PD BBA 570

AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

RANGE-LIVESTOCK PRODUCTION IN SOUTH KORDOFAN, SUDAN: FINAL REPORT ON RESEARCH ACTIVITIES FROM 1980-1985

WSARP PUBLICATION No.48

NOVEMBER 1985

AGRICULTURAL RESEARCH CORPORATION
WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

THE GOVERNMENT OF SUDAN
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
THE WORLD BANK
CONSORTIUM FOR INTERNATIONAL DEVELOPMENT
WASHINGTON STATE UNIVERSITY

RANGE-LIVESTOCK PRODUCTION IN SOUTH KORDOFAN, SUDAN: FINAL REPORT ON RESEARCH ACTIVITIES FROM 1980-1985

W. TRENT BUNDERSON, RANGE SCIENTIST

WSARP PUBLICATION NO. 48

NOVEMBER 1985

2

THE WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

IS SUPPORTED BY

THE GOVERNMENT OF SUDAN

THE AGRICULTURAL RESEARCH CORPORATION

US AGENCY FOR INTERNATIONAL DEVELOPMENT

THE WORLD BANK

THE USAID PORTION OF THE PROJECT IS BEING IMPLEMENTED BY

THE CONSORTIUM FOR INTERNATIONAL DEVELOPMENT
TUCSON, ARIZONA, USA

WITH

WASHINGTON STATE UNIVERSITY, PULLMAN, WASHINGTON, USA

AS THE LEAD UNIVERSITY

Correct Citation:

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

Range-Livestock Production in South Kordofan, Sudan:
Final Report on Research Activities from 1980-1985
WSARP Publication No. 48
Khartoum, Sudan and Pullman, Washington, USA

4

TABLE OF CONTENTS

	Page No.
I. RESEARCH ACTIVITIES CONDUCTED	1
INTRODUCTION	1
OBJECTIVES OF THE RESEARCH PROGRAM	2
RANGELAND CLASSIFICATION AND EVALUATION IN SOUTH KORDOFAN	3
Introduction	3
Herbarium Establishment	4
Classification of Rangeland Communities	5
The Ecological Status of Range Resources in Relation to Land-Use	6
Conclusions and Recommendations	7
RESOURCE UTILIZATION AND LIVESTOCK PRODUCTIVITY	9
Introduction	9
Resource Utilization	10
Livestock Productivity	12
INTEGRATION OF IMPROVEMENTS IN RANGELAND PRODUCTIVITY AND GRAZING WITH AGRO-FORESTRY PRACTICES	14
Introduction	14
Current Productivity and Land-Use	14
Results	16
Conclusions and Recommendations	19
CATTLE SUPPLEMENTATION TRIALS WITH NATIVE FORAGES	20
Introduction	20
Results	20
Conclusions and Recommendations	23
INTRODUCTION OF FORAGE LEGUMES	24
Introduction	24
Objectives and Strategies	24
Results	25
Conclusions and Recommendations	26

TABLE OF CONTENTS

	Page No.
INTRODUCTION OF ANIMAL DRAFT IN THE NUBA SYSTEM.....	28
PROPOSED PILOT TRIAL TO IMPROVE DRY SEASON GRAZING IN SOUTH KORDOFAN.....	30
Introduction.....	30
Land-Use Planning for Agricultural Development...	30
An Integrated Land-Use Plan for Transhumant Agro-Pastoralists in South Kordofan.....	32
1. Introduction.....	32
2. Rationale.....	32
3. Design and Organization.....	34
4. Conclusions and Recommendations.....	37
REFERENCES.....	37
II. OTHER ACTIVITIES.....	39
MAJOR MEETINGS, CONFERENCES, AND WORKSHOPS.....	40
PUBLICATIONS (INTERNAL AND EXTERNAL).....	42

LIST OF TABLES

Page No.

Table 1. DEMOGRAPHICS AND PRODUCTION CHARACTERISTICS OF BAGGARA AND NUBA CATTLE HERDS..... 12 b

Table 2. DEMOGRAPHICS AND PRODUCTIVITY OF BAGGARA SHEEP FLOCKS.. 12 c

LIST OF FIGURES

		Page No.
Figure 1.	HERBAGE AVAILABILITY AND UTILIZATION BY LIVESTOCK AND LOSSES FROM VARIOUS CAUSES OVER THE YEAR.....	6 b
Figure 2.	DESIGN CONSIDERATIONS FOR LAND-USE PLANS.....	32 b

ACKNOWLEDGEMENTS

I am indebted to a large number of people for their support and assistance during almost 5 years in Sudan. In particular, I would like to thank Dr. D.A. Dafalla, WSARP Project Director, and Mr. Mukhtar Kenani, Kadugli Station Director, for their active role in supporting the research program. Leadership and support other than that of the Project and Station Directors, were provided by the Project Coordinators Drs. J.B. Henson and J. Noel, and their staff, and chiefs of party, Drs. R. Harwood, G. Owens, and L. Hogan. I am also grateful to my colleagues Drs. R.H. Cook, B. Fadlalla, I. Hashim, J.R. Gingrich, N.A. Patrick, T. Woldetatios, and T.E. Gillard-Byers, and to Mr. H. Mukhtar, Mr. Abu Sabah, and Ms Michaels for their valuable input at Kadugli. A special word of thanks is extended to Dr. Don Dwyer who assisted in the design and organization of the range-livestock research from its inception.

My senior and junior technicians, Mr. Ahmed Salah Ombadi and Mr. Ali Sheihk El Dein deserve special recognition for their intensive efforts and assistance in field activities, logistics, and data organization. Similarly, I would like to thank my research assistants,Juma and Sayid, for their enthusiastic and valuable help under extremely trying field conditions. A special word of thanks is also due my driver, Mr. Nicola Dahia who was my constant companion and field assistant throughout my residency in Sudan. The engineering and construction work of Dr. D. Higgins on the research station are also much appreciated, particularly with regard to the establishment of the exclosures and experimental farm, and the building of the irish bridge across the swamp to the farm. Without these individuals, none of the research conducted would have been possible.

I would also like to thank the Kadugli Research Station as a whole for their part in supporting the research and for making living conditions extremely pleasant in Kadugli. With regard to the latter, extra thanks is extended to Mrs. Shirley Higgins in the Khartoum Support Office for all her hard work in organizing the transport of supplies, equipment and airplanes to and from Kadugli, as well as travel both outside and in Sudan. I would also like to thank Mr. J. Hannum, Mr. Osman Abdalla, and Mr. L. Stenquist as Administration Officers in Khartoum.

Finally, I would like to thank the Government of Sudan, the ARC and its Director General, The World Bank, and USAID for their overall support of the project.

RANGE-LIVESTOCK PRODUCTION IN SOUTH KORDOFAN, SUDAN: FINAL REPORT ON RESEARCH ACTIVITIES FROM 1980-1985

W. Trent Bunderson
Range-Livestock Ecologist
Kadugli Research Station, WSARP

I. RESEARCH ACTIVITIES CONDUCTED

INTRODUCTION

This report summarizes the research activities and recommendations of the WSARP range-livestock ecologist stationed at Kadugli Research Station from the period October 1980 to May 1985. Its content is intended to provide a clear overview of the activities conducted in a context relevant to the constraints faced by traditional agriculture in the region, and the potential for production improvements.

Details of proposed research activities are contained in WSARP Publ. Nos. 18 & 22, with results provided in Bunderson (1981), Bunderson, et al. (1984), and Volumes I-IV of the 1984/85 Annual Report for Kadugli Station. Summaries of research activities and results are provided below based on the proposals developed by the range ecologist. These are:

1. Range Resource Classification and Evaluation in South Kordofan
2. Range-use Patterns and Livestock Productivity of Transhumant Baggara and Sedentary Nuba Systems in Kordofan
3. Extent and Impact of Burning and Measures for Fire Control
4. Integration of Improvements in Rangeland Productivity and Utilization with Agro-Forestry Practices
5. The Production of Native Hay and Supplemental Feeding of Cattle during the Dry Season
6. Introduction of Food and Forage Legumes into the Cropping Systems of Transhumant and Sedentary Groups in South Kordofan

10

7. Introduction of Animal Draft into the Nuba System

8. Proposed Pilot Trial to Improve Dry-season Grazing in South Kordofan

Research activities conducted were initially designed to address the range-livestock system as it presently exists. Studies emphasized evaluations of the current and potential productivity of both range and livestock, focusing on key constraints faced by traditional producers. The characterization of the systems targeted and identification of constraints was followed by a dynamic and iterative process to design interventions appropriate to the needs and priorities of producers. For detailed descriptions of the Nuba and Baggara systems, and associated research programs see WSARP Publ. Nos. 18 & 22, and the 84/85 Annual Report.

OBJECTIVES OF THE RESEARCH PROGRAM

The principal objective of the range-livestock program for both the Nuba and Baggara systems was to first characterize these systems and their constraints in sufficient detail to provide direction for research, then to design and implement appropriate improvements.

For the Nuba system, baseline studies demonstrated a priority for better integrating crop and livestock activities to address the potential for a semi-intensive system of mixed farming. Emphasis was placed on cattle and goats since sheep and swine numbers are relatively low and are kept by fewer producers. Although goats are probably the most important species raised, research on these animals is recent, and results presented here are therefore limited to cattle.

