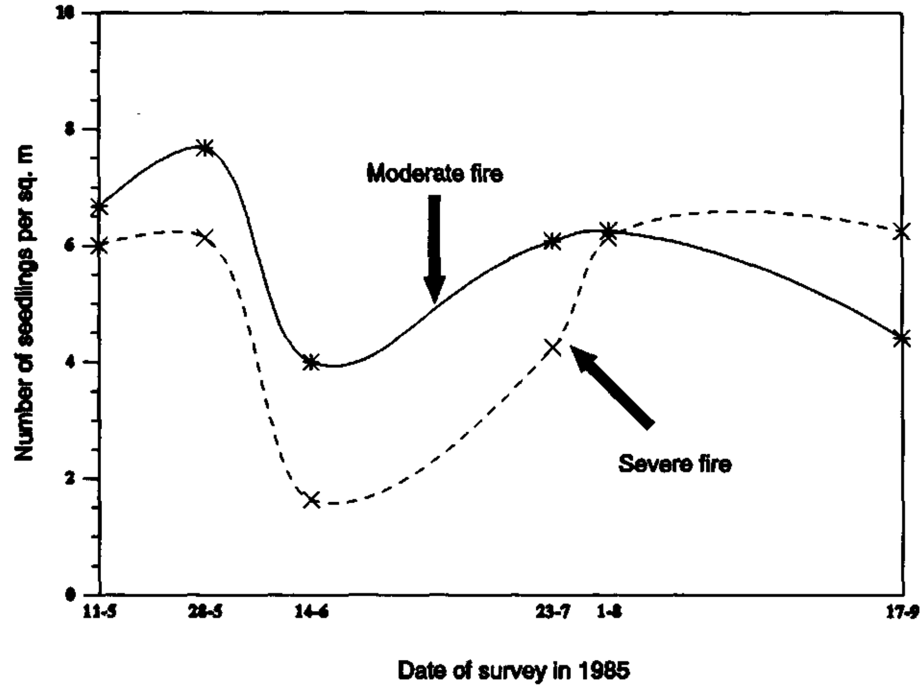

Figure 5.5 Survival of *T. glaucescens* seedlings on sites that had severe burn contrasted to that on sites with moderate burn. In the first category the seedlings were without cover. In the second, much cover existed. The figure shows that initially covers favour seedling survival but later this situation changes. Based on observations in Pandero 1984.

Dispersal was less effective in Chobe than in Pandero (Figure 5.1) since the denser tree cover in Chobe reduced wind speed and obstructed fruit trajectories (Kawatani & Meroney 1971; Grace 1977; McNaughton 1989). The contrast in dispersal direction between the two sites (Figure 5.2) is attributable to differences in their canopy architecture. As shown by Grace (1977), Jacobs (1983) and McNaughton (1989) the denser the barrier to wind the greater the deflection of the wind and also the stronger the air current passing through small passages in the canopy architecture. The tree canopy in Chobe was denser and therefore could have neutralised all except the strongest winds, the flow of which through openings in the canopy was channelled so they even blew with greater force. In contrast, the lighter canopy cover in Pandero allowed the winds to blow through more freely. At the time of assessing fruit dispersal in the two sites, wind directions were variable. As explained above the greater tree cover in Chobe could have moderated all but the strongest winds which then resulted in more directional fruit dispersal. The lack of such moderation in Pandero explains the relatively even dispersion of fruits around the parent plants (Figure 5.2).

The differences in dispersal distances between early, and late/no burn show the importance of fire in the local tree regeneration ecology. During burning, a convection heat wave is generated (Daubenmire 1968; Davis 1976; Chandler et al. 1983). This accelerates the fall of tree leaves and also speeds up the drying and related weight losses in the *T. glaucescens* fruits. The thick central core of the fruit makes it dry unevenly, causing the wings to curl (cf. Stevens, 1974 p. 90). Although this seems possible without fire, the convection current in early-burning speeds it up. The curling of the fruit wings increases the resistance of airborne fruits to the pull of gravity and helps to keep the fruits longer in the air, enabling a longer dispersal distance in a cross-wind (van der Pijl 1969; Burrows 1973 & 1975; Sheldon & Burrows 1973; Sharpe & Fields 1982). Longer fruit dispersal distance (Figure 5.1) after early- than late-burns is proof that dispersal of *T. glaucescens* is favoured by early-burning. On the other hand, the match between plant phenology and the hot, dry and windy conditions typical of the dry seasons, help define the geographical range of *T. glaucescens* and other plants with related temperaments (Exell & Stace 1972).

Although early burning favoured long dispersal distances, as discussed earlier (see also Figure 5.1), the fruits falling on unburnt sites risk being destroyed in a late fire. On early-burnt sites, termites introduce other effects. As has been observed in other species (Beatie & Culver 1982; Munyanziza 1994) superficially germinated seedlings tended to suffer high mortality especially in drought. The burial of the fruits by the termites thus probably enhanced *T. glaucescens* seedling establishment.

In contrast to older fruits, the failure of untreated fresh fruits to germinate (Figure 5.4), proves that an endogenous primary dormancy exists in the fresh fruits (Silvertown 1981, 1987 & 1988; Silvertown & Doust 1993). Whatever the nature of this dormancy, it disappears in the course of the dry season, probably broken by heat as shown by our experiments. We suspect that Uzoechina (1978) used seeds collected later in the dry season, at a time when this dormancy was already broken. As shown in figure 5.4, heat is one component of the mechanism that can break the *T. glaucescens* fruit dormancy. Under field conditions such heat is from fire or solar radiation. Although fire of moderate intensity stimulated seed germination (Sabiiti & Wein 1987 & 1988), more intense fires can destroy the seeds (Sabiiti & Wein 1987; Munyanziza 1994). As shown from other studies (Sabiiti (1985; Sabiiti & Wein 1988) fire also reduced seed damage by beetles. Although the source of heat used to scarify the fruits was insignificant (Figure 5.4), consistently more fruits germinated after treatment with hot water than with fire. The water imbibed by the fruits during scarification with hot water favoured germination. The damage by beetles on the fruit reserves can be a major regeneration factor (cf. Mucunguzi 1995). If the high rate of fruit damage by beetles in Chobe is true of all denser woody cover, then beetles are a more critical regeneration factor in *T. glaucescens* than has been hitherto recognised. This could help explain the lack of *T. glaucescens* regeneration in closed woodlands (Eggeling 1947). In what ways fire can be appropriately managed in this type of situations requires more detailed and in particular less reductionist studies.

Distances of fruit dispersal observed in the present study (Figure 5.1) prove that the existence of lone *T. glaucescens* trees are likely to be the direct result of distant dispersal. The shrivelled and defective state of the *T. glaucescens* fruits from lone parents is directly linked to their lack of germination. Cross-pollination is important in various other species of the genus *Terminalia* (Srivastava 1993). Although distant fruit dispersal was possible in *T. glaucescens*, the likely outcome, lone trees, having minimal chances for cross-pollination, would produce defective and sterile fruits (Bierzychudeck 1981). These points confirm that the optimum environment of *T. glaucescens* is neither the open field, nor the closed forest.

The presence of *T. glaucescens* seedlings in both woodland and grassland proves that germination was possible in both sites. Moisture availability and fungal infections are judged to be factors that controlled seedling establishment in Pandero. During the period from May to July, plant growth was limited by moisture supply (Figure 2.5). Shading in wooded sites previously moderately burnt reduced water stress and so favoured seedling survival. After July improved moisture availability and increased shading make light the factor limiting seedling survival, which thus declines in the shaded sites as shown in figure 5.5. The combination of shading and higher humidity after July favoured fungal infections which are responsible for the greater seedling mortality in wooded and unweeded sites. These are additional ecological interactions that explain the decline of *T. glaucescens* in secondary succession towards more densely wooded vegetation (Eggeling 1947; Dawkins 1949). They also confirm *T. glaucescens* to be a colonising species, i.e. a tree adapted to rather but not totally open landscapes. On the other hand the observations also show how micro-site heterogeneity has the power to increase chances for seedling survival.

The studies presented in this chapter have shown that fire can affect the patterns of *T. glaucescens* fruit dispersal, survival, germination and possibly seedling establishment. All these processes of tree regeneration ecology appear to be favoured by early-burning. In a denser woody vegetation the dispersal of the fruits was negatively affected and there was a high incidence of fruit damage by beetles. While fruits falling on early-burnt sites are buried by termites, those falling on sites yet to be burnt (late-burnt) risk getting burnt. Distant fruit dispersal enables individual trees to establish themselves in new sites but since the individuals require cross-pollination they are not able to procreate. Although it may take a fruit to reach a new site, it will take more individuals to colonise it. The expansion of *Terminalia* woodlands is therefore more gradual than could be expected from its fruit dispersability. It is concluded that the optimum environment of *T. glaucescens* is neither the open nor the dense woody vegetation, a situation which fire helps to maintain. The restoration and the preservation of *Terminalia* woodland in the Murchison Falls Park will therefore require fire rather than its exclusion.

The studies in the present chapter prove the importance of in-depth understanding in park design. This type of research often at first does not appear important. Besides, it often requires much expertise and infrastructure. The aspects involved could be ecological as illustrated in this chapter, however, all aspects of the dynamics of a park system require similar attention. Incorporating insights into such cultural, sociological, ethiological, political, historical or epidemiological aspects that are often left out of park design could prove critical. Park design which makes no provision for research on aspects other than "purely" ecological are therefore, in this context, inappropriate. It is crucial that park design defines an institutional process through which appropriate research programmes may evolve. Such institutions can incorporate partnership with specialised bodies such as universities and research institutes which have relevant expertise and infrastructure to effectively carry out some of the research. For this to be effective there is need for improved institutional models of park systems.

CHAPTER 6. FACTORS IN LANDSCAPE DYNAMICS[3]

6.1 Abstract

This chapter examines the impacts of fire and large herbivores on the small trees as possible factors explaining the subdued recovery of Pandero woodland (chapters 4 and 5). Past reports from the Murchison Falls Park highlighted the loss of woody vegetation under the influences of fire and excessive numbers of elephants. Reductions in the elephant numbers fulfilled one of the pre-conditions speculated by earlier authors to be crucial to the recovery of woody vegetation. Growth patterns of the small trees in Pandero have been analyzed and the results proved that they were being suppressed. Rather than fire, large herbivores other than the elephants were suppressing the small trees. Although experimental exclusion of fire and the large herbivores enabled some recovery of woody cover, *Terminalia glaucescens* and *Prosopis africana* decreased. Decline in these key tree components of the former woodlands proves that restoration of past woodlands will require more than controlling a few factors believed to be exclusively responsible for their destruction. An incorrect definition of the park system will lead to misleading assumptions as to the park processes. It is therefore recommended that park design should help define appropriate institutions to facilitate the evolution of relevant modelling approaches.

6.2 Introduction

Until now, ecological research was analytical and looked for factors and how these supposedly worked. *Factor* is a Latin word. It means "maker". In analytical science it means a simple cause that *makes* things happen. As the earlier chapters have shown, there is no such a thing as a simple linear chain of factors and their effects. There are many factors, and sometimes they are in their turn effects of other factors, like sergeants who function sometimes like officers, sometimes like soldiers. The ecosystem is a complex web of such interactions, "singing in the bottle". The present chapter still concerns factors, by distinguishing them, but not separating them from the whole system. The next chapter is considering them as an "ecological control network". It has been shown in chapters 2 and 3 that most of the woody vegetation of the Murchison Falls Park was destroyed by a combination of repeated burning and pressure from high elephant densities. Although the elephant numbers have drastically fallen due to increased poaching, as shown in preceding chapters, regeneration of the woody vegetation remained subdued. The present study therefore examined the relative importance of fire and the large herbivores as factors co-determining the tree regeneration.

A peculiar feature of the woodlands on these three sites was the presence of trees of relatively uniform sizes. This created the visual impression that the trees were even-aged and belonged to one of two age categories: the mature (old, large), and the immature (young, small) trees (Figures 4.2, 4.4 and 4.6). According to many authors this structure could exist

[3] A part of this chapter has been published in 1991 as "Vegetation changes induced by exclusion of fire and large herbivores in the Murchison Falls National Park, Uganda". In: *African Wildlife: research and management*, edited by Kayanja, F.I.B. and Edroma, E.L. UNESCO/ICSU Press, Paris.

because the woodlands were composed of trees that grew up at the same time after some *zero event*, i.e. a major disruption resetting tree development at stage zero (Dawkins 1949; Langdale-Brown et al. 1964; Geerling 1987; Oldeman 1990). However, each year (see chapter 5) a large number of fruits are produced and a considerable proportion of seedlings establish themselves making it unlikely that the trees are even-aged. Evidently (Figure 4.6 and Table 4.1), despite increases in numbers of the small trees, a recruitment gap in the tree population in Pandero has persisted and has even widened. This observation was interpreted in chapter 4 as proof that the small trees were being suppressed. This is verified in the present study through the analysis of the patterns in the size structure and size increment of the selected small *T. glaucescens* trees.

In previous studies on fire effects in this park, most analyses have been based on the time of burning: early, late or no burning (Spence & Angus 1971; Wheater 1972; Lock 1977). More than one fire per dry season is not uncommon, but occurs so irregularly that tables of occurrences have very localised value only and can not be generalized. No fire burns uniformly (see Figures 6.1 and 6.2). There are often significant variations in the intensity and thoroughness of burns (Blaisdell 1953; Daubenmire 1968; Stronach & McNaughton 1989). It was unrealistic because of a lack of provable representativity either to implement controlled burning experiments or to document fire behaviour in all cases. Against this background, the present study relied on descriptions of the fires, with emphasis on their severity as judged by the thoroughness of the burns (Figures 1.1, 1.2, 4.4 and 6.2). The distribution and the impacts of large herbivores on the small trees have then been recorded with reference to the thoroughness of burning. Does severe burning make small trees more prone to herbivore damage by exposing them?

Experimental plots were initiated in the park in Chobe and in Wairingo during the 1960s (Spence & Angus 1971; Lock 1977). The plots were in formerly wooded sites and were subjected to different regimes of fire and large herbivore impacts, so as to determine their relative importance in the vegetation dynamics. From some plots, both fire and the large herbivores were excluded while in others, both were allowed. Preliminary results from the plots (Spence & Angus 1971; Smart, Hatton & Spence 1985) showed that excluding fire and large herbivores provoked considerable development of woody vegetation. During the present study a part of the Wairingo exclosure was examined to verify changes in its woody plants under virtually no fire and no large herbivores from 1967 to 1985. Emphasis was put on assessing the status of *T. glaucescens*, a key tree component of the woodlands that existed in the region. Two plots were previously established in Wairingo: the one was ditched the other was fire-proof and unditched (Lock 1977). Only the ditched plot could be found back. Although the Wairingo exclosure had not been maintained since 1978 (Figures 6.3 and 6.4), a decline in herbivore numbers since then reduced the risk of their entry to the plot. It also seemed that fire has been infrequent and mild in the region during that time (pers. observ. 1985). The results therefore provide a fair image of the trend to be expected in the vegetation under reduced pressure from fire and the large herbivore populations.

Figure 6.3 Picture taken while standing in the ditch around the exclusion plot in the Wairingo area showing the situation inside the plot. The ditch was generally free of fire. The woody plants in the background were mainly *Albizia* sp. Photograph by the author in March 1984.

6.3 Study area and methods

The location and the description of Pandero have been presented in chapters 2, 3 and 4 (see also Figure 2.3). The area studied was south of the Paraa-Purongo road at UTM coordinates 354262 and the samples were taken from the woodland and from the adjacent derived grassland (Figures 3.4 & 3.5). Discussions of mammals and their population patterns in the area are in sections 2.8 and 3.4 and chapter 7. The studies in Wairingo were confined to the ditched plot described by Lock (1977). This was locáted at UTM coordinates 576350 between the Joliya and the Wairingo rivers (Figure 2.2; Lands & Surveys Department 1960b). The plot was in a grassland derived from a woodland co-dominated by *Terminalia* and *Prosopis* (Buechner & Dawkins 1961; Lock 1977). The mean annual rainfall totals about 1100 mm (Figure 2.10) and the key large herbivores are similar to those in Pandero (Laws et al. 1975).

Fire severity was described in terms of its thoroughness (Daubenmire 1968). This was done using the categories: *severe, moderate*, and *no burn* (see Figure 6.2) based on the amount of shrubs and herbs left unburnt by the fire (Blaisdell 1953). In no burn the plants were left intact by the fire, after severe burn less than 15 cm high of the plants remained (Figures 1.2, 6.1 and 6.2; see also chapter 7). Intermediate to these extremes was the moderate burn, where half-burnt plant materials abounded (Figures 1.1 and 6.2; see also chapter 7).

