Visit to the Family Farm Prototype Unit and Ranches of the Eastern Plains of Colombia

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AND

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C O N T E N T S

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THE CARIMAGUA FARM FAMILY UNIT

The Carimagua Farm Family Unit was established in 1974 to test the hypothesis that through the use of new pasture technology, family operations of this size would be viable under the conditions of the Llanos Orientales and that family farms might become a development avenue for this region.

The unit was established on 300 hectares of average quality savanna with a minimum of investment: a house for the family, a windmill, paddocks and a small corral.

The target was to provide a family with a monthly cash income of US$100 besides their subsistence food with a herd of 36 beef cows and their followers. The unit was to operate at a stocking rate of 0.30 AU and a calving rate of 65-70% to be achieved through the introduction of a limited area of improved pastures.

The project was initiated before its time relative to pasture technology. The first improved pastures established in 1974 were a complete failure (*Stylosanthes guyanensis*, *Paspalum plicatulum*). This plunged the system into a vicious circle. Low weight gains caused an increase in the herd size with the same number of cows, as heifers conceived at higher ages and steers took longer to reach the established selling weight of approximately 300 kg liveweight.

This over time led to an increase in herd size (Table 1) and stocking rate, concomitant with further decreasing weight gains and calving rates. These dropped from 52.5% in 1976 to 44.1% in 1979 (Table 2). Production per animal unit and year decreased from 45 kg to 33 kg during the same period.

By 1979 germplasm had been identified and tested sufficiently to justify major adjustments to the unit. In view of the good performance of

A. gayanus - *P. phaseoloides* pastures in grazing trials, 23 hectares of this legume-grass association were established[1]. Taking account of the low quality of the stock initially introduced to the unit, a major culling was undertaken and nine new cows were introduced. A year later the calving rate had risen to 62% and 129 kg of beef liveweight were produced per animal unit (Table 3). In 1981 calving rates remained the same level and 99 kg/AU were produced. In 1982 the calving rate rose even further to 74% but only 74 kg were produced per animal unit. This increase in reproductive performance and simultaneous decrease in beef production reflects a series of changes that have occured in the farm family unit during the last years. 1980 reflects a very high production due to the new pastures. Cows gained about 100 kg of weight each (Table 3). This has had a very noticeable effect on claving rates and weaner weights in subsecuent years and has directly influenced the high productivity level achieved in 1980: 130 kg beef produced per animal unit.

In 1981, cows already had high liveweights and therefore a large proportion of the pasture was used by other stock categories rapidly reaching the predetermined selling weight of 300 kg. This is reflected by very important sales in that year (37 kg sold/100 kg liveweight of initial cattle inventory).

The high calving rate of 1982 implied a very high grazing pressure on the improved pasture as calved cows have the highest priority for its use. This implied that other categories of young stock which would have made an efficient use of improved pasture, had to graze native savanna. Thus recent evolution of the use of the improved pastures in the unit has been: from fattening cows in 1980 and young stock in 1981 to feeding lactating cows almost exclusively in 1982. This is reflected by a series of performance indicators (Table 4).

In order to assess the capability of the unit to achieve its economic target (US$100 family income per month), a simple budget analysis was performed using registered physical performance and estimated input requirements and prices. This income analysis must be viewed as a rough estimate due to the

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1/ The farm lay-out and some other features are shown in Figure 1.

the series of CIAT interventions (upkeep of firebreaks, specific culling policy, etc.) which somewhat limit its representativity for the situation of potential settlers in the region.

Table 5 presents the budget for four years at 1981 prices. A capital investment of about 2 million pesos or US$33,000 is needed. This figure excludes land but includes cattle which amount to 80% of the total investment. Assuming a real 10% opportunity cost of capital the monthly family income was of US$40 in 1977, US$5 in 1978, prior to the establishment of the improved legume-grass association. It rose to US$152 in 1981 and US$67 in 1982. At 5% interest rate the corresponding figures are US$178, US$111, US$289 and US$200 per month.

The monthly target family income of US$100 can thus be achieved under the lower interest rate assumptions and when the emphasis of the unit is towards fattening either cows or steers. The shift towards breeding markedly reduced the profitability. This result which is consistent with a series of other analyses led to an ex-ante analysis of other options for small scale farms. The most promising option resulted to be the dual purpose beef and milk production even at the low milk productivity levels assumed.

Therefore the decision was made to shift the emphasis of the unit towards dual purpose production and more appropriate crossbred Zebu - Brown Swiss heifers were purchased in September 1983. Presently the unit is in the transition towards this production system.

The operation of this prototype unit and the economic analyses conducted related to it, have led us to the conclusion that improved pasture technology might substantially improve the feasibility of small scale farming in the Llanos Orientales, with all its positive facets of land for rural population, employment generation, even income distribution, settlement of further population offering services to the farming community, etc. Some of the most important limitations and advantages of small family units are listed in Table 6. At present serious consideration is being given to the future role of research with respect to testing of components of technology in similar models. It appears that new contacts with national agencies are essential in

order to effectively communicate the results of our research efforts and to facilitate their application.

Table 1. Carimagua Family Farm Unit: herd development

	1975	1976	1977	1978	1979	1980	1981	1982
1. Cattle Inventory:								
- Cows	36	40	32	24	34	34	35	37
- Female calves	14	8	12	11	5	11	6	17
- Heifers:								
1-2 years	10	14	7	10	10	5	9	6
2-3 years	12	10	14	5	9	10	3	9
3-4 years	6	10	10	7	2	9	5	
4-5 years		4	10	10				
- Male calves	10	13	11	10	10	10	11	12
- Steers:								
1-2 years	11	10	11	11	9	9	7	10
2-3 years		11	10	11		8	4	4
3-4 years			11					2
- Bulls	2	2	2	2	2	2	2	2
- Heads of cattle	101	122	130	101	81	98	82	99
- Animal Units (AU)	88	110	117	90	72	88	72	84
2. Sales								
- Cows			8	16	15	2	8	6
- Heifers				8	3		8	
- Steers:								
1-2 years							3	
2-3 years	12			5	11		5	2
3-4 years	12			10	11		8	2
4-5 years				11				
3. Purchases								
- Cows					9			

Table 2. Carimagua Family Farm Unit: beef production (kgs)

	1975	1976	1977	1978	1979	1980	1981	1982
Initial liveweight of the herd	23051	27597	30502	20629	17471	27967	24809	27848
Sales: cows			2336	4128	1005	644	3096	1920
steers				7462	3740		5456	1256
other				2123	819		1825	
Annual production[1]		4546	5241	3840	2406	11140	7222	6215
Production per hectare		15	17	13	8	37	24	21
Production per animal unit		41	45	43	33	130	97	74

1/ Sales ± change in inventory

Table 3. Carimagua Family Farm Unit: evolution of herd size and animal weights, 1976-1982

	1976	1977	1978	1979	1980	1981	1982
1. Herd Size							
- Cows (No.)	40	32	24	34	34	35	37
- Females in reproductive	40	43	38	34	34	35	37
- Total animal units (AU)	110	117	90	72	88	75	84
- Stocking rate (AU/ha)	0.44	0.47	0.36	0.29	0.35	0.30	0.28
2. Liveweights							
- Cows	298	321	291	250	356	360	346
- Weaners	-	122	94	125	162	130	165
- Heifers 1-2 years	-	-	130	141	237	252	230
- Heifers 2-3 years	-	188	151	231	299	348	335
- Heifers 3-4 years	255	270	235	273	356	385	-
- Heifers 4-5 years	290	292	322	300	-	-	-
- Steers 1-2 years	-	-	165	174	211	303	273
- Steers 2-3 years	-	218	176	157	301	341	289
- Steers 3-4 years	-	276	258	183	-	-	347
- Bulls	-	-	-	-	-	-	-
- Cull cows	-	323	292	240	322	387	320
- Steers for sale	-	-	287	170	-	341	314

Table 4. Carimagua Family Farm Unit: physical performance indicators, 1976-1982

	1976	1977	1978	1979	1980	1981	1982
Stocking rate: AU/ha	0.44	0.47	0.36	0.29	0.35	0.30	0.28
Kg (LW)/ha	92	102	69	58	93	83	93
Cows with calf/ha improved pasture	-	-	-	-	0.91	0.74	1.26
Calving rate (%)	53	53	55	44	62	61	74
Calf mortality rate (%)	10	9	5	6	5	19	0
Adult mortality rate (%)	0	8	0	0	1	2	3
Cow culling rate (%)	0	20	40	31	6	19	8
Beef production: kg LW/ha	15	17	13	8	37	24	21
kg LW/AU	41	45	43	33	130	99	74
Kg beef sold/100 kg initial inventory	0	8	45	27	4	37	13
Cows + calves / Total herd size (%)	50	42	45	60	56	63	67

Table 5. Carimagua Family Farm Unit: preliminary farm income analysis (1981 Col$)

	Before		After	
	1977	1978	1981	1982
A. Capital				
- Stock	1'742.970	1'533.930	1'605.609	1'579.740
- Infrastructure	240.000	216.000	120.000	96.000
- Pastures	-	-	237.967[a]	211.520
Total	1'982.970	1'749.930	1'963.657	1'887.260
B. Gross Income	314.460	230.400	433.320	372.900
C. Operating Costs				
- Mineral supplementation and drugs	56.750	43.653	40.750[b]	48.015
- Fertilizers	-	-	30.049[b]	30.049
- Depreciation of:				
. infrastructure	30.000	30.000	30.000	30.000
. improved pastures	-	-	26.440	36.440
Total	86.750	73.653	127.239	134.504
D. Net Income	277.710	156.747	306.081	238.396
E. Inputed Return to Capital (excluding land)				
- At 5% p.a.	99.485	76.697	98.182	94.363
- At 10% p.a.	198.970	153.393	196.365	188.726
F. Return to Family Labour				
- At 5% p.a.	128.225	80.050	207.899	144.033
- At 10% p.a.	28.740	3.354	109.717	49.670

