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MAB
A Special Issue

About this issue ...

This special issue of Ambio examines interactions between human populations, the ecosystems in which they exist, and the resources available to them. Examples are given from many parts of the globe of on-going attempts to optimize the use of natural systems. The articles in this issue are intended to present the results of selected projects of the Man and the Biosphere Program (MAB). From ca 1000 projects, some of the more outstanding examples were chosen to illustrate a wide variety of approaches to environmental and resource-management problems throughout the world.

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Cover: detail from "Landscape with the Fall of Icarus" by the Flemish artist Pieter Breughel the Elder, ca 1558. Reproduced by courtesy of the Royal Museum of Fine Arts, Brussels, Belgium.

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Pastoralism and Desert Encroachment in Northern Kenya

BY H F LAMPREY AND HUSSEIN YUSSUF

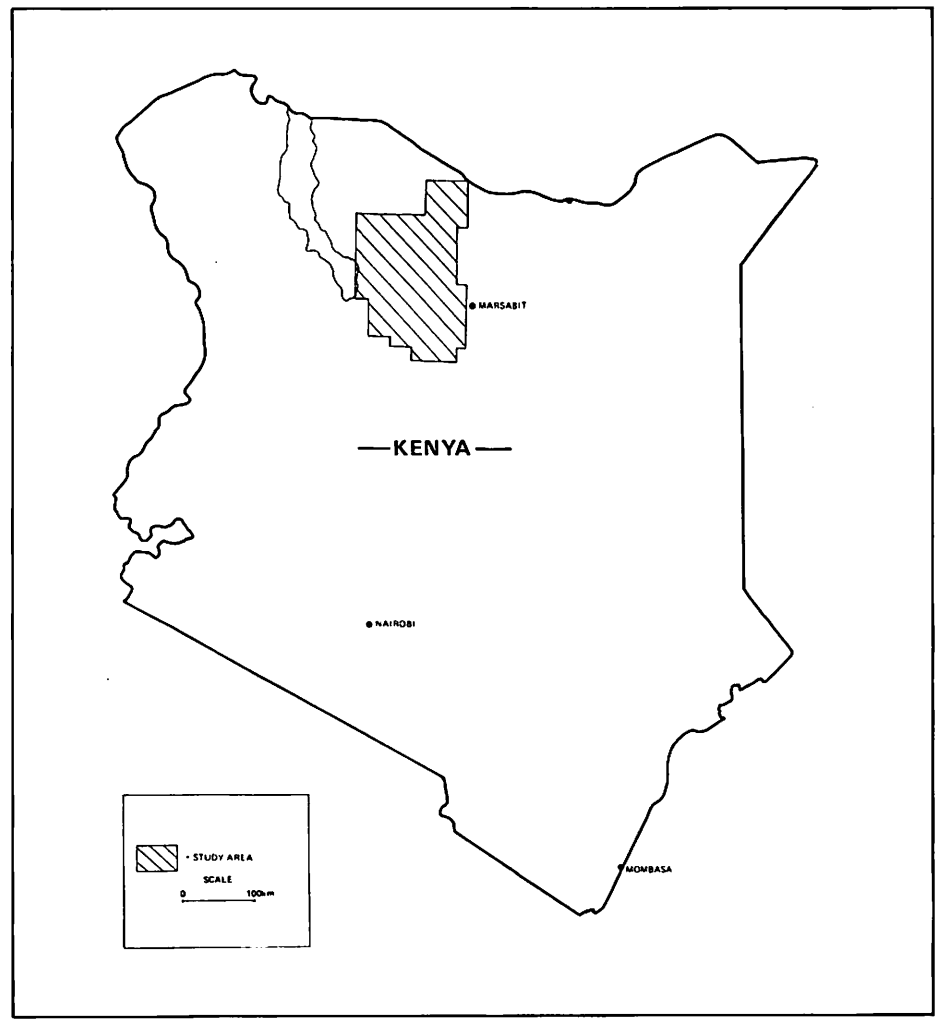
About 20 percent of the lowlands near Mt Kulal are overgrazed by small stock and camels. At the same time 40 percent of the area is totally unused because of fears of inter-tribal raiding.