Figure 6.4 Picture showing the actual state of the ditch built to keep large herbivores away from the exclosure in Wairingo. The walls of the ditch were no longer steep, so animals crossed it into the plot. There were some spoors of hartebeest in the plot. Grass grew in the ditch but surprisingly the plot was not burnt even though its surroundings had burnt. The fire was of moderate severity and stopped in the ditch. Photograph by the author March 1984.

During December 1984 and January 1985 impacts of the large herbivores under these classes of burning severity were compared. Impact of the latter was judged by using herbivore distribution as a parameter. Several *T. glaucescens* coppice shoots randomly selected in January 1985 were examined for herbivore damage (broken/ trampled/ browsed) to assess the relationship between fire severity and the likelihood of damage. Also the relationship between the height of the coppice shoot and damage by fire and animals were analyzed. These relationships have been assessed using the Chi-squared test.

From February 1984 to November 1985 the height, the diameters (at 0.0 and at 0.5 m above ground) of 79 randomly selected coppice shoots of *T. glaucescens* were monitored. These served to determine the relative growth rates of the coppice shoots, and to assess the relationship amongst these parameters of coppice.

The Wairingo exclosure was found back and the north-eastern quarter described by Lock (1977) was marked out. The species, the number and the heights of all woody plants in the quarter were recorded. This was done in March 1984, during the beginning of the rainy season when the woody plants had regained features useful in their identification and were not yet covered by other plants. Moreover, later in the year the area was inaccessible due to bad roads. Data from the survey were compared with those published by Lock (1977).

6.4 Results

The time and source of fire in Pandero varied during the present study, as is usual in this region. In the 1983/84 dry season it burnt twice: partly in December (early burn) and the rest in February (late burn). We started the first fire as an experiment. The second one was started by poachers elsewhere in the park and spread into Pandero. The first fire was very patchy and there were virtually no severe burns (Figure 1.1). In the second fire, some moderately burnt patches got burnt a second time. This burning pattern recurred during the 1984/85 dry season but the first fire was about 10 days later. During those ten days, other parts of the park got burnt first and some elephants resided for a few days in Pandero. The elephants trampled the herbaceous material (Figure 6.5) compacting it, directly affecting its texture and thus its properties as fuel. Termites were notably more active (see e.g. Figure 6.7) and consumed sizable portions of the plant material on the trampled sites than on sites not trampled. The subsequent first fire was more thorough than in 1983/84 dry season. Though there was a second fire, its spread appeared to be considerably hindered by discontinuity of the available fuel resulting from a generally severe first fire.

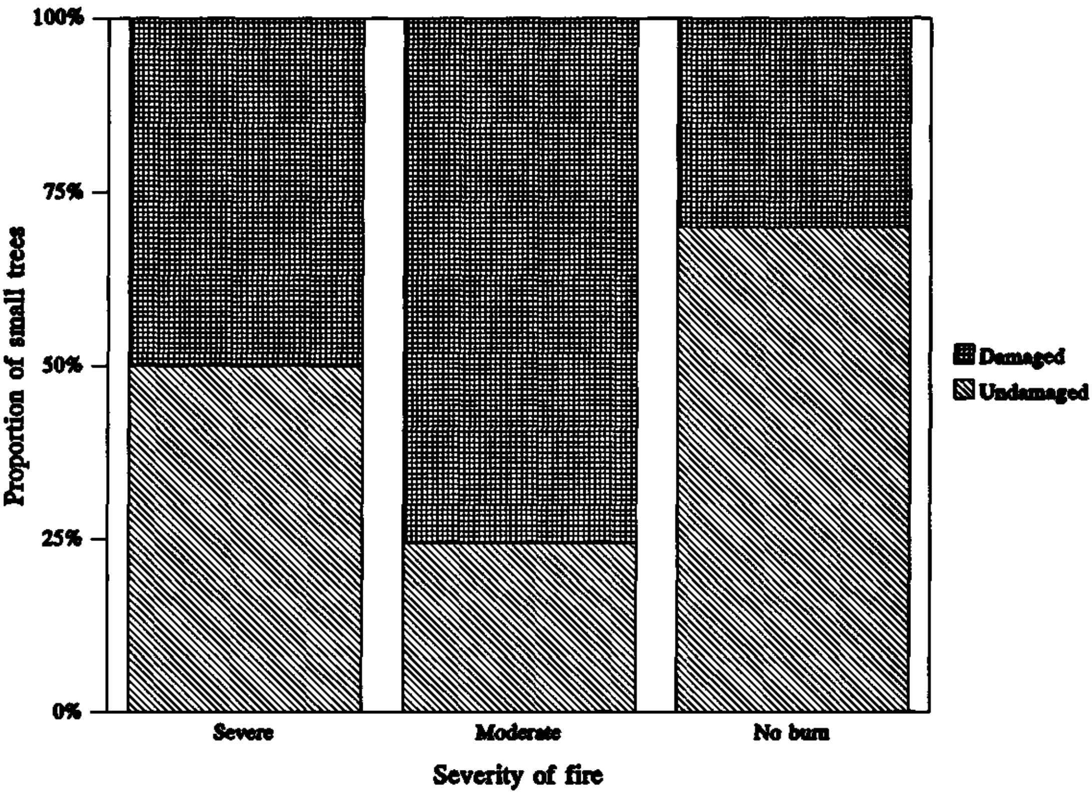

Figure 6.8 The likelihood of herbivore damage (trampled/broken/browsed) in small *T. glaucescens* trees in sites under severe, moderate or no burns in Pandero.

While the buffalo and the hartebeest tended to concentrate on burnt sites, the elephant tended to avoid them. Also within the burnt areas the buffalo and the hartebeest showed preference for the more severely burnt patches. The herbivores damaged a higher proportion of small trees in the moderately- than in the severely-burnt patches (Figure 6.8). But on the moderately-burnt patches the herbivore damage was largely trampling whereas on the severely burnt the damage was largely by breaking. The larger of the small trees that stuck out in the severely burnt patches were notably more likely to get broken.

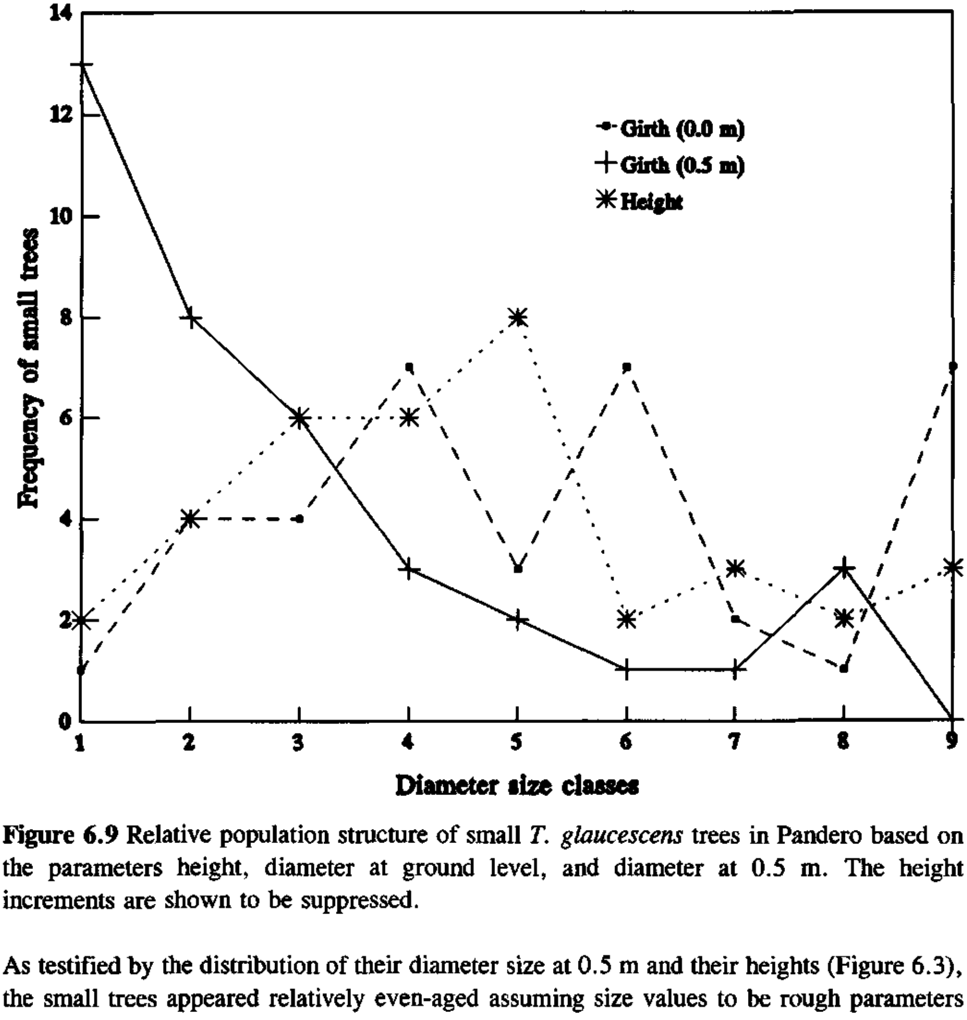

Figure 6.9 Relative population structure of small *T. glaucescens* trees in Pandero based on the parameters height, diameter at ground level, and diameter at 0.5 m. The height increments are shown to be suppressed.

As testified by the distribution of their diameter size at 0.5 m and their heights (Figure 6.3), the small trees appeared relatively even-aged assuming size values to be rough parameters of age (but see Oldeman 1990). In contrast, the distribution of the diameter sizes at 0.0 m revealed striking variations in age amongst the small trees. The mean rate of height growth of the small trees damaged by herbivores was significantly lower than those without damage

(Figure 6.9). As shown in figure 6.10 the rate of growth of the small trees was positively correlated to their diameter sizes, especially those at ground level.

Table 6.1 Relative composition (%) of woody plants in the Wairingo ditched experimental plot (number of individual plants in brackets). All woody plants in a quarter of the plot were recorded in 1964 and 1967 by Lock (1977) and in 1984 by the author (Oneka 1991).

	Date of survey		
Species	1964	1967	1984
Acacia hockii De Wild.	0 (0.0)	0 (0)	0.6 (2)
Albizia zygia DC	27.7 (83)	35.3 (48)	53.1 (172)
Bridelia scleroneuroides Muell. Arg.	3.0 (9)	3.7 (5)	0.9 (3)
Combretum molle G. Don.	53.3 (106)	22.8 (31)	13.9 (45)
Crataeva adansonii (DC) MacBride	6.3 (19)	8.1 (11)	8.6 (28)
Ficus sp.	0.3 (1)	0.7 (1)	0 (0)
Gardenia jovis-tonantis (Welw.)Hiern.	0 (0)	0 (0)	0.3 (1)
Grewia mollis Juss.	2.0 (6)	2.9 (4)	0 (0)
Harrisonia abyssinica Oliv.	0 (0)	0 (0)	1.9 (6)
Lonchocarpus laxiflora Guill. & Perr.	8.7 (2)	1.5 (2)	0.3 (1)
Markhamia platycalyx (Bak.) Exell	0.3 (1)	0.7 (1)	0.3 (1)
Maytenus senegalensis (Lam.) Baill.	0 (0)	0.3 (1)	0.3 (1)
Piliostigma thonningii (Schumach.) Milne-Redhead	1.3 (4)	2.2 (3)	1.2 (4)
Securinega virosa (Wild.) Baill.	2.7 (8)	2.9 (4)	1.2 (4)
Stereospermum kunthianum Cham.	9.3 (28)	13.2 (18)	14.5 (47)
Terminalia glaucescens Planch. ex Benth.	11.0 (33)	5.9 (8)	2.5 (8)
Zizyphus mauritiana Lam.	0 (0)	0 (0)	0.3 (1)

The Wairingo ditched plot had not been maintained since 1978. Hartebeest spoors found in the plot proved that large herbivores entered the exclosure. Due to lack of maintenance, the ditches became overgrown with grass (Figure 6.4) but there was no evidence of recent burning. At the time of this survey the vegetation around the ditched plot had burnt but the fire did not enter the plot (Figure 6.4). It is likely that if fire occurred in the plot, it was not frequent and probably not severe. Since the 1960s the number of woody plants and mean height of the trees had increased inside the exclosure (Table 6.1). Beside an increase from 12 to 15 woody species, their relative importance had also changed. *T. glaucescens* has declined further. Since 1967 such species as *Acacia hockii, Gardenia jovis-tonantis, Maytenus senegalensis, Harrisonia abyssinica* and *Ziziphus mauritiana* have appeared in the plot. At the same time *Grewia mollis* and *Ficus* sp. have disappeared.

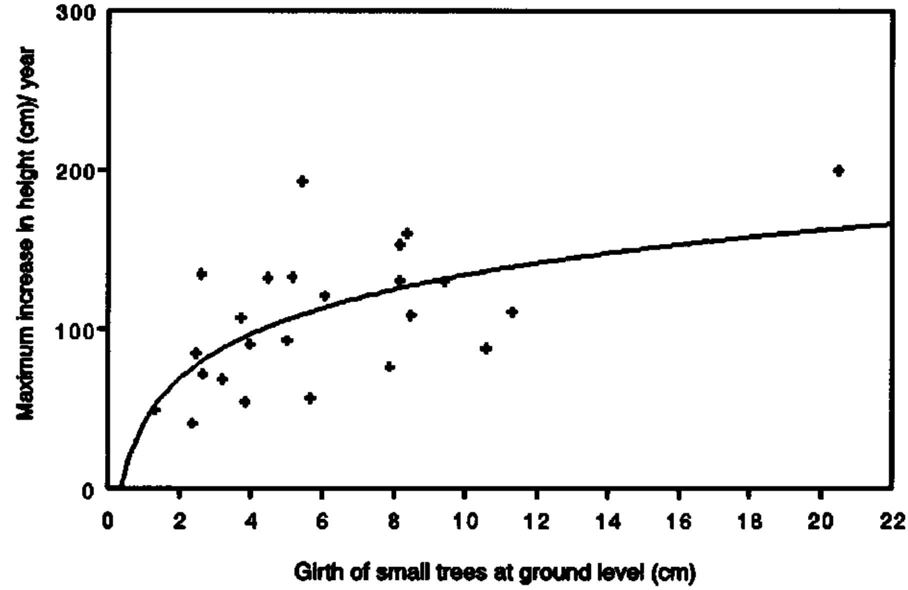

Figure 6.10 The relationship between girth at ground level and growth rate of small *T. glaucescens* trees in Pandero during 1984 and 1985. Curve: mean height increment as measured in Pandero.

6.5 Discussion

Observed variation in the fire severity illustrates how any temporal and/or spatial changes in the burning circumstances can significantly affect severity of the fires. As shown by Chandler et al. (1983) and van Wilgen et al. (1985), in each of the fires observed, the spatial pattern in fire severity could be partly explained by the variations in the micro-climatic factors. The interaction and the inter-dependence of all elements of the landscape system (Oldeman 1990), make it virtually impossible to predict the landscape with certainty based on a few factors only. Variations in each of the interacting elements inherently trigger uncertainties virtually unaccountable for in classical cause/effect system models (Gleick 1987). For instance, spatial variation in the fuel load (see Figure 6.5) affects the fire pattern in the observed fires (Daubenmire 1968; Rothermel 1972; Davis 1976; Kessel 1979). Patterns in the fuel load are historically determined by an extremely complex web of interaction, e.g. among organic biomass production and natural mortality, and *accidents* such as fire and/or animal consumption which redistribute the biomass. This is proven by the more thorough burning in later burning as the fuel is more dry and more uniformly combustible. Variations in the moisture content of the fuel therefore are topical too in explaining the patchy burn in the first fire 1983/84.

The movement of elephants into Pandero during the 1984/85 dry season prior to the first fire in that location could have been prompted by earlier burning elsewhere (Bell & Jachmann 1984). Any other factor could also have forced the elephants to move either (as it happened) to Pandero, but they could have gone as well to other sites. The effects of only a few days delay in burning on the fire severity illustrate the dynamic interactions amongst the different factors. They also show how the presence of elephants, even for a brief moment, can alter potential fire patterns drastically. Modelling fire effects on the vegetation without including trampling and subsequent ecological processes hence leads to a misrepresentation of the overall processes in play. In effect, this is a salient aspect of Gleick's (1987) characterisation of modelling chaos. The elephant trampling (see Figure 6.5) prepares the plants for the termites (see Figure 6.7). Any delays in burning allow more time to the termites to feed, so altering and/or reducing the fuel load. The role played by termites in removing dead plant material strongly diminishes the possibility for fire to recycle nutrients in the landscape (Figures 6.5 and 6.7). From these observations only it is evident already that the exclusive use of time of burning (early/ late) as guideline to plan controlled burning is improper as it concentrates on too few landscape factors.