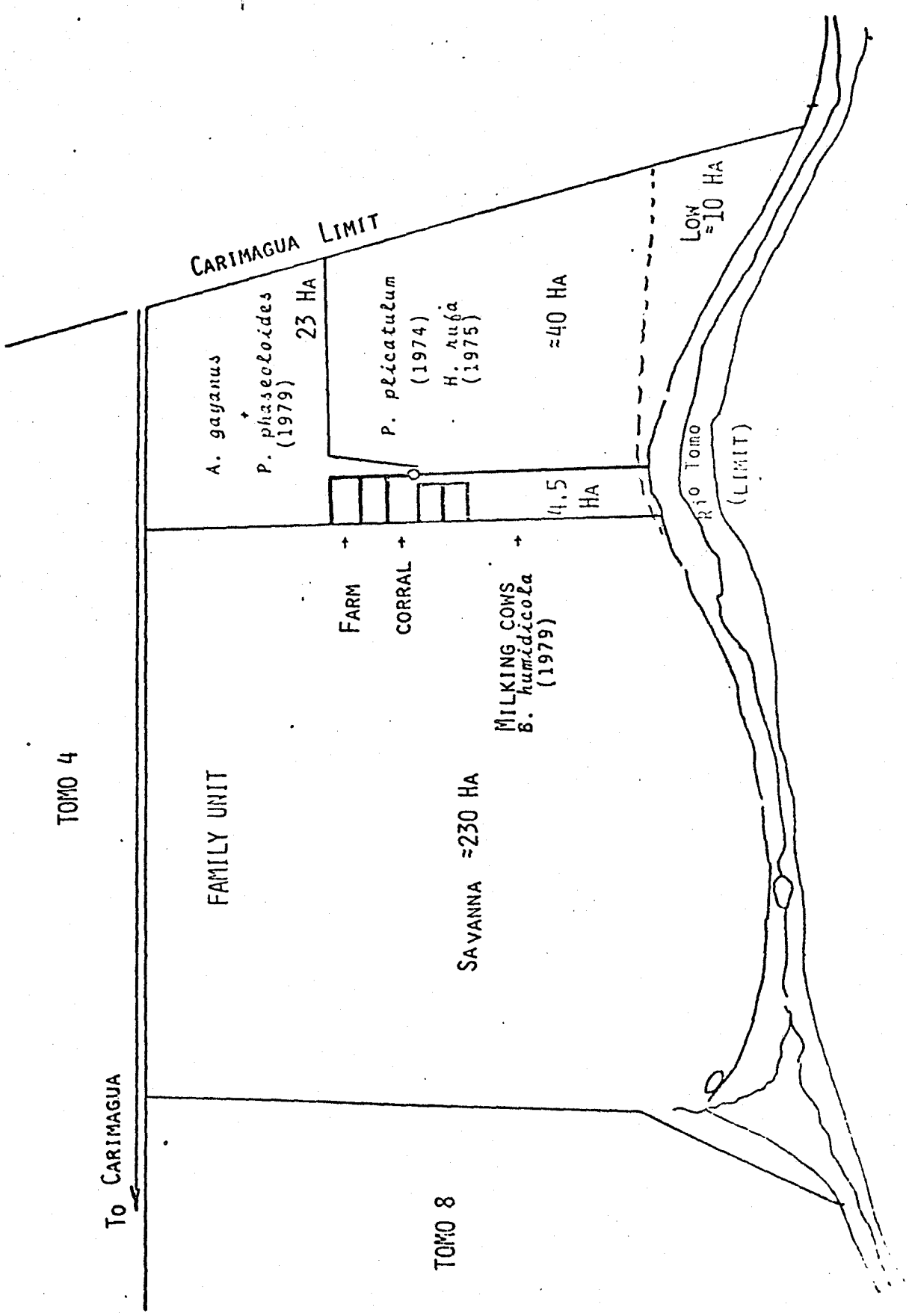
a/ Pasture establishment (23 ha) costing Col$11.496/ha persisting for 10 years.

b/ Refertilization of 50% of the improved area every year.

Exchange rate 1 US = 60 Col.$

Table 6. Limitations and advantages of small, livestock oriented family farm units in tropical savanna regions

Problems:	- credit (policy) - cash flow, eary years - lack of infrastructure - lack of community - "traditionalist" mentality
Advantages:	- available pasture technology - low requirement for purchased inputs - efficient use of resources - investment liquidity - would give rise to community - quality of management due to scale


CARIMAGUA LIMIT
A. gayanus
+
P. phaseoloides
(1979)
23 HA
P. plicatulum
(1974)
H. rufa
(1975)
=40 HA
LOW
=10 HA
4.5
HA
FARM
CORRAL
MILKING COWS
B. humidicola
(1979)
RIO TOMO
(LIMIT)
TOMO 4
FAMILY UNIT
SAVANNA =230 HA
TO CARIMAGUA
TOMO 8

Economic Aspects of Small Scale Ranching on Improved Pastures in the Colombian Llanos

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Foreword

The Eastern Plains of Colombia comprise some 17 million hectares of generally flat land with high solar radiation and rainfall. The traditional land-use is very extensive livestock production stocking one animal to five to ten hectares.

The large gap between the potential due to climate and topography and actual production is due to chemical conditions of the soils; very acidic and with high aluminium saturation. This gap has challenged agronomic researchers at national and international research centers. After several years of joint research, ICA (Instituto Colombiano Agropecuario) and CIAT (Centro Internacional de Agricultura Tropical) have identified several grasses and legumes that perform well with only limited amounts of fertilizers thus doubling beef output per animal and increasing it more than ten times per hectare.

This substantial increase in land productivity makes smaller farm sizes economically viable, opening new land-use options such as dual purpose milk production. Land settlement has a long tradition in Colombia. Nevertheless settlement schemes never included the savannas of the Eastern Plains.

This document by Dr. Bruce Davidson, Senior Lecturer of Agricultural Economics at the University of Sydney on sabbatical leave at CIAT from December 1, 1982 to June 5, 1983 is a first attempt at looking into the microeconomic aspects of small scale livestock farming in the Eastern Plains using improved pastures.

Microeconomic attractiveness is considered a first threshold in the process of defining social desireability of such a settlement scheme. Further studies, if the microeconomic performance is considered satisfactory should analyze the most efficient way to supply the necessary infrastructure for such a project and evaluate such a scheme from a national point of view.

It is hoped that this report may contribute to a productive discussion of the issues involved in small-scale cattle farming thus helping to make the appropriate decisions leading to an efficient adjustment of land use in the Eastern Plains in response to the new technology available.

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ECONOMIC ASPECTS OF SMALL SCALE RANCHING ON IMPROVED PASTURES IN THE COLOMBIAN LLANOS

Bruce R. Davidson
September 1983

Introduction

The traditional form of land use in the Colombian Llanos consists of grazing cattle on the native grasslands after burning. The quality of these pastures is so low that it is only possible carry 0.2 livestock units per hectare and to produces store cattle for sale after three years of grazing. Weaning rates are only 45% and heifers cannot be mated until they are three years of agre (Tropical Pastures Programme - pp.288-291). As the productivity of both land and cattle are low at least 250 hectares of land grazing 50 cattle are required if a ranch is to be economically viable. The typical ranch in region consists of 1000 hectares of land grazing 200 cattle (Gutiérrez Palacio, U., pp.26-35).

Research carried out by CIAT and other research organizations has established that more productive types of pasture can be established. While the research work carried out by CIAT was aimed at improving tropical pastures in Tropical America the results can be used to examine the effect of the new pasture technology in a specific area. In the Colombian Llanos the new technology could be used to increase the productivity of existing ranches in the area. However, it is also possible that there might be a means of establishing a more intensive type of land use using smaller areas of land and fewer cattle per economic unit than in the traditional system of ranching. Such a system of land use was visualized by CIAT when the family farm unit was established at Carimagua in 1974.

Using data obtained from CIAT experiments at Carimagua, together with information from the family farm unit and from ranchers on the Llanos it is

possible to calculate the costs and returns that might be expected from small ranchs using the new systems of pastures technology at different levels of intensity.

However as the Colombian Llanos cover a wide area it is necessary to examine the region in detail before estimating the economic results which might be obtained by small ranchers in the region.

The Colombian Llanos

In Colombia the tropical savannas extend from the foothills of the Andes in the west and to Venezuela in east and north. In the south they are bounded by the rain forest of the Amazon basin (Brunnschweiler, D., pp.4-14).

Climate

As mean monthly temperatures throughout the region range from a minimum of 25°C in July to 28°C is in March temperature is adequate for plant growth at all times of the year.

The climatic factor limiting plant growth in the region is moisture Rainfall declines from 4000 mm in the east of the region to 1500 mm in centre and rises again to 2500 mm in the west. Precipitation occours in two distinct season, between May, June and in October and November. Because of the seasonal pattern of rainfall and the high rate of evaporation in the region the growing season is limited to nine months in the west of the region and to as little as 6 to 7 months in the central and eastern areas.

Topography

The whole region is a large plain lying between 180 and 480 metres above sea level. It is drained by east west flowing rivers rising in the Andes and flowing into the Orinoco. North of the Meta river in the Casanare the land is so low that large areas of it are inundated with flood water during the wet season. In the central region the plain is bisected and the land form consists of a series of broad valleys and low flat topped hills

(the Serrania).

Soils

The productivity of the Colombian Llanos is determined more by the nature of its soils than by any other physical factor. While all of the soils are well structured clays and clay loams which can be worked at any time of the year the chemical nature of the soils varies widely in the region although they are generally acid with a high free aluminium content Soils together with the topography and the degree of flooding divide the Llanos into a number of subregions with differing agricultural and pastoral potential (Brunnschweiler, D., pp.8-10).

The Piedmont

This the most fertile subregion of the Llanos is bounded by the foot hills of the Andes in the east and the Metica river in the west. The soils of the subregion are younger and less leached than those of other subregions. The soils fall into the orders of Entisoils and Inceptisoils which have a higher chemical status and pH and less free aluminium than the Oxisoils and Ultisoils which are the main soils orders in other regions of the Llanos.

As rainfall decreases from west to east in the region the Piedmont also has a longer growing season than the more easterly regions. It is also closer to the large market and supply centre at Bogotá than any other part of Llanos.

With these favourable characteristics it is not surprising that the Piedmont is the subregion in which store cattle from the less favoured parts of the Llanos are fattened. In addition an increasing area in the subregion is devoted to producing rice, sorghum and other crops. The proportion of the subregion cropped is likely to increase as population and the demand for food increases.

The Serrania

Between the Metica river in the east and the Manacacías river in the

west is the disected plateau known as the Serrania. The landscape is one of low hills and broad valleys which can be cultivated and sown to improved pasture species. The soils are Oxisols and Ultisols low in nutrient elements, with a low pH and a high level of free aluminium. The region is well watered with numerous creeks along the banks of which more fertile alluvial soils supporting trees are found. With the poor soils in this subregion the traditional land use is producing store cattle on the native savanna.

The Altillanura

The large plane stretching from the Manacacías river west to Venezuela, south of the Meta river and north of the Amazon forest is known as the Altillanura. The soils are Ultisols and Oxisols and similar the those of the Serrania. Like the latter area the subregion is well watered with creeks bounded by richer alluvial soils supporting trees. With the same low quality soils the traditional land use as in the Serrania is breeding and raising store cattle for fattening outside the subregion.

Conceptual Aspects of Small Scale Ranching

The new pasture technology which has been developed could be applied on the existing large holdings in the Llanos. On these holding much of the initial capital in the form of land buildings, fences and at least the initial breeding herds are already available. It also possible that spare capital is available to introduce the new techniques. In these circumstances it is legitimate to ask whether small scale ranching is a desireable or a necessary method of utilizing the new techniques (Tropical Pastures Programme 1981, pp. 287-290).

Small ranching might have a number of advantages over large ranches even if it is assumed that both would introduce the new pasture technology:

- If small ranches were established using the new pasture technology the benefits from pasture research would be spread over a far larger group of people than if they were limited to a few large land holders.
- On smaller units greater efficiency in pasture utilization might be achieved because of closer supervision of livestock and better

management of pastures.

- Larger ranches in the Llanos have shown little inclination to introduce more intensive types of farming such as dairying or pig raising. On small ranches these enterprises might be essential if the landholder is to make a satisfactory living.

The introduction of a dual purpose system of beef and milk production could have the following effects:

- The gross and possibly the net value of production per unit area from dairying and beef production would be higher than from beef production alone. Research into the relationship between farm and non farm population in rural areas suggests that the size of non farm population in a region is determined by the total gross or net income from agriculture in the region. If income from beef and dairying is greater than from beef production alone a larger non farm population could be supported in the region (Davidson 1976). In addition dairying is a labour intensive type of farming, requiring more workers per unit area than beef production alone.
- If a larger on and off farm population were needed for a dual purpose system of dairying and beef production then employment opportunities would be increased in the region.
- A larger population in any region would also make it possible to provide desirable essential services such as education, health services and communications at a far lower per capita cost than in a more sparsely settled region.
- The larger population will also increase the demand for goods from outside the region, increasing the profits of businesses supplying these goods and the employment in them.