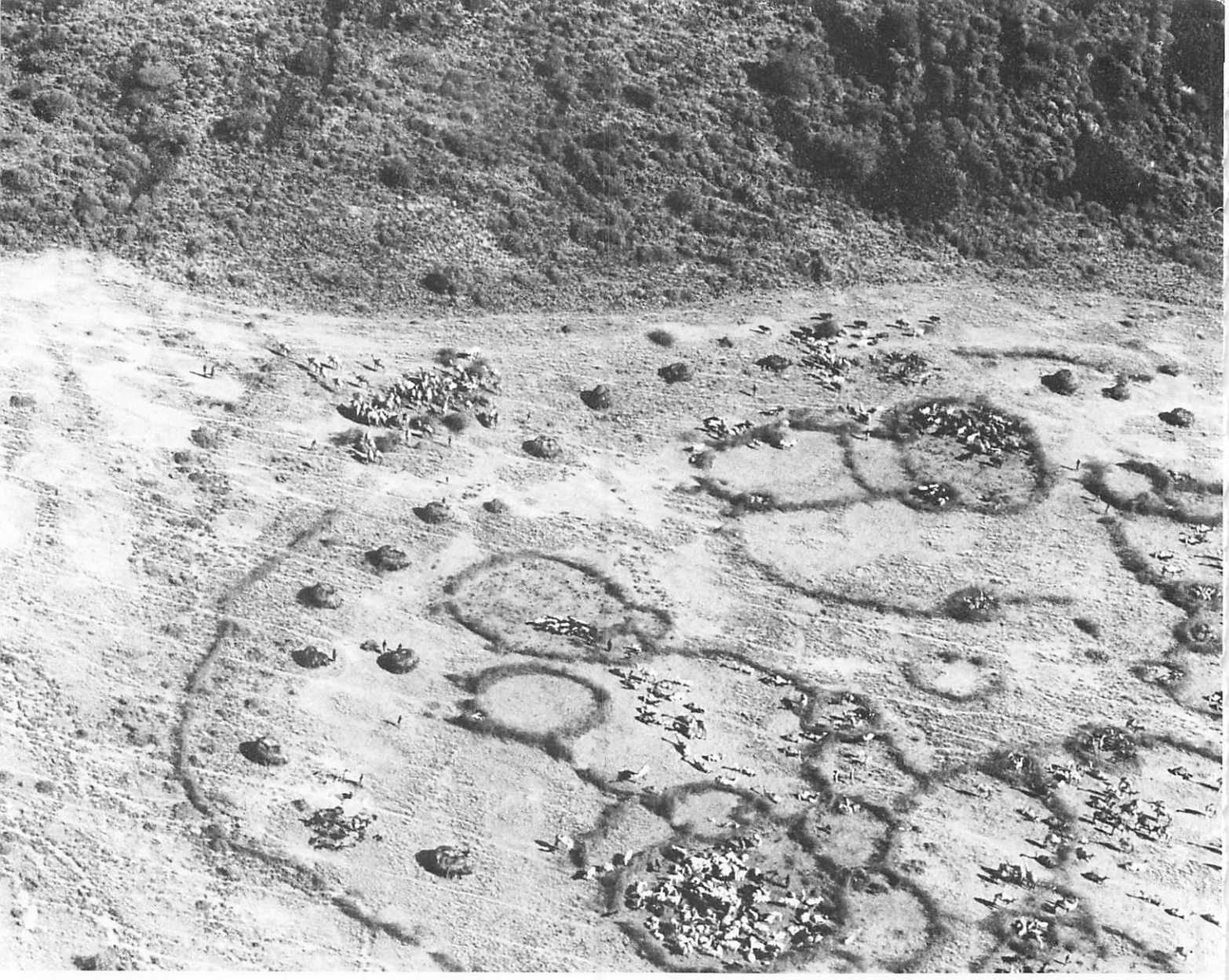
More than half of the land surface of Kenya is arid or semi-arid rangeland inhabited almost solely by nomadic pastoralists of several tribes. Their economy is broadly similar to those of pastoral societies living elsewhere in northeastern Africa and in the Sahelian zone who subsist almost entirely upon their herds (1).

Two separate processes are taking place simultaneously in the sub-desert areas of northern Kenya. First there is the gradual increase in overall density of people and livestock. In the regions as a whole the human population is still lower than 1/km² and is supported by cattle, camels, sheep and goats at a total density (estimated by aerial census methods) of 4.6 Tropical Livestock Units (TLU) or 1150 kg liveweight (1 TLU = 250 kg liveweight) per square kilometer. There is evidence that these densities of people and animals, if distributed evenly across the region, would not constitute overpopulation except during drought periods. However, a second process, which is particularly destructive in its impact on the savanna ecosystems, is also taking place and is compounding the effects of the growing populations.