Activities with the Baggara focused on practical methods for improving the year-round nutrition and condition of cattle and sheep. Attention centered on these two species because of their dominant role in the system, as well as their importance for local markets and commercial export. Most research emphasized dry-season supplementation of breeding stock to alleviate stress and improve productivity. Although range improvement and grazing management programs are vital to long-term increases in productivity, efforts in this direction were considered unproductive until adequate controls over land-use are exerted to achieve specified objectives. An attempt is made to address this issue in the latter part of this report by outlining a pilot land-use plan for Baggara transhumants in South Kordofan.

Research activities conducted by the range ecologist in Kadugli are summarized below according to the proposals developed.

RANGELAND CLASSIFICATION AND EVALUATION IN SOUTH KORDOFAN*

Introduction

Baseline information on the structure and composition of rangelands, with studies on their current and potential productivity, are fundamental not only to understanding livestock systems, but to any program of research and development aimed at improving such systems on a sustained level of productivity. The classification and evaluation of rangelands provide a sound basis for land-use planning since they describe the ecological status of natural resources as influenced by past and present land-use, and

---

* Encompasses the proposal on the extent and impact of burning with measures for fire control

12

determine their productive potential under proper management. Continued long-term monitoring of rangelands is vital to research and development efforts because it provides assessments of the impact of various land-use practices and the success of attempted improvements in terms of whether the resource base is improving, stable, or deteriorating.

The following sections outline the activities conducted to achieve these objectives.

Herbarium Establishment

Knowledge of a region's primary resource is fundamental to sound land-use planning, as well as to an understanding of existing agricultural practices, and how these impact on the productivity and stability of the natural resource base. Extensive plant collections provide a first step for investigations into the use and potential of rangelands, and a herbarium, with emphasis on the Nuba Mountains region, is being established as a plant reference library for scientists and agriculturalists working in the area. A separate report on the plants collected and identified in the area is provided in Bunderson (1985c). This contains a taxonomic list of approximately 250 plant species collected in the province and organized into a herbarium at the Kadugli Research Station. The list is arranged chronologically, according to plant reference numbers, into the following general groups: (a) trees and shrubs, (b) forbs and woody herbs, and (c) grasses and sedges. Information provided on each species includes the latest, valid botanical name by genus and species, along with the associated family. The taxonomy of all plants was verfied by the East African Herbarium in Nairobi, Kenya.

A second report is in preparation and is intended as a practical guide and reference to the plants of South Kordofan with summarized information on their ecology, distribution, and economic importance. This reference provides a list of over 300 plants identified in the province, complete with annotated notes on vernacular names, life form, general habitat characteristics, abundance, distribution, forage value, and uses.

Classification of Rangeland Communities

Major rangeland communities in the Central Districts of South Kordofan have been classified on the basis of botanical composition, physiognomy, topo-edaphic characteristics, and climate. A preliminary classification is provided in Bunderson (1981), and a detailed description is being published separately. In general, vegetation communities are heterogeneous and complex, but strongly associated with land-form and soil type. On this basis, vegetation can be distinguished into the following broad categories:

1) Deciduous broad-leaf savanna on sandy clay and loam soils of jebel hillsides and footslopes
2) Semi-deciduous thorn savanna on cracking clay plains
3) Mixed thorn and broad-leaf savanna on non-cracking clay plains
4) Swamp grassland on seasonally flooded cracking clay depressions
5) Mixed thorn and broad-leaf savanna on alluvial plains
6) Riparian semi-evergreen woodland along drainage courses

Within each of these zones are found several plant communities, all exibiting some degree of variability due to local changes in soils and relief as well as the effects of human activities and grazing by livestock.

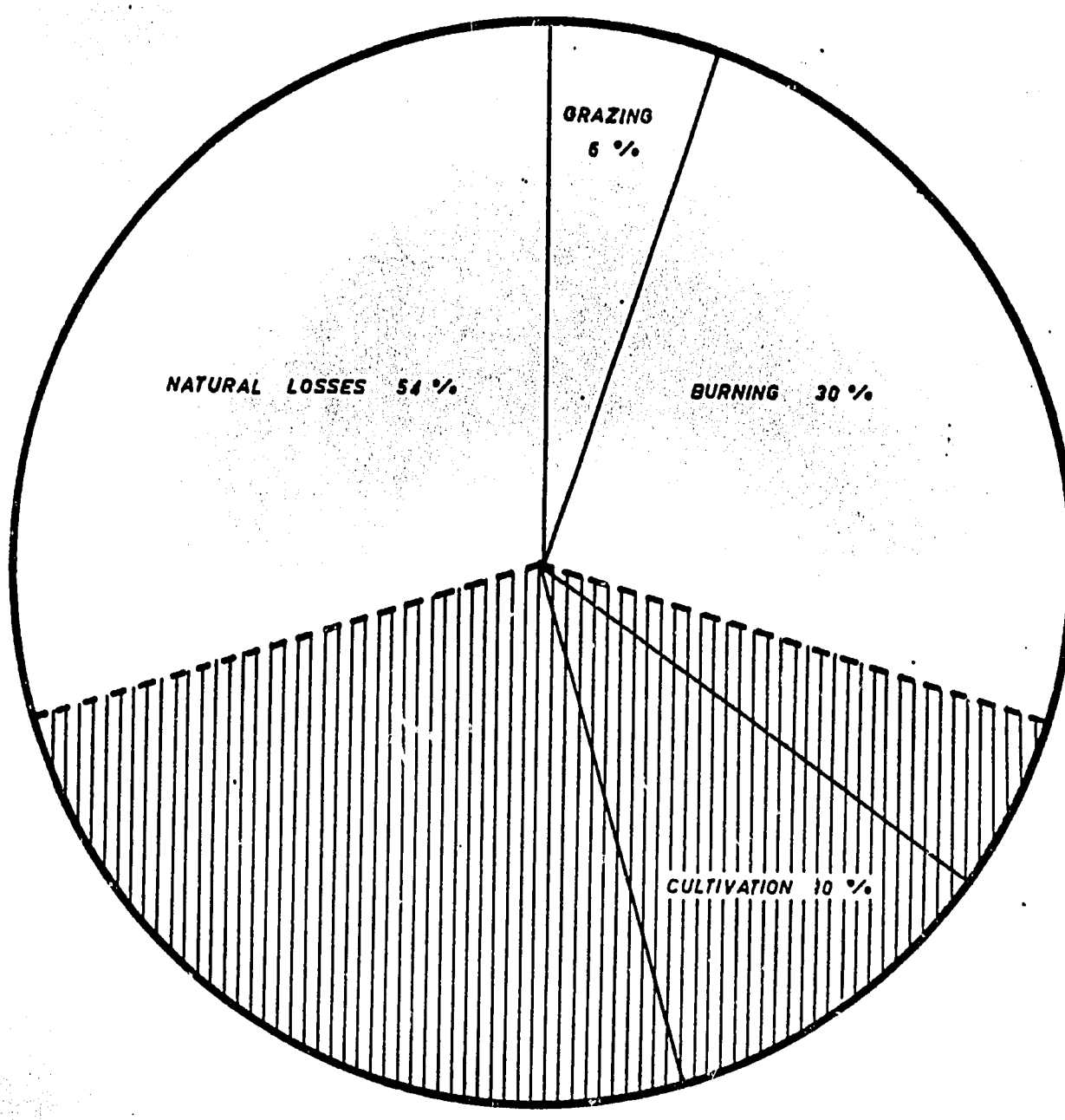
The Ecological Status of Range Resources in Relation to Land-Use

The most important uses of range resources in South Kordofan are (1) pasture and browse for domestic livestock, and (2) sources of fuel and building material for the rural and urban populations. Assessments of the current condition and productivity of rangelands in the region have been discussed in earlier papers based on data collected from 1981-1983 (Bunderson, 1984a; Bunderson, et al., 1984). Results for the wet and dry seasons of 84/85 support the contentions made concerning the influence of grazing, fire, cultivation, and tree cutting on rangeland, but also demonstrate the significant effects of drought. The effects of some of these factors on herbage availability for livestock are shown in Figure 1.

Virtually all domestic livestock, both migratory and sedentary, are grazed on open rangelands. Pasture and browse are communal and free, and there are no traditions concerning range conservation, and the establishment of reserves for seasonal grazing, or of land enclosures for fodder production, fuel, or timber. However, many groups and branches of tribes have maintained a limited degree of autonomy over rangeland by virtue of their greater numbers, sedentary nature, control over water, or use of land by village communities for settlement and cultivation.

In terms of grazing, the existing livestock biomass in the central districts of South Kordofan consumes only 6-10% of the net primary production (NPP) averaged for wet and dry years respectively (Bunderson, 1984b). Utilization of forage here is clearly inefficient relative to other regions in Africa where grazing frequently exceeds 25% of NPP with no adverse effects. The

FIGURE: 1 HERBAGE AVAILABILITY AND UTILIZATION BY LIVESTOCK AND LOSSES FROM VARIOUS CAUSES OVER THE YEAR.



AREAS INCCESSIBLE TO LIVESTOCK.

major factors influencing range condition and grazing intensity are detailed in Bunderson (1985c).

Conclusions and Recommendations

The current condition of range resources in the Nuba Mountain region of South Kordofan is fair to good. Grazing per se has little direct impact on vegetation resources because the timing and intensity of use are not condusive to physiological damage. However, the absence of sufficient grazing pressures, particularly during the growing season, has contributed substantially to the development and maintenance of coarse, low quality plants in the herb component (Bunderson, et al., 1984). Exceptions where grazing has been excessive include localized footslopes with permanent water, and many burnt areas containing perennial grass whose vigor and growth are reduced by early dry-season fires and the consequent selectivity of grazing attracted by new regrowth. In general, the utilization of forage resources has been inefficient due to the poor spatial and temporal distribution of livestock. This is partly related to the forced out-migration of livestock during the rainy season by unfavorable disease, pest, and environmental conditions.