While small ranches practising a more intensive type of farming in Llanos than large scale beef raising could be beneficial for the region and even for the nation as a whole the possible weaknesses and dangers of such a development must be recognized. Sufficient capital must be available for the small rancher to be able to establish the ranch and maintain himself until the ranch reaches its full productive capacity. The profits after full development

must be large enough to give as high a return as the rancher would obtain in some other investment with equal risk and to repay him for income he may have forgone during the development phase. If these conditions are not met a small ranch project is unlikely to attract investors. It is always possible that any given objective of a small ranching project such as employment or land settlement could be achieved with less capital by development of some other region or sector of the economy.

In the following study of the economics of small scale ranching no attempt has been made to answer the questions posed above. The investigation is limited to examining the economic viability of small ranches in the Llanos. The results obtained could be used as a basis of a wider study to determine whether this type of settlement were desirable from a national point of view.

The Economic Basis of the Investigation

For the individual farmer in any land settlement scheme the critical requirements are sufficient capital to establish the holding and to maintain himself until returns from the holding are large enough to do so. In addition an individual is unlikely to be induced to settle unless the returns he finally obtains from the holding are greater than he would from some other form of employment. He is also unlikely to find land settlement attractive if the maximum debt incurred is extremely large or a long period must elapse before the debt is repaid.

The answer to above questions is most easily obtained by developing a cash flow statement for the holding and then recording the following:

1. The initial capital required to establish the holding.
2. The maximum debt incurred during development.
3. The period required to repay borrowed capital.
4. The net income obtained during development and at full development.

The same data, together with the value of assets at the end of the period can be used to calculate the internal rate of return from the investment. This can be used to determine whether some other form of investment

migh give a higher return both to the individual settler and to the nation.

The Parameters

The costs and returns associated with small scale ranches will vary according to a large number of factors. These include the type of improved pasture technology adopted, the location, the capital invested in the holding, herd development, the grazing enterprises adopted and the prices of the commodities produced and of the resources used. The pasture technology used is particularly important as this determines the number of animals carried per unit of land, and the physical performance of the herd in terms of weaning rate, liveweight gain, milk production and age of mating.

Pasture Systems

A wide range of pasture improvement systems have been developed by CIAT and other research organizations. These include grass-only pastures, mixed grass and legume pastures and legume pastures used in conjunction with the grasses of the native savanna.

Sufficient information was available to investigate the possibility of small scale ranching based on each of the following pasture systems, details of the establishment, maintenance and management of which are listed in Table 1.

1. Grass Only

   All livestock are assumed to graze on a pasture of *Brachiaria decumbens* at a stocking rate of 1.7 animal units/ha. The pasture is established from cuttings sown with fertilizer.

2. Grass Legume and Grass Pasture

   Breeding cows and fattening steers and heifers would be grazed on mixed grass and legume pasture and other livestock on *Brachiaria decumbens*.

   As stock would be fattened during the wet season it was assumed that fattening steers and heifers could be grazed on mixed legume

and grass at a rate of 2 animal units/ha. However as breeding stock would be grazed on the mixed grass legume pasture throughout the year the stocking rate would only be 1.7 animals/ha. Store stock would be grazed on a grass pasture of *Brachiaria decumbens* at a stocking rate of 1.7 animal units/ha.
It was considered that after a period of five years that legumes in the grass legume pasture would die out and such pasture would become grass pasture and would be maintained as such.

3. The Protein Bank

An area equal to five percent (5%) of the native pasture required to support the livestock would be sown to the legume Kudzu. The legume bank would have to be are re-established every six years. The combined area of protein bank and native pasture would be stocked at a rate of 0.28 livestock units per hectare.
It was assumed that milking would be impossible using the protein bank and that surplus stock would have to be solds as store cattle rather than as fat cattle.

Pasture Maintenance

The pastures would be maintained with a top dressing of 50 kg of Sulpomag applied every two years. In addition grass pastures would be renovated by discharrowing every four years.

Weaning rates, the rate of liveweight gain, the age at which heifers are mated and fat stock sold vary with the type of pasture. In the initial investigation it was assumed that these parameters would be the same as those obtained in the CIAT experiments at Carimagua (Tropical Pastures Programme, 1981). These are listed in Table 2 for the pasture system investigated.

The Small Ranch Plans

Although a number of different pasture types were examined as a basis for small scale ranching all plans had some commen features. In each it was assumed that the final unit would consist of 100 cows and their followers and

that in the first year sufficient land would be purchased to support a herd of this size (Table 3). The basic unit of 100 cows was selected arbitrarily as a convenient size for carrying out the initial calculations. It can also be used as a base for determining the costs and returns from larger or smaller herds.

It was visualized that a number of small ranches would be establishment in the same area thus only two sides of the boundary would have to be fenced by any one rancher. No subdivision fences would be constructed but the protein bank would fenced. Other permanent improvements would be limited to a simple house and a corral costing $80,000 [1] each. The initial capital invested in each type of holding is listed in Table 4.

It was assumed that food for the farm family would be produced on the holding by cultivating two hectares of food crops. Although the average annual wage for farm workers in the area is $150,000 it was assumed that in order to aquire a ranch the owner who was able to supply his family with subsistance food would only require and be satisfied with a cash income of $37,500 per annum. Any other surplus cash would be devoted to debt repayment and herd development.

As high quality pastures have been developed for the Llanos small ranches are most likely to succeed if these pastures are utilized as productively as possible. This will only occour if good quality livestock and grazed on them and full advantage is taken of their productive capacity.

Where ever the type of pasture established permited it was assumed that surplus livestock would be fattened before sale rather than being disposed of as store cattle. Fat cattle would be trucked to market and store cattle walked out.

In addition it was assumed that all cows with calves would be milked and the milk made into cheese. Whey would be used as a protein source for

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1/ All prices in Colombian pesos of 1983.

pigs fed on fresh cassava roots grown on the farm. In this way it would be possible to support one sow and her offspring for every 50 cows milked (see Appendix A). Details of the prices expected for livestock products are tabulated in Table 5 and the gross margin for the pig interprise is calculated in Appendix A. It was assumed that 17 cows could be milked by the owner and that when this number was exceeded labour could be hired in units of one quarter of a man equivalent at a wage of $37,500 per quarter man equivalent for each additional four cows milked.

The System of Herd Development

In all the small ranching systems in which dairying was an enterprise it was assumed that fifteen highly productive cows capable of taking full advantage of improved pastures would be purchased at a price of $45,000 per head. In systems not including dairying it was assumed that lower quality cows costing $22,000 per head would form the basis of the herd.

Dairying and fattening was limited to grass and grass legume, and grass only pasture systems. It was considered that the protein bank was only capable of producing store cattle. In the initial year the rate of herd development was limited to increasing the herd by the number of female stock bred on the holding. Once all debts incurred had been repaid it was assumed that the small rancher would be prepared to invest any surplus cash available at the end of the year in purchasing additional cows during the next year. This procedure would continue until a breeding herd of 100 cows was established. Any surplus heifers from the 100 cows herd after full development would be sold as fat heifers.

The development rate of the herd was thus determined by the weaning culling and mortality rates which in turn varied with the type of pasture technology adopted and by rate at which borrowed capital was repaid and surplus capital becomes available to purchase additional cows.

The effect of the pasture system, milk sales and beef output on the rate of herd build up is shown in Figure 1. The rate of growth of the herd is similar under all pasture and herd management systems until the 8th year

when the capital debts of ranches using the grass and grass legume system are repaid. After this year surplus capital generated by sales of milk and cattle can be used to purchase more cows and the herd increases rapidly.

In the grass only system debts are not repaid until year ten and the rapid growth in the herd is delayed until after this year. Ranches based on protein bank pasture do not repay their debts until year 26 and herd growth is much slower than in the grass and grass legume and the grass only systems as it depends entirely on the rate of natural increase of the herd.

Pasture Expansion

On all holdings an area of improved pasture equal to that needed to support the fiften cows purchased would be established in the first year. This would be expanded each year so that the area of improved pasture on the property would always be sufficient to supply fodder to all of the cattle grazing on it. The area of pasture required varied with the pasture system assumed. As the area of pasture required in all herd management and pasture systems depends on the rate of herd growth thus the rate of pasture expansion would be similar to that of herd growth illustrated in Figure 1.

In the initial years less grass and grass legume pasture could be sown by grazing non breeding and non fattening livestock on native pasture. However as the rate of liveweight gain on such pasture is much less than on improved pasture the age of mating of heifers and the age of sale of fat sotck is delayed this alternative was not investigated.

The Location of Small Ranches

The improved pasture techniques were developed specifically for the Altillanura but they could also be applied in the valleys of the Serranía. The legume technology is not suited to the Piedmont neither improved grasses nor legumes could be grown in the flooeded regions of the Casanare.

In this study it is visualized that small ranches would be located between Puerto López and Puerto Gaitán. As a faved road exists between the

principal market at Bogotá and Puerto López transport costs would be lower than in more remote regions. This advantage would be offset to some extent by higher land prices.

Enquires indicated that a price of $3,000 per hectare would have to be paid for land suitable for pasture improvement.

Financial Results

Cash flow statements for small ranches established using various pasture systems are shown in Appendix B, Tables B1 to B7 and the details are discussed below.

Capital

The initial capital to establish small ranches using either grass and grass legume or grass only pastures is similar, $1.4 millions and $1.5 millions respectively. The capital requirement of the grass and grass legume system is slightly lower as only 161 hectares of land are required compared with 185 hectares in the grass only system (**Table 4**).

If dairying is excluded and lower quality cattle are purchased the initial capital is reduced to $1 million. The distribution of initial capital between assets is similar for the grass legume and grass and the grass only systems of ranching: approximately 46% being invested in cattle and 35% in land and the remainder in buildings and fences. This similarity persists at the end of development period. The total capital is then approximately $7 millions per ranch the distribution of capital using both pasture systems is similar in both systems: approximately 75% being invested in cattle, 13% in pastures and 8% in land in both systems (see **Table 6**).

The capital structure of ranches based on the protein bank is very different from those based on grass or grass and legumes. As the final carrying capacity is lower a much larger area of land must be purchased. This increases the total initial capital required to almost $4 millions compared with $1.5 millions in the grass and grass legume systems. Similarly a far

higher proportion of capital is invested in land, 80% in the protein bank compared with approximately 35% in the grass and grass legume systems (Table 6). This difference persists at full development when the protein bank has 36% of total capital invested in land compared with 8% in this asset in the other two systems. As a smaller area of pastures is sown in the protein bank the value of this asset is much lower at full development than in the grass and grass legume systems (Table 6).

The similarity of the grass only and grass and grass legume systems also apply to other economic aspects both during development and at full development. The maximum debt for both of occurs in the first year as milk sales make it possible to reduce the debt from the beginning. However with a slightly lower initial investment, a faster growth rate and above all a higher level of milk production the initial debt is repaid is 8 years is the grass and grass legume system compared with 10 years in the grass only system. Similarly of a herd of 100 cows is achieved after 18 years in the grass and grass legume system, compared with 21 years for the grass only system (Table 4).

Financial progress using the protein bank is much slower than with other pasture systems, The initial best is only repaid after 26 years as opposed to 8 years in the grass and grass legume system. The absence of milk to sell and the sale of cattle as stores rather than as fat cattle and the larger initial debt all prolong the period of repayment (see Table 4).

The poor performance of the protein bank is partly due to the larger area of land required as this is priced at $3,000 per hectare and partly to the lower value of sales from ranches with this type of grazing system.

Costs

On ranches established on the grass only and grass legume systems total costs and the structure of costs are similar. In both one half of the costs are accounted for by labour employed in milking. On ranches based on the protein bank total costs are much lower ($0.3 millions as compared to $1.0 millions in the grass only or grass and grass legume systems) as no labour is

required for milking (**Table 7**).