Centers of human and livestock concentration have arisen and are expanding rapidly around the few springs and boreholes in the region. Although the presence of fresh water is the most important factor in such concentrations, the fact that these

Figure 1. Location of the study area in Kenya.





This photo of a Rendille nomadic *Manyatta* was taken at 8 a.m. during a systematic livestock census flight in the IPAL working area. Livestock (camels and cattle) can be seen leaving the enclosures either for water or grazing. The circle of houses is inside the outer perimeter and the animal enclosures are grouped towards the middle. Tree felling for the construction of fences is a major cause of desert encroachment in the region.

settlements offer security against inter-tribal raiding is of at least equal significance. The lack of security against raids is a major reason why large areas of the region are avoided by pastoral nomads, while the more secure areas are grossly over-exploited. Each of the concentration areas, where livestock densities may be as high as 25 TLU/ km^2 for the greater part of the year, becomes a nucleus of denuded land which spreads outwards as the people are compelled to go further for grazing and for the wood they need for fuel and for night enclosures for their livestock. As a growing proportion of the population becomes settled and as other nomadic families spend increasing periods of time in the vicinity of the settlements, these areas of localized denudation spread and eventually coalesce into large tracts of desert.

The IPAL Project in Kenya

The Mount Kulal area in the sub-desert country of northern Kenya is the research site of IPAL—the Integrated Project on Arid Lands (2)—started early in 1976.

The area selected for the project in Kenya is an approximate rectangle, 22 500 km^2, of desert and sub-desert situated between Lake Turkana in the west and Marsabit Mountain in the east (Figure 1). The greater part of the region lies at about 500 m above sea level but includes Mt Kulal which rises to 2500 m, with 34 km^2 of rainforest on its summit ridge. The mountain is the main water catchment for the few springs in the surrounding desert country. Mt Kulal was formally designated as a biosphere reserve under the MAB program in April 1978.

The project working area is the home of most of the Rendille people and also includes a large part of the Gabra tribe, both of which are nomadic pastoralist peoples who keep camels, sheep and goats. They occupy the north and south of the working area respectively and do not overlap geographically because of past antagonism. Small numbers of cattle-keeping Boran and Samburu occupy the more mountainous fringes of the area, the latter living on Mt Kulal itself.

THE BASELINE INVENTORY

During the first four years of work, the collection of an inventory of baseline data on the climate, soils, water distribution, vegetation, wildlife, domestic animals and of human populations has been a major focus of the project. Vegetation, soil and geomorphological maps have been made, using ground and aerial reconnaissance,

aerial photography and satellite imagery (3, 4). Vegetation classification has followed Pratt and Gwynne (5). A wide range of primary physiognomic vegetation types (nine types, see Table 1) occurs within the study area including a large number of compositionally defined tertiary vegetation types (73).

Primary vegetation types are apparently well correlated with climate, modified to some extent by geology and geomorphology (3). Tertiary types are much more closely related to local soil differences and also, in some cases, reflect different land use histories. The principal primary vegetation types within the project area are annual grassland, dominated by *Aristida adscensionis* and *A mutabilis* and dwarf shrubland, dominated by *Duosperma eremophilum* and *Indigofera spinosa*.

A preliminary map of climatic patterns has been prepared (6). In addition to the general aridity of the region, the most important characteristic of the climate is its variability, which has been strikingly demonstrated in the past ten years. During the drought years of 1968 to 1976, mean annual rainfall in the semi-desert areas was approximately 50 mm as compared with the previous long-term average of 150 mm. In contrast, the 1977 rainfall was over 350 mm, which was reflected in the greatly increased plant productivity in that year.

Primary plant production, sampled by clipping herb and dwarf shrub vegetation in randomly placed 0.5 m² frames, is being related to rainfall and also to the environmental characteristics of the individual sites, and to the impact of livestock.

Table 1. Primary (physiognomic) vegetation types.