Primary biological factors preventing the realization of the area's ecological and land-use potential are exploitive agro-forestry practices, uncontrolled burning, and inadequate water supplies. Outside the Nuba Mountains, resource degradation is especially acute on the qoz and non-cracking soils where continuous wet-season pressures from grazing, expanding cultivation, and tree cutting preclude opportunities for rest and recovery. These factors, together with existing grazing patterns, are

reducing the abundance and diversity of valuable tree and forage plants. Under current trends, deteriorating resources and diminishing controls over land-use are decreasing the ability of the resource base to support the needs and conflicting demands of the human population.

Future research should continue monitoring the productivity and condition of the exclosures and permanent transect lines established in 1981 and 1982. This is vital for research and development planning because it assesses the impact of various land-use practices, as well as the success of attempted improvements in terms of whether the range is improving, stable, or deteriorating. The frequency for monitoring vegetation depends on the parameter under investigation. For information on herbage production in different plant-soil communities, annual measurements are necessary, and should be related to rainfall. Herbaceous and woody composition need only be evaluated every 3-5 years, unless there is reason to believe that rapid changes are taking place. The results of these studies should be used to continually assess livestock carrying capacities, and how these are affected by factors causing changes in range condition.

A controlled experiment on the effects of fire and grazing at different seasons would greatly assist in evaluating the status of rangelands, and how they should best be managed. The design of the experiment should include sites on cracking clays and footslope soils to compare differences between plant communities, with the following treatments:

(1) control, with no burning and no grazing

(2) early dry-season fire annually

(3) late dry-season fire annually

(4) wet-season grazing,

(5) dry-season grazing

(6) combined wet and dry-season grazing

Details concerning site selection, plot size, experimental design, species and class of livestock used, stock density, timing of grazing periods, sampling procedures, and length of the experiment, need to be established by the scientist involved, and the resources he has available.

A final note is in order with regard to range management: Until government and donor agencies address the issue of sound land-use planning (with cooperation from researchers and traditional producer groups), problems of resource deterioration, widespread burning, and escalating conflicts over land-use will continue to undermine the agricultural potential of Western Sudan.

RESOURCE UTILIZATION AND LIVESTOCK PRODUCTIVITY

Introduction

The proposed research herein was conducted to identify key elements, inefficiencies, and constraints in the Nuba and Baggara systems of livestock production. The activities are closely allied to those of the research described above, and complement the nutritional and disease studies of Cook & Fadlalla (in Bunderson, et al., 1984); Fadlalla, et al., (1985); Cook & Fadlalla, (1985), as well as the socio-economic surveys of Abu Sabah &

Patrick (1984) and Gillard-Byers & Abu Sabah (1985). The information collected was designed to provide a basis for developing appropriate interventions to improve and stabilize livestock productivity within these two systems.

Resource Utilization

Patterns of resource utilization for crop and livestock activities among the Nuba and Baggara are described in Bunderson, (1981) and Bunderson, et al., (1984), with additional studies on nutrition by Fadlalla, et al., (1985); Cook & Fadlalla, (1985); Bunderson & Cook, (1985); and Hashim & Bunderson, (1985).

For Nuba livestock, grazing practices essentially focus on the use of hill ranges and footslopes during the cropping season, with care devoted to minimizing insect pests on livestock, and herding animals away from cultivated land. Intensive use is made of crop residues from house gardens and "near" farms by all species of livestock during October and November following their harvest. Similarly, crop residues from the "far" farms on the cracking clays are grazed extensively during January-March, but their use is more communal, involving transhumant and other village herds in addition to resident stock. With the depletion of crop residues and footslope grazing during the dry season, livestock are concentrated in the clay plains where they are frequently forced to travel 20-30 km/day for food and water. As the dry season advances, forage supplies continually decline, causing increased energy expenditures, and reduced food intake due to poor quality forage and the limited time available for feeding. Although

selective foraging, especially on browse vegetation, helps to compensate for the low quality and quantity of grazing available, the diet at this time is usually well below maintenance requirements, particularly for pregnant and lactating cattle. The results of poor dry-season nutrition are manifested in extended parturition intervals, poor growth and development, low milk yields, and greater vulverability to disease and mortality.

For Baggara livestock, the advent of the rains initiates plans for the annual migration north. This movement is undertaken primarily to escape the greater incidence of disease, insects, and mud associated with the south, but also to take advantage of the better quality forage of the sandy, arid north., even though range conditions here are declining. In addition, the Baggara have few options to move into the relative insect and mud-free hill and footslope ranges of the Nuba Mountains since these are largely controlled by sedentary Nuba groups. Settlement of Baggara transhumants in the plains therefore provides little attraction, and may in addition cause conflicts with cultivators whose crops are commonly located in these areas.

Movement north by Baggara herds usually begins in early July after sufficient water and forage are available to permit departure from their dry-season range. Distances travelled and time spent by individual groups in the north is governed largely by the quality and availability of forage and water, although traditional routes, kinship ties, cultivation sites, and markets are also important determinants. The return trip generally starts in late September or early October, with arrival in the south between mid October and early November. During the early dry season, extensive use is made of areas in the plains with ephemeral sources of water in order to

reserve forage supplies around permanent water for use later in the season. By December, the majority of Baggara have settled at specific sites for the remainder of the season, unless forced to move for lack of forage caused by widespread fires, or competition for forage and water. Early dry-season grazing is also concentrated in seasonal swamps which contain vegetation that remains green and nutritious long after that of other areas has dried up. However, because of their small size and localized distribution, swamp grazing is usually depleted by December or January, or in some cases, is burnt off due to conflicting interests (e.g., proximity to cultivated fields causing dangers of crop damage by tresspassing animals).

From the mid to late dry season, grazing patterns and livestock nutrition are similar to the Nuba with extensive use of crop residues from the "far" fields during January-March, and of the clay plains until the start of the rains (see above).

Livestock Productivity

To properly evaluate the impact and magnitude of various constraints on livestock productivity, baseline information was needed on the demographics and productivity of representative Nuba and Baggara herds. Due to the reluctance of livestock producers to allow the examination and handling of their animals, a period of one to several months was required for developing mutual trust with producers in order to permit data collection on herds.

Summarized information on the size, demographics, and production characteristics of Nuba and Baggara cattle herds are shown in Table 1. Similar data are presented for Baggara sheep in Table 2. Cattle in both the

22

TABLE 1: DEMOGRAPHICS AND PRODUCTION CHARACTERISTICS OF BAGGARA AND NUBA CATTLE HERDS

DEMOGRAPHICS*	BAGGARA	NUBA
Calves < 12 months	16.3 %	19.5 %
Females 12-24 months	5.6 %	2.9 %
Males 12-24 months	4.1 %	3.0 %
Females 2-4 years	10.6 %	10.0 %
Males 2-4 years	7.1 %	9.5 %
Females > 4 years	43.0 %	45.1 %
Males > 4 years	13.3 %	10.0 %
Castrates > 3 years	5.0 %	-
Total Numbers Sampled	1,939	697
Number of Households	17	36
Mean Number/Household	114	19

* Source: Bunderson (in Bunderson, Cook, & Fadlalla, 1984)

PRODUCTION CHARACTERISTICS	BAGGARA	NUBA
Parturition Interval	20-24 months	20-24 months
Age at First Parturition	4-5 years	4-5 years
Breeding Age	3.5-4 years	3.5-4 years
Calves Born/Breed.Female**	42.3 %	48.0 %
Calf F:M Ratio (12 months)	1.04:1	1.1:1
Breed. F:M Ratio	5:1	4.5:1
Total F:M Ratio	2.1:1	2.1:1
Pre-Weaning Mortality (estimated)	15 %	15 %
Adult Mortality (estimated)	10 %	10 %
Production Index***	0.285	0.295

** Calculated as follows: (% Calves/Breeding Females) / (1 - 0.10)

Since the herds already reflect an estimated calf mortality of 10%, the proportion of calves to breeding females was divided by (1-0.10) to determine the number of calves born.

*** Calculated as follows: $\frac{(12 \text{ months})}{\text{Part. Int.}}$ x (Calf Survival) x (% Breed Females-young < 2 years)

TABLE 2: DEMOGRAPHICS AND PRODUCTIVITY OF BAGGARA SHEEP FLOCKS

SEX & AGE CLASSES*	DRY SEASON	WET SEASON
Lambs 0-6 months	35.4 %	20.1 %
Immatures 7-9 months	6.5 %	14.0 %
Breeding Ewes 10-24 months	17.5 %	29.0 %
Breeding Ewes > 2 years	38.2 %	29.1 %
Rams 10-24 months	1.9 %	7.0 %
Rams > 2 years	0.5 %	0.8 %

* Source: Bunderson (1985)

ANNUAL PRODUCTION CHARACTERISTICS

Parturition Interval	11-13 months
Age at First Parturition	15-18 months
Breeding Age	10 months
Lambs Born/Breeding Ewes**	107.0 %
Twinning in Lambing Ewes	10.2 %
Breeding Ewes/Flock	57.2 %
Total F:M Ratio	3.7:1
Lamb F:M Ratio	1.1:1
Breeding F:M Ratio	15.1:1
Lamb Mortality 0-6 months	25 %
Adult Mortality	15-20 %
Peak Lambing Season	Dec-Feb
Peak Breeding Season	Jul-Sept
Production Index***	0.67

** Calculated as follows: (% Dry Season Lambs 0-5 months/Ewes) + (% Wet Season Lambs 0-6 months/Ewes) / (1 - 0.15)

Lambs 6 months old in the dry season flocks were subtracted from the total lambs observed to avoid double counting caused by the 1 month overlap between the two sample periods. The result is added to the wet season percentage, and divided by (1 - 0.15) to represent the actual number of lambs born, i.e. the lamb composition already reflects a 15% mortality level.