Revenue

The most striking feature of the total sales from ranches based on the grass only and grass/grass legume systems is the similarity of the value of total sales from the two systems, $2.4 and $2.8 millions respectively. With higher milk yields milk sales and the dependent pig enterprise account for between 40% and 50% total revenue of ranches using grass and grass legume pastures. Even on ranches relying on grass only pastures the dairying and pig enterprises contribute more than one third of total revenue. Obviously the success of this type of ranching is heavily dependent on the success of the dairy enterprise (**Table 8**).

With no milk or pig sales the total revenue from ranches relying on the protein bank is lower than that from other systems and returns are further reduced because cattle must be sold as stores rather than when fattened. The return from sales of this systems of ranching of $1.1 millions is less the half of that obtained from ranches based the grass only and grass and legume pasture systems.

Net Cash Returns

Providing sufficient initial capital were available and could be repaid over a period of years small ranchers established on all of the pasture systems would yield a satisfactory cash income after they were fully developed. The net cash income from ranches on grass or grass/legumes of $1.5 to $1.7 millions is 10 times the average annual wage paid to rural workers in the area. Even the net cash income at full development from ranches using the protein bank of $800,000 is five times the average rural wage (**Table 9**).

Sensitivity Analysis

The use of the experimental results achieved at Carimagua as a basis of calculation assumed that ranchers would achieve the same output from a given area of pasture as research workers. There is no known research into the

relationship between experimental and farm yields from grazing in the tropics. The limited amount of information from pastures in temperate region suggests that the average beef producer only achieves 60% of the output obtained in experiments using the same stocking rate and the same pasture technology (Davidson, B.R. and Martin, B.R., 1968).

A similar reduction for milk yields would have to be made if these where based on experimental results. However these were based on those obtained by a technically efficient farmer in the same region and the highest yield (945 litres per lactation) assumed in the calculation was only 78 of the 1,200 litres achieved by the farmer. In temperate areas average farm milk yields are approximately 75% of experimental yields.

In addition it is possible that cows would not be milked on small ranches. Ranchers might object to this labour-intensive enterprise because of difficulties in obtaining labour for milking or because of difficulties in marketing cheese.

The effect of dairying and of high beef yields on small ranches was examined by recalculating the cash flow for the grass and grass legume and the grass-only systems assuming:

1. That the dairying was carried out but that revenue from beef sales were reduced to 60% of that obtained under experimental conditions on grass and grass legume pasture. On grass only pastures where pasture management would be simpler and the average farmer should achieved yields closer to chose obtained in experiments the reduction is beef output was limited to 80% of experimental yields.
2. That no cows were milked or pigs kept and that gross revenue from beef cattle was only 60% of experimental results in the grass and grass legume system and 80% of experimental results in the grass only system.
3. In the protein bank grass system where dairying had not been included as an enterprise the cash flow calculation was repeated assuming gross revenue from beef sales was only 60% of that achieved under experimental conditions.

The results of these recalculations are compared with the original cash flow in Table 4.

In the grass and grass legume system the reduction of beef returns to 60% delays the period of debt repayment from year 8 to year 10 and reduces annual net cash return at full development from $1.8 millions to $1.0 millions. If dairying is excluded as an enterprise and beef revenue is reduced to 60% the maximum debt occurs in year 4 (not in year one) as returns from milk are not available to reduce the debt in the early years and net cash income is negative until year 10. Debt repayment is delayed from year 8 until year 26 and annual net cash returns at full development are reduced from $1.7 millions to $0.5 millions.

In the grass only pasture system the reduction in beef yield to 80% has little effect. However if dairying is also excluded debt repayment is delayed from year 10 until year 20, full development is delayed from year 21 to year 27. The reduction in beef yield and the exclusion of dairying reduces net income at full development from $2.2 millions to $1.2 millions.

The effect of a reduced output of beef sales and of having no milk sales on herd growth in the two pastures systems is shown in Figure 1. The delay in debt repayment delays the period of rapid herd growth and after it commences the rate of herd growth is not as rapid. It is also obvious that the loss of milk sales has a larger effect on herd growth than the reduction in beef sales in both pasture systems.

If beef returns are reduced to 60% of experimental yield using the protein bank system debt repayment is delayed from year 26 to year 35 and net cash income at full development is reduced from $0.7 millions to $0.3 millions.

If the criterion for success is that ranches should produce a net cash income greater than the average wage in the area of $150,000 per annum, then at full development the ranches give in all systems satisfactory returns even if dairying is excluded from the calculation and beef output is only 60% or 80% of that obtained in experiments. However the above adjustments leave a much narrower margin of success (Table 9). Using the grass only and grass

and grass legume systems net cash return at full development of $0.5 millions and $0.7 millions are three and four times the average wage of $150,000 and not ten times the annual wage as they would be if beef yields were obtained equal to those in experiments and dairying was included as an enterprise. Even on ranches based on the protein bank, where dairying was never considered to be a viable enterprise, the reduction of beef output to 60% of that obtained in experiments reduced net cash returns at full development from $0.8 millions or five times the average wage of $150,000 to $382,000, little more than double the average wage.

However lower beef yields than those obtained under experimental conditions and the exclusion of dairying from the ranching system are only two of the parameters which could have an adverse effect of the success of the small ranching system. It has been assumed throughout that animals could be maintained in a healthy condition and losses would be limited to 4% per annum in all years. A large loss due to disease in the early years could increase the debt incurred and increase the period of debt repayment and development. Poor seasons in the early periods of development would have precisely the same effect.

In addition it has been assumed that the settler would be willing and able to maintain himself by means of a subsistance cropping with a cash income of only one quarter ($37,500) of the normal wage in the region ($150,000) during the period of development. Whether settlers would be prepared to accept such a low standard of living for a period ranging from 20 5o 30 years is uncertain. Alternatively, they might accept slower growth of the herd.

Although the calculations suggest that small ranches at full development might give annual net cash returns ranging from amounts twice as great to ten times the average wage in the area this type of settlement could not be recommended without further investigations.

These could include an investigation of the probability at diseases and weather during development and there affect on development. The aims of prospective settlers and particularly their willingness to accept a low standard of living over the long development period should also be examined.

Small Ranches as an Investment

The returns that might be expected by a potential investor in small ranches based on different pasture systems can be found by calculating the internal rate of return over the period of the investment. As ranches based on the different pasture systems took different periods of time to reach full development internal rates of return even calculated for all systems for a period of 29 years; the time taken by the system which took the longest period to reach full development. The results are shown in Table 10 and indicate that the highest returns are obtained from ranches based on the grass and grass legume pasture system. Providing dairying is included as an enterprise even if beef yields are reduced to 60% of experimental yields in the grass and grass legume system and to only 80% in the grass only system the former system gives a higher return. If dairying is excluded the grass only system gives a higher return than the grass and grass legume system. The better return obtained from grass and grass legume pastures is entirely dependent on the higher milk yields expected from these pastures.

The returns obtained from ranches on which dairying is included as an enterprise range from 13.5% to 18.9%. If dairying is not included as an enterprise the internal rate of return does not exceed 10%. The protein bank system in which cattle are sold as stores and not as fats as in the grass only and grass and grass legume systems and where dairying is excluded as an enterprise, produces a return of only 5% or less.

As the farmer was expected to only draw $37,500 per annum for living expences the internal rate of return is higher than if his labour was charged at the full wage level. If the settler is assumed to be capable of earning the average annual wasge of $150,000 in the region this could be assumed to equal the opportunity cost of his labour. If the internal rate of return is recalculated assuming the farmer receives $150,000 in cost per annum rather than $37,500 the internal rate of return declines by 4 points in all systems.

Whether $150,000 or $37,000 represents the true opportunity cost of labour depends on the effect of settlement on employment in a country when the level of unemployment is high.

No attempt was made to compare the returns obtained with those available from other forms of investment. In a country with a 30% inflation rate such a comparison would only be valid if the effect of inflation on future farm net incomes and the final value of farm assets were taken into consideration.

An increase in land values such as has been occurring in Colombia in recent years could favour investment in the ranches developed using the protein bank pasture system as a much larger area of land, 980 hectares, is purchased compared with the 160 hectares using grass and grass legume pasture. The effect of increasing land values can be examined by comparing the internal rates of return assuming that there is no increase in land values with those obtained assuming that land values increase at a rate of 3% per annum over the 29 year period to full development. The results of this calculation for ranches of 160 hectares using grass and grass legume pasture and ranches of 980 hectares based on the protein bank are shown in **Table 11**. When the increase in land values is included the proportionate increase in the internal rate of return for the protein bank system of 21% is larger than for the grass and grass legume system of 0.3%. However the latter remains the better investment. Land values would have to increase by much more than 3% per annum to make the protein bank the superior investment.

Financing Small Ranches

Although herds were limited to 100 cows and the initial herd to 15 cows the initial capital required for the more profitable ranching systems was approximately $1.50 million. This is a substantial sum in a region where average wages only $150,000 per annum.

Special credit is available to farmers at low interest rates as "Small Farmer Credit" (See **Appendix C**) loans and the possibility of financing the development of a ranch using this type of finance was examined by assuming that it was taken of by a rancher dairying on grass and grass legume pasture and obtaining an output of beef equal to 60% of that obtained under experimental conditions. The rancher was assumed to purchase land and borrow $1,138,000 in his first year of operation. This would reduce initial the capital he required to establish a ranch to $330,020. It was also assumed that both farm inputs

purchases and commodities sold and farm assets would inflate at a rate of 30% annum.

It was found that under these conditions the farmer was capable of meeting his obligations under the loan agreement and that the loan and interest would be fully repaid in eight years. The farm would be fully developed in 20 years. The internal rate of return was calculated after deflating the net income stream and the value of assets at the end of the period. The return was 21.8%. This might be compared with the internal rate of return of 14.5% from a ranch based on the same pasture system with the same level of beef output: i.e, grass/grass legume with dairying and 60% of experimental beef output assuming no inflation and no external finance (Table 10).

The faster rate of development and the higher rate of return are due partly to the loan delaying the period when investment must be made by the farmer and partly to inflation which reduces loan interest and principle repayment in real money terms.

Conclusion

Positive and a satisfactory incomes could be obtained from small ranches of less than 200 hectares with land valued at $3,000 per hectare in parts of the Colombian Llanos using new pasture technology for dairying and beef production. The highest returns and the shortest period of capital repayment would be achieved using the grass and grass legume pastures if dairying is included as an enterprise. If dairying is excluded better results are obtained from ranches based on grass only pastures. The returns obtained from ranches based on both grass and grass legume and grass only pastures are much higher than those achieved from the protein bank which requires approximately 1,000 hectares of land. The low returns from the protein bank are caused by having to sell cattle as stores and by the system being unsuited to dairying.

Even if beef output on commercial ranches is only 60% of that achieved in experiments on grass and grass legume pasture and 70% of that achieved on grass only pasture ranches would recover the capital they had invested over a period of 10 years and receive an annual net income from fully developed ranches

of $1 million pesos.

In all systems in which dairying is excluded repayment of the initial capital invested would extend over a period at least 20 years and annual net cash income would range from $300,000 to $700,000.

The protein bank system, which requires the largest area of land gave the lowest returns. However, this situation could change if land price rose very rapidly. In these circumstances the high value of assets at the end of the period could increase the internal rate of return of the protein bank system more than that of other systems based on much smaller land areas.

It appears that the more profitable small ranches dairying on grass and grass legume pastures could be financed satisfactorily using the loans uner the "Small Farmer Credit" system.