	Area (km²)	% of total
Annual grassland	7 655	33.3
Dwarf shrubland	6 352	27.6
Shrubland	4 649	20.3
Bushland	1 378	6.0
Barrenland	948	4.1
Perennial grassland	780	3.4
Woodland	786	3.5
Evergreen to semi-deciduous bushland	328	1.4
Forest	124	0.5
Total Area	23 000	

Impact of livestock

Using the enclosure plots at the Balesa Kulal sub-desert site, the effects of different stocking rates with camels, sheep and goats upon herb and dwarf shrub vegetation have been measured. The trials simulate actual densities observed during the project's systematic aerial surveys and vary from 2.75 TLU km²/yr (*ie* 1 camel and 10 sheep or goats/km²/yr) to *ca* 25 TLU/km²/yr, as observed within 10 km of settlements. Consumption figures are obtained by measuring the dry matter (DM) biomass before and after each stocking trial with allowance made for growth during the trial period (Table 2).

Aerial surveys reveal that about 20 percent of the lowland portion of the IPAL study area has a carrying capacity which has been exceeded by smallstock and camels alone (7). These high stocking rates occur near settlement and water. Meanwhile some 40 percent of the study area is unused due to fear of inter-tribal raids.

Preliminary data indicate that perennial woody plants comprise 33 percent of the diet of sheep, 52.4 percent of the diet of goats and 77.4 percent of the diet of camels (7, 8). *Indigofera spinosa*, where available, is the most preferred plant species.

It is estimated that about 7 percent of the primary production in the 200 mm rainfall zone is eaten by smallstock and camels. In the area of highest stocking rate, intake exceeded production by 21 percent, indicating a degrading environment. Paddock trials, although inconclusive so far, suggest that the impact due to trampling and other herbivores may be greater than expected.

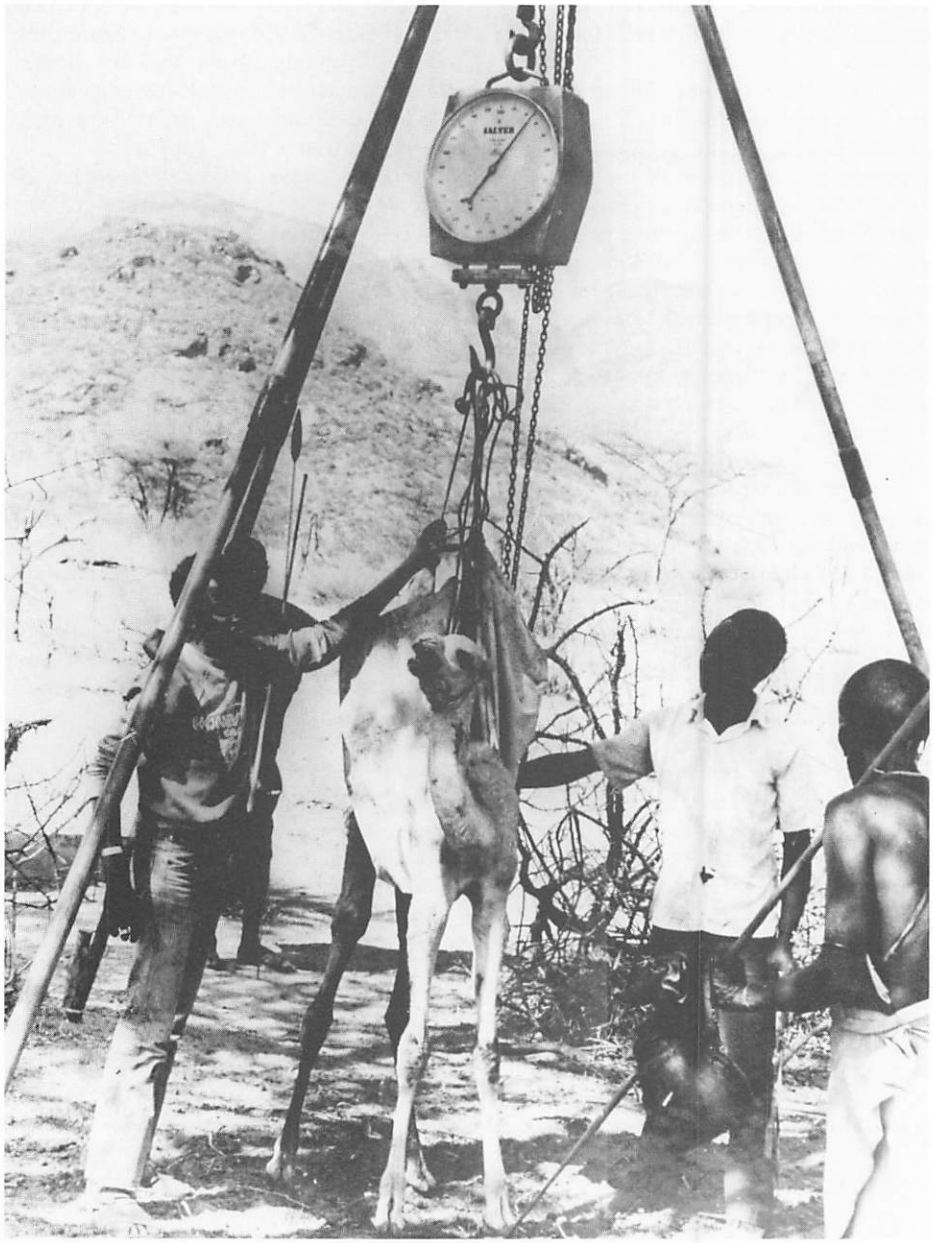
Flock composition—of sheep in particular—shows a differential loss of adult