Mean annual increase in heights of the small trees shown in figure 6.10 represents a high growth rate. At these rates, in nearly 30 years (see chapter 4) there should have been considerable recruitment of small trees into large ones. A lack of recruitment despite such growth rates proves that the height growth had been suppressed. According to Sabiiti & Weins (1987) the more severe the fires, the greater the percentage of top-kill in small trees. Their model, however, does not account for differences inside the compartment of small trees (see Figure 6.9). The larger coppice shoots have thicker protective bark, which makes them less vulnerable to fire (Vines 1968). This means that the larger coppice shoots suffered a lower percentage of top-kill, whence their greater prominence in more severely burnt patches.

Although the larger among the small trees were more likely to be broken by the larger herbivores, their faster growth (Figure 6.10) was sufficient to enable their recruitment into trees. In fact, studies elsewhere (Hopkins 1963; Sabiiti 1985) have shown that fire may also stimulate faster coppice growth. These positive influences would offset the effects of burning. The lack of recruitment in Pandero (Figure 4.6) proves that in this place, to the contrary, the heights of the small trees were being suppressed.

Remnants of the bigger partially burnt coppice stools stood out on severely burnt patches where their exposure made them susceptible to selective damage by the large herbivores. This seems to explain why more coppice shoots were broken than were trampled on the more severely burnt patches. More trampling than breaking on the less severely burnt patches proves damage there was less selective. The risk of damage by the large herbivores was exacerbated by the large group sizes of the animals (see also chapter 7; Malpas 1980). Whether indirectly by trampling or directly by breaking/ browsing, large groups of buffalo and of elephant inflicted maximum damage on the small trees. As this process is influenced by the structure of the vegetative cover, manipulation of the latter offers a means to manage the landscape processes.

The heights, girth sizes and growth rates of the small trees in Pandero show that they were being suppressed (Figure 6.9). Despite their high growth rates, repeated damage by large herbivores prevents the small trees from growing beyond their present sizes. Fire did not kill the coppice directly. Thick bark sufficiently shields the small shoots from fire. Evidently, the patchy and mild burning characteristic of early burning minimises damage to small trees by the large herbivores (Figure 6.8).

Differences in the population structure of the small trees depending on the parameters used to characterise it (Figure 6.9) highlight the need to specify more than by DBH only, at what heights the measurements are taken (James 1989). The higher up the stems, the more uniform are the diameter sizes. This conveys a false impression of even-aged trees. Without sufficient reference to the heights significant errors could be introduced in the evaluation of tree regeneration, in similar cases.

The decline in *Lonchocarpus laxiflorus* following the exclusion of fire and large herbivores from the Wairingo plot (Table 6.1) could be a direct result of the cessation of burning. Buechner & Dawkins (1961) showed that *L. laxiflorus* was stimulated by regular burning. In other parts of the park, where fire occurred regularly, even in the presence of large herbivores, the species appeared to be on the increase (pers. observ. 1985). Increase in herbs and climbers in the plot may have been responsible for the decline in *T. glaucescens* and *Grewia mollis*. A similar trend was observed in Budongo forest (Eggeling 1947) and in the Chobe plots (Smart et al. 1985; Spence & Angus 1971). The appearance of "new" species could be due to changes in some properties of the landscape. For instance changes may have been induced by stimulation of the germination of *Acacia hockii, Gardenia jovis-tonantis* and *Maytenus senegalensis* from their soil seed-banks. Arrival of *Harrisonia abyssinica* and *Ziziphus mauritiana* may be explained by dispersal of the fruits by birds. These explanations remain speculative as long as the processes underlying the observed changes, which are the results of the interaction among many factors, are not observed in a new way (see chapters 7 and 9).

The floristic composition of the vegetation since the exclosure (Table 6.1) fits into the later stages of ecological succession to forest proposed by Eggeling (1947). In this succession, *T. glaucescens* is shaded out and replaced by shade tolerant species. The *Terminalia* woodland that existed in the Wairingo area (Buechner & Dawkins 1961) may have been a fire-induced pioneer community, a situation made more likely by the forest remnants in the vicinity. As other factors also exert their influence, restoration of the former woodland will require more than merely excluding fire and large herbivores.

Evidently there is a complex interaction amongst fire, large herbivores, termites and the trees. Fire severity and timing significantly influence the ecology of the herbivores (large herbivores and termites). Distribution of the large herbivores is directly influenced and so are their impacts on the small trees. Likewise, the herbivores may exert significant influence on the fire characteristics. There was neither proof of fire killing the small trees, nor could burning alone explain the subdued growth of the same small trees. Evidently, tree growth was being hindered primarily by the large herbivores. In the present study most damage was shown to be caused by the hartebeest and the buffalo, which occurred in large groups. To minimise damage by the large herbivores, Pandero needs to be burnt as early as possible. This maximises the chances for moderate burns to occur. Moderate burns keep elephants at bay and also leave the small trees better protected against hartebeest and buffalo damage. From the experimental plot it is concluded, however, that the restoration and maintenance of the former woodlands will require more than the management of factors believed up-till now to have destroyed them. Neither has the damage by small herbivores been considered in this study whereas they could be critical as shown by Belsky (1984). The chapter has shown that factors in the park landscapes do not act in isolation and the fuzzy, complex and relatively chaotic nature of their interactions call for new less reductionist approaches to understand and deal with them. The evolution of a more appropriate approach to the design and management of the park landscapes will require improved appreciation of the dynamics of such complex landscapes. It is therefore vital for park design to define an appropriate institutional setup capable of developing such understanding.

CHAPTER 7. KEY ECOLOGICAL CONTROL NETWORKS

7.1 Abstract

This chapter illustrates the assumption that when the key ecological mechanisms are identified and managed it is possible to direct the development processes of a park system. Changes in the patterns of fire and herbivores as possible explanations of the subdued recovery of the woodland discussed in preceding chapters are evaluated. During earlier years of the park, fire and excessive elephant densities destroyed most of its woody vegetation. In a bid to halt further landscape deterioration, a culling programme was initiated to reduce numbers of the large herbivores. Measures to control fire were also strengthened. The civil wars and related increased poaching over-ran programmed management. The elephant numbers tumbled, fulfilling one of the pre-conditions speculated by earlier authors to be essential to the recovery of the woody vegetation. But recovery of the woodlands has remained elusive. This is consistent with the hypothesis that the open tree cover resulted in the production of more herbaceous fuel, hence more intense fires feeding back again to high tree mortality.

Patterns in fire and large herbivore populations in the park were examined. Trends in the large herbivore densities, fuel load and fire behaviour characteristics were analyzed. The results showed that despite continuing poaching, no more decline in the elephant numbers is apparent, densities of the buffalo, hartebeest and warthog appeared unchanged and the Uganda Kob show an increase. Also, despite the loss of tree cover no significant change in the fuel load and the fire intensity were detected. Differences in the tree cover seemed to help compensate for variability in other micro-environmental factors. The unexpected increase in numbers of some antelopes, the absence of change in the fuel load and the fire intensity falsify the hypothesis above and demonstrate the complex dynamics of the park ecosystems. The relationships involved are *fuzzy* and prove that *order* exists in the system structure despite this apparent *chaos*. The results also highlight how a few prominent factors may make one overlook other critical factors in developing ecological control networks of a park.

7.2 Introduction

It has been shown in preceding chapters that break-down in law and order following recent wars in Ugandan have resulted in significant increase of guns in the countryside. The guns exacerbated poaching in the Murchison Falls Park just as the park's administrative structures tumbled (chapter 2). Until this moment, the main debate on the park was on means to restore its woody vegetation believed destroyed by the elephant (*Loxodonta africana* Blumenbach) and fire (chapter 3). The present chapter puts in perspective changes in the patterns of the fire and the herbivore populations in the park. These were the key ecological factors previously blamed for deteriorating the landscapes of the park, the control of which were expected to lead to the recovery of its woody vegetation. This is done against the background that although increased poaching has devastated the park's elephant population (Eltringham & Malpas 1980; Malpas 1980; Kayanja & Douglas-Hamilton 1983) and may have wiped out the rhinos (Edroma 1982), there was no visible recovery of the woodlands.

Murchison Falls Park has had major changes in its large herbivore populations. Initially there were major increases but recently there have been drastic declines. Increases in the herbivore numbers were largely the results of their influx from areas inhabited by people coupled with their natural increase through births (Brooks & Buss 1962; Laws et al. 1975; Eltringham & Malpas 1980; see also chapter 2). Many species were driven into the park area from the park surroundings where hunting continued and agriculture expanded. Agricultural production called for the eradication of wildlife, considered *vermin and pests* (Kinlock 1988). This drove the animals to the relative safety of the park area (Sikes 1966). Inside the park area, the herbivores increased through births (Brooks & Buss 1962).

Figure 7.1 Most of the park roads, also used as fire-breaks, were covered by grass from the sides. At the peak of the dry season when most fires occurred, control was virtually impossible because the fires easily crossed the roads. Photograph by the author, September 1984, driving in Pandero in the direction to Purongo.

Amongst the large herbivores, the elephant received the most attention as it was considered to be the main agent behind the loss of woodlands and forests. Since the elephant range South of the Nile (Figure 2.3) was one of the most devastated areas, most past studies in the park were confined to the elephant and to that park area (Buss & Brooks 1961 & 1963; Brooks & Buss 1962; Buechner et al. 1963; Buss & Savidge 1966; Buss & Smith 1966; Laws et al. 1975; Malpas 1978; Eltringham & Malpas 1980). Accordingly, too few records exist on other herbivores to be able to assess their roles in the vegetation dynamics, especially in other parts of the park. Patterns in the large herbivore populations as possible explanation of the subdued recovery of the woodlands and forests are, therefore, examined on a shallow data-base.

Most available records on fire in the park indicates only where, when, and/or how frequently fire occurred in the park (Buechner & Dawkins 1961; Spence & Angus 1971; Wheater 1972). As shown in chapter 6, from these types of record it is impossible to reliably deduce trends in determinant fire behaviour characteristics. The present study therefore observed patterns in some aspects of the fires, especially those that can help assess possible changes in the fire regimes. The hypothesis tested was that lower tree cover leads to greater herbaceous production and thus more fuel, more intense fires, higher tree mortality and therefore fewer trees (Laws 1970a; McMurtrie & Wolf 1983; Sabiiti 1985; van Wijngaarden 1985). As it was neither possible to conduct controlled burning (see Figure 7.1) nor to document all the fires as they occurred, the study emphasizes an indirect characterisation of the fires (see Figure 7.2 and also Chapter 6).

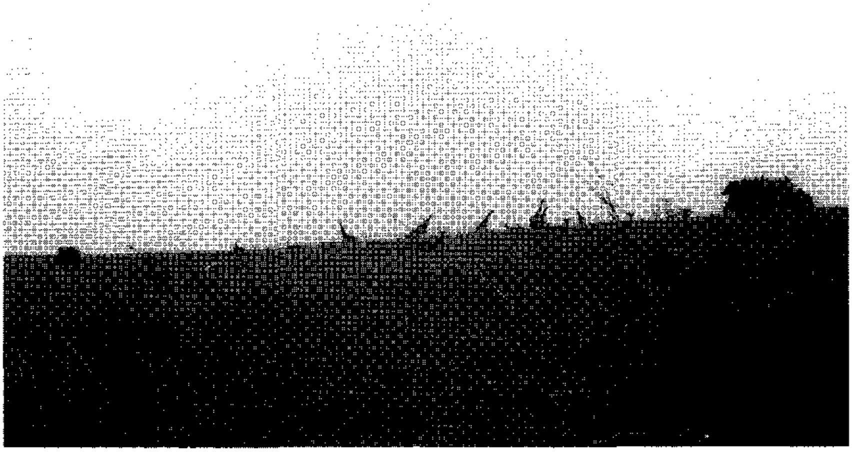

Figure 7.3 A mixed population of herbivores on a typical open, tree-less landscape along the road from Paraa to Pakwach. In the middle distance are Uganda Kobs and in the background are giraffes. Photograph by the author 1985.

7.3 Study area

This study was done in the northern bank of the Murchison Falls Park (Figure 2.3 & section 3.3). The large herbivores were counted along the roads Paraa to Tangi Gate (26 km) and Paraa to Wangkwar Gate (30 km, Figure 2.3). These roads cross rolling plains (Figures 1.2 & 7.3) covered largely by short (<1 m) *Brachiaria* and *Hyparrhenia* grasslands (section 2.8 & Figure 7.4). Medium to tall (1 to 2 m) *Hyparrhenia* and *Loudetia* grasslands covered part of the sample area but were burnt during the December-March dry season, so they were quite open (Figures 1.2 & 7.5). The fire studies were conducted in the woodland and the grassland in Pandero described in chapter 3 (Figure 3.5). During the dry season when most fires occur in the area, the north-easterly trade winds prevail with mean speeds varying from under 3 km/h to peaks exceeding 15 km/hr (cf. Figure 2.11). At this time there is a combination of intense solar radiation, high temperatures, strong winds and virtually no precipitation (cf. Figure 2.5). This results in very low relative humidity, very high evapo-transpiration rates, so most plant materials dry up and the risk of fire starting accidentally becomes very high.

7.4 Study methods

Seven herbivore counts were conducted: three on the Tangi and four on the Wangkwar roads (Figure 2.3). For each count, the species and numbers of all large herbivores sighted within a distance visually estimated at 500 m on either side of the road were recorded. The animal density (numbers/km²) was calculated by dividing the total animal numbers by the size of the area covered in the sample (Leuthold & Leuthold 1976; Caughley 1977; Norton-Griffiths 1978). The number of animals from the counts have not been corrected because detailed documentation of factors such as recommended by Burnham et al. (1980) was lacking. A similar deficiency in comparative population estimates (Douglas-Hamilton et al. 1980; Tindigarukayo & Pomeroy pers. comm. 1985) meant that any corrections would not necessarily make our data more comparable with other data. As many of the animals occurred in groups, emphasis was placed on determining the group size as accurately as possible. Question such as driving speed during the census were not considered since the vehicle was stopped when counting a large herbivore group (e.g. Figure 7.5). Despite a lack of corrections our data hence represent a fair estimate of the herbivores found within the Paraa sector of the park.

Figure 7.4 A pair of oribis often seen near the road in the vicinity of Te Okuto and near the junction of the road from Paraa to Pakwach, where the picture was taken. It also shows the short grassland, in which the oribi lives. Photograph by C. Lewis August 1969.

Fuel load was assessed in 12 plots, six of which were in the grassland and six in the woodland (Figure 3.1). Within each plot, all herbs enclosed in 5 to 10 randomly distributed quadrat (0.25 m x 0.25 m) were clipped at ground level, air-dried (in the absence of laboratory facilities) and weighed. From the weight, the herbaceous biomass (g. m^{-2}) in the two vegetation types was estimated. Because of the bulky herbaceous biomass in Pandero, smaller quadrat were used there than in similar studies elsewhere (Sabiiti 1985). Spatial variation in both the herbaceous biomass in woodland and grassland have been evaluated using Student's *t* test (Zar 1984).

Severity of the burns was assessed from thoroughness of the burn per site. It was described in terms of one of three categories: *severe, moderate,* and *no burns*. These categories were assessed according to the height of herbs and shrubs left unburnt by the fire (Blaisdell 1953). While in *no burn* no plant material was burnt (Figure 7.2), after a *severe burn* less than 15 cm of the plants was left (Figure 7.3). *Moderate burn* was intermediate between these two extremes, only part of the plant materials being burnt (Figure 7.4).

During December 1984, some fire behaviour characteristics were recorded. At the time of burning, a visual assessment was made of wind speed, flame height and rate of spread of the fire front.

Figure 7.5 Picture of a buffalo herd in the Te Okuto region of the Murchison Falls Park showing the visibility at the time of animal census in 1985. Photograph taken by the author from a Suzuki car used for most of the animal censuses.

7.5 Results

The densities of large herbivores observed both in the present study and in past censuses are summarized in Table 7.1. Long term trends in the elephant population are shown in figure 7.6. Whereas the species differed in their general trends, all of them showed high ratios of juveniles. The elephants occurred in a few large herds and their density north of the Nile was ca. 44% of the peak on record (Figure 7.6). The buffalo (*Syncerus cafer* Sparrman) density appeared not to have changed since 1980. Densities of the hartebeest (*Alcelaphus buselaphus* Pallas) and the Uganda Kob (*Kobus kob* Neuman) increased quite considerably.