*** Calculated as : (12 months/Part. Int) X (Litter Size) X (Lamb Survival to 6 months) X (% Breeding Ewes/Flock w/o Lambs)

Nuba and Baggara herds reflect slow rates of growth and maturation, extended parturition intervals, relatively high mortalities, and a low proportion of breeding-age females in the herds. Overall production indices of 0.28-0.30 are low when compared with the 0.5-0.6 levels typical of commercial ranching operations in the semi-arid regions of the United States. Baggara sheep show considerably better performance than cattle, but their productivity is again low relative to western standards.

The principal factors responsible for this low level of productivity have been studied in considerable detail by animal and range scientists at Kadugli Station (Fadlalla, et al., 1985; Cook & Fadlalla, 1985; and Bunderson, et al.,1984). The over-riding factor is an inadequate level of dry-season nutrition, particularly for breeding stock and young growing animals. The impact of this is compounded by disease and parasitic infestations to which animals are more likely to succumb under nutritional stress (Cook, personal communications and unpublished data). The results significantly affect growth, reproductive performance, and survival. Mortality is particularly high in sheep because the peak lambing season occurs in the mid dry season when grazing and environmental conditions are far from optimal.

Despite the low level of productivity relative to Western Standards, it must be recognized that livestock in pastoral systems involve several species,and serve multiple functions, which collectively represent a substantial level of productivity when compared with the single-output characteristics of many commercial operations.

INTEGRATION OF IMPROVEMENTS IN RANGELAND PRODUCTIVITY AND GRAZING WITH AGRO-FORESTRY PRACTICES

Introduction

The importance of the cracking clay plains for cultivation and for grazing during the dry season, stimulated interest in their productivity and efficient utilization. The primary objective of this study was (1) to evaluate woody vegetation in terms of its value and potential for various land-use practices, and (2) to determine how the density and composition of this resource can be manipulated to better integrate cultivation, grazing, and use of wood resources.

Current Productivity and Land-Use

Cultivation: The cracking clay plains in the Nuba Mountain region of the central districts occupy approximately 14,000-15,000 km^2, representing 45-50% of the land surface. Except for seasonal swamps, all have high crop potential, and although cropped more than other soils in the area, only about 45% are currently in the cultivation cycle, which includes both crop and fallow land. Most cultivation on cracking clays is under traditional management, which on average involves 8-10 years of continuous cultivation with grain and oil-seed crops, followed by a similar period of fallow under native vegetation. Other groups cultivating these soils include the Nuba Mountain Agricultural Production Corporation (NMAPC) which is a mechanized-assisted group of schemes for smallholder tenants; the Mechanized Farming Corporation (MFC) of State and large-scale tenant farms; and private large farms. All three types of farms are government supported. NMAPC involves some 300 km^2, with about 2,100 km^2 of MFC State Farms and tenant farms, the latter representing 95% of these (HTS, 1981). The numbers, distribution,

and size of private farms are unknown, although each must be officially registered with the Regional Ministry of Agriculture in El Obeid. In general, the historical record of government-assisted farms has demonstrated a pattern of destructive exploitation where good crop yields are rapidly followed by poor yields and the abandonment of large tracts of land.

Grazing: As mentioned earlier, the clay plains provide the major source of grazing during the dry season, both in terms of crop residues and native forage. Under average rainfall (i.e., 600-750 mm), open savanna produces 3.5-7.0 tons of herbage per hectare, while woodland and bush thickets produce 1-2 tons/ha.

Tree Cutting: Most tree cutting in the cracking clays is associated with land clearing for cultivation, although trees are also cut for charcoal, firewood, fodder, thorn fencing, and light building needs. In addition to cultivators, these activities involve professional charcoal makers, urban dwellers, and livestock producers, particularly camel groups. The most important trees used are *Acacia seyal* and *Balanites aegyptiaca*, with some limited use of *Anogeissus leiocarpus* and *Acacia nilotica* where these occur along the banks of seasonal streams.

Burning: Fires occur in the clay plains for a variety of reasons, ranging from negligence on the part of charcoal-makers and playing children, to intentional burning. For example, cultivators burn rangeland to discourage grazing around their villages and unharvested fields in order to reduce the danger of crop damage by tresspassing animals. In some cases, this practice also reduces competition with migratory groups for limited supplies

of water. Nomadic groups owning camels and small ruminants set fires to stimulate growth of new leaves in trees, and to induce leaf fall from the previous season's growth. Fallen leaves are readily consumed by sheep and goats, while new leaves on trees are accessible to camels. Both sources provide nutritious diets. Fallow land is also burned after the start of the rains, to eliminate standing dead grass and to kill new germinating weeds when being cleared for cultivation.

Results

In order to evaluate the current ecological status of woody vegetation in the Nuba Mountains, it was necessary to examine the density and age distribution of trees and shrubs in different soil types, and how these change over time in response to the environment and disturbing influences such as fire, grazing, cultivation, and tree cutting for fuel and construction.

In the absence of excessive disturbance, research indicates that most woody species increase, showing good seedling growth and establishment. Fire will kill or prevent establishment of some species, but more commonly retards growth of seedlings and young plants through branch and top-kill. Many of the latter regenerate rapidly following fire. Early dry-season fires appear to do less harm to woody vegetation than later fires, and woody growth is slower in more open areas. This results from the competitive effect of tall dense grass on woody seedlings, and from hotter fires in these areas. In some species, germination appears to be activated by fire which breaks seed dormancy. Browsing generally has little adverse impact on woody plants,

except in localized areas on jebel footslopes and hillsides where high small ruminant densities prevent seedling growth and establishment. If accompanied by fire and/or tree cutting, woody growth is curtailed, and replacement cannot keep pace with tree mortality and removal. In areas where woody vegetation is cut extensively for fuel, building, or cultivation, the density and diversity of trees show declining trends.

On cracking clays, the combined effects of fire and cultivation are the primary factors preventing bush encroachment. Excessive bush reduces the value of land in terms of grazing, wood production, and cultivation. However, intensive cropping pressures (e.g., on mechanized schemes), sometimes with frequent fire, has led to the virtual disappearance of woody vegetation, apart from a few scattered trees. The results adversely affect soil fertility, nutrient cycling, soil-moisture relationships, grazing quality, availability of shade, and the abundance of wood. Resources must therefore be drawn upon from other areas which may also be under pressure.

For areas where cultivation is absent, burning and grazing is rarely sufficient to suppress woody growth. Vegetation in such areas is usually dense with plants of low diversity and size. This reduces the quality of wood products, and decreases the productivity and availability of forage.

In addition to the information gathered from the evaluation of rangelands in the region (see previous section), some experimental plots and transects were established on the research station farm.

These were designed specifically to examine the impact of fire and bush thinning on the structure, composition, and productivity of cracking clay

vegetation. Emphasis was placed on areas where relatively high densities of bush appeared to reduce their value for grazing and wood/timber production.

Treatments for the experimental plots involved the following:

(1) early dry season burns annually, no hand-thinning (2 replicas)

(2) late dry season burns annually, with one hand-thinning (2 reps)

(3) one hand-thinning, no burns (2 reps)

(4) controls - no burns and no hand-thinning (2 reps)

Additional information on fire is available from exclosures and unprotected transects (see Bunderson, 1984a; and Bunderson, et al., 1984). For the above experiment, late season fires with no hand-thinning were planned, but the high bush densities and reduced ground cover at this time of year, prevented the area's ability to burn. Goat browsing treatments were also part of the original plan, but experimental animals were not available at the time needed.

The results showed that a combination of early dry-season fires with limited hand-thinning helped control the density of woody vegetation to more desirable levels, and appears to prevent the development of bush thickets. However, many of the woody species showed remarkable resilience and/or regenerative capabilities following fire and/or hand-thinning. Effects on the herb component primarily decreased the abundance of two unpalatable species, Cymbopogon nervatus and Aristida hordaceae, and promoted a good forage species, namely Sehima ischaemoides. Herb production was also greatly improved, although this was also true for treatments involving hand-thinning. Late dry-season fires had limited effects on retarding the

density and growth of most woody species, but their impact on herb composition under high bush densities was similar to the early burns.

Conclusions and Recommendations

The importance of woody vegetation is demonstrated by its wide range of uses and stabilizing influence on the environment (i.e., browse; improved herbage growth; nutrient cycling and enhanced soil fertility; soil moisture conservation; shade for people and animals; tree and wood products such as fruit, fuel, building material, fencing, gum, and medicine). In the northern zones, increasing pressures on wood resources are precipitating a need for land-use planning and improved agro-forestry practices. Although woody vegetation in South Kordofan is more abundant and resilient to land-use pressures, demands for wood products are increasing. In areas with high human population densities, usually on coarse-textured soils, certain valuable trees with low fire-tolerance and regeneration are declining in abundance.