Table 1. Cash costs of establishing maintaining and renovating pastures

	Grass *Brachiaria decumbens*	Grass & Legume Brachiaria + Stylosanthes	Protein Bank Kudzu
Establishment[1]:			
Disc-harrowing (twice) 3 hrs per ha ($700)	2100	2100	2100
Seed 2 kg per ha	-	1400	1400
Fertilizer:			
- Basic slag (330 kg/ha)	2145	2145	2145
- Sulpomag (100 kg/ha)	-	2766	2766
Total establishment. . .	**4245**	**8411**	**8411**
Maintenance:			
Sulpomag (50 kg every 2nd year)	1383	1383	1383
Applying fertilizer 0.5 hrs/ha ($700/hour)	350	350	350
Total maintenance. . . .	**1733**	**1733**	**1733**
Renovation:			
Disc-harrowing every 4th year 1 ha per hour	700	-	-

Bogotá prices 1983: Basic slag . . . . . $ 4.700 per tonne
Sulpomag . . . . . $ 25.852

Transport Bogotá-Puerto Gaitán . . . . . $ 1.800 per tonne

1/ Sowing and spreading fertilizer by hand

Table 2. Coefficients of animal production with different pasture systems

	Grass pasture (*Brachiaria decumbens*)	Mixed grass and legume pastures	Protein bank and native pasture
Stocking rate (AU/ha)	1.7	1.7 all year 2.0 wet season	0.28
Weaning rate (%)	70	75	70
Weaning ages (months)	10	10	10
Age at mating (years)	2-2½	2-2½	2½-3
Liveweight gain/year (kg)	145	180	120
Age at sale (years):			
- Stores	2-2½	1½-2	2-2½
- Fat cattle	3-3½	2½-3	-
- Cull cows	9	9	9
Weight at sale (kg/head):			
- Fat steers and heifers	400	400	-
- Store steers and heifers	250	250	250
- Cull cows	350	350	290
Milk yield (litres/day)	2.8	3.5	-
Length of lactation (days)	270	270	-

Table 3. Area, land utilization on small ranches at full development (hectares)

	Grass and grass legume	Grass only (Brachiaria)	Protein Bank
Total area	160	185	980
Pastures:			
Grass (Brachiaria)	60	172	-
Grass and Legume	87	-	-
Legume	-	-	49
Native pasture	-	-	918
Food crops	2.5	2.5	2.5
Cassava (for pigs)	0.5	0.5	-
Other land	10	10	10

Table 4. The results of investing in small ranches based on different pasture and animal production systems

PASTURE SYSTEM Animal Production - System	Initial investment (Col.$000)	Maximum debt		Year of debt repayment (year)	Year of full development (year)	Annual net income (Col.$000)	Area land (ha)
		Year	Value (Col.$000)				
GRASS LEGUME AND GRASS							
Milk and Beef:							
- Full yield	1441	1	1446	8	18	1724	160
- 60% beef yield	1441	1	1446	10	20	1016	160
- Beef only 60% yield	1096	4	1433	26	26	452	160
BRACHIARIA ONLY							
Milk and Beef:							
- Full yield	1522	1	1522	10	21	1461	185
- 80% beef yield	1522	1	1522	10	22	1157	185
- Beef only 80% yield	1177	4	1511	20	27	774	185
PROTEIN BANK							
Beef only:							
- Full yield	3618	4	3904	26	29	819	980
- 60% beef yield	3618	10	4073	35	29	382	980

Table 5. Prices of livestock, livestock products and farm resources. Bogotá, 1983 (Col.$)

Beef: ($/kg liveweight)	$ 70
Milk (after manufacturing into cheese)(per litre)	$ 115
Pigs (1 per kg live)	$ 130
Dual purpose cows: (per head)	$ 45,000
Beef cows: (per head)	$ 22,000
Basic slag (per tonne)	$ 4,700
Sulpomag (per tonne)	$ 25,852
Transport:	
- Bogotá - Puerto Gaitán (per tonne)	$ 18,800
- Cattle fat: Puerto Gaitán - Bogotá (per head)	$ 1,574
- Pigs: Puerto Gaitán - Bogotá (per kg)	$ 20

Table 6. Capital and full development

	Grass only		Grass and Legume		Protein Bank	
	Col.$	%	Col.$	%	Col.$	%
Land	555,000	7.9	480,000	6.8	2940,000	35.9
Buildings	160,000	2.3	160,000	2.2	160,000	2.0
Fences	82,050	1.2	76,020	1.1	188,220	2.3
Cattle	5289,300	74.7	5436,300	77.2	4681,300	57.1
Pastures	983,250	13.9	894,240	12.7	217,185	2.7
TOTAL.	7069,600	100.0	7046,560	100.0	8186,705	100.0

Table 7. The distribution of average annual costs on small ranches after full development (percentage)[1]

	Grass and grass legume		Grass only		Protein Bank
	With milk	With no milk	With milk	With no milk	
Pastures:					
Replacement	14.1	28.4	-	-	19.9
Maintenance	12.2	24.7	16.4	32.4	12.2
Renovation	1.0	2.1	6.6	13.1	-
Sub-total. . . .	27.3	55.2	23.0	45.5	32.1
Minerals	14.5	29.4	18.8	37.1	41.7
Purchase bull	3.2	6.4	3.6	7.2	9.5
Labour milking	50.5	-	49.4	-	-
Fixed costs	4.5	9.0	5.2	10.2	16.7
TOTAL COSTS.	100.0	100.0	100.0	100.0	100.0
TOTAL COSTS Col.$000	1040	515	910	460	347

1/ Alternatives not included have the same cost structure but differ in the output levels assumed.

Table 8. Composition of average annual revenue on small ranches after full development (percentage)

	Grass and Grass Legume			Grass Only (Brachiaria)			Protein Bank	
	Dairying		Not dairying	Dairying		Not dairying	Not dairying	
	Full beef output	Beef output reduced to 60%	Beef output reduced to 60%	Full beef output	Beef output reduced to 80%	Beef output reduced to 80%	Full beef output	Beef output reduced to 60%
Sales:								
Cull cows-Fat	12.3	9.8	20.2	14.4	13.5	22.4	-	-
Stores	-	-	-	-	-	-	27.3	26.9
Fat steers	33.1	26.5	54.3	34.4	32.0	53.3	-	-
Fat heifers	14.2	11.3	23.2	14.4	13.4	22.4	-	-
Store steers	-	-	-	-	-	-	50.2	49.5
Store heifers	-	-	-	-	-	-	20.4	20.1
Old bulls	0.8	1.1	2.3	1.0	1.1	1.9	2.1	3.5
TOTAL beef.	60.4	48.7	100.0	64.2	60.0	100.0	100.0	100.0
Milk	36.1	48.1	-	31.6	36.8	-	-	-
Pigs	3.5	3.2	-	4.2	3.2	-	-	-
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL RECEIPTS (Col.$000)	2797	2098	1023	2383	2049	1229	1115	678

Table 9. Annual net cash returns from small ranches after full development

Pasture type	Level of production	Annual net cash income (Col.$000)
Grass and Grass Legume	Dairying and full beef production	1,757
	Dairying and 60% of full beef production	1,058
	No dairying and 60% of full beef production	507
Grass Only	Dairying and full beef production	1,473
	Dairying and 80% of full beef production	1,138
	No dairying and 80% of full beef production	768
Protein bank	No dairying and full beef production	768
	No dairying and 60% of full beef production	332

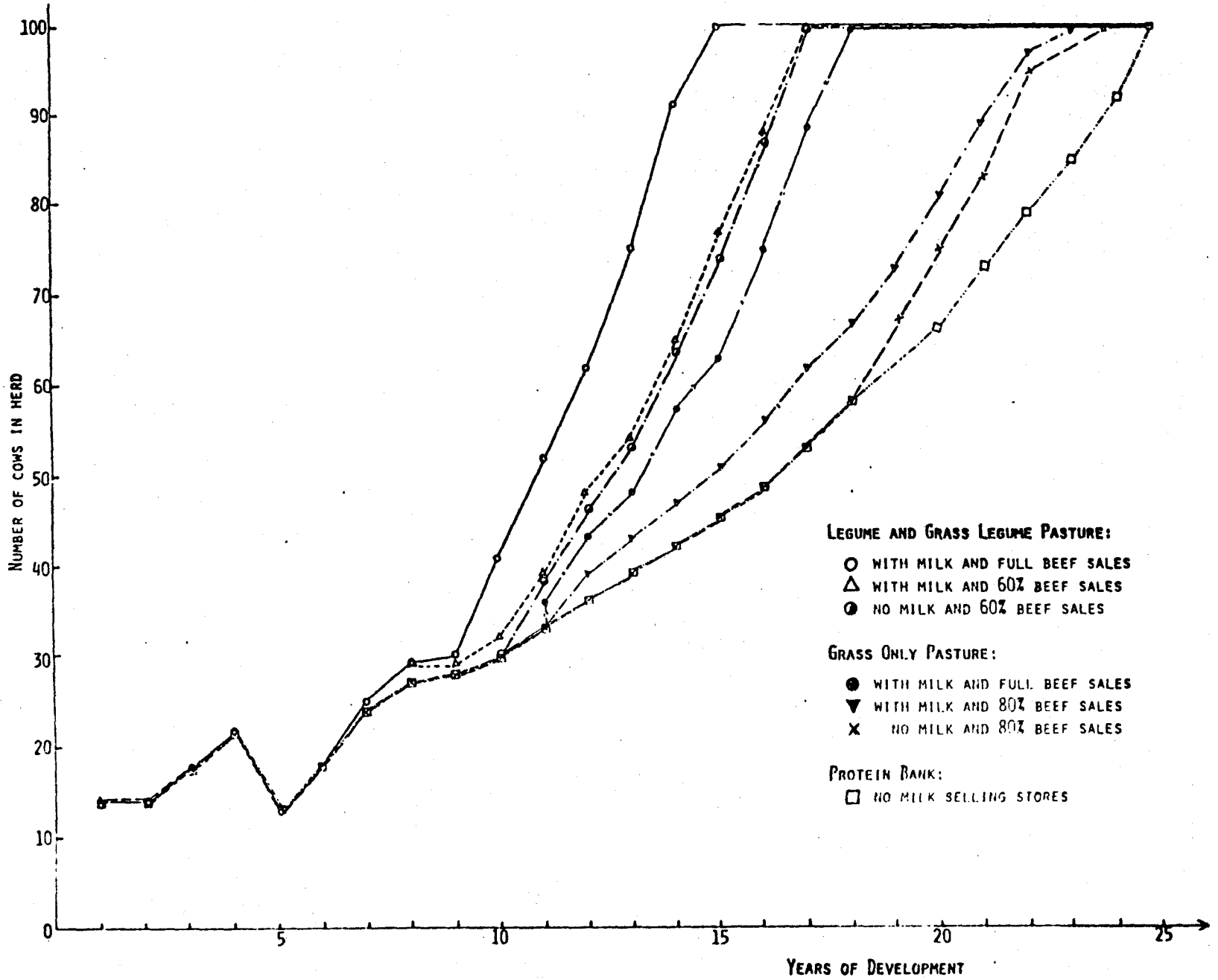
Table 10. Internal rates of return from investments in small ranches (percentage)

Pasture System	Internal rate of return	
	With labour opportunity cost of $37,500 per annum	With labour opportunity cost of $150,000 per annum
Grass and Grass-Legume:		
- Milk and beef (full yield)	18.9	15.4
- Milk and 60% beef yield	14.5	10.8
- No milk and 60% beef yield	6.7	3.2
Grass only:		
- Milk and beef (full yield)	15.1	11.9
- Milk and 80% beef yield	13.5	10.1
- No milk and 80% beef yield	9.0	5.5
Protein Bank:		
- Beef only full yield	5.3	3.5
- Beef only 60% full yield	3.0	1.1

Table 11. The effect of a 3% per annum increase in land values over a twenty nine year period on the internal rates of return from investment in small ranches using different pasture systems

	Grass and grass legume	Protein bank
Area (hectares)	160	980
Internal rates of return (%):		
i) No increase in land value	18.90	5.30
ii) 3% per annum increase in land value for 29 years	18.97	6.43
Increase in internal rate of return due to a 3% per annum increase in land values (%)	0.4	21.3

FIGURE 1. HERD GROWTH DURING DEVELOPMENT WITH DIFFERENT PASTURE AND HERD MANAGEMENT SYSTEMS



APPENDICES

APPENDIX A

ECONOMIC ASPECTS OF REARING PIGS ON WHEY AND CASSAVA

As milk is sold as cheese a large quantity of whey is produced and this could be used to supply at least part of the protein requirements of pigs. Cassava could be grown to meet the carbohydrate requirements of pigs.