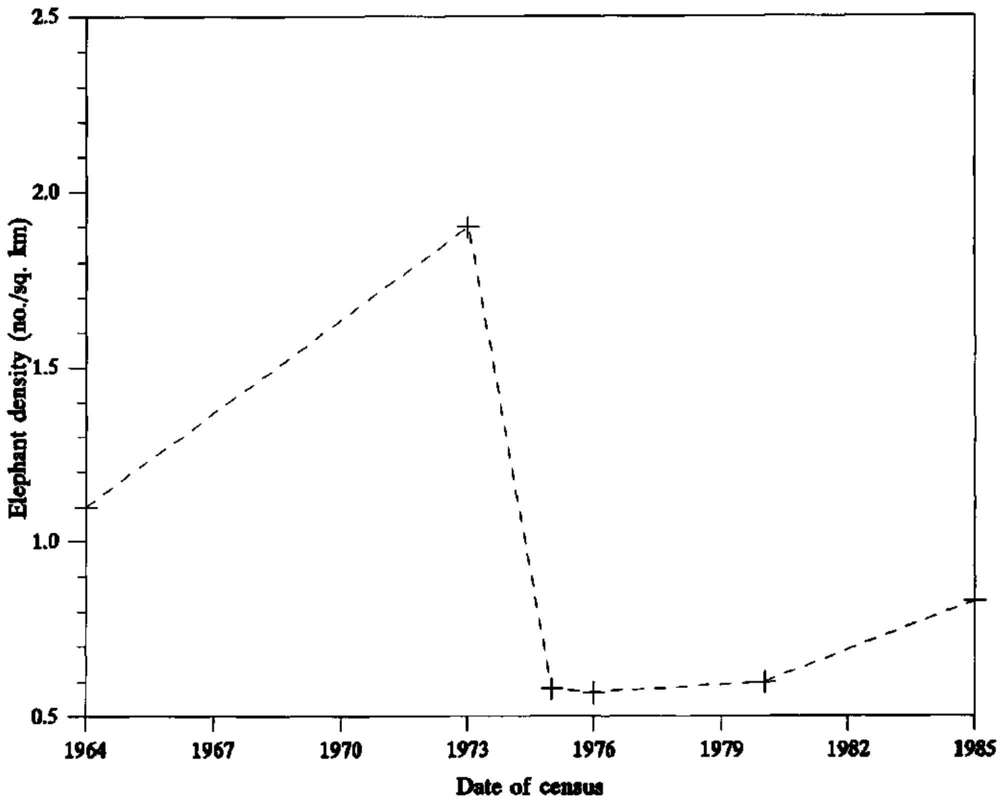

Figure 7.6 Recent trends in elephant density in the Murchison Falls Park based on past reports (Laws et al. 1975; Douglas-Hamilton et al. 1980; Eltringham & Malpas 1980). The data of 1985 are from a census by the author in the Paraa sector.

Giraffe (*Giraffa camelopardalis* Lydekker) density were low and their distribution was uneven. Densities of the oribi (*Ourebia ourebi* Zimmerman) were higher than those recorded recently (Tindigarukayo & Pomeroy pers. comm. 1985) while the waterbuck (*Kobus defassa* Ruppell) and the warthog (*Phacochoerus aethiopicus* Pallas) densities were notably lower.

As shown in chapter 6 by the end of December 1984, sites in Pandero which had not burnt attracted elephants, which trampled the herbage and so spread the fuel uniformly on the ground (Figure 6.5). There was a notable increase in the activities of termites (*Hodotermes* spp; Figure 6.7). The amount of plant biomass eaten by the termites appeared substantial.

Although the herbaceous materials were not uniformly distributed, differences between woodland and grassland (Figure 7.7) were not significant (P=0.05, df=10). Over the months, the differences became even smaller. Initially the herbaceous biomass in the woodland slightly exceeded that in the grassland but in the later half of the year this was the

Table 7.1 Densities of large herbivores ($n.km^{-2}$) in the Paraa sector of the Murchison Falls Park, Uganda. The 1980 data are from Malpas (1980), those of 1983 are from Tindigarukayo & Pomeroy (pers. comm. 1985), and the data for 1985 rest on assessment by the author.

Species	1980	1983	(±95%)	1985	(±95%)
Buffalo	7.53	0.45	0.45	6.37	2.39
Elephant	0.60	0.00	0.00	0.83	0.77
Giraffe	0.00	0.23	0.70	0.53	0.02
Hartebeest	4.28	1.81	0.80	7.51	1.85
Oribi	0.18	2.84	1.50	6.65	3.25
Uganda Kob	9.71	10.90	1.40	16.18	5.88
Warthog	2.01	2.09	2.90	2.15	1.31
Waterbuck	1.66	2.46	1.10	0.33	0.30

other way round (Figure 7.7). Simultaneous variations in the strength and direction of the winds were seen to affect fire behaviour characteristics considerably. The winds continuously changed the fires from front- to back-fires, now sped the forward movement of the fires, then again slowed it as the wind direction changed. The mean flame height was considerably higher in woodland than in grassland.

7.6 Discussion

Compared with past records on the park area South of the Nile, densities of the large herbivores observed in the present study (Table 7.1) indicate that the buffalo, warthog, oribi and waterbuck numbers have not been reduced despite severe poaching. In fact, the kob and hartebeest numbers were even much higher (Table 7.1). Similar trends in herbivore numbers under comparable circumstances have been observed in the Queen Elizabeth Park (Laker-Ojok 1991). Increases in some herbivores under such conditions are probably linked to under-utilized grazing capacity (de Bie pers. comm. 1990), but this hypothesis needs to be checked.

Tindigarukayo and Pomeroy (pers. comm. 1985) attributed the low buffalo density recorded in 1983 to chance absence of large herds within the area they sampled. According to Malpas (1980) there were higher densities of the buffalo, the kob and the hartebeest in the Paraa than in the Chobe sector. Density differences observed in 1985 could therefore be due rather to this fluid distribution within and between the two sectors than to increases in animal numbers. The movement of buffaloes in large groups and their concentration in burnt areas tended to intensify their impact on the landscape. The trampling and breaking of small trees by the buffaloes visibly affected the recruitment of small into big trees.

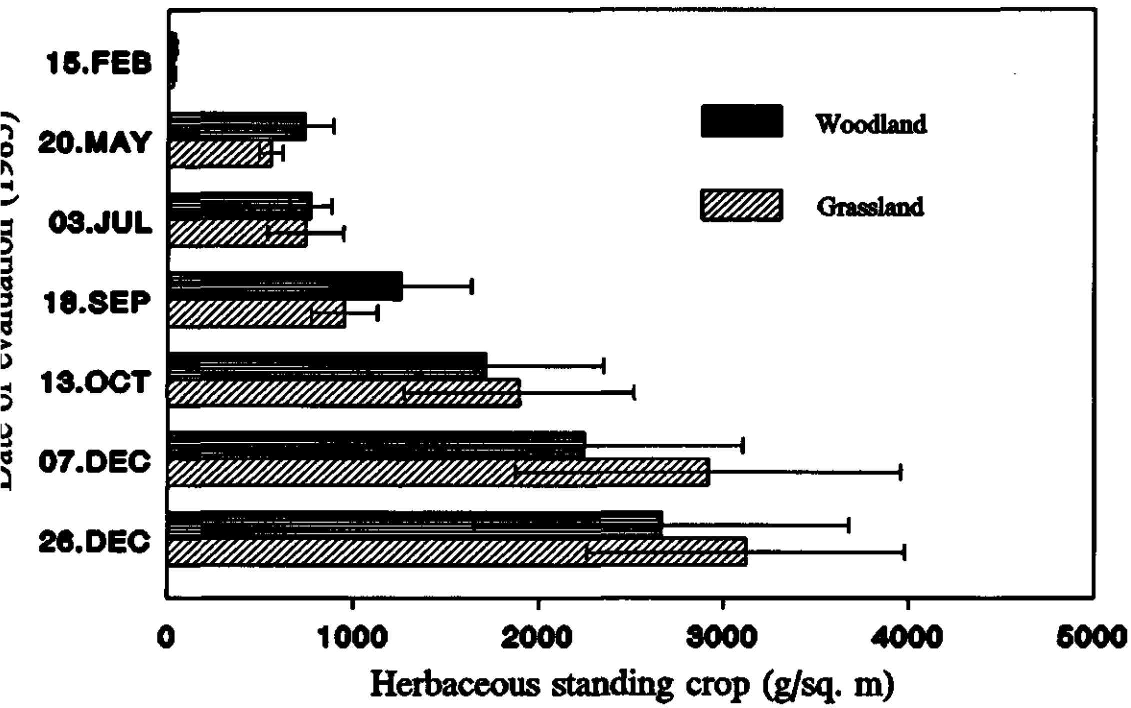

Figure 7.7 The amount of herbaceous material in woodland and in the grassland in Pandero, 1985. Despite the differences in tree cover, the quantity of herbaceous material did not differ significantly between grassland and woodland in Pandero.

Rises in Uganda Kob and hartebeest densities confirm reports by Malpas (1980) on the kob population trend. The high juvenile ratio in both populations substantiates other observations (Tindigarukayo & Pomeroy pers. comm. 1985) and proves that the kob and the hartebeest populations were growing. Very low numbers and the uneven distribution of the giraffe (*Giraffa camelopardalis* Lydekker) in the park might explain why these animals are irregularly observed. This may also explain why counts display such a large variability. Oribi (*Ourebia ourebi* Zimmerman) numbers may have been under-estimated in 1980 due to their small body sizes (Tindigarukayo & Pomeroy pers. comm. 1985). Waterbuck (*Kobus defassa* Ruppell) and warthog (*Phacochoerus aethiopicus* Pallas) were not abundant in the Paraa sector. With regard to the regeneration of *Terminalia* woodland the roles of these species were not immediately apparent. The hartebeest, like the buffalo, concentrated on burnt sites and were responsible for considerable damage on coppice shoots.

From the results it is evident that the elephant numbers in the Murchison Falls Park North of the Nile were still far below their recorded peak, but that they had probably stabilized and may even have started to increase (Figure 7.6). The halt in further decline in the numbers of elephants had been hopefully expected from the anti-poaching measures taken since 1980. However, the low elephant numbers should remain a management concern, considering the importance of the elephant in the park ecosystems. Besides, the remaining few elephants have formed large groups which, despite their low numbers, continue to exert locally sufficient pressure to limit regeneration of woody vegetation (see Figures 6.6 & 6.7). This point once more illustrates the dynamic and complex nature of the park systems. As the habitat recovers in the park, control of poaching is expected to lead to rapid regrowth of the herbivore numbers. However, changes in animal numbers and related environmental factors should be monitored closely to keep management planning up to date. Since June 1985, civil unrest in northern Uganda has paralysed the anti-poaching programme in the park. Because ranger patrol has been impossible in most of the park, poachers operate freely. The loss of management control under such a fragile political situation underlines the urgent need to review the park's over-all design searching for different inherent solutions.

The pattern of herbaceous production is comparable to that reported by Sanford et al. (1982) from a similar vegetation type in Nigeria. What is different is, that their results suggest a fixed relationship between tree-cover and the herbaceous production which our results (Figure 7.7) prove not to be the case. Seasonal differences in herbaceous production can be particularly important if they are superimposed, e.g. upon variations in the climatic and/or grazing pressure. Although the study of Belsky and Amundson (1992) also does not indicate seasonal patterns, it offers a possible explanation to the differences observed in this study. Based on their conclusions, variations in soil factors partly resulting from the influences of trees create even more sources of variation to be taken into account in this kind of research. Or, as shown by Kennard and Walker (1973), the species of grass could affect the herbaceous production since herbs differ in their performance under shade. These cases illustrate the problem of adopting the straight cause-effect approaches without sufficient care in dealing with ecological problems. Previous assumptions that herbaceous biomass would invariably increase with decline in tree-cover (Laws 1970a; Sabiiti 1985; van Wijngaarden 1985) would therefore always be subjected to necessary qualifying conditions. Variations in the herbaceous biomass were caused by changes in environmental factors limiting plant growth. During the wetter periods, shaded areas had less production due to light limitation. In the drier periods moisture supply is the factor limiting primary production, so then shaded areas are more productive. These fluctuations influence the amount of fuel for any fire at any one moment and hence co-determines fire intensity. Replacement of woodland by grassland does not always result in greater fire intensity. The presence of woody vegetation introduces greater spatial variation in the fuel load and fire behaviour characteristics. Variation in the micro-environment in the landscape so buffer effects of macro-environmental factors on primary productivity.

The fuel loads observed in the present study were significantly higher than what would be expected from the primary production as a function of the precipitation (Phillipson 1975). This higher fuel load could be due to higher soil quality and lower grazing pressure. The main grass species found in the area are not palatable for most of their growing period (de Bie 1991). This explains the rather low grazing pressure observed during this study. In applying predictive models like the one proposed by Phillipson (1975) it is advisable therefore to take into consideration such factors as grazing. This is important, especially when adapting such models in predicting fire regimes (Daubenmire 1968; Davis 1976; Glover

1968; Rothermel 1972) in park design. The fire behaviour characteristics were rather surprising, considering the amount of fuel, a greater frontal fire intensity would have been expected than was observed in a similar study with lower fuel load (Sabiiti 1985). Despite the large fuel load frontal fire intensity was lowered, as the fire moved faster under the influence of a stronger wind. The role of weather at the time of burning was therefore critical as it determined the fire behaviour directly. In this respect the influence of a denser tree cover would reduce these fluctuations. The moderate fire severity which was widespread in most of the fires (see Figures 6.2 & 7.2) could not kill trees. It may therefore be assumed that it did not hinder the recovery of the woodland in this area.

The present study has shown that it is risky and difficult to isolate key ecological factors in an ecological process. The park systems are characterised by dynamic shifts in the relative importance of their parts and of the factors impacting on them. As soon as one of the ecological factors ceases to be limiting, other limitations take its place. Any management interventions aiming at restoring the woody vegetation will have to take this into consideration. Ecological control networks of a park system are complex and dynamic and should be treated accordingly in the design of the park. The nature of the problem calls on park design to define research objectives so appropriate model reference bases can be built.

CHAPTER 8. HUMAN CONTROL NETWORKS OF A PARK[4]

8.1 Abstract

In this chapter man is viewed as an important component of the park system dynamics. Impacts of man through such activities such as hunting, land clearing, setting fires and also inside parks various management activities constitute control networks shaping the park system. Poaching in the park is examined to illustrate these control networks. The study analyses the response of the park to the perceived threat from poachers. The creation of the Murchison Falls Park provided a sanctuary to wildlife harassed and displaced by people. Poaching has remained one of the most serious problems faced by the park authority. Analysis of poaching showed that most of the poachers were young, unemployed and-able-bodied. Poaching was most serious during off-farming seasons. It is shown that the use of out-posts is an ineffective control strategy for inaccessible areas providing poor working environments for the rangers and with poor transport infrastructure. In such a situation, is there a need for new objectives to manage the relationship: park versus people around it? It is also shown that the park has problems controlling people who are inside the park system. These are the people who determine whether or not any of the set objectives are actually accomplished. It is recommended that park design should emphasize institutional development aimed at building a network of human control that involves not only people who work inside the park but also the society at large, in which the park is embedded. It is recommended that the design of parks should therefore facilitate the evolution of a favourable socio-economic and political environment for the park. Towards this end, appropriate educational programmes are crucial.

8.2 Introduction

Human control networks in the Murchison Falls Park are largely oriented to anti-poaching. Although there have also been problems controlling tourists in the park (Cott 1969) the main focus of the present study is on the poaching problem. Poaching, illegal hunting and fishing, has been a major problem in the park since its inception in 1952. Most of the poachers come from the park fringes. Poaching has also been pointed out as one of the most important mortality factor in other parks (Parker & Martin 1983; Douglas-Hamilton 1987 & 1988; Leader-Williams 1988; Leader-Williams, Albon & Berry 1990; Barnes & Kapela 1991). It has been mainly controlled through para-military anti-poaching patrols by rangers. Although hunting and fishing have strong roots in the region and pre-date the park (Bere 1934b; Willock 1964; Aerni 1969) their deleterious impacts on wildlife became apparent much later only (Laws et al. 1975). Continued hunting wiped out wildlife outside and drove its remnants into the park. Growing human pressure has blocked seasonal migration of animals and confined them to the park (Brooks & Buss 1962). Since the 1970s, declining political stability has resulted in the collapse of law and order with automatic guns widespread amongst local people. Poaching increased still further and has devastated the populations of most large

[4] This is a modified version of a report first published in 1990 as "Poaching in Murchison Falls National Park, Uganda" in: *Cultural aspects of landscape*, edited by Svobodová, H., p. 147-154. PUDOC, Wageningen.

herbivores (see chapters 2 & 7). The park elephant population, *Loxodonta africana* (Blumenbach) has fallen by more than 80% of the last recorded peak (Laws et al. 1975; Eltringham & Malpas 1980; Malpas 1980; Edroma 1982; Hatton, Hobsley & Smart 1982). The rhinoceroses, *Diceros bicornis* (L) and *Ceratotherium simum* (Burchell), are probably extinct (Edroma 1982; Douglas-Hamilton et al. 1980). The present study was done in 1984 which was a period of relative stability in Uganda. Since the 1979 war, this was one of the first years with fairly complete and consistent poaching records in the park. The main objective of the present study was to examine the spatial and temporal patterns in poaching and the anti-poaching patrols.