For areas with severe bush encroachment problems, the quality and availability of both grazing and wood products can be improved through selective hand-thinning followed by a 2-3 year burning regime in the early dry season. Trees and bush harvested from these efforts can be used for fuel, building, and other household needs. Mechanisms should be developed to divert excessive tree cutting from jebel footslopes and hillsides to the cracking clays where the woody vegetation shows greater resilience to land-use pressures. If feasible, such a plan should be activated on a village basis, with attempts to establish wood lots in jebel areas to supply

products not currently available from tree resources in the clay plains.

Research should continue monitoring the effects of fire and bush-thinning in the experiment described above. Efforts should also be devoted for establishing improved agro-forestry practices to ensure the long-term availability of valuable tree and wood resources.

CATTLE SUPPLEMENTATION TRIALS WITH NATIVE FORAGES

Introduction

The overall objective of supplementation is to improve the dry-season nutritional status of traditional Nuba and Baggara cattle by providing a low-cost supplement to meet the maintenance requirements of breeding female stock, whereby:

(1) survivability of breeding females and their calves is increased

(2) the productivity of breeding females is improved in terms of annual calving rates, and

(3) calf growth is improved, leading to more productive animals and reduced age at first calving, assuming any increased milk production is left for the calf

Results

Potential supplements considered included sesame-cake, legume hay, sorghum residues, and harvested hay from native pastures. Initial in-herd trials during 1983 and 1984 (see Bunderson, et al., 1984, and Bunderson and Cook, 1985), focused on native hay because of its low cost, and abundance relative to alternative supplements. However, the quality of hay produced was inadequate due to the labor and time required to hand-harvest and store early-maturing pastures at peak nutritive value without risk of spoilage by

rain prior to the end of the wet season. Chemical analysis of hay harvested in both 1983 and 1984 showed an average crude protein content of 4.4% with an estimated TDN of 45%. Comparative weight changes between control and supplemented groups were used as a preliminary indicator of the value of specific feeding trials in terms of whether the activity was worth continuing. In both 1983 and 1984, differences in weight loss between the two groups were not significant, and could not justify the costs incurred. The quality of hay was the key limitation, and in order to produce sufficient quality hay, considerable capitalization would be required to ensure an early, timely harvest with safe storage from rain. Such an enterprise is presently beyond the capabilities of traditional producers, and hence hay production is not recommended for future trials.

Based on these results, alternative supplements were investigated further. An analysis of various supplements and their associated costs to meet the crude protein requirements of 225 kg lactating cows was conducted, and is shown in Bunderson and Cook (1985). Sesame cake was considered too costly and limited in supply to be realistically adopted by most producers. Sorghum stalks, were generally abundant, but too low in quality. Legume hay from cowpeas and groundnuts appeared to offer the greatest potential, although for wide-scale adoption, their production must be expanded.

In 1985, in-herd feeding trials were conducted with a Nuba and Baggara herd involving groundnut and cowpea hay with sorghum residues fed at a ratio of approximately 3:2 (Hashim and Bunderson, 1985). Originally, only cowpea hay was to be used, but the poor crop season of 1984 significantly reduced anticipated yields of our forage crops, and the difference had to be made up

with groudnut hay and sorghum residues. As it turned out, the experiment was cut short from 60 to 43 days due to shortages of feed, and the ration fed, when combined with normal grazing, fell short in meeting the protein requirements of the cows by an estimated 30%. The results for this period are also only preliminary since the experiment should continue for another 2-3 seasons.

In terms of weight change, lactating animals in the supplemented group lost 191% and 46% less weight than the control for the Nuba and Baggara herds respectively. For pregnant animals which had not calved during the feeding period, the Nuba supplemented group gained 117% more weight than the control. No control animals were present in this physiological class in the Baggara herd, so no direct comparison could be made, but supplemented animals lost 1% of their weight vs a 5% gain in the Nuba group. No pregnant cows which calved during the feeding trial, were present in the Nuba herd, and only supplemented cows were present in the Baggara herd. These lost 13.8% of their body weight, with at least half the loss due to the birth of the calves.

Data on calf weights is not complete owing to several deaths and illnesses occuring during the supplement period. Until the causes of these are determined, along with differences in calf-milk consumption, effects of cow supplementation on calves cannot be assessed.

Conclusions and Recommendations

The experiment as conducted during the 1985 season was not entirely satisfactory because of shortages in anticipated legume hay, and constraints in station resources. However, preliminary results indicate potential for substantial benefits through supplementation with legume forage. It is recommended that the experiment be continued for at least 2 years with the following modifications:

(1) cowpea forage should be used exclusively because of its higher protein content (14% vs 9% for groundnuts), and because it shows greater potential for increased production in the Nuba Mountains

(2) cowpea forage should be produced and fed in sufficient quantity to provide 70-75% of the total protein requirements of lactating and late pregnant cows for a 60 day period beginning either March 15 or April 1.

(3) sorghum stalks should no longer be fed as part of the supplement due to high harvest and storage costs relative to the benefits received

(4) the same animals should be involved in the experiment, but with an additional 5 cows in each group

(5) an evaluation of grazing conditions and of the diet of the animals at the start and end of the supplement period in terms of:

   (a) total dry matter intake

   (b) diet using bite-count or micro-histological analysis

   (c) time available and spent grazing

   (d) distance travelled to forage and water

The study in (5) is necessary because of the location-specific variations in the other factors listed, as well as differences between physiological classes of animals. The results will assist not only in determining deficiencies in the grazing diet, but what the causes are and how management can be adjusted to help overcome these deficiencies.

INTRODUCTION OF FORAGE LEGUMES

Introduction

Detailed results of this research are contained in Bunderson, et al., (1984), Bunderson, (1985a), and Bunderson, et al., (1985). Legumes are currently grown on a limited scale by traditional producers in the Nuba Mountains. Although yields from these crops are low, they are valued for their contribution to the diet and cash needs of the household. Residues from legume crops are recognized for their forage value, but availability of feed is short and inefficiently utilized.

Crop production overall is constrained by the necessity for a bush-fallow system of cropping. This involves extended periods of continuous cultivation under cereal and oil-seed crops, followed by similar periods of fallow when the soil becomes exhausted or infested with *Striga*. Livestock production is limited by poor nutrition during the dry season which is influenced by widespread burning, restricted water supplies, and the absence of sound grazing management practices. The results are manifested in poor animal growth and reproductive performance, with increased susceptibility to disease and mortality.

Objectives and Strategies

Interventions incorporating legume crops into the system were considered appropriate technology since the general use of such crops is familiar to local farming communities, and their value as feed for animals is well recognized. Given the nature of the Nuba system, legume research provides potential for high short-term payoffs. With minor modifications, the

results should also have application over much of Western Sudan, including private and commercial operations, as well as those of traditional production.

The overall objective for improved use of leguminous crops is to stabilize and improve the agronomic resource base, and to provide a protein supplement to both households and livestock during periods of critical food shortage. Anticipated results are:

(1) stabilized yields of cereal and oil-seed crops in a system with a longer period of continuous cultivation

(2) reduced incidence of Striga, insects, disease, and weed competition

(3) increased assurance against total crop failure from drought or pest damage

(4) shortened fallow periods with reductions in the relative proportion of land in fallow vs that under cultivation

(5) reduced time and labor costs in clearing new or long-abandoned land

(6) improvements in the grazing quality and utilization of fallow areas, and of land drawn out of the fallow system by (4) above

(7) improved diets of households during the "hunger" period from September to January

(8) improved livestock nutrition and productivity

The basic strategy to accomplish these objectives is to introduce a simple but efficient system for intercropping sorghum and sesame with legumes that are well-adapted and high yielding in both grain and forage.

Results

Legumes producing high yields of forage with excellent nodulation, and resistence to drought, insects and disease included:

(1) mung beans (Vigna radiata), a variety obtained from the Agricultural Research Corporation (ARC) in Khartoum with a yield of 2.2 tons/ha of dry matter in 1984

(2) two cowpea varieties (Vigna senensis), one from local farmers and one from the Range and Pasture Administration (RPA) in Khartoum yielding up to 1.4 tons/ha in 19841

(3) guar (Cyamopsis tetragonobola) a variety obtained from the RPA in Khartoum yielding 1.5 tons/ha in 1984

(4) phillipesara (Phaseolus trilobus), a variety obtained from the ARC in Khartoum yielding over 1 ton/ha in 1984

Ironically, the best forage producers namely mung beans, cowpeas, and guar also showed high potential for grain production. In addition, the resin from guar can be used as a commercial cash crop. With improved plant spacing and normal rainfall, grain and forage yields should increase by 75-100%.

Conclusions and Recommendations

Based on these results, the important issue was how to make the expansion of legume crops attractive to farmers. Farmer assessments of on-farm trials indicated that legume monocropping on the cracking clays was unlikely to be adopted. To help understand the farmer rationale for this, an economic evaluation was performed to assess the costs and benefits of legume monocropping vs. traditional and improved intercropping with sorghum. The latter entailed superimposing improved legume varieties on traditional sorghum crops. No reduction in sorghum yield was expected because of the excessive spacing used in local practices. The results, presented in Bunderson, (1985a) and Bunderson, et al., (1985) demonstrate the economic advantage of improved legume intercropping. They also indicate difficulties

with introducing crop rotations involving sole legumes, a contention supported by perceptions of traditional farmers. However, legume sole crops could replace sesame planting on land coming out of fallow, and in areas where continuous cereal-crop production has exhausted the soil or led to Striga infestation. This requires more thorough investigation from the socio-economic perspective, as well as the biological.