The feed requirements of pigs fed on cassava and soya meal have been established in experiments carried out by CIAT and the Instituto Colombiano Agropecuario (ICA); the details of the ration at various stages of the pigs life cycle are listed in Table A1 (Gómez, G.)

Assuming that each sow has a litter of 7 pigs which are sold at 100 kg liveweight and that pigs are capable of consuming 25 litres of whey per day it is possible to calculate the quantities of whey and soya meal needed to supply the same quantity of protein as was supplied by soybean meal alone. The results of this calculation are presented in Table A2 and indicate that by feeding 25 litres of whey per head soya meal requirements would be reduced from 330 kg to 123 kg for a sow and litters of 7 pigs raised to 100 kg liveweight. In the experiment 100 kg liveweight was raised in 98 days. In practice it was considered that this weight would only be achived in 136 days.

The complete ration of cassava whey and soya meal is shown in Table A3 and indicates that 4,765 kg of cassava would be required to feed a sow and a litter of 7 pigs. The maximum requirement of whey consists of 25 litres per day for 7 piglets plus and additional 25 litre for the sow giving a total daily requirement of $(25 \times 1) + 25 = 200$ litres of whey per day if each cow is expected to produce 4 litres of whey per day (200 - 4) 50 cows would be required to supply enough whey for a sow and seven fattening piglets.

The complete ration for a sow and litter is shown in Table A3. The total cassava required in the ration of one sow and her litter is 4.8 tons. Experiments carried out by CIAT in the Llanos suggest that with fertilizer yields of 10 to 12 tons per hectare of cassava might be expected. Thus a total area of approximately 0.5 hectares of cassava would be required to feed each sow and her litter.

The variable cost of producing 0.5 hectares of cassava using a hired machinery are listed in Table A4.

It is assumed that 7 porkers per sow per litter would be sold in Bogotá ea.$130 per kg and that freight charges would equal $20 per kg giving an on farm price of $110 per kg.

The gross margin per sow per litter calculated on the basis of the above information is shown in Table A5. If there are only 230 days between succesive weaning each sow would be capable of producing 1½ litters per annum.

Table A1. Life cycle feeding programme based on fresh sweet cassava (kg)

	Body weight		Total intake per animal	
	Initial	Final	Cassava	Soya meal
Pre-gestation (60 days)	95	120	240	36
Gestation (114 days)	120	155	353	71
Lactation (56 days)	155	145	364	68
Growing and finishing (per pig) (98 days)	17.5	100	397	115

Table A2. The replacement of soya meal with whey in pig rations (kg)

		Total soya meal	Protein in 40% soya meal	Protein supplied by 25 litres whey	Protein required as soya meal	Soya meal required
Pre-gestation	(60 days)	36	14.4	12.0	2.4	6
Gestation	(114 days)	71	28.4	22.8	5.6	14
Lactation	(56 days)	68	27.2	11.2	16.0	40
Growing and finishing (7 pigs)	(136 days)	156	62.0	37.0	25.0	63
TOTAL		331	132.0	83.0	49.0	123

Table A3. Rations for sow and pigs reared on cassava, whey and soya meal

	Cassava (kg)	Whey (litres)	Soya meal (kg)
Pre-gestation	240	1500	6
Gestation	353	2850	14
Lactation	364	1400	40
Fattening (7 pigs)	3808	23800	63
TOTAL	4765	29550	123

Table A4. Variable costs of cassava production

	Col.$
Cultivation:	
Disc harrowing twice ea.3hrs/ha (ea.$700/hr)	2,100
Ridging ea.1½ hrs/ha (ea.$700/hr)	1,050
Fertilizer:	
1 tonne 10N 20P 20K per ha (ea.$6,786/ton)	6,786
½ tonne lime every 3 years (ea.$4,700/ton)	783
Freight:	
1½ tonnes fertilizer Bogotá to Puerto Gaitán	2,700
TOTAL variable costs per hectare.	13,419

Table A5. Gross margin per sow per litter

		Col.$
Sales 7 porkers: 100 kg ea. ($110/kg) ($130/kg minus $20 freight)		77,000
Variable costs:		
- Soya meal:	123 kg (ea.$33/kg)	4,059
- Freight:	123 kg soya meal (ea.$1,800/ton)	221
- Variable cost	0.5 ha cassava (ea.$13,419/ha)	6,710
	Total variable costs....	10,990
Gross margin per litter		66,010

APPENDIX B

CASH FLOW STATEMENTS

Table 81. Grass and Legume - Rearing fat cattle, pigs and milking (culling rate = 16%)

Expenditure Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
No. cows	-	-	-	-	-	-	-	-	-	30	41	52	62	75	91	100	100	100	100
Cows milked	-	11	11	11	14	10 for 6 months 7 for 9 months	10	14	19	22	23	30	39	47	56	68	75	75	75
Buy land: 160 ha ($3,000/ha)	480,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($45,000/ea)	675,000	-	-	-	-	-	-	-	-	45,000	360,000	405,000	405,000	495,000	585,000	225,000	-	-	-
Build corral and house	160,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Build fences: 2,534 ($30/m)	76,020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
Establish grass-legume ($8,411/ha)	-	84,110	-	33,644	16,822	-	75,699	42,055	58,877	8,411	67,288	126,165	109,343	134,576	109,343	126,165	176,631	151,398	159,809
Establish grass ($4,245/ha)	-	16,980	16,980	8,490	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintain pasture ($1,733/ha)	-	-	-	24,262	6,932	34,660	10,398	34,660	25,995	43,325	38,126	45,058	51,990	71,053	74,519	98,781	97,048	124,776	133,441
Renovate pasture ($ 700/ha)	-	-	-	-	-	2,800	2,800	1,400	-	2,800	9,800	1,400	2,800	4,200	9,800	7,700	6,300	9,100	10,500
Buy bull ea $50,000	50,000	-	-	50,000	-	-	50,000	-	-	50,000	-	-	100,000	-	-	100,000	-	-	100,000
Buy minerals $ 586	-	12,892	17,580	22,854	26,370	29,300	26,370	29,886	36,332	38,676	48,052	58,600	74,422	89,072	107,238	123,060	138,296	147,086	151,188
Labour milking	-	-	-	-	-	-	-	-	-	37,500	37,500	112,500	187,500	262,500	337,500	450,000	525,000	525,000	525,000
TOTAL CASH OUT	1441,020	160,484	81,062	185,752	96,626	113,262	211,769	154,503	167,706	272,214	607,268	795,225	977,557	1102,903	1269,902	1177,208	989,777	1003,862	1126,440
Receipts																			
Fat cows: 350 x $70-Freight = $22,926	-	-	-	-	-	298,038	-	-	-	91,704	114,630	137,556	183,408	206,334	275,112	320,964	343,890	343,890	343,890
Fat steers: 400 x $70-Freight = $26,426	-	-	-	132,130	132,130	105,704	158,556	211,408	105,704	158,556	237,834	264,260	290,686	369,964	475,668	554,946	687,076	845,632	924,910
Fat heifers 400 x $70-Freight = $26,426	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	184,982	317,112	396,390
Bulls: $35,000	-	-	-	35,000	-	-	35,000	-	-	35,000	-	-	35,000	-	-	70,000	-	-	70,000
Pigs: G.M. per sow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99,000	99,000	99,000	99,000	99,000
Milk: $13,466	-	-	-	-	-	-	-	-	-	296,252	309,718	403,980	525,174	632,902	754,096	915,688	1009,950	1009,950	1009,950
$14,175	-	155,925	155,925	155,925	198,450	192,780	141,750	198,450	269,325	-	-	-	-	-	-	-	-	-	-
TOTAL CASH IN	-	155,925	155,925	323,055	330,580	596,522	335,306	409,858	375,029	581,512	662,182	805,796	1034,268	1209,200	1603,876	1960,598	2324,898	2615,584	2844,140
NET CASH.	-1441,020	-4,559	74,863	137,303	233,954	483,260	123,537	255,355	207,323	309,298	54,914	10,571	56,711	106,297	333,974	783,390	1335,121	1611,722	1717,700
Net cash - full opp cost of owner ($-112,500)	-	-117,059	-37,637	24,803	121,454	370,760	11,037	142,855	94,823	196,798	-57,586	-101,929	-55,789	-6,203	221,474	670,890	1222,621	1499,222	1605,200
ACCUMULATED	-1441,020	-1445,579	-1370,716	-1233,413	-999,459	-516,199	-392,662	-137,307	70,016	379,314	434,228	444,799	501,510	607,807	941,781	1725,171	3060,292	4672,014	6389,714

Table B2. Grass and Legume - Rearing fat cattle (60% of cattle returns) with milk and pigs

Expenditure Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						7/9 months to 6 months															
Cows milked	-	11	11	11	14		10	14	19	22	22	24	29	36	41	49	58	66	75	75	75
Buy land: 160 ha ($3,000/ha)	480,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($45,000/ea)	675,000	-	-	-	-	-	-	-	-	-	-	135,000	270,000	180,000	360,000	360,000	360,000	270,000	-	-	-
Build corral and house	160,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Build fences: 2,534m ($30 / m)	76,020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
Establish grass-legume ($8,411/ha)	-	84,110	-	33,644	16,822	-	42,055	42,055	33,644	25,233	25,233	84,110	100,932	67,288	84,110	100,932	142,987	176,631	117,754	117,754	142,987
Establish grass ($4,245/ha)	-	16,980	16,980	8,490	0	8,490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintain pasture ($1,733/ha)	-	-	-	24,262	6,932	34,660	10,398	38,126	19,063	46,791	25,995	51,990	31,194	69,320	51,990	83,184	69,320	103,980	98,781	131,708	123,043
Renovate pasture ($ 700/ha)	-	-	-	-	-	2,800	2,800	1,400	-	4,200	9,800	1,400	2,800	5,600	9,800	4,900	6,300	8,400	11,900	7,000	13,300
Buy bull: ea $50,000	50,000	-	-	50,000	-	-	50,000	-	-	50,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-
Minerals and Vet. $586	-	12,892	17,580	22,854	26,370	29,300	26,370	29,886	33,988	38,090	42,778	48,638	58,014	66,804	78,524	92,588	106,652	123,646	137,710	172,284	150,602
Labour milking	-	-	-	-	-	-	-	-	-	-	37,500	75,000	112,500	150,000	225,000	300,000	375,000	450,000	525,000	525,000	525,000
TOTAL CASH OUT.	1441,020	160,484	81,062	185,752	96,626	121,752	178,125	157,969	133,197	248,316	187,808	442,640	721,942	585,514	855,926	1088,106	1106,761	1179,159	1037,647	1000,248	1001,434
Receipts:																					
Fat cows: 350x$70x0.6-Freight= $13,126	-	-	-	-	-	170,638	-	-	-	52,504	65,630	65,630	78,756	91,882	105,008	131,260	157,512	183,764	196,890	196,890	196,890
Fat steers: 400x$70x0.6-Freight= $15,226	-	-	-	76,130	76,130	60,904	91,356	121,808	60,904	91,356	137,034	152,260	152,260	167,486	197,938	243,616	289,294	334,972	395,876	472,006	517,684
Fat heifers:400x$70x0.6-Freight= $15,226	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	106,582	167,486	228,390
Bulls: $35,000	-	-	-	35,000	-	-	35,000	-	-	35,000	-	-	35,000	-	-	70,000	-	-	70,000	-	-
Pigs: G.M. per sow ($66,000)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	66,000	66,000	66,000	66,000	66,000
Milk sold: $13,466	-	-	-	-	-	-	-	-	-	296,252	296,252	323,184	390,514	484,776	552,106	659,834	781,028	888,756	1009,950	1009,950	1009,950
$14,175	-	155,925	155,925	155,925	190,450	192,780	141,750	198,450	269,325	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL CASH IN	-	155,925	155,925	267,055	274,580	424,322	268,106	320,258	330,229	475,112	498,916	541,074	656,530	744,144	855,052	1104,710	1293,834	1473,492	1845,298	1912,332	2018,914
NET CASH: farmer ($37,500)	-1441,020	-4,559	74,863	81,303	177,954	302,570	89,981	162,289	197,032	226,796	311,108	98,434	-65,412	158,630	-874	16,604	187,073	294,338	807,651	912,084	1017,480
farmer ($150,000)	-1441,020	-117,059	-37,637	-31,197	65,454	190,070	-22,519	49,789	84,532	114,296	198,608	-14,066	-177,912	46,130	-113,374	-95,896	74,573	181,833	695,151	799,584	904,980
ACCUMULATED	-1441,020	-1445,579	-1370,716	-1289,413	-1111,459	-808,889	-718,908	-556,619	-359,587	-132,791	178,317	276,751	211,339	369,969	369,095	385,699	572,772	867,105	1674,756	2586,840	3604,320