Table 2. Primary production and livestock offtake of the herb and dwarf shrub layers at the Balesa Kulal experimental site. Measured after 133 mm rainfall in the month of April 1977. Estimates in kg/ha dry matter.

Paddock and livestock species and stocking rates	Dwarf shrub *Indigofera spinosa*[4]					Dwarf shrub *Duosperma*				
	Old growth	New growth	Total	Animal offtake		Old growth	New growth	Total	Animal offtake	
				total	%[5]				total	%
Control: no animals	6.3	3.9	10.2	0	0	86.0	17.2	103.2	0	0
SW. s/g[1] heavy[3]	189.4	121.9	311.3	97.5	80.0	0	0	0	0	0
NW. s/g medium	10.9	7.1	18.0	3.7	52.1	54.1	10.8	64.9	0.1	0
SE. s/g light	30.1	19.1	49.2	11.9	61.7	165.4	33.0	198.4	1.1	3.2
NW. c[2] heavy	7.2	4.5	11.7	2.5	55.6	34.1	6.8	40.9	0	0
SE. c medium	21.0	13.5	34.5	7.5	55.6	12.5	2.4	14.9	0.01	0.5
NE. c light	15.8	14.3	30.1	4.1	28.7	55.0	11.0	66.0	0.2	0.1

[1] s/g: sheep and goats.
[2] c: camels.
[3] Heavy stocking: 20 TLU km²/yr; Medium: 10 TLU km²/yr; Light: 5 TLU km²/yr. (Simulated stocking rates.)
[4] *Indigofera spinosa* is palatable; *Duosperma* and *Sericocomopsis* are relatively unpalatable.
[5] Animal offtake: total and as percentage of new growth.
[6] SE paddock: high productivity probably due to ground water in drainage line.

Dwarf shrub *Sericocomopsis*					All dwarf shrubs					Herbs All species		Total	
Old growth	New growth	Total	Animal offtake		Old growth	New growth	Total	Animal offtake		Total rainfall	Productivity per mm	Total rainfall	Productivity per mm
			total	%				total	%				
152.0	33.4	185.4	0	0	244.3	54.5	298.8	0	0	309	2.32	363	2.7
306.1	67.3	373.4	3.8	5.6	495.5	189.2	684.7	101.3	53.5	296	2.22	458	3.4
80.0	17.6	97.6	0.3	1.8	145.0	35.5	180.5	4.1	11.5	360	2.71	395	3.0
11.5	2.4	13.9	0	0	207.0	54.7	261.7	1.3	23.8	1229[6]	9.24	1284	9.6
56.2	12.3	68.5	0.6	4.6	90.3	23.6	113.9	3.1	13.1	761	5.72	785	5.9
11.4	2.4	13.8	0.03	1.4	44.9	18.3	63.2	7.5	40.0	390	2.93	471	3.5
123.1	27.1	150.2	0.2	0.6	193.9	52.4	246.3	4.5	8.6	555	4.17	853	6.4



A young camel is being weighed to provide growth data.

males. Growth of both smallstock and camel young is stunted by competition with humans for milk. Preliminary calculations of human requirements suggest that there is an excess of livestock over needs on the order of about 4 camels or 65 smallstock per Rendille family. Further data on livestock have been obtained in a study of traditional livestock management in the southern part of the project area (9).