8.3 Study area and methods

The study covered the whole of Murchison Falls Park. The park landscapes have been described in chapter 2. One of the most important ecological factors in the region is the rainfall seasonality (section 2.6). As shown in figure 2.7, the park is drained by an extensive network of rivers and streams. Watersheds of the major streams were used in the present study to divide the park into eight easily identifiable poaching zones (Figure 2.4). At the time of this study (1984) the park was administered from Paraa and Chobe, assisted by about 16 ranger out-posts located at strategic positions in the park. A string of major settlements (Dima, Kamdini, Karuma, Olwiyo, Pakwach, Panyimur and Wanseko) were found at the park fringes (Figure 2.4). Most inhabitants of the region subsisted on rain-fed agriculture and fishing.

All known poaching and anti-poaching patrols in the park were tagged to the zones in which they occurred (Figure 2.4). The date, place and number of rangers in the patrols, the poaching offence (hunting/ fishing) and its intensity (number of poachers, the species and the number of animals killed, tools used) were obtained from the patrol logs and other park records. Intensity of both poaching activities and the anti-poaching patrols were expressed in terms of the number of persons per 25 km^2, that is per unit area supposedly patrolled by one ranger. Details on the patrols and on the poachers (sex, origin and exhibits against them) were obtained from the park records at Paraa and Chobe. Some of the poachers were interviewed to find out their age, level of education and reasons for poaching. Observations were also made in the park surroundings.

8.4 Results

Poaching caused most (60%) of the animal deaths recorded in the park (Table 8.1). The animals most often killed were the hippopotamus (*Hippopotamus amphibius* L.), the buffalo (*Syncerus caffer* Sparrman), the warthog (*Phacochoerus aethiopicus* Pallas) and the kob (*Kobus kob* Neumann). Animals culled by the park authority were only those likely to die from wounds or as was the case with a baboon (*Papio anubis* J.P. Fischer) threatened people in the park. Other animals poachers killed were the hartebeest (*Alcelaphus bucephalus* Pallas), the waterbuck (*Kobus defassa* Pallas), the elephant, the oribi (*Ourebia ourebi* Zimmermann) for their meat, the leopard (*Panthera pardus* L.) and the crocodile (*Crocodylus niloticus*) for their skins. The rhinos were killed for their horns. Pangolin (*Uromanis longicaudata*) and the bushbuck (*Tragelaphus scriptus* Pallas) mainly preyed upon by the big cats while the giraffe (*Giraffa camelopardalis* Lydekker) were seen to be neither a major target of poachers nor of predators.

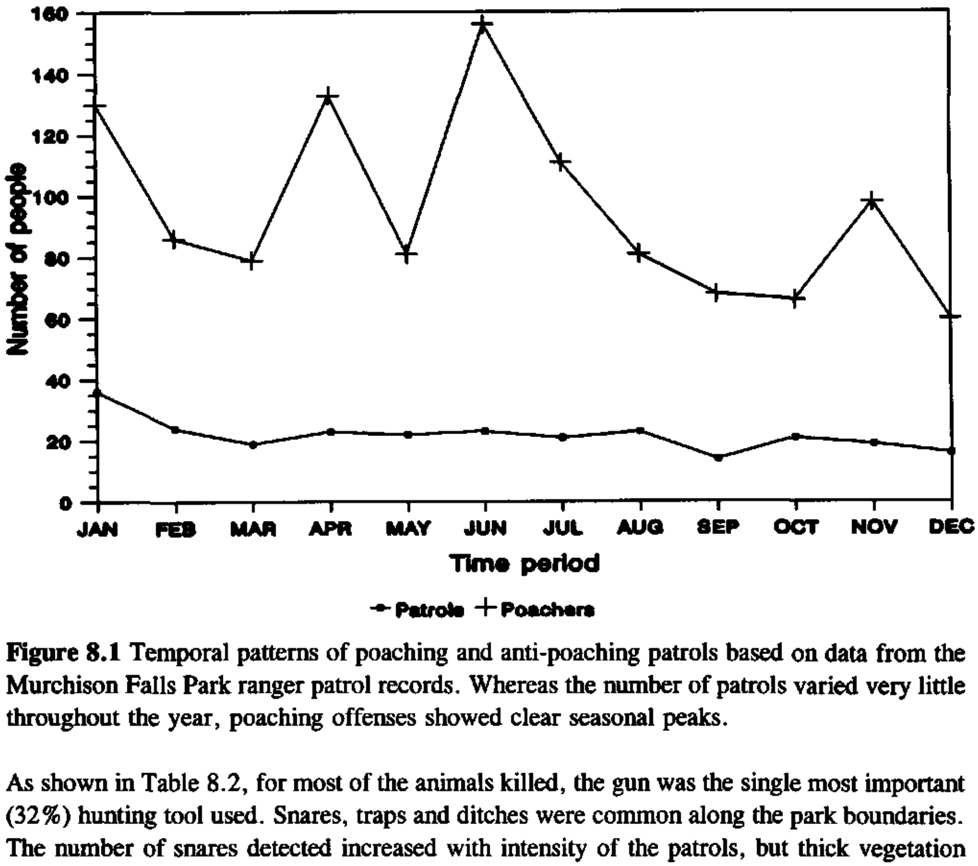

Figure 8.1 Temporal patterns of poaching and anti-poaching patrols based on data from the Murchison Falls Park ranger patrol records. Whereas the number of patrols varied very little throughout the year, poaching offenses showed clear seasonal peaks.

As shown in Table 8.2, for most of the animals killed, the gun was the single most important (32%) hunting tool used. Snares, traps and ditches were common along the park boundaries. The number of snares detected increased with intensity of the patrols, but thick vegetation still may have concealed some. Ditches were common close to human settlements and in places where hippopotami grazed. Although the use of dogs, traps, nets and fire were still widespread in hunting by the local people as reported by Aerni (1969) they were virtually non-existent in poaching. Early in the dry season local people set fire outside the park boundaries to stimulate lush forage regrowth. In this way, the animals could be lured out of the park, by the greenery, beyond the controls against their being killed. Within the park itself, poachers were neither observed to start fires, nor to use poison to kill animals as described by Edroma (1973b) in the Queen Elizabeth Park.

The park had few, irregular and unevenly spread ranger patrols while poaching remained widespread and serious throughout the year, peaking in the dry season (cf. Figure 2.5; Table 8.3). As was expected, more poaching offenses were detected as intensity of patrols increased (Table 8.3). Rangers at Chobe detected and recorded some poaching across the Nile and this more than trebled when rangers were stationed there. Reports made by mobile ranger patrols confirmed the seriousness of the poaching problem in the park area

South of the Nile (Table 8.3). This contrasted rather sharply to reports from rangers stationed at Rabongo and Wairingo ranger out-posts in the Waiga zone.

Table 8.1 Known causes of animal mortality in the Murchison Falls Park in 1984 according to park ranger patrol records. Animals culled were those with bad wounds or as was the case for a baboon was a threat to people in the park. Natural causes of animal mortality included predation and old age. The data show that poaching was the single most important mortality factor in the park.

		Percentage of animals		
Species	Number	Poached	Natural	Culled
Hippopotamus	89	82	13	1
Buffalo	84	62	36	2
Uganda Kob	44	41	59	0
Warthog	26	57	42	0
Waterbuck	13	39	62	0
Hartebeest	13	15	85	0
Oribi	9	0	100	0
Elephant	5	60	40	33
Others	3	0	50	0
Total	293	60	38	2

Patrols were fewest from September to December due to acute financial problems. Monthly government subventions were late and very few tourists came, so that wages, dry rations, medical drugs and vehicle maintenance were negatively affected. Few patrols could be made, most of them (21.5%) in the zone "Nile below Falls" (Table 8.3), where of course then most (73.6%) of the poacher arrests occurred.

Almost all poachers were male (98.0%), aged between 20 and 40 years (81.7%), unemployed (81.4%) and not educated beyond primary school. Public servants accounted for a rather high proportion of the poachers (army 9.5%, game guards 2.6%, park rangers 1.5% and road workers 1.5%). The mean group size of poachers was five people. Most of the poachers (63.2%) were fishermen from Wanseko and Panyimur. The number of poachers from Acholi and Lango (Figure 2.4) was high only during the dry seasons and substantially lower than from the above places.

Table 8.2 Hunting tools identified in poaching offenses in Murchison Falls Park in 1984, based on data from the park's ranger patrol log books. The data show that the gun was the single most important tool used to kill animals by poachers. It was believed by the park authorities that guns were used in most of the cases of unspecified hunting tool.

		Percent of animals killed by				
Species	Number	Gun	Spear	Snare	Others	Unspecified
Hippopotamus	65	28	12	2	1	57
Buffalo	57	18	12	9	0	61
Uganda Kob	22	59	9	14	0	18
Warthog	15	47	17	16	0	20
Waterbuck	5	60	0	0	0	40
Hartebeest	4	50	0	0	25	25
Elephant	2	0	0	50	0	50
Total	170	32	12	6	1	49

Table 8.3 Spatial patterns of poaching and anti-poaching patrols based on field records from ranger patrols in 1984. All recorded patrols and poaching offenses were plotted in zones where they took place (see Figure 2.4).

	Percent of total		Number per 25 km² (intensity of)	
Zone	Area (%)	Patrol%	Patrol	Poaching
Ayago	6.8	18.9	4.3	24.0
Buligi	6.1	4.5	1.3	4.7
Chopi	4.6	13.6	19.7	64.4
Nile above falls	27.6	15.1	6.9	33.4
Nile below falls	6.6	21.5	5.6	28.6
Tangi	12.0	7.9	1.1	3.7
Waiga	24.7	2.3	0.2	0.4
Zoila	11.6	0.8	0.1	0.9
Unspecified	-	6.0	-	-

8.5 Discussion

The irregular and uneven deployment of anti-poaching patrols were ascribed to such factors as few rangers, limited supplies (dry ration and drugs), undependable transport (vehicles, spares and fuel), poor communication systems and inaccessibility of most of the park. Most of the patrols were deployed in the zones Ayago, Chopi, Nile-above-Falls and Nile-below-Falls (Table 8.3) because of their greater accessibility from ranger posts. Due to their proximity to the ranger posts, these zones also received most of the patrols which were in direct response to reports of poaching.

Regular and intensive patrols in the zone Nile-below-Falls were to curb crocodile poaching (Cott 1968; Willock 1964) but only 3.2% of the cases recorded in the area involved people directly killing crocodiles. As many as 95.3% of the people arrested in this zone were fishing illegally in the park. Easy money (fines, bribes, sale of confiscated canoes and nets) came in from the water patrols. There was a lack of proof that such patrols were curbing crocodile poaching, as indeed they were not. The financial gains from the fishing patrols might explain this strategy. Reports of serious poaching South of the Nile is consistent with decline in animal numbers there (Malpas 1980) contradicts reports from rangers stationed in out-posts in the region and questions suitability of the out-post strategy. It was apparent that rangers at such remote camps, with inadequate supplies and supervision, soon lost their morale and their sense of duty and hence made compromises over poaching. A lot of poaching may be safely assumed to have gone unrecorded in such remote areas. These points underline the need for leadership at various levels of park setup and for corruption mitigating processes in the design of parks.

Although both guns and spears were often used by hunting groups, the gun certainly caused most damage since more animals can be killed by fewer people with guns than without them. The presence of ditches and snares along the park boundaries posed a silent but permanent threat to animal survival close to the boundaries. This perhaps explains why animal numbers remained low (Laws et al. 1975; Malpas 1980).

To avoid being detected, poachers were weary of using fire because the smoke can be seen from far away but they still set fires at the park fringes. This was an indirect access to resources inside the park, but one that still effected control. Nets were rather expensive and bulky if the poachers had to flee. Poison is used in this region only when the animals being killed are not for human consumption. The absence of poisoning in poaching confirms that most of the animals were killed to get meat for human consumption. This partly explains the use of poison by poachers in the Queen Elizabeth Park (Edroma 1973b) where some of the animals are not killed for food. For example, some predators are poisoned because they are causing problems to the people with livestock.

High numbers of hippopotami were killed (Table 8.1) because their daily rhythms (living close to water) made them easy to locate and kill. Buffaloes, on the other hand, were relatively mobile and formed larger herds which became more aggressive as hunting pressure increased, so fewer were killed. Warthogs were a specialty amongst local people who sought it out. If such selective hunting continues unabated some of the species may be wiped out as befell the rhinos.

Hunting and fishing expeditions were very risky and physically demanding therefore people who poached were mainly those who had virtually no other means of subsistence and were physically fit to withstand days of restless, dangerous and distant bush treks. Working conditions of most public servants were such that most of them could not even feed their families, let alone meet other social obligations such as pay for the education of their children. This, coupled with a limited awareness of the need to preserve the animals, explains the incidence of poaching by road workers, rangers and game guards.

The origin of the poachers explains the seasonality in their numbers. People from Wanseko and Panyimur poached mainly in Nile-below-Falls (Table 8.3). These people have a strong fishing tradition and frequently fish illegally in park waters. Due to frequent water patrols they therefore often appeared to account for a high proportion of recorded poaching. Although fewer poachers came from Acholi and Lango this could be due to fewer patrols. The seasonality of the numbers from there appears to be related to periods when most local people there were not busy with agricultural activities. These findings emphasize the importance of aiming at an over-all regional economic development in the design of parks (see e.g. Wheater 1968).

A park-wide aerial patrol would be essential for effective coverage of this park considering its large size. This is especially so for the less accessible parts of the park where there are no roads. The above analysis shows that the number of wardens and rangers, and their mobility need to be upgraded to make possible a combination of patrols based on mobile forces as well as ranger out-posts. In the long term, gun fights need to be gradually replaced by education emphasizing conservation.

Ready acceptance of game meat amongst local inhabitants is one of the factors that underlie the serious problem of poaching in the park (Aerni 1969). Demand for game meat provides sufficient incentive to consider seriously possibilities for strategies such as game ranching and controlled harvesting in the region in the design of the park. The present heavy poaching pressure and resulting low animal numbers, coupled with logistic and administrative difficulties, preclude any animal culling programmes as implemented earlier in the park (cf. chapter 2). The motor of the increasing poaching problem is formed by socio-cultural and economic forces, acting upon people as an incentive to poach. In view of this it is necessary to develop better keyed strategies. This should involve experiments to involve local people such as in the CAMPFIRE programme in Zimbabwe (Hannah 1992; Kemf 1993). This type of experiments will require deep insight into the underlying processes.

The study has shown the importance of human control networks in the dynamics of a park system. It has shown that the over-all socio-economic structures and forces are as critical components of the dynamics of such a system. To minimise negative effects of the human control networks it has been shown that there is a need for an over-all national growth and development with the decline of poverty. Coupled to this, the operational problems of the park have shown that the park need a network of supporting forces at all levels of the human society in which it is embedded. For this it has been shown that good leadership and corruption mitigating processes are required. The role played by rangers in collecting data used in this proves that well-coordinated ranger patrols can help make routine observations useful in management decisions. To be more effective for this purpose, the rangers will need basic training in relevant data collection techniques and will have to be deployed more evenly and regularly. The use of computer-based information systems in managing such data could help directly in redistributing the patrol resources. It could be used in planning conservational education programmes. How these can be incorporated into the development programme should be specified in park design. The emphasis should be put on generating broad-based support and as much as possible getting local people involved to ensure that the park survives. Which approaches are used to achieve these aims are matters of tryouts because no one really knows the formulas that work. In this respect park design should therefore approach the problem once more as if dealing with a puzzle.

CHAPTER 9. LOOKING BEYOND THE WARS

9.1 Abstract

The issues and arguments raised in preceding chapters are hereby summarised, conclusions are drawn and some recommendations are made. As illustrated by case studies, the lack of understanding of the dynamics of a park system reduces its design to speculation. While the complexity of the park systems calls for the accumulation of insight, their dynamic nature cautions that there will always be unknowns. The case-studies show that it is important to have a deep insight into the history of a park to be able to appreciate its present patterns and processes. They also show this kind of insight to be critical in speculating on a park's future, its objectives and the means to achieve them. It is important that park designers recognise that without a complete understanding of the patterns and processes of a park system, its design remains practically partial and essentially speculative. A park design that concentrates exclusively on prescribing fixed infrastructure and management schedules, as is common practice, compares to equating a system to a selection of its components.

All the case studies have highlighted the importance of a good definition of a park system in its design. It has been shown that the structure of a park system is a web of complex and dynamic components which are in similarly sophisticated interactions amongst themselves. As shown in the preceding chapters the place of some these components in the system structure and/or function of a park are not readily apparent. As an institution, a park system designed without some of these components will grow and develop abnormally. This may show out in forms such as extinction of species and impoverishment of indigenous people. Deep insight into the structure and functioning of the park system is essential to its design. Mechanisms to develop and appropriately deploy this type of insight into a park system is an important component of the design of a park. To design a park attention should therefore focus on defining appropriate structures and mechanisms through which the park's objectives, patterns and processes can evolve. In this context, future research on park design should therefore focus on defining appropriate institutional models of park design.