Table B2. Grass and Legume - Rearing fat cattle (60% of cattle returns) with milk and pigs

Expenditure Year:	0	1	2	3	4	5	6	7	8	9
Cows milked	-	11	11	11	14	7/9 months to/ 6 months	10	14	19	22
Buy land: 160 ha ($3,000/ha)	480,000	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($45,000/ea)	675,000	-	-	-	-	-	-	-	-	-
Build corral and house	160,000	-	-	-	-	-	-	-	-	-
Build fences: 2,534m ($30 / m)	76,020	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
Establish grass-legume ($8,411/ha)	-	84,110	-	33,644	16,822	-	42,055	42,055	33,644	25,233
Establish grass ($4,245/ha)	-	16,980	16,980	8,490	0	8,490	-	-	-	-
Maintain pasture ($1,733/ha)	-	-	-	24,262	6,932	34,660	10,398	38,126	19,063	46,791
Renovate pasture ($ 700/ha)	-	-	-	-	-	2,800	2,800	1,400	-	4,200
Buy bull: ea $50,000	50,000	-	-	50,000	-	-	50,000	-	-	50,000
Minerals and Vet. $586	-	12,892	17,580	22,854	26,370	29,300	26,370	29,886	33,988	38,090
Labour milking	-	-	-	-	-	-	-	-	-	-
TOTAL CASH OUT.	1441,020	160,484	81,062	185,752	96,626	121,752	178,125	157,969	133,197	248,316
Receipts:										
Fat cows: 350x$70x0.6-Freight= $13,126	-	-	-	-	-	170,638	-	-	-	52,504
Fat steers: 400x$70x0.6-Freight= $15,226	-	-	-	76,130	76,130	60,904	91,356	121,808	60,904	91,356
Fat heifers: 400x$70x0.6-Freight= $15,226	-	-	-	-	-	-	-	-	-	-
Bulls: $35,000	-	-	-	35,000	-	-	35,000	-	-	35,000
Pigs: G.M. per sow ($66,000)	-	-	-	-	-	-	-	-	-	-
Milk sold: $13,466	-	-	-	-	-	-	-	-	-	296,252
$14,175	-	155,925	155,925	155,925	190,450	192,780	141,750	198,450	269,325	-
TOTAL CASH IN	-	155,925	155,925	267,055	274,580	424,322	268,106	320,258	330,229	475,112
NET CASH: farmer ($37,500)	-1441,020	-4,559	74,863	81,303	177,954	302,570	89,981	162,289	197,032	226,796
farmer ($50,000)	-1441,020	-117,059	-37,637	-31,197	65,454	190,070	-22,519	49,789	84,532	114,296
ACCUMULATED	-1441,020	-1445,579	-1370,716	-1289,413	-1111,459	-808,889	-718,908	-556,619	-359,587	-132,791

10	11	12	13	14	15	16	17	18	19	20
22	24	29	36	41	49	58	66	75	75	75
-	-	-	-	-	-	-	-	-	-	-
-	135,000	270,000	180,000	360,000	360,000	360,000	270,000	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
25,233	84,110	100,932	67,288	84,110	100,932	142,987	176,631	117,754	117,754	142,987
-	-	-	-	-	-	-	-	-	-	-
25,995	51,990	31,194	69,320	51,990	83,184	69,320	103,980	98,781	131,708	123,043
9,800	1,400	2,800	5,600	9,800	4,900	6,300	8,400	11,900	7,000	13,300
-	-	100,000	-	-	100,000	-	-	100,000	-	-
42,778	48,638	58,014	66,804	78,524	92,588	106,652	123,646	137,710	172,284	150,602
37,500	75,000	112,500	150,000	225,000	300,000	375,000	450,000	525,000	525,000	525,000
187,808	442,640	721,942	585,514	855,926	1088,106	1106,761	1179,159	1037,647	1000,248	1001,434
65,630	65,630	78,756	91,882	105,008	131,260	157,512	183,764	196,890	196,890	196,890
137,034	152,260	152,260	167,486	197,938	243,616	289,294	334,972	395,876	472,006	517,684
-	-	-	-	-	-	-	-	106,582	167,486	228,390
-	-	35,000	-	-	70,000	-	-	70,000	-	-
-	-	-	-	-	-	66,000	66,000	66,000	66,000	66,000
296,252	323,184	390,514	484,776	552,106	659,834	781,028	888,756	1009,950	1009,950	1009,950
-	-	-	-	-	-	-	-	-	-	-
498,916	541,074	656,530	744,144	855,052	1104,710	1293,834	1473,492	1845,298	1912,332	2018,914
311,108	98,434	-65,412	158,630	-874	16,604	187,073	294,338	807,651	912,084	1017,480
199,608	-14,066	-177,912	46,130	-113,374	-95,896	74,573	181,833	695,151	799,584	904,980
178,317	276,751	211,339	369,969	369,095	385,699	572,772	867,105	1674,756	2586,840	3604,320

Table 33. Grass and Legume - Rearing fat cattle (60% of cattle return). No milk, no pigs

Expenditure	Year:	0	1	2	3	4	5	6	7	8	9	10	11
Total cows		-	15	16	18	22	13	18	25	29	29	32	36
Buy land: 160 ha ($ 3,000/ha)		480,000	-	-	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($22,000/ea)		330,000	-	-	-	-	-	-	-	-	-	-	-
Build corral and house		160,000	-	-	-	-	-	-	-	-	-	-	-
Build fences		76,020	-	-	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation		-	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
Establish grass-legume ($8,411/ha)		-	84,110	-	33,644	16,822	-	75,699	42,055	33,644	25,233	25,233	100,932
Establish grass ($4,245/ha)		-	16,980	16,980	8,490	-	-	-	-	-	-	-	-
Maintain pasture ($1,733/ha)		-	-	-	24,262	6,932	34,660	10,398	34,660	25,995	43,325	32,927	48,524
Renovate pasture ($ 700/ha)		-	-	-	-	-	2,800	2,800	1,400	0	2,800	9,800	1,400
Buy bull: ea $50,000		50,000	-	-	50,000	-	-	50,000	-	-	50,000	-	-
Minerals and Vet. $586		-	12,892	17,580	22,854	26,370	29,300	26,370	29,886	33,988	38,090	42,778	46,294
TOTAL CASH OUT.		1096,020	160,484	81,062	185,752	96,626	113,262	211,769	154,503	140,129	205,950	157,240	243,652
Receipts:													
Fat cows: 350x$70x0.6-Freight= $13,126		-	-	-	-	-	170,638	-	-	-	52,504	65,630	65,630
Fat steers: 400x$70x0.6-Freight= $15,226		-	-	-	76,130	76,130	60,904	91,356	121,808	60,904	91,356	137,034	152,260
Fat heifers: 400x$70x0.6-Freight= $15,226		-	-	-	-	-	-	-	-	-	-	-	-
Bulls: $35,000		-	-	-	35,000	-	-	35,000	-	-	35,000	-	-
TOTAL CASH IN		-	-	-	111,130	76,130	231,542	126,356	121,808	60,904	178,860	202,664	217,890
NET CASH.		-1096,020	-160,484	-81,062	-74,622	-20,496	118,280	-95,413	-32,695	-79,225	-27,090	45,424	-25,762
ACCUMULATED		-	-1256,504	-1337,566	-1412,188	-1432,684	-1314,404	-1409,817	-1442,512	-1521,737	-1548,827	-1503,403	-1529,165

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
39	43	47	51	56	62	67	74	81	89	97	100	100	100	100
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502	46,502
58,877	58,877	50,466	58,877	126,165	100,932	92,521	84,110	109,343	168,220	151,398	142,987	117,754	134,576	185,042
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38,126	69,320	50,257	81,451	60,655	93,582	86,650	114,378	105,713	126,509	128,242	126,509	128,242	126,509	128,242
2,800	4,200	9,800	7,700	6,300	7,000	11,900	9,800	14,700	11,900	16,800	14,000	19,600	22,400	25,200
50,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-
51,568	56,256	60,944	66,804	73,250	79,696	87,314	96,104	104,894	115,442	123,646	137,124	145,328	150,016	151,774
247,873	235,155	217,969	361,334	312,872	327,712	424,887	350,894	381,152	568,573	466,588	467,122	557,426	480,003	536,760
78,756	78,756	91,882	91,882	105,008	118,134	118,134	131,260	144,386	157,512	183,764	196,890	196,890	196,890	196,899
152,260	167,486	182,712	213,164	228,390	243,616	274,068	289,294	319,746	350,198	395,876	426,328	472,000	502,458	532,910
-	-	-	-	-	-	-	-	-	-	-	91,356	167,486	213,164	243,616
35,000	-	-	35,000	-	-	70,000	-	-	70,000	-	-	70,000	-	-
266,016	246,242	274,594	340,046	333,398	361,750	462,202	420,554	464,132	577,710	579,640	714,574	906,382	912,512	973,425
18,143	11,087	56,625	-21,288	20,526	34,038	37,315	69,660	82,980	9,137	113,052	247,452	348,956	432,509	436,665
511,022	-1499,935	-1443,310	-1464,598	-1444,072	-1410,034	-1372,719	-1303,059	-1220,079	-1210,942	-1097,890	-850,438	-501,482	-68,973	367,692

Table 84. Rearing fat cattle, pigs and milking on Brachiaria (no adjustments)