Forage crops appear to offer no practical advantage because farmers are reluctant to devote land, labor, and capital for cultivating fodder when the activity competes directly with the needs of important food and cash crops. This conflicts somewhat with the research of ILCA on fodder banks, which suggests that confining livestock to specific areas serves to eliminate the labor costs of forage production (Chater, 1985). There still remain the costs of planting and weeding, and of controlled livestock confinement. Fodder banks also assume that some form of protection is offered the crop during establishment and growth, as well as for the period prior to supplementation. This would require physical control, such as fencing, or radical changes in the communal systems of land-use which currently prevail over most of Africa's grazing land. The latter form of protection appears particularly unrealistic, at least in the short-term. If fencing cannot be implemented, or harvesting is necessary to conserve forage quantity and quality prior to its feeding, then the costs of harvesting and storage must also be born by the farmer. The latter costs pose some difficulty for supplementing Nuba livestock. These are being addressed through the introduction of animal-drawn carts and modifications in traditional storage structures (Bunderson & Cook, 1985; Gillard-Byers, 1985).

Current and future research in the Nuba Mountains should focus on appropriate varieties of cowpeas, mung beans, guar, and possibly pigeon peas in both on-station and on-farm trials. Recommended trials are shown in Bunderson (1985a). Assuming forage legumes become more competitive in the near future, additional trials should be conducted with well-adapted forage species. Forage production efforts for livestock feeding studies should only be conducted with assistence of mechanized implements because of the large quantities of fodder required.

Well-executed improvements in legume intercropping should substantially reduce current limitations of crop production in the Nuba Mountains. Recent studies on livestock also indicate that animal nutrition and productivity can be significantly improved through dry-season supplementation with legume forage (Bunderson & Cook, 1985; Hashim & Bunderson, 1985; Cook & Fadlalla, 1985).

INTRODUCTION OF ANIMAL DRAFT IN THE NUBA SYSTEM

In 1983, the range ecologist undertook several experiments to examine the potential for introducing ox-drawn carts into the Nuba system. The carts and animals were kindly loaned to WSARP by the Nuba Mountain Rural Development Project in a collaborative effort to evaluate this potential. The rationale was that animal draft could significantly reduce labor constraints associated with cropping activities, and could also function to better integrate crop and livestock production.

Initially, the oxen and carts were used for transporting forage in a

researcher-managed experiment involving the harvesting, transport, and storage of native hay for livestock feed (see Hay Production and Cattle Feeding Trials above). During the harvest season of 1983/84, the oxen and carts were used in on-farm trials with 45 producers in two different villages, Bilinya and Sema. Uses of the technology were determined by each producer, and included the transport of sorghum heads, crop residues, native hay, and grass thatching from distant field sites to the storage and grain-threshing areas of the household.

The advantages of the technology were the savings in time and labor for transporting crops, forages, and building material from locations as far as 8 kms away from the household. The result allowed farmers to rapidly complete their crop harvest, providing time to engage in other activities. These included the transport of greater quantities of sorghum stalks for building and livestock feed, and of grass thatching for house repairs and new structures.

The receptiveness of the technology among producers was extremely good, and because of its demonstrated success, the program was expanded upon for the 1984/85 season. With the arrival of Dr. Gillard-Byers, the new agricultural economist, a decision was made for the 84/85 season to organize a collaborative effort between the range-livestock and socio-economic sections at Kadugli. The former provided background on the previous trials, as well as technical assistance to operate and maintain the animals and carts during the year. The latter designed an experiment at the village of Kalulu where 13 producers were granted access to the carts during the harvest season in December. Uses of the technology were determined by the participating

households, and information was documented on the labor efficiency and producer receptiveness of the ox-drawn carts. The results of this experiment, and associated recommendations, are reported by Gillard-Byers, 1985.

PROPOSED PILOT TRIAL TO IMPROVE DRY SEASON GRAZING IN SOUTH KORDOFAN

Introduction

In 1983, a pilot trial was proposed by the range ecologist to improve the utilization of dry-season ranges in South Kordofan for increased livestock production. Project authorities supported the concept but determined that implementation could not be undertaken by WSARP. Rather, our role should examine the general feasibility of the plan with feed-back from the Regional Government. The feasibility study, and its rationale, is outlined in the 1984/85 Work Plan (WSARP Publ. No. 22), and includes strategic disease control measures proposed by Dr. Cook. The Range-Livestock section at Kadugli (involving Drs. Fadlalla, Cook, Bunderson, Hashim, and El Wakeel) subsequently undertook the lead in pursuing discussions with the Regional Government and examining the potential for implementation. The description below provides an elaboration of the proposed trial, but reflects my own views, and not necessarily those of the project and other scientists.

Land-Use Planning for Agricultural Development

In order to realize the agricultural potential of Western Sudan, sound-land-use policies must be formulated for effective implementation. Such policies are fundamental to the success of range-livestock development efforts. Prior to implementation, these efforts must exercise control over land-use,

42

and for long-term improvement, should address the causes of production constraints rather than their symptoms. Examples requiring this approach include:

(1) reseeding rangelands to improve their productivity and quality for grazing and soil stabilization, either through aerial application or normal ground procedures

(2) reforestation for soil stabilization, replenishment of wood and wood products, nutrient recycling, and browse/fodder production

(3) the control and/or use of fire

(4) water development, particularly in the more fragile rangelands of the north, to improve the availability of grazing and distribution of livestock

(5) introducting systems of grazing management, and/or changes in the seasonal distribution of livestock, to improve range and livestock productivity

Depending on location, many of these efforts may be prohibitive due to cost. In areas of low agricultural potential, or where deterioration has been especially acute, the technical and sociological difficulties of reclaiming them may simply be intractable. The point made here is supported by the unimpressive record of development in semi-arid Africa. It also illustrates the inappropriate identification and application of potential improvements, rather than an absence of relevant technical information.

WSARP recognizes the enormity of the land-use question in Western Sudan. While the project has not been directly involved in this issue, land-use policy and planning are ostensibly keys to reconciling many of the problems of agricultural production in the country. Investigations into the ecological status and utilization of rangelands in South Kordofan have provided a basis for an initial attempt to address land-use planning as

43

applied specifically to pastoral-dominated systems. The design of such a plan for South Kordofan is outlined on a strictly experimental basis below.

An Integrated Land-Use Plan for Transhumant Agro-Pastoralists In South Kordofan

1. Introduction

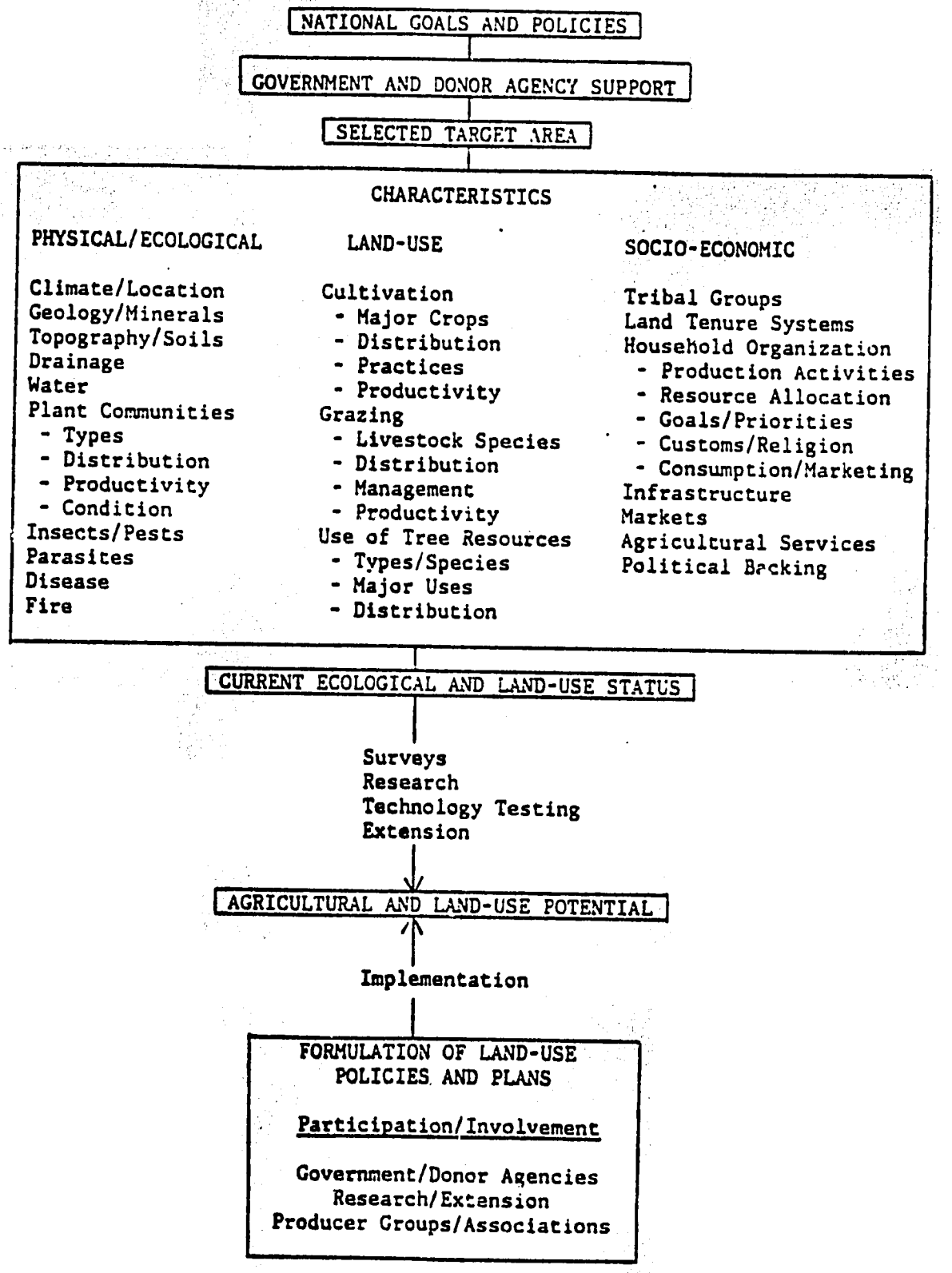
Livestock in Kordofan represent major agricultural and economic resources for Sudan. Worldwide in this climatic zone, productive agricultural systems invariably integrate the livestock component. However, changing land-use pressures and conflicting agricultural interests are undermining traditional forms of livestock production. This is largely related to the limited influence of pastoralists over patterns of resource use. With production almost entirely under traditional management, land-use planning is requisite to the long-term stability and improved productivity of these systems.