Historical perspectives and human ecology

Evidence from archaeology, historical records, and the recollections of living members of the pastoral tribes has been drawn together to present a history of the last 2000 years of human occupation of the region and, as far as possible, of the changes in distribution of the different ethnic groups and their causes (10).

The project works in very close contact with the indigenous Gabra and Rendille people, and by gaining their confidence it has been possible to obtain essential information on their societies, their animal husbandry, their opinions on gaining a living from marginal lands and their own impact upon the vegetation, among many other subjects. There has also been cooperation in establishing fenced experimental plots in villages for demonstrating the protection and controlled use of vegetation and the planting of trees (11).

In conclusion it must be emphasized that IPAL is, by its very nature, a pilot project of ecological research, training and demonstration. Much of the basic inventory has now been completed, and the project is now entering a more action-oriented phase. It is hoped that the experience gained within the project can be disseminated adequately through training, publication and demonstration in the many countries where similar situations occur (12).

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12. The present phase of IPAL, which started in mid-1980, emphasizes the use of the research site for training and demonstration activities. There are also plans to fill gaps in the present effort, in such fields as human ecology, cattle production, agricultural and marketing economics.

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Grazing Lands

During the next two decades, the rising food needs of an enlarged world population will lead to increased pressure on many land surfaces. Increased output of food will be sought from higher yields in intensified agriculture and, to a lesser extent, from bringing some forested lands into food production. There will also be increased demands on grazing lands and related marginal lands which are not suitable for intensive agricultural use.

Grazing lands cover about one third of the world's land surface. They include many areas in arid and semi-arid regions, as well as mountainous and high altitude zones which are too steep or too hot, too cold or too dry for intensive cultivation. These lands have low productivity per unit area, and are inherently fragile. Overexploitation triggers soil erosion, desertification and other processes of degradation. Productivity is quickly diminished, with far-reaching consequences on the local and national economy and on the well-being of the peoples concerned. Traditionally, livestock production is the main use of these areas, but other considerations, such as tourist value of these spacious lands, are also important.

Under the aegis of MAB, a number of field projects have been launched aimed at finding forms of land management which are both ecologically and economically viable. Articles follow on three of these projects, in Kenya, in Tunisia, and in New Zealand. They illustrate some of the key issues, problems and research approaches associated with improved management of grazing lands. One recurrent theme is that of diversifying and enhancing productivity. Another is that of reconciling different interests and land use conflicts.

In Northern Kenya, the Integrated Project on Arid Lands (IPAL) examines the trend to growing sedentarization of nomads in a desert environment, with all its concomitant problems: increasing livestock populations, over-use of rangelands, "permanent" water shortages and famines that lead to a reliance on outside aid. But there are hopes that the trend can be reversed with proper management.

In the arid and semi-arid areas of southern Tunisia, research has suggested new ways of combining crop production and animal husbandry. A number of different approaches have been tried, including studies of energy flow in human systems and ways of associating modern technology with traditional agricultural practices. Improved range management techniques, including deferred spring grazing and separation of goat and sheep flocks, help combat the spread of desertification.

The Waitaki is a 1.3 million ha river basin in New Zealand, which includes a spectrum of ecosystem types, ranging from montane peaks to coastal plains. The Waitaki example highlights the importance of viewing contemporary problems in an historical perspective, and illustrates ways of reconciling land use conflicts and differences in local and national interests.

One common characteristic of these field projects is that they all deal with large areas of land. Man's traditional response to a harsh climate has been mobility: he has used the wide open spaces as his capital, and trekked out of dry areas in time of drought, or migrated vertically in mountainous terrain to follow the pattern of the seasons. It is an open question if these traditional patterns, so well attuned to the land, can be maintained in the face of increasing sedentarization of nomadic peoples, the demand for more food, and the attempts by more people to earn their livelihood from grazing lands with severe ecological constraints.

quantify the nitrogen available to plants on a day-to-day basis over the year (10). One model includes an organic part treating the mineralization of nitrogen and its dependence on the growth or activity of soil microorganisms; and an inorganic part treating ion transport and exchange processes. There is also a root sub-model describing the uptake of nitrogen as a function of root density and certain physical and chemical properties of the soil. Using this model, it is possible to describe the amount of nitrogen available yearly. However, it has not been possible to reveal the true pattern over the year, primarily due to our incomplete understanding of how soil organisms regulate the turnover of organic matter.