The computer-based information systems offer the possibilities to manage and to process relevant data and could be useful in testing a model design before resources are committed to implement it. These possibilities remain to be explored and exploited. Future research should help define appropriate park information system models as well as develop strategies to implement them.

The elements of park design examined warn of its complexity and dynamics. The dynamics means park design is tantamount to puzzling and should formally be treated as such. To succeed, park design should therefore facilitate the evolution of institutional capabilities that would shape the park system.

9.2 Park development circumstances

The good definition of a park system is essential to the analysis of its structures and processes. As shown in the case studies focusing on the ecological aspects of the park system alone, as hitherto done, is inappropriate. The case studies have shown various components of a park system to be outside its legal physical boundaries. Improved procedures to define the park system are essential to the design of the park since it depends on such procedures what perceptions are made operational as the park system. Greater attention will need to be given to the role of socio-economic, cultural and political aspects in defining the park systems and also how these can be handled to favour park development.

The circumstances under which a park develops are unique for every park. As shown in chapter 2, structures and processes initiated by past events enabled the evolution of present patterns and processes which prepare settings for future processes. The manner in which many of the park systems have evolved indicates that risks exist of changes beyond human control in the systems. Such changes could be part of long-term cycles, of non-cyclic events or a combination of them (see chapter 2). As illustrated in chapter 2, in the Murchison Falls Park, changes in the regimes of the Nile river system have been influenced by the evolution of the Victoria lake system but also more recently by wetter climatic phases (see chapter 2). The creation of the Rift Valley and related drainage systems and erosional processes in the park region are examples of non-cyclic, very long-term landscape processes. The risk of these types of changes becoming acute, and of their ramification, are great in many park systems. In designing a park it is therefore necessary that they are adequately recognised and incorporated in the design as contingencies. Some of the park processes are relatively short-term and of these many are amenable to management control. The vegetation changes discussed in the case studies are examples of this. As shown in the case studies, however, to properly deal with these aspects requires very comprehensive and long-term research and monitoring programmes. Many of the processes, for example reversal of drainage network following the formation of a rift valley are beyond human control. It is therefore important that in the design of a park these types of differences amongst the park processes are recognised and planned for accordingly. Research on and monitoring of a park system can help determine what is applicable, and for this park design should help define appropriate institutions. Besides, there is the need to clarify the part played by management interventions in ecological processes, especially those for which knowledge on the system dynamics is still patchy. The design of a park in such a case should define a suitable institutional setup to deal with the questions raised by changes in the system. How effectively and efficiently a park system responds to changes in its circumstances provides good tests of its institutional maturity. As the park system develops, its response to changes should be more efficient and effective as it benefits from experience. Park design should help to define institutions to enable this accumulation and deployment of experience in the park.

Design of parks has been and remains largely in the hands of biologists and ecologists so it inevitably suffers from professional bias. Professional bias undermines any truly holistic approach to the design of parks. As demonstrated in the case of a team of blind men describing an elephant (chapter 1), given appropriate *formulas*, the design of a park should only improve with the number and degree of divergence of views regarding it. In the absence of such formulas, there is a lack of serious inputs from outside small groups of professions. This is a major drawback to park design and it underscores the need for research to educate relevant brains and to find appropriate design models to enable broader-based and informed debates on park design.

Many of the required research and monitoring needs are true for all parks and can benefit from standardisation and automation of procedures. The other aspects, which are unique to a park, are the true challenges in the design of the park. The situation becomes very risky by any lack of professionalism, e.g. a biologist defining the research agenda for anthropological studies for a park or the inverse. The seriousness of such issues is underlined by the fact that such a research agenda determines which research activities get supported. The design of a park must erect safeguards against these types of imbalances. The persisting question is, which profession is in a position to implement this balancing and the concomitant charting of the research and monitoring programmes? While research into specific aspects of the park dynamics is needed, research is also needed on and in the programmes themselves. The lack of resources in many countries necessitates the evolution of suitable mechanisms to facilitate international technical cooperation. Park design could help provide the operational framework for such cooperation.

Since the parks, like Noah's ark, were established to preserve special features, e.g. biodiversity, how can the parks be trusted when extinctions occur even inside them? This is particularly serious where the extinctions are attributable to inappropriate development strategies (chapters 1 and 2). Equally serious, especially in poor countries, is the plight of local people deprived of access to resources which they perceive as potentially improving the quality of their life if the park did not exist. As shown in chapter 8 the human control network can not be confined to programmes inside the park. In fact as that case study has shown the broader socio-economic and political processes are also very important. Mechanisms to chart the interactions involved need to be treated seriously in the design of the park. As shown in chapters 4, 5 and 6 deep insight into such aspects are critical for any park design to succeed. Already when launching the park ideas attempts were made to reconcile the conservation and development roles of the park. As shown in the case studies, the continued lack of appropriate insight in the dynamics, though it can be explained by their complex and dynamic nature, is partly because the importance of this type of aspects were not recognised in the design of the park. It is now over a century since the park idea was born. There should have been less uncertainty nowadays, as to which way goes forward and more certainty as to how to achieve a balanced and productive contest of visions. Recognising park design as solving a puzzle which must not fail, clarifies the context and demonstrates the value of the functional relationships amongst monitoring, research, planning and management as illustrated in the preceding chapters. An enhanced awareness of this aspect in designing a park would help focus attention on devising means to develop appropriate institutional capabilities.

Persistent problems of high personnel turn-over and resulting discontinuity and instability of programmes are features salient to parks. The cover picture illustrates this problem: many of these experienced staff members were lost from the park system. This personnel instability is an inherent property of the park system. Parks are long-term whereas people are only temporary. As illustrated in chapter 1, if treated as an institution, the loss of persons (cf. the loss of individual cells in a multi-celled organism) should not affect its normal function. Park design should identify the components (cf. organs in an organism) of the park system, based on this define a process (cf. recipe for appropriate nutrition) to mitigate the losses. This situation underscores the need for park design to define and initiate processes to facilitate institutionalising the roles played by individuals in a park system.

As shown in the case studies a good identification of these components, their representation and control are very complex operations. These operations are long-term and therefore requires a memory system that supersedes that of individual persons. A society lives even when its individual members die because, among others, the socio-cultural processes provide for the continuity. For a park to survive its design should enable it to develop similar institutional basis. The immediate technical problem involved in doing this is the lack of appropriate philosophy and conceptual models made more difficult by the lack of techniques to develop them. After identifying key components of such a system, existing specialised techniques could play more constructive roles. In this respect, many of the possible programmes stand to gain from the growing possibilities offered by computer-based information systems. Such systems will, therefore, need to be given serious consideration as research tools but also in the parks themselves. In this respect priority should be given to the definition of what would be appropriate systems and their implementation strategies. In many poor countries, especially those ravaged by war, such computer-based information systems should be incorporated in internationally funded programmes to rehabilitate the parks.

9.3 Concluding remarks

The case studies presented in the book have shown parks as complex and dynamic systems. As in all living systems, their evolution is the result of a multitude of factors interacting. The present book has proved that many of these interactions are fuzzy and chaotic. This situation means that for the park systems to be properly understood and designed new approaches are required. The new approaches should help deal with the uncertainties such as appear from case studies presented in the present book. In the absence of such approaches, despite many years of study, the lack of deep insight in the parks persists. As illustrated by the cover photograph it is already difficult to discern patterns in the immediate foreground, comparable to the immediate future along the dimension of time. In designing a park, any lack of deep insight into its present system's dynamics reduces to speculation the design of the park as far as the focus on its future patterns and processes is concerned. That situation would be symbolised by dense cloud covers in the middle distance and background of the photograph. Since in many countries the parks have become, like in the story of Noah's ark, the only hope for many life-forms to survive, there is an urgency for the design of the parks to address the uncertainties.

The complex and dynamic nature of the park systems call for the definition of *reference standards* in the design of a park. To develop these standards requires clear objectives as well as profound insight into the patterns and processes of the park system. Given the circumstances of most parks in which these are all areas where lacunae exist, the evolution of capability to be able to establish those standards should receive priority in the design of parks. In order to facilitate that process, the design of the park should define necessary curricula. Such curricula should combine aspects such as education, research and monitoring necessary to develop relevant institutions and working techniques. As illustrated in the preface and in chapter 1 the general increase in informed public debate should offer a solid basis for the conservation programmes. With regard to the research programmes, besides concentrating on specific themes, attention should be given to establishing their context in an over-all park design.

As shown in the preceding chapters, treating park design as a puzzle would force the fact to be recognised, that in the absence of deep insight into park system dynamics whichever design of the park is comparable to an empirical attempt to fit a puzzle. This perception would focus attention on the evolution of institutional models capable of dealing with the nature of the puzzles discussed in the park design process. There is an urgent need to define what would be appropriate structures as well as contents of the institutions involved in the development of a park. This issue is relevant for the plans, the design and also the implementation of the design. It is important that the institutional setup of park design reflect its complex and dynamic nature. In this respect there is need for research to develop institutional models of the design process. Equally necessary are research on the research and monitoring institutions/ programmes themselves. The potential use of computer-based information systems will need to be seriously examined. The main advantage of the use of computers is that they help stream-line the information flow and help buffer against human and institutional instability. The computer-based information systems also enable the desk-testing of designs prior to their expensive implementation. Their use will help to illustrate ideas in the design process.

New approaches are needed to get dependable working models of the landscape dynamics and how to obtain and to use such information in the development of park design. Priority should be given to institution building with greater continuity, transparency and accountability as eminent aims. Institutional continuity is essential as park development is long-term whereas park staff is only temporary. Emphasis should therefore be put on ensuring that conditions favour building on progress already made by preceding group, or individuals. Greater transparency and accountability are important because without them, fair evaluations of how the design puzzles are proceeding are impossible. As Chase (1987) demonstrated, systematic concealment of fallacies and failures in parks often nurture irreversible, destructive processes. It is important that the parks succeed but are also seen to have functional roles. It is noteworthy that the linkage between park and economic development is seen today in broader perspective. In both cases there is the need for visionary leadership: inspiring, mobilising and directing both staff and population towards a future that in the short-term may even politically be unpopular. The needed leadership is visionary because it is long-term focused. Also emphasized are the needs for raising of public awareness, with an eye to the evolution of capacities for public participation in informed debates on the parks. These are critical if park design is to become truly transparent and broad-based. Figure 9.1 summarises this point. It highlights people, especially children, and the need for their education. The incorporation of comprehensive educational programmes in the design of parks is critical. In many countries ravaged by war the children have lost their parents or their families may have lost all their property in the wars. A lack of appropriate education of these children will feed-back, among other serious drawbacks, as a park management problem in future generations (chapter 8.

Figure 9.1 Children of park employees on an educational trip ordered by the park's chief warden. The boat is on the river Nile close to the Falls on very turbulent water full of crocodiles. The children portray the future of a people afloat in an unpredictable water. Not equipped with appropriate survival know-how, if the boat is rocked all in it could drown. Education should thus be part of any park design. Photograph by the author 1985.

The future of most parks remains in the balance and along with it the fate of many life-forms, a situation comparable to, in Myers's words, "the sinking ark". This situation epitomizes the global conservation and development problems. The present book has argued that the main causes of the problems are the lack of insight into the architecture and dynamics of living systems and the lack of appropriate design approaches to deal with their complex and dynamic characteristics. This situation is compounded by personal and institutional conflicts which, if submerged by major violent wars, create the most incompatible ingredients of park development. They are ingredients of park annihilation. In designing parks, these circumstances should be treated with the seriousness they deserve, consciously incorporating resistance to or resilience after the impact of war. Since the parks are long-term oriented, priority should be given to institutional aspects of the their development. Every park is unique and dynamic, so whatever design is proposed is basically speculative. Looking beyond the wars it is therefore recommended that park design be tackled as a living puzzle!

CAPTIONS TO FULL COLOUR FIGURES:

Figure 1.1 *Terminalia* woodland in Pandero showing its orchard-like, open, structure through which it is possible to see. The tree directly behind the termite hill is *T. glaucescens.* Most of the foreground had a moderate fire severity (with much plant materials left after fire). Photograph by the author December 1983.

Figure 2.9 Wallow located between Pandero and Te Okuto along the road from Purongo to Paraa. This is one of the sites that has water throughout the year and is frequented by animals especially during the dry seasons. The bare ground seen at the edge of the wallow is proof of grazing and trampling by herbivores. Photograph by the author 1985.

Figure 3.3 An oblique view on the Pandero woodland from Pandero hill. In the foreground is the road from Purongo to Paraa. The many dead trees in the middle prove that the woodland in the region was more extensive. Photograph by the author 1985.

Figure 4.3 A small *Prosopis africana* tree in Pandero exemplify the many small trees concealed by the tall grass, dying back every time the grass is burnt. Photograph by the author, 1985.

Figure 6.1 Picture taken just before fire broke out in Pandero in December 1984. A coppice of *T. glaucescens* is marked in the foreground in this figure to compare with the image after fire. The herbaceous material was still rather moist as visible from the green plants. Photograph by the author.

Figure 6.2 Picture taken from about the same position as figure 6.1, but just after a fire in Pandero in December 1984. The fire was patchy with fore-ground severely burnt while the middle distance is moderate burnt and the background not burnt. The small *T. glaucescens* tree marked has lost all it leaves but otherwise appears intact. Photograph by the author.

Figure 6.5 Fresh grass growing through dead grass trampled by elephants in Pandero, December 1984. The trampled dead grass was attacked by termites which, together with the fresh grass, lowered the flammability of the materials. Photograph by the author.

Figure 6.6 A small *T. glaucescens* tree broken and surrounding vegetation trampled by elephants in Pandero. The larger of the small trees were often the ones damaged. Such damages were localised seemingly hindered recruitment of small into big trees. Photograph by the author 1984.

Figure 6.7 A small (immature) *B. aethiopum* palm tree, trampled and its leading shoot broken by elephants. The removal of the terminal meristem effectively kills the small palm tree. This problem was common. Signs of termites can be seen in the left foreground. Termite activity appeared enhanced by the elephant trampling. Photograph by the author 1984.