Figure 2 illustrates a simplified model of the ecological, socio-economic, and political factors associated with developing a comprehensive land-use plan. It is clearly a difficult and complex process, requiring dedicated committment from all parties concerned for successful implementation. For South Kordofan, this model is applied on a pilot trial basis to areas currently receiving little or no agriculture use due to an absence of dry-season water, along with health hazards caused by insect pests, disease, and mud during the rainy season.

2. Rationale

The region in question is characterized by a mean annual rainfall of 750-850 mm on extensive cracking clay plains south of the Nuba Mountains. This

FIGURE 2: DESIGN CONSIDERATIONS FOR LAND-USE PLANS



115

area shows high agricultural potential and represents a substantial portion of the province. Properly conceived and implemented, a development plan for the region should significantly increase animal and crop productivty, while reducing the scope and intensity of land-use conflicts. The success of the plan could set a precedent from which to model future land-use strategies, not only for other parts of Western Sudan, but for African savanna systems in general.

The proposed trial centers on the strategic development of water with an associated land-use plan to efficiently exploit the productive resources of areas currently unavailable for grazing or cultivation. For an area where no agricultural activities presently exist, the advantages of pioneering a land-use plan are manifest, since there is no necessity for altering or manipulating current practices. The plan is designed specifically for, but not limited to, transhumant agro-pastoralists, such as the Baggara, for several reasons:

(1) Transhumant groups are the most important livestock producers in Sudan, but their livelihood is threatened by the encroachment of mechanized and traditional cultivation into areas formerly used exclusively for grazing. In this regard, cultivators enjoy the benefits of a rudimentary system of land tenure, although the Government of Sudan holds residual rights to all unsurveyed and unregistered land. This system is primarily usufruct in nature, where rights to cropland can be claimed by individuals, or inherited patrilineally or matrilineally (depending on the tribe in question), as long as the crop-fallow system of cultivation is maintained. For regions with limited resources, use rights can be rented, purchased, borrowed, or obtained as gifts. In areas with plentiful land, usufructory rights can be acquired simply through land clearing.

In recent times, cultivation has expanded enormously, frequently in areas ecologically unsuited to cropping. This has been the most significant factor in the deterioration of the northern regions, (i.e., north of 11o.45'N.Lat.). In other areas,

116

cultivation is over-exploiting the natural resource base through inappropriate practices, often leading to the abandonment of large tracts of land whose recovery to former conditions could take decades at best.

(2) The continuing displacement of transhumant pastoralists is reducing their socio-political stability as well as the productivity of their animals. It is also causing an escalation in land-use conflicts and a disruption in the previous balance between the resource base and its economic utilization. The proposed development provides a potential alternative for transhumants to secure their livelihood and contribute to the long-term productivity of agriculture in the province.

(3) The mobile nature of transhumant groups, coupled with their gradual displacement, makes them ideally suited for a transition to a new region with a land-tenure system which provides increased stability and control over their resources. A similar transition by most sedentary groups in South Kordofan is unlikely to be attractive because of their strong socio-cultural ties with specific regions, and a more influential control of land relative to pastoral groups.

3. Design and Organization

The initial stage of the proposed pilot trial should follow the format in Figure 2, and should involve:

(1) discussions and coordination with the regional and national governments, as represented by the appropriate agencies and departments

(2) aerial surveys, complemented by adequate ground truthing, and conducted on a seasonal basis to determine the potential for development in the southern plains by providing information on:

   (a) current numbers and seasonal distributions of livestock and pastoral settlements in this part of the province

   (b) the sources and distribution of surface and ground water

   (c) the extent and distribution of major vegetation and soil types

   (d) the structure and physiognomy of the vegetation in terms of dominant trees, woody canopy cover, herbaceous cover and height, general phenology, and the relative proportion of perennial and annual grass

47

(e) the nature, extent, and distribution of fire and cultivation

(3) an inter-disciplinary ground team of specialists to select a suitable site for a pilot trial, along with specific transhumant groups interested in participation

(4) an evaluation of natural resources to assess the area's land-use potential in terms of the number of households and livestock which can be supported on a seasonal and year-round basis

Assuming a positive outcome for undertaking the proposed land-use plan, the site design is then developed, the components of which are outlined below.

Selection of Partcipating Groups: The long-term success of the plan depends on the selection of an appropriate group of participating households. Such a group would, in effect, represent an association of agro-pastoralists who would have specific rights over water and land for grazing and cultivation. The selection process should consider traditional rights, if any, of tribal groups in the region concerned. Access to such areas, and their corresponding pattern of use, should be thus organized in order to establish control over specific territories for common agricultural objectives. The results should lead to reduced land-use conflicts, as well as increased animal and crop productivity over the long-term. The ultimate choice for group and household participation in an association should reflect the priorities for grazing rights in the proposed area of the trial.

Water Development: The location, type, and storage characteristics of the water source developed will largely determine the numbers of households and livestock supported, and are therefore vital to the implementation of the entire plan.

48

Grazing Management: One of the most important factors associated with the inefficient utilization of rangelands and the inter-related problem of poor animal nutrition during the dry season, is the absence of a system to control the distribution of animals. An important component of this plan is to introduce a relatively simple system of grazing management to improve the use and availability of forage resources for increased livestock production.

Agro-Forestry: Although the nature of the environment currently limits the use of this region to dry season grazing, the potential for cultivation and forestry is high. In order to realize this potential, the integration of agro-forestry with livestock production is necessary. The plan developed presents one approach to accomplish this, and illustrates its flexibility for accomodating dramatic changes in traditional transhumant systems.

Monitoring and Evaluation: Monitoring criteria concerning the status and success of the pilot land-use plan are obviously required to determine the potential for large scale application, as well as for making necessary adjustments and improvements. Key elements to examine include:

(a) the degree to which the proposed plan is followed, both in its entirety and according to its component parts, and whether any observed deviations are detrimental in terms of achieving the specified objectives

(b) a socio-economic evaluation of producer attitudes toward the land-use plan, and of the benefits and costs over a 2-5 year period

(c) the adequacy of the water supply and its organization of use

(d) the nutritional status and productivity of livestock by species, and the contributing factors involved

(e) the composition and productivity of range vegetation in relation to different intensities of grazing

(f) the distribution of grazing, and its effect on the seasonal and year-round availability of forage

(g) crop productivity and the status of soil phosphorus and nitrogen

(h) the effectiveness of agro-forestry practices in structuring the land-use plan, and in meeting household needs

4. Conclusions and Recommendations

Implementation of the proposed trial should be coordinated with the assistance of WSARP scientists, although it will clearly require funds and resources from Government and Donor Agencies, perhaps involving the establishment of a new project.

The agricultural potential of Western Sudan is unlikely to be realized unless sound land-use policies are formulated and implemented with the cooperation of traditional groups. The question of land tenure is vital to the maintenance and improvement of the resource base for the long-term support of crop and livestock production in semi-arid regions. The proposed land-use trial is designed to provide direction in this effort, and will hopefully contribute to the agricultural development of Western Sudan.

REFERENCES

Abu Sabah, M.A. and N.A. Patrick. 1984. The sedentary production system of the Nuba Mountains Area. WSARP Unpublished Research Paper, Khartoum Suadan and Washington State University, Pullman.

Bunderson, W.T. 1981. Annual report on range research in Southern Kordofan. WSARP Publ. No. 10, Khartoum, Sudan and Washington State University, Pullman, 65pp.

Bunderson, W.T. 1984a. The nature and influence of fire on the range ecology of semi-arid savannas in Western Sudan. Proc. 2nd Intern. Rangeland Congress, Adelaide, Australia, May 1984.

Bunderson, W.T. 1984b. Primary productivity and energetic relationships of wild and domestic ungulate communities in

Gillard-Byers, T.E. 1985. Introduction of animal transportation technology. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Gillard-Byers, T.E. and M.A. Abu Sabah. 1985. Diagnostic activities and database development. In: WSARP 84/85 Annual Report of Research, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Western Sudan Agricultural Research Project, 1983. Work Plan Volume IV, Initial Research Proposals, Kadugli Research Station. WSARP Publ. No. 18, Khartoum, Sudan and Washington State University, Pullman.