The main achievement of the soil biology studies has been an increased insight into the decomposition of organic materials in the soil (11). A lot was learned about the organisms in the mor layer. According to current textbooks, a mor is dominated by fungi, but we have discovered that the bacterial production is almost as large as that of the fungi (12). It has been possible to identify the biologically active bacteria and fungi. Preliminary experiments have begun to study the interaction of soil organisms and their influence on the turnover of organic matter and nutrients.

Abiotics

Energy exchange and water cycling were studied intensively. We now possess—along with meteorological information—energy, radiation and water budgets for the most intensively investigated stands (Figure 5). The studies of individual processes, especially on soil energy and soil water dynamics, have provided new perspectives (13). Special interest is now devoted to forest evapotranspiration. At an international workshop, different energy and water models were compared using one and the same data set.

Methodology

A major innovation in Swedish ecosystem research has been the use (sometimes abuse) of mathematical modelling (15). In the beginning of the project complex models were developed, but it was soon found that these were impossible to test in the real world. However, they helped to identify unknown areas as well as sensitive parts of the model, and thus made it easier to state new hypotheses to be tested.

Experience gained on project establishment, coordination and management has been of great value in setting up new projects, such as those on energy forests and the effects of acid precipitation.

CONCLUSION

The SWECON project has fostered the development of individual disciplines, such as plant ecophysiology and soil biology, and also encouraged interdisciplinary collaboration. The use of mathematics allowed us to better define the problems and hypotheses, and influenced the design of experiments.

The basic research done on primary production, especially tree growth, can serve as a basis for an integration of "cause-and-effect" production research with more traditional forest production research. Hopefully with time it will be possible to develop yield tables based on causal relationships.

The work on nutrient cycling and nutrient budgets, as well as that on soil processes, provided valuable insight into environmental problems such as the effects of acid deposition. It has been possible to establish hydrogen ion budgets (16) which can be used as an aid in comparing the atmospheric inputs of acid with the acid turnover by natural processes within the ecosystem. Inputs of nitrogen compounds in polluted rain were similarly studied.

This long-term project on the Swedish coniferous forest has also contributed to the establishment of a new discipline called *systems ecology*.

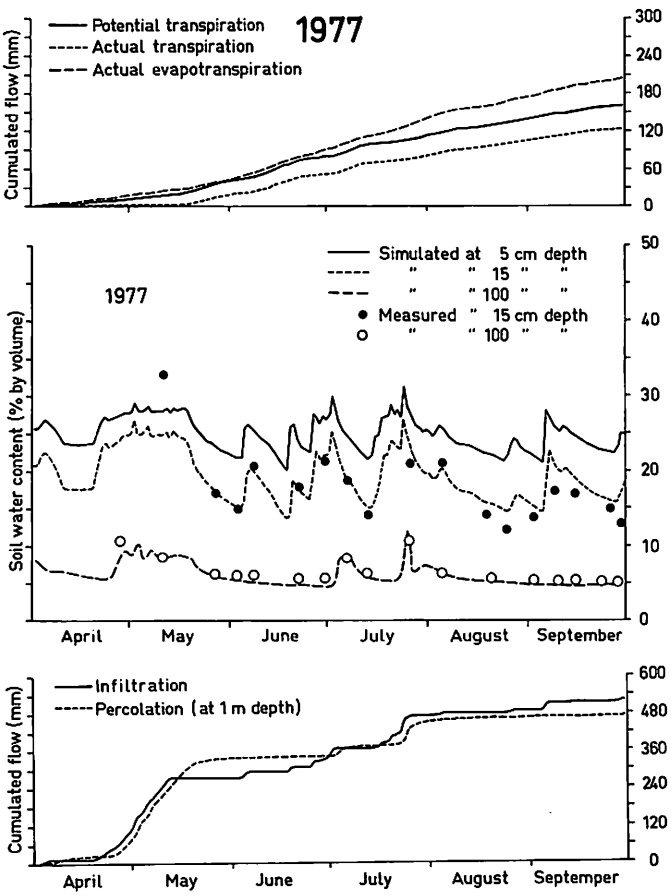


Figure 5. Water flows and contents at Jädraås, April 1 to Sept. 30, 1977. Simulated potential and actual transpiration, and actual evapotranspiration (top). Water content, simulated and measured with neutron probe. Measured values are means from two access tubes chosen from four tubes as the most representative (middle). Simulated infiltration and percolation (bottom). From P-E Jansson 1980.

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