Figure 7.2 Fire in Pandero in 1984 showing that the flames indeed reach the crowns of the big *T. glaucescens* trees. In the foreground, a patch of grass is not burnt; and

fig. 1.1

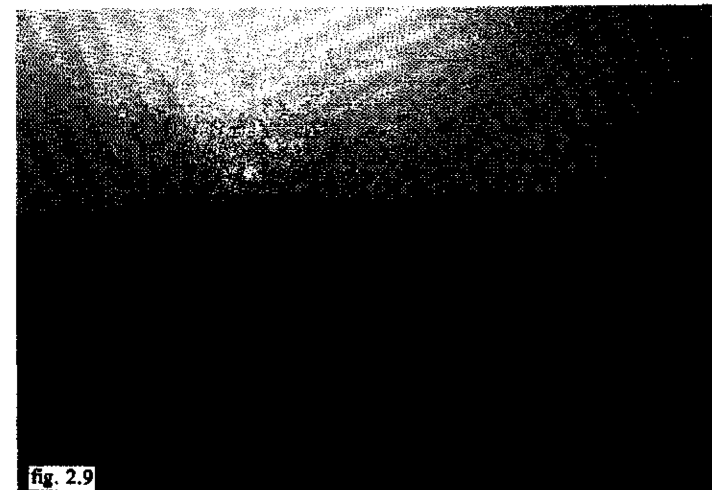

fig. 2.9

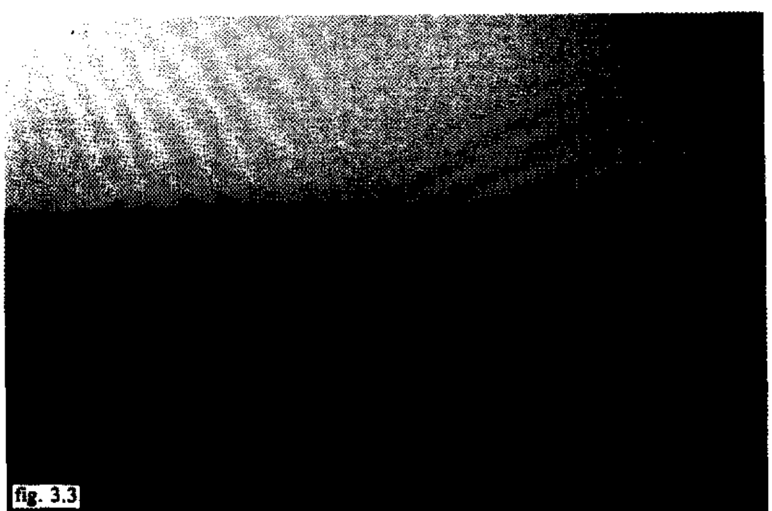

fig. 3.3

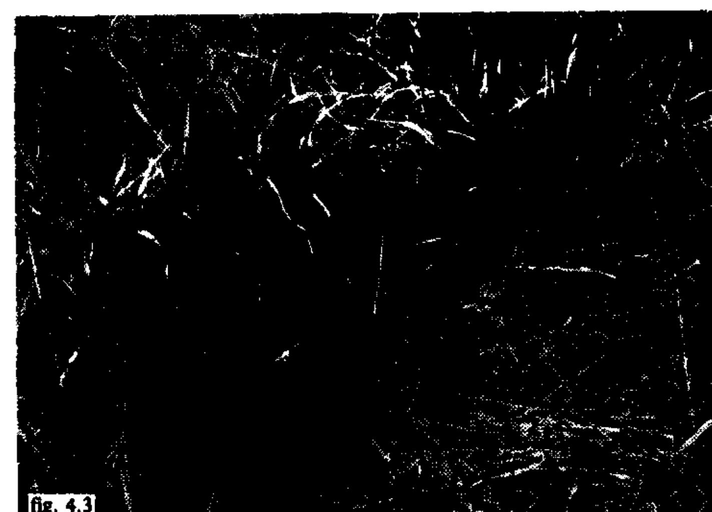

fig. 4.3


fig. 6.1

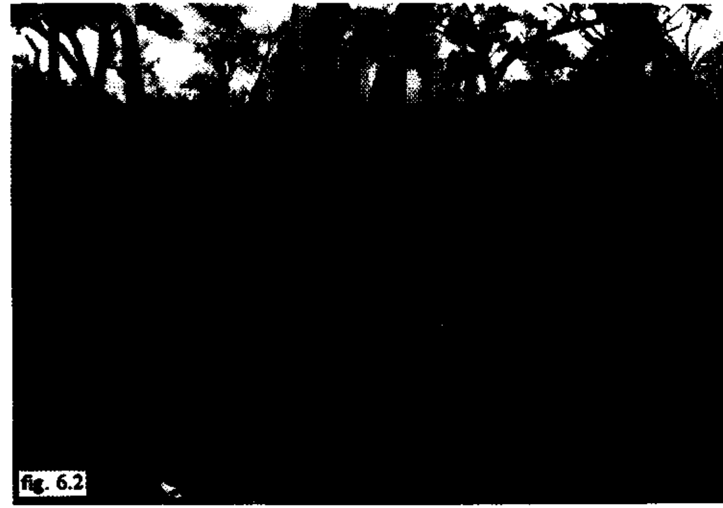
fig. 6.2


fig. 6.5


fig. 6.6

SUMMARY / SAMENVATTING/ RESUME

On Park Design: looking beyond the wars

The present book opens with an account of a buffalo hunt in the company of soldiers in one of the national parks in Uganda. One buffalo was hit close to the heart but fled away as if it was not fatally wounded. The soldiers seeing it flee, fired more rounds of ammunition at it until, with limbs broken, the buffalo fell down. This account is used to demonstrate some of the ravages of wars on parks. It is argued that most parks around the world are destined to perish because of defects in their design leading to institutional fights and inappropriate development programmes. The present book raises issues aimed at generating debates on the design of parks looking beyond the wars.

The book is a synthesis of studies started while the author worked for the Uganda National Parks. It discusses why many parks in poor countries, especially those ravaged by wars, might not survive. The institutional setup is often not conducive to the accumulation and the deployment of resources necessary for the sustained development of the parks. The book differs from its predecessors with similar titles in four main respects. First, many studies of park design have been confined to the design of recreation parks found largely in urban areas, whereas this one focuses on nature reserves. Second, most studies on park design adopt one of the approaches which have been widely used in the design of recreation parks, whereas this one considers them inappropriate. Third, the book proposes that the design of a park should be perceived and treated as a puzzle. Finally, using case studies the book highlights some institutional aspects of park design. It is expected that ensuing debates generated by the issues raised by the book would contribute to science and hopefully improve its role in sustainable land development.

It is shown in the book that for the parks to succeed their design requires clear objectives and deep understanding of their systems' dynamics. Prevailing instability, poverty, lack of know-how on the park system dynamics, widespread deterioration of the environmental conditions, and the complex and dynamic nature of park systems underline the urgent need to innovate appropriate institutions. Poor countries, especially those ravaged by wars, are emphasized because it is there that the need for institutional reform of the park systems is most apparent. Besides, it is more likely that such reforms can be incorporated in internationally funded post-war reconstruction and rehabilitation programmes, than it is under the usual development programmes. Cautiously the book also draws attention to the "wars" within and amongst groups of people (especially specialists) which make impossible serious collaboration. The latter wars are salient features of parks and it is essential that they are treated accordingly in the design of the parks. Against this background, institutional dimensions of park design receive much attention in the book.

The book uses the word park within the context of category II, *National Park*, as defined in the "1990 United Nations List of National Parks and Protected Areas". This is land set aside primarily to preserve specific natural and/or cultural features. In this sense and as hereafter discussed, the parks are comparable to *Noah's Ark* in the Bible. With respect to wars, two main types are discussed: the one is violent the other non-violent. Both types of wars are portrayed as the results of conflicts of interests in the absence of appropriate institutional mechanisms to prevent and/or diffuse them. Prevalence of wars lead to many changes and tragedies in the midst of which the care for parks does not fit in with priorities. Hence, parks suffer from wars. The present book argues that with the war ravages as *fait-accompli,* the parks would gain most if the circumstances created by the wars were converted into opportunities to review their design. Such reviews could help to create a sound basis for the sustainable development of the parks. The book argues that the survival of the parks will depend on their design, i.e. their make-up. It is this *make-up of a park* as well as how this is defined that is, therefore, the focus of the book. Parks as living systems are portrayed as structurally and functionally complex and dynamic. In comparison to the design of a house, park design is complex. The manner in which a house is designed is a fairly straight-forward architectural process. As for a park, its complexity and dynamics render much of these approaches inappropriate and yet, as shown in the book, that is how parks are being designed habitually.

The book proposes that the design of a park be treated as a puzzle because like in ordinary puzzles it is made up of parts which somehow must be correctly related for the puzzle to be solved. If the puzzle is wrongly handled the proofs of that will inevitably surface. Unlike ordinary puzzles the parts are not static and also have complex and dynamic interactions amongst themselves. In the book some of these are demonstrated to highlight the fallacies in design approaches which do not treat this reality with the seriousness it deserves. The book argues that given the above characteristics of a park its future would be ensured if greater emphasis were placed on the institutional dimensions of the park's development. Institutions are portrayed as living systems. As such they are made-up of parts which make them function as entities. The death of an individual person or the loss of one facility in the institution, is compared to the death of a cell in an multi-celled organism or of a tree in a forest. It is argued that if some of the parts (cf. organs in an organism) do not function properly, the growth and development of the institution will be affected. Similarly, an unfavourable external environment, despite normally functional internal systems, will hinder the normal growth and development of the institution. Instead of putting the emphasis on defining the details of management programmes (e.g. frequency of burning), park design should therefore focus on defining an appropriate institutional make-up that would favour a sustainable development of the park. Accordingly the design should enable the park to develop its capabilities and to increasingly be able to use experiences drawn from past attempts iteratively so as to solve the ceaselessly changing design puzzle. To accumulate experience on a long-term basis calls for the innovation of appropriate *memory systems*, and in building this "park organ" the computer-based information systems could play an important role.

Viewing the design of a park as a puzzle calls for the innovation of tools to minimise the risks and expenses associated with failures to solve the puzzle. In this respect the potential role of computers is again highlighted. It is suggested that the use of computer-based information systems could facilitate desk-top testing and communicating of park design ideas. There remains, however, the need to define what would constitute appropriate information system models for such purposes.

Through case studies on the Murchison Falls Park, Uganda, attention is drawn to the dynamic and complex nature of a park system. Murchison Falls Park is an example of a park that has witnessed drastic ecological changes and has been ravaged by wars. Looking beyond

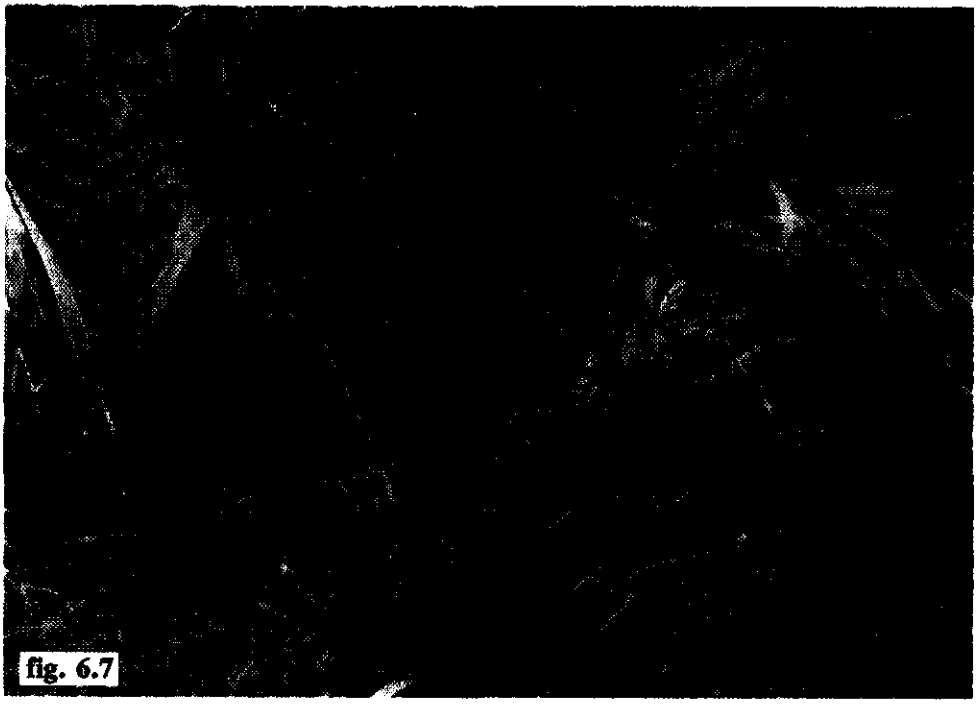
fig. 6.7

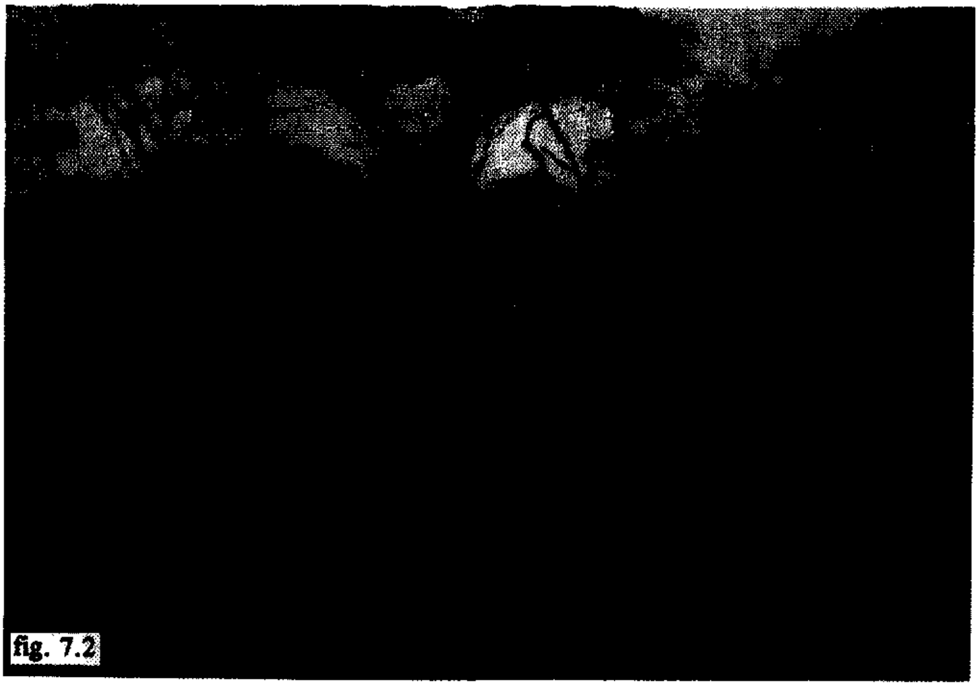
fig. 7.2

the wars the park region needs reconstruction and rehabilitation of its socio-economic infrastructure. With special reference to the park, key aspects of the design of a park has been examined. Amongst others aspects such as fire, vegetation dynamics, patterns in herbivore densities and poaching have been examined in a series of case studies on the park. Through these studies of the park system structure and processes various aspects on which park design should focus are highlighted. The studies highlight the need for deep insight into the patterns and processes of a system if a design is to succeed. Since in all parks such insight always is lacking, the book argues that park design is reduced to trial and error and should be formally treated as such. The book concludes there is an urgent need for new perceptions in the design of parks, that for this tools have yet to be innovated, and that the future of green design and with it sustainable land development will depend on the improved understanding of the dynamics of relevant institutions. It is recommended that park design should take advantage of the fast growing computer-based information systems to manage, process and feedback relevant data and to test model design in virtual versions before resources are committed to their implementation. Future research should help define appropriate park information system models. Looking beyond the wars these are some of the key areas on which park design should focus for sustainable progress to be made in the attempts to solve the park design puzzles.

Over ontwerpen van parken: verder na de oorlog

Dit boek begint met de beschrijving van een buffeljacht in gezelschap van militairen in één van de nationale parken in Oeganda. De buffel wordt in de hartstreek geraakt, maar hij vlucht alsof niet dodelijk gewond was. De soldaten lossen daarop nog ettelijke schoten voordat de buffel met gebroken poten neervalt. Een voorbeeld van oorlogsvernietiging in parken. De meeste parken ter wereld dreigen ten onder te gaan door hun ontwerp dat er net naast is, leidt tot conflicten en voert naar onbruikbare ontwikkelingsprogramma's. Zelfs al zien ze er gezond uit, vol van leven, door de aard van het park-ontwerp zijn ze gedoemd ten onder te gaan. Dit boek wil bijdragen aan de discussie over het ontwerpen van parken, waarbij verder dan strijd en oorlog wordt gekeken.

Het boek is een synthese van onderzoek door de schrijver toen deze werkte voor de Oegandese nationale parken. Het boek gaat erover, waarom vele parken in ontwikkelingslanden niet kunnen voortbestaan, met name de parken die zwaar te lijden hebben onder de gevolgen van strijd en oorlog. Dit boek verschilt in vier opzichten van andere die een gelijksoortig thema behandelen. Ten eerste, vele onderzoeken naar park-ontwerp zijn beperkt tot het ontwerpen van recreatie-parken in stedelijke gebieden, terwijl dit boek zich concentreert op natuur-parken. Ten tweede, de meeste studies naar park-ontwerp gebruiken gangbare benaderingen voor het ontwerpen van recreatie-parken. Deze benaderingen zijn echter voor natuur-parken niet geschikt. Ten derde stelt de auteur voor om park-ontwerp als een legpuzzel op te vatten. Tot slot, richt hij met wetenschappelijke gegevens de schijnwerper op de institutionele aspecten van park-ontwerp. De onderwerpen die in dit boek de revue passeren zijn bedoeld om discussies te stimuleren die bij zullen dragen aan de ontwikkeling van wetenschap en haar rol in de duurzame ontwikkeling van het landgebruik.

Dit boek geeft aan dat voor goede park-ontwerpen een duidelijke doelstelling nodig is, namelijk hoe en waarheen parken zich zouden moeten ontwikkelen, alsmede een diepgaand inzicht in de dynamische ontwikkelingsprocessen van parken. Instabiliteit, armoede, gebrek aan kennis van en inzicht in ontwikkelingsdynamiek van parken, wijdverbreide verslechtering van het milieu en de complexe aard van park-ontwikkeling vereisen nieuwe instituties. Arme landen, vooral als ze aangetast zijn door strijd en oorlog, staan in dit boek centraal, omdat juist daar de behoefte aan institutionele hervorming van parken zichtbaar is. Daarnaast is er meer kans dat dit soort hervorming op gang kan worden gebracht binnen internationaal gefinancierde herstelprogramma's, dan binnen gangbare ontwikkelingsprogramma's. Ook besteedt dit boek aandacht aan de verschillende soorten strijd binnen en tussen groepen mensen (met name specialistisch georiënteerde groepen), waardoor die waardevolle samenwerking onmogelijk wordt. Dit laatste soort strijd en oorlog vormt een markant kenmerk van parken en het is dan ook van essentieel belang het besef ervan in park-ontwerpen mee te nemen. Het is ook tegen deze achtergrond dat aan de institutionele dimensie van park-ontwerp in dit boek veel aandacht wordt besteed.