Western Sudan Agricultural Research Station, 1984. Research Program for the Kordofan Region for 1984/85. WSARP Publ. No. 22, Khartoum, Sudan and Washington State University, Pullman.

Western Sudan Agricultural Research Project, 1985. Annual Report of Research for 1984/85. Khartoum, Sudan and Washington State University, Pullman.

II. OTHER ACTIVITIES

TRAINING

During the period of residency in Kadugli, training of technicians and research assistants was conducted in many areas of range-livestock research. These included:

(1) plant taxonomy and preparation of herbarium specimens

(2) measurements of herbaceous and woody vegetation using recognized sampling procedures

(3) plot layout and experimental design

(4) livestock surveys of herd composition, animal productivity, and grazing management practices with local producers

(5) forage crop research in both on-station and on-farm trials

(6) livestock feeding trials under controlled experimental conditions

(7) training in ox-draft technology, including general maintenance and operation of animals and equipment

Africa. Proc. 2nd Intern. Rangeland Congress, Adelaide, Australia, May 1984.

Bunderson, W.T. 1985a. Improved integration of legume crops. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Bunderson, W.T. 1985b. Flock demographics and productivity of Baggara Sheep. In: WSARP 84/85 Annual Report of Research, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Bunderson, W.T. 1985c. Rangeland evaluation and land-Use in South Kordofan. WSARP 84/85 Annual Report, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Bunderson, W.T., and R.H. Cook. 1985. Cattle in-herd feeding trials, 1984. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Bunderson, W.T., R.H. Cook, and B. Fadlalla. 1984. Range-Livestock Research Activities for 1982/83. WSARP Publ. No. 29, Khartoum, Sudan and Washington State University, Pullman, 130 pp.

Bunderson, W.T., T. Woldetatios, and T.E. Gillard-Byers. (1985 in press). Improved integration of legume crops into the Agro-Pastoral System of the Nuba Mountains, Sudan. In: Farming Systems Symposium, Kansas State University, Manhattan. October, 13-16, 1985.

Cook, R.H. and B. Fadlalla. 1985. In-herd livestock feeding trials. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Chater, S. 1985. The eating bank. Intern. Agric. Develop., Vol. 5, No.4, 12-13.

Fadlalla, B., I. Hashim, and R.H. Cook. 1985. Studies on the seasonal nutritional status of transhumant livestock. In: WSARP 84/85 Annual Report of Research, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Hashim. I., and W.T. Bunderson. 1985. Cattle in-herd feeding trials, 1985. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman.

Hunting Technical Services, Ltd. 1980. South Kordofan Central Districts Indicative Development Plan. Borehamwood, England.

Hunting Technical Services, Ltd. 1981. South Kordofan Central Districts Rural Development Plan. Borehamwood, England.

(8) experience in using common field and laboratory equipment

(9) tabulation and analysis of raw data

(10) construction and maintenance of fences and fire lines

MAJOR MEETINGS, CONFERENCES, AND WORKSHOPS

October, 1980	Project-wide meetings at Kadugli to discuss and develop an integrated program of research for South Kordofan. Input was provided by consultants Dr. R. Rogers, Dr. T. McQuire, Dr. D. Dwyer, as well as GTZ, Hunting Technical Services, and the Nuba Mountain Corporation.
February, 1981	Attended and partcipated in a international conference in Wad Medani, Sudan on Animal Production.
March, 1981	ILCA consultant Dr. R.T. Wilson arrived to assist in research planning on range-livestock production in the Nuba and Baggara systems.
June, 1981	Met with Faculty of the Animal Science and Forestry/Range Departments at WSU, and presented a seminar on WSARP activities in Sudan.
September,1981	Dr. D. Dwyer, Head of the Range Department at USU consulted and reviewed the range-livestock research activities at Kadugli during the previous year.
April, 1982	Project-wide meetings at Kadugli to further expand, modify, and integrate the program of research in South Kordofan. Attended by all senior administrative and scientific staff, including coordinators from WSU.
July, 1982	Travelled to Ethiopia to meet with ILCA staff and conduct a library search of relevant research material for Sudan. Also travelled to Kenya and obtained food and forage legume seeds from the Kenya Agricultural Research Institute and the Kenya Seed Company.
November, 1982	USAID and World Bank Project Evaluation, Research Component at Kadugli.
March, 1983	WSARP Farming Systems Workshop. Paper presented on "Natural and Domesticated Resources in Kordofan in Relation to Farming Systems Research".
April, 1983	WSARP Regional Planning Workshops at El Obeid, Kordofan

53

and El Fasher, Darfur. Paper presented on "Relationships between WSARP Research Programs and Range Utilization in Western Sudan".

May, 1983 — Field trip with Drs. Cook and Fadlalla to South Darfur to strengthen links between WSARP and Western Savanna Development Corporation. Trip report produced.

June, 1983 — Research Planning Workshop on Ghazala Gawazet Research Station-Past, Present, and Future Activities. Held at Khartoum.

July, 1983 — Research meetings with Range-Animal Nutrition Consultant, Dr, J. Holechek, Assist. Professor, New Mexico State University.

October, 1983 — Completed consultancy for Western Savanna Development Corporation on techniques and procedures for evaluating and monitoring range conditions and carrying capacities in South Darfur. Report produced.

May, 1984 — Attended the 2nd International Rangeland Congress in Australia, Presented three papers.

August, 1984 — Dr, D. Dwyer visited Kadugli to review the progress of WSARP's range-livestock research. Report produced.
USAID consultants DR. W. Wright and Dr. C. Gotsch visited Kadugli to review and evaluate WSARP's research program. Report produced.

October, 1984 — Dr. Brown and other USAID representatives visited Kadugli to review and aquaint themselves with WSARP's research program.

Dr. A.E. Hall of Cowpea CRSP, Riverside visited Kadugli to examine cowpea production in the region. Report produced with a supplement by Woldetatios, Bunderson, and Gillard-Byers.

December,1984 — Meetings for research planning between the Regional Government in Darfur and WSARP, WSDC, and the Jebel Marra Project.

Meetings with the Regional Ministry of Agriculture in El Obeid to discuss the practicality of implementing a pilot grazing trial with transhumant Baggara through the development of water. Also, measures to combat drought and declining crop yields in the future. Minutes prepared.

January, 1985 Attended a Farming Systems Workshop hosted by WSARP and CIMMYT in Wad Medani, Sudan.

March, 1985 Authored a paper with Dr. Cook as Co-author, which was presented at the ICARDA Farming Systems Symposium in Syria.

April, 1985 Completed contract in Sudan, and departed for the U.S.

PUBLICATIONS (INTERNAL AND EXTERNAL)

1981 Annual report on range research in Southern Kordofan. WSARP Publ. No. 10, Khartoum, Sudan and Washington State University, Pullman, 65pp. (Bunderson)

1983 Techniques for evaluating and monitoring range conditions and carrying capacities in South Darfur. Consulting Report to the Western Savanna Development Corporation, WSARP Publ.Series, Washington State University, Pullman. (Bunderson).

Livestock Production Systems-The Case of Western Sudan. WSARP Publ. Series, Washington State University, Pullman. (Bunderson, Cook and Fadlalla).

The nutritional status of Sudan Desert Sheep - A first approximation. WSARP Publ. Series, Washington State University, Pullman. (Cook & Bunderson).

Transhumant Production Systems: The nutritional status of transhumant cattle during the dry season in Kordofan, Sudan - A first approximation. WSARP Publ. Series, Washington State University, Pullman. (Cook, Fadlalla, & Bunderson).

1984 The nature and influence of fire on the range ecology of semi-arid savannas in Western Sudan. Proc. 2nd Intern. Rangeland Congress, Adelaide, Australia, May 1984. (Bunderson).
Pastoral Systems - Basic problems in resource management: An opportunity for farming systems research. Proc. 2nd Intern. Rangeland Congress, Adelaide, Australia, May 1984. (Bunderson, Cook, & Fadlalla).

Primary productivity and energetic relationships of wild and domestic ungulate communities in Africa. Proc. 2nd Intern. Rangeland Congress, Adelaide, Australia, May 1984. (Bunderson).

Range-Livestock Research Activities for 1982/83. WSARP Publ. No. 29, Khartoum, Sudan and Washington State University, Pullman, 130 pp. (Bunderson, Cook, & Fadlalla).

1985 Improved integration of legume crops. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman. (Bunderson).

Flock demographics and productivity of Baggara Sheep. In: WSARP 84/85 Annual Report of Research, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman. (Bunderson).

Rangeland evaluation and land-Use in South Kordofan. WSARP 84/85 Annual Report, Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman. (Bunderson).

Cattle in-herd feeding trials, 1984. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman. (Bunderson & Cook).

Cattle in-herd feeding trials, 1985. In: WSARP 84/85 Annual Report of Research, WSARP Publ. No. 40, Khartoum, Sudan and Washington State University, Pullman. (Hashim & Bunderson).

(In press). Production and Feeding of Conserved Forages to Traditional Cattle in the Nuba Mountains Sudan. Proc. of Farming Systems Symposium, ICARDA, Syria. March 25-28, 1985. (Bunderson & Cook).

(In press). Improved integration of legume crops into the Agro-Pastoral System of the Nuba Mountains, Sudan. In: Farming Systems Symposium, Kansas State University, Manhattan. October, 13-16, 1985. (Bunderson, Woldetatios, & Gillard-Byers).

S6