Het boek gebruikt het woord park in de context van categorie II, *Nationaal Park*, zoals deze wordt gedefinieerd in de "1990 United Nations List of National Parks and Equivalent Reserves". Dit betreft land dat gereserveerd is voor het behoud van specifieke natuurlijke en/of culturele kenmerken. In deze zin, en ook zoals hierna parken worden gedefinieerd, zijn zij vergelijkbaar met een soort dynamische ark van Noach uit de Bijbel.

Twee soorten oorlog komen aan bod: gewelddadig en niet-gewelddadig. Deze twee vormen van strijd zijn het resultaat van conflicterende belangen, in afwezigheid van geschikte institutionele mechanismen om ze te voorkomen of onschadelijk te maken. De strijd leidt tot vele vaak tragische veranderingen waarbij er op de prioriteitenlijst geen zorg voor en onderhoud van parken staat. Echter, als tot uitgangspunt wordt gekozen dat de gevolgen van oorlog en strijd een *fait-accompli* zijn, hebben de parken het meeste baat bij een omzetting van deze gevolgen in mogelijkheden het park-ontwerp te herzien. Zulk een herziening en herstructurering kan leiden tot een duurzame basis voor park-ontwikkeling. Het boek toont op grond van argumenten dat de overleving van parken afhangt van hun ontwerp, van de manier waarop ze worden opgebouwd en van hun ontwikkeling. Daarop concentreert dit boek zich. Parken zijn levende systemen en worden dienovereenkomstig weergegeven als complex en dynamisch. De manier waarop een huis wordt ontworpen is een tamelijk rechttoe-rechtaan architectonisch proces. Voor een park is zo'n wijze van ontwerpen echter niet geschikt. Toch toont dit boek aan dat dit voor het ontwerpen van parken nog steeds de meest gehanteerde methode is.

Dit boek stelt voor om het ontwerpen van parken als een legpuzzel te zien. Net zoals legpuzzels bestaan ontwerpen van parken uit verschillende stukjes die op één of ander manier in elkaar moeten worden gepast. Als ze niet bij elkaar passen klopt het plaatje niet. In tegenstelling tot legpuzzels zijn de verschillende onderdelen van het park-ontwerp niet statisch en bestaan er ingewikkelde en dynamische relaties tussen hen. In hoofdstuk worden enkele voorbeelden gegeven van gebrekkige benaderingen voor park-ontwerp die geen rekening houden met deze realiteit.

Gegeven de voorgaande kenmerken van parken, zou de toekomst van parken beter verzekerd zijn als er meer aandacht zou worden besteed aan de institutionele dimensie van park-ontwikkeling. Een institutie wordt in het boek beschouwd als een levend systeem. Ze bestaat uit verschillende doch samenhangende onderdelen die haar doen functioneren als één geheel. De dood van een individu binnen een institutie wordt vergeleken met de dood van een cel in een organisme met meerdere cellen. Als enkele delen (vergelijk organen van een organisme) niet goed functioneren, kan de groei en ontwikkeling van de institutie worden aangetast. Een ongunstige externe omgeving kan, ondanks een normaal functioneren van interne systemen, de groei en ontwikkeling van een institutie eveneens bemoeilijken of verhinderen.

In plaats van een minutieus gedetailleerd managementprogramma zou park-ontwerp een geschikte institutionele opbouw moeten opleveren om de duurzame ontwikkeling van het park te begunstigen. Het park-ontwerp zou het park in staat moeten stellen om de eigen mogelijkheden te benutten en te ontwikkelen. In het park-ontwerp zou steeds opnieuw gebruik moeten worden gemaakt van terugkoppeling naar eerdere ervaringen om de ontwerp-puzzel op te lossen.

Park-ontwerp als een puzzel vraagt om een vernieuwing van het intellectuele gereedschap om de risico's en kosten die gepaard gaan met het oplossen van de puzzel te minimaliseren. Met betrekking daartoe wordt er in dit boek aandacht gegeven aan de rol van computers. Het gebruik van in computers opgeslagen informatie-systemen kan het uitwisselen van ideeën en visies over park-ontwerp en het nagaan van uitwerkingen van verschillende park-ontwerpen vergemakkelijken. Wel blijft steeds de discussie noodzakelijk over de vraag welke-informatie-systemen geschikt zijn voor verschillende park-ontwerpen.

Met behulp van voorbeeld-studies in het Murchison National Falls park in Oeganda wordt de aandacht gevestigd op de dynamische en complexe aard van een park-systeem. Dit park heeft drastische ecologische veranderingen ondergaan en werd vernield door oorlogen. Nu vrede terugkeert naar het park-gebied is het noodzakelijk de infrastructuur van het park en de regionale sociaal-economische infrastructuur weer op te bouwen. Bestudeerd werden onder anderen de voorbeelden van brand, grazers waaronder olifanten, bomen, stropers, termieten en hun onderlinge samenhang bij verschillende tijdschema's. Elke voorbeeld-studie laat de noodzaak zien van een diepgaand inzicht in patronen en processen van een systeem, wil een ontwerp effectief zijn. In vrijwel alle parken is er gebrek aan dit inzicht en verwordt het ontwerp tot speculatie.

De auteur concludeert dat er nieuwe visies en percepties voor park-ontwerp nodig zijn. De toekomst van een duurzame ontwikkeling van landgebruik hangt af van een beter begrip van de dynamiek van de institutionele aspecten van parken. Daarbij zou gebruik moeten worden gemaakt van de snel groeiende op computers vastgelegde informatie-systemen om relevante data te verzamelen en te verwerken en om verschillende park-ontwerpen virtueel te testen alvorens ze toe te passen. Toekomstig onderzoek zou gericht moeten zijn op het definiëren van geschikte informatie-systemen voor deze doelen. Verder dan oorlog kijken met behulp van doeltreffende informatie-systemen: zo zou er duurzame vooruitgang geboekt kunnen worden om de puzzel van park-ontwerp op te lossen.

Concevoir des Parcs au-delà des guerres[5]

Cet ouvrage débute sur l'histoire vécue d'une chasse au buffle, en compagnie de soldats, dans l'un des Parcs Nationaux en Ouganda. Le buffle est atteint près du coeur mais il essaie quand même de s'enfuir, comme s'il n'était pas mortellement touché. Alors, les soldats le mitraillèrent jusqu'à ce que, les pattes cassées, le buffle s'effondre. Cette image est utilisée pour illustrer quelques aspects des ravages dûs aux conflits dans des parcs. Selon l'analyse, la plupart des parcs dans le monde sont menacés de disparition à cause de la faiblesse de leur plan, avec des conséquences telles que des conflits et des programmes de développement inadéquats. Le présent ouvrage a pour but de susciter des débats sur le concept des parcs au-delà des guerres.

Le livre fait la synthèse d'une série d'études commencées pendant que l'auteur travaillait pour les parc nationaux en Ouganda. Il examine pourquoi beaucoup de parcs dans les pays pauvres, spécialement ceux ravagés par les guerres, pourraient être amenés à disparaître. Les institutions structurant des parcs ne contribuent souvent pas à l'accumulation et l'emploi des ressources nécessaires pour un développement durable des parcs. Cet ouvrage diffère des écrits précédents portant sur le même objet sur quatre aspects principaux: en premier lieu, beaucoup d'études sur le concept des parcs se sont limitées aux parcs récréatifs que l'on trouve surtout dans les centres urbains, alors que l'ouvrage présent met l'accent sur les réserves naturelles; deuxièmement, la plupart des études de ce genre adoptent des approches généralement utilisées pour les parcs récréatifs qui nous paraissent inadaptées; troisièmement, nous proposons que le concept d'un parc soit perçu et traité comme un "puzzle"; et enfin, cet ouvrage souligne des aspects institutionnels du concept de parcs. Nous attendons que les thèmes traités susciteront des débats qui peuvent contribuer à l'évolution de la science et de son rôle dans le développement durable des terres.

L'ouvrage montre que, pour que les parcs réussissent, leur concept exige un objectif clair et une profonde compréhension de la dynamique de leurs systèmes. L'instabilité, la pauvreté, le manque de savoir-faire en matière de dynamique des parcs, la vaste détérioration des conditions environnementales, et la nature complexe et dynamique de ces systèmes soulignent l'urgence de créer des institutions appropriées. Les pays pauvres, spécialement ceux ravagés par des conflits sont les plus concernés, parce que c'est chez eux que le besoin d'une réforme institutionnelle sera la plus apparent. En plus, il serait préférable que ces réformes soient incorporées dans des programmes internationaux de reconstruction et de réhabilitation d'après guerre, plutôt que dans des programmes courant de développement. Soigneusement, l'ouvrage attire également l'attention sur les "guerres" nées du fait du conflit interpersonnel, notamment entre les spécialistes, et qui rendent toute coopération sérieuse impossible. Ces conflits ont des implications importantes sur la physionomie du parc et il est essentiel qu'elles soient prises en compte dès sa conception. C'est la raison pour laquelle les aspects institutionnels en concevant des parcs ont reçu bien d'attention dans cet ouvrage.

Nous utilisons le mot parc dans le contexte de la catégorie II, *Parcs Nationaux*, tel que défini par la *"Liste des Nations Unies des Parcs Nationaux et des Aires Protégées 1990."* Le

[5] Outre le mot "impossible", les dictionaires Français ne contiennent pas non plus de mot traduisant "design". Nous avons donc traduit à peu près, et selon le cas, par "concept", "conception" "structurant" ou "plan" et pour le "design on paper" par "épure".

parc est un territoire etabli primordialement pour préserver un aspect naturel et/ou culturel. Dans ce sens et comme ce sera discuté ci-après, les parcs sont comparables à une version dynamique de l'arche de Noé biblique. Deux genres de guerres sont ici discutées, le premier violent et le second, non-violent. Les deux sont des conséquences de conflits en l'absence de mécanismes institutionnels appropriés pour les prévenir en/ou absorber. La nature et fréquence des conflits entraînent beaucoup de changements et tragédies qui ne permettent pas d'accorder une quelconque priorité aux parcs. Par conséquent, ceux-ci souffrent du fait des conflits. Nous soutenons qu'en considérant ces ravages en tant que *"fait-accompli"*, les parcs pourraient en bénéficier, à condition que les conséquences des conflits soient transformées en occasion pour revoir leur concept. Cela pourrait favoriser la création d'une base durable pour le développement des parcs. La survie des parcs dépend de leur conception. C'est ce travail de conception et la manière dont il est défini qui est l'objet principal de cette étude. Les parcs font partie des systèmes vivants et comme tels sont inclus dans les ensembles complexes et dynamique. La manière dont une maison se conçoit est en définitive juste un processus architectural assez linéare. Comme pour les parcs, leur complexité et dynamique rendent inadaptée cette approche, mais pourtant, comme souligné dans l'ouvrage, c'est ainsi que les parcs ont toujours été conçus.

Le présent livre propose que les parcs soient conçus en *"puzzle"*, et leurs différentes pièces bien agencées. Si au départ, les pièces du "puzzle" sont mal placées, ceci apparaîtra inévitablement dans le résultat. Contrairement à un "puzzle" ordinaire, les pièces ne sont pas statiques et ont aussi des interactions dynamiques et complexes. Dans l'ouvrage, quelques-uns de ces aspects sont démontrés pour mettre en évidence l'erreur d'une approche conceptuelle sans tenir compte de cette réalité avec le sérieux qu'elle exige. Le devenir des parcs pourrait être assuré, si beaucoup d'attention était prêtée à la dimension institutionnelle du développement des parcs. Les institutions sont perçues comme des systèmes vivants et dès lors considérés comme étant constitués de pièces qui, du fait de leurs interactionen font une entité. La mort d'un membre de l'institution est comparée à celle d'une cellule à l'intérieur d'un organisme multicellulaire ou d'un arbre en forêt. Il est démontré que lorsque quelques-unes des parties (comme des organes dans un organisme) ne fonctionnent pas proprement, la croissance et le développement de l'institution s'en affectés. De la même manière, un environnement externe défavorable, malgré le fonctionnement normal du système interne, entraverait la croissance et le développement de l'institution. Au lieu de mettre l'accent sur les détails concrets des programmes de gestion, le dessein des parcs devrait dans ce cas accorder plus d'attention à la définition d'un cadre institutionnel adéquat pour leur développement. Il devrait permettre au parc de développer ses capacités propres et en même temps user de rappeler ses expériences passées pour résoudre le *"puzzle"*. Cette importance des experiences passées est une justification essentielle pour l'evolution d'une *mémoire institutionelle* pour laquelle l'ordinateur paraît indispensable.

Considérant la complexité du concept du parc, il y a lieu de procéder à une modernisation de moyens afin de minimiser les risques et les dépenses associés aux solutions mal conçues du "puzzle". Dans ce contexte, le rôle potentiel de l'ordinateur a été de nouveau souligné. Il est suggéré que l'utilisation des systèmes informatiques basés sur l'ordinateur pourrait faciliter la conception structurale des parcs. Il resterait à définir quels seraient les systèmes d'information appropriés à cette démarche. A travers des études de cas sur le parc

Murchison Falls, en Ouganda, la nature dynamique et complexe d'un parc a été mis en relief. C'est un parc qui a eu à faire face à des changements écologiques drastiques et a été ravagé par la guerre. En dépit des conflits la région a besoin de reconstruire et de réhabiliter les infrastructures socio-économiques. Chaque étude de cas met l'accent sur les besoins d'un renforcement du processus et des infrastructures du système, si le parc conçu devrait se réaliser. Nous avons examiné, entre autres, les feux, les herbivores, les arbes, les élephants, les braconniers et les termites, ainsi que le reseau fluide de leurs interactions, aboutissant à des résultats distincts d'après le calendrier suivi. Vu que ce genre de considération a toujours fait défaut dans tous les parcs, nous démontrons que l'essentiel en concevant des parcs se réduit à de l'empirisme et devrait formellement être traité comme tel. L'ouvrage conclut qu'il y a besoin de nouvelles perceptions dans le concept des parcs et pour cela, l'innovation des outils reste entièrement à faire. C'est pourquoi, de l'évolution des conceptions et, avec elle, du développement durable de terres, dépendront l'amélioration de notre compréhension de la dynamique des institutions impliquées. Il faudrait aussi tirer avantage du développement rapide des systèmes informatisés pour gérer et traiter les données pertinentes et tester un modèle conceptuel en univers virtuel avant que les ressources ne soient mises en oeuvre pour le réaliser. Des recherches futures devront être entreprises pour définir des modèles de systèmes d'information adéquate pour les parcs. Regardant loin au-delà des guerres, ce sont là quelques idées maîtresses sur lesquelles le concept structurant des parcs devraient mettre l'accent afin de résoudre ce "puzzle" éternel.

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CURRICULUM VITAE

Michael ONEKA was born 12 August 1958 in Koc, northern Uganda. After his formal primary education in Purongo (next to the Murchison Falls Park), Koc Goma and Gulu he joined Lango College, Lira for his secondary school education. While in Lango College (1973-78) he got involved in scouting, debating, wildlife conservation activities and many other extra-curricula activities. At Makerere University (1979-82) he took a bachelor of science degree course in Geography, Botany and Zoology with a concurrent diploma course in Education. He majored in Geography and Botany specialising in plant ecology and biogeography graduating with B.Sc.(Hons) and Dipl. Educ.

Upon his graduation he was employed by the Uganda Teaching Service Commission (Ministry of Education) as teacher and worked in King's College Budo (May 1982 to August 1983). In this capacity he became Head of the Geography Department taking care for planning and coordinating the teaching of Geography in the school. He also took care of preparing pupils for both ordinary level and university entrance certificate examinations and actively participated in various educational curricula debates. When he joined the research division of the Uganda National Parks, Uganda Institute of Ecology (August 1983 to December 1988), he did management-oriented research and actively took part in wildlife conservation education programmes. In 1987/88 he did a post-graduate diploma course in rural and land ecology surveys at the ITC (International Institute for Aerospace Survey and Earth Sciences), Enschede, the Netherlands. In the course he specialised in vegetation and rangelands surveys. Since November 1988 he has been a researcher at the Departments of Terrestrial Ecology and Nature Conservation, and of Ecological Agriculture. Prior to admission to the doctorate programme of the Wageningen Agricultural University he studied silviculture, landscape planning for the tropics, landscape architecture, and nature management. His main research interest has been on the processes of park development especially their institutional dimensions. The research scopes have covered such areas as fire ecology and management, management planning, surveys of wildlife and their habitats, conservation education, and computer-based information systems (GIS) in protected areas management. Michael is a landscape ecologist with keen interest in permaculture and has actively participated in various environment and development fora. He also retains a very broad interest in socio-cultural, economic and political issues. He communicates in Luo (Acholi), English, French and Dutch.