Expenditure Year:	0	1	2	3	4	5	6	7
Cows milked	0	11	10	10	13	9-6 months 6-9 months	9	13
Buy land: 160 ha ($ 3,000/ha)	555,000	-	-	-	-	-	-	-
Buy cows: 15 ($45,000/ea)	675,000	-	-	-	-	-	-	-
Build corral and house ($80,000 ea)	160,000	-	-	-	-	-	-	-
Build fences: 2,735m ($30/m)	82,050	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	47,105	47,105	47,105	47,105	47,105	47,105	47,105
Establish Brachiaria ($4,245/ha)	-	55,185	21,225	21,225	25,470	8,490	-	-
Maintain pasture ($1,733/ha)	-	-	-	22,529	8,665	31,194	19,063	34,660
Renovate pasture ($ 700/ha)	-	-	-	-	-	9,100	3,500	3,500
Buy bull: ea $50,000	50,000	-	-	50,000	-	-	50,000	-
Buy Minerals and Vet. $586	-	12,892	17,580	22,854	28,714	30,472	26,956	30,472
Labour milking $150,000/man	-	-	-	-	-	-	-	-
TOTAL CASH OUT.	1522,050	115,182	85,910	163,713	109,954	126,361	146,624	115,737
Receipts:								
Fat cows: 350x70-Freight= $22,926	-	-	-	-	-	298,038	-	-
Fat steers: 400x70-Freight= $26,426	-	-	-	-	132,130	105,704	105,704	158,556
Fat heifers: 400x70-Freight= $26,426	-	-	-	-	-	-	-	-
Bulls: $35,000	-	-	-	35,000	-	-	35,000	-
Pigs: G.M. per sow ($99,000)	-	-	-	-	-	-	-	-
Milk: $15/litre culling ($10,773)	-	-	-	-	-	-	-	-
not culling ($11,340)	-	124,740	113,400	113,400	147,420	135,380	102,060	147,420
TOTAL CASH IN	-	124,740	113,400	148,400	279,550	529,122	242,764	305,976
NET CASH.	-1522,050	9,558	27,490	-15,313	169,596	412,761	96,140	190,239
- Full opp cost of owner (-$112,500)	-	-102,942	-85,010	-127,813	57,396	300,261	-16,360	77,739
ACCUMULATED	-1522,050	-1512,492	-1485,002	-1500,315	-1330,719	-917,958	-821,818	-631,579

8	9	10	11	12	13	14	15	16	17	18	19	20	21
17	19	20	21	25	32	37	45	52	61	70	70	70	70
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	135,000	360,000	270,000	405,000	360,000	450,000	405,000	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105
16,980	12,735	21,225	21,225	42,450	38,205	59,430	59,430	67,920	72,165	59,430	59,430	46,695	21,225
19,063	34,660	25,995	39,859	34,660	48,254	51,990	64,121	76,252	88,383	103,980	117,844	128,242	142,106
4,200	10,500	3,500	3,500	7,000	12,600	7,000	7,000	14,000	18,900	16,800	16,800	25,200	30,800
-	50,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-	100,000
35,160	38,090	42,778	48,052	58,014	66,804	80,282	94,346	100,754	127,748	141,226	155,290	165,838	171,112
-	-	37,500	37,500	75,000	150,000	187,500	262,500	300,000	375,000	450,000	450,000	450,000	450,000
122,508	193,090	178,103	332,241	724,229	633,238	838,307	994,502	1066,031	1134,301	918,541	846,469	863,080	962,348
-	91,704	91,704	114,630	137,556	160,482	183,408	229,260	252,186	298,038	343,890	343,890	343,890	343,890
184,982	105,704	158,556	211,408	211,408	237,834	237,834	290,686	369,964	422,816	528,520	607,798	713,502	819,206
-	-	-	-	-	-	-	-	-	-	-	105,704	237,834	343,538
-	35,000	-	-	35,000	-	-	70,000	-	-	70,000	-	-	70,000
-	-	-	-	-	-	-	-	99,000	99,000	99,000	99,000	99,000	99,000
-	204,687	215,460	226,233	269,325	344,736	398,601	484,785	560,196	657,153	754,110	754,110	754,110	754,110
192,780	-	-	-	-	-	-	-	-	-	-	-	-	-
377,762	437,095	465,720	552,271	653,289	743,052	819,843	1074,731	1281,346	1477,007	1795,520	1910,502	2148,336	2429,744
255,254	244,005	287,617	220,030	-70,940	109,814	-18,464	80,229	215,315	342,706	876,979	1064,033	1285,256	1467,396
142,754	131,505	75,117	107,530	-183,440	-2,686	-130,964	-3,227	102,815	230,206	764,479	951,533	1172,756	1354,896
-376,325	-132,320	155,297	375,327	304,387	414,201	395,737	475,966	691,281	1033,987	1910,966	2974,999	4260,255	5727,651

Table B5. Brachiaria: Rearing fat cattle, pigs and milking (cattle returns reduced to 80%; pigs to 66% and Milking 70%)

Expenditure	Year:	0	1	2	3	4	5	6	7	8
Cows milked		0	11	10	10	13	13-6 months 9-9 months	9	13	17
Buy land: 185 ha ($ 3,000/ha)		555,000	-	-	-	-	-	-	-	-
Buy cows: 15 ($45,000/ea)		675,000	-	-	-	-	-	-	-	-
Build corral and house ($80,000 ea)		160,000	-	-	-	-	-	-	-	-
Build fences: 2,735m ($30/m)		82,050	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation		-	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105
Establish Brachiaria ($4,245/ha)		-	55,185	21,225	21,225	25,470	8,490	-	-	16,980
Maintain pasture ($1,733/ha)		-	-	-	22,529	8,665	31,194	19,063	34,660	19,063
Renovate pasture ($ 700/ha)		-	-	-	-	-	9,100	3,500	3,500	4,200
Buy bull: ea $50,000		50,000	-	-	50,000	-	-	50,000	-	-
Buy minerals and vet. $586		-	-	-	-	-	-	-	-	-
Labour milking		-	-	-	-	-	-	-	-	-
TOTAL CASH OUT.		1522,050	115,182	85,910	163,713	109,954	126,361	146,624	115,737	122,508
Receipts:										
Old cows: (22.926 x 0.8) = ($18,341)		-	-	-	-	-	238,433	-	-	-
Fat steers: (26.426 x 0.8) = ($21,141)		-	-	-	-	105,705	84,564	84,564	126,846	147,987
Fat heifers: (26.426 x 0.8) = ($21,141)		-	-	-	-	-	-	-	-	-
Bulls: $35,000		-	-	-	35,000	-	-	35,000	-	-
Pigs: 2/3 G.M.per sow ($66,000)		-	-	-	-	-	-	-	-	-
Milk: $15/litre culling ($10,773)		-	-	-	-	-	-	-	-	-
not culling ($11,340)		-	124,740	113,400	113,400	147,420	135,380	102,060	147,420	192,780
TOTAL CASH IN.		-	124,740	113,400	148,400	253,125	458,377	221,624	274,266	340,767
NET CASH		-1522,050	9,558	27,490	-15,313	143,171	332,016	75,000	158,529	218,259
- Full opp cost of owner (-$112,500)		-	-102,942	-85,010	-127,813	-30,671	219,516	-37,500	46,029	105,759
ACCUMULATED.		-1522,050	-1512,492	-1485,002	-1500,315	-1357,144	-1025,128	-950,128	-791,599	-573,340

9	10	11	12	13	14	15	16	17	18	19	20	21	22
19	20	21	23	27	34	40	44	53	62	70	70	70	70
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	135,000	315,000	315,000	225,000	405,000	405,000	405,000	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105
12,735	21,225	16,980	25,470	33,960	46,695	42,450	63,675	67,920	67,920	63,675	59,430	38,205	21,225
34,660	25,995	39,859	34,660	46,791	45,058	60,655	64,121	77,985	90,116	105,713	117,844	131,708	142,106
10,500	3,500	3,500	7,000	12,600	7,000	6,300	11,200	10,200	14,700	13,300	21,700	29,400	25,900
50,000	-	-	50,000	-	50,000	50,000	-	50,000	50,000	-	50,000	50,000	-
-	42,778	46,880	52,740	60,944	72,078	82,040	96,690	112,512	128,920	142,984	157,048	166,424	171,112
-	37,500	37,500	37,500	75,000	150,000	187,500	225,000	300,000	375,000	450,000	450,000	450,000	450,000
193,090	178,103	191,824	389,475	591,400	732,936	701,050	912,791	1078,722	1178,761	822,777	903,127	912,842	857,448
73,364	73,364	91,705	91,705	110,046	128,387	165,069	183,410	220,092	256,774	275,115	275,115	275,115	275,115
84,564	126,846	169,128	169,128	180,269	190,269	211,410	253,692	317,115	380,538	422,820	486,243	570,807	655,371
-	-	-	-	-	-	-	-	-	-	-	105,705	190,269	274,833
35,000	-	-	35,000	-	-	35,000	-	35,000	35,000	-	35,000	35,000	-
-	-	-	-	-	-	-	-	66,000	66,000	66,000	66,000	66,000	66,000
204,687	215,460	226,233	247,779	290,871	366,282	430,920	474,012	570,969	667,926	754,110	754,110	754,110	754,110
-	-	-	-	-	-	-	-	-	-	-	-	-	-
397,615	415,670	487,066	543,612	591,186	684,938	842,399	911,114	1209,176	1406,238	1518,045	1722,173	1891,301	2025,429
204,525	237,567	295,242	154,137	-214	-47,998	141,349	-1,677	130,454	227,477	695,268	819,046	978,459	1167,981
92,025	125,067	182,742	41,637	-112,714	-160,498	28,849	-114,177	17,954	114,977	582,768	706,546	865,959	1055,481
-368,815	-131,248	163,994	318,131	317,917	269,919	411,268	409,591	540,045	767,522	1462,790	2281,836	3260,295	4428,276

Table B6. Brachiaria fattening without milk and 80% of beef returns (calving rate: 70%)

Expenditure — Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Buy land: 185 ha ($ 3,000/ha)	555,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($22,000/ea)	330,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Build corral and house ($80,000 ea)	160,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Build fences: 2,735m ($30/m)	82,050	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105
Establish Brachiaria ($4,245/ha)	-	55,185	21,225	21,225	25,470	8,490	-	-	16,980	12,735	25,470	12,735	16,980	16,980	16,980
Maintain pasture ($1,733/ha)	-	-	-	22,529	8,665	31,194	19,063	34,660	19,063	34,660	25,995	39,859	36,393	45,058	43,325
Renovate pasture ($ 700/ha)	-	-	-	-	-	9,100	3,500	3,500	4,200	10,500	3,500	3,500	7,000	12,600	7,700
Buy bull: ea $50,000	50,000	-	-	50,000	-	-	50,000	-	-	50,000	-	-	50,000	-	-
Buy minerals and Vet. $586	-	12,892	17,580	22,854	28,714	30,472	26,956	30,472	35,160	38,090	43,364	46,880	50,982	55,084	59,186
Labour milking ($150,000/man)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL CASH OUT.	1177,050	115,182	85,910	163,713	109,954	126,361	146,624	115,737	122,508	193,090	145,434	150,079	208,460	176,827	174,296
Receipts:															
Fat cows: (22,926 x 0.8) = ($18,341)	-	-	-	-	-	238,433	-	-	-	73,364	73,364	91,705	91,705	110,046	110,046
Fat steers: (26,426 x 0.8) = ($21,141)	-	-	-	-	105,705	84,564	84,564	126,846	147,987	84,564	126,846	169,128	169,128	190,269	190,269
Fat heifers: (26,426 x 0.8) = ($21,141)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bulls: $35,000	-	-	-	35,000	-	-	35,000	-	-	35,000	-	-	35,000	-	-
TOTAL CASH IN	-	-	-	35,000	105,705	322,997	119,564	126,846	147,987	192,928	200,210	260,833	295,833	300,315	300,315
NET CASH.	-1177,050	-115,182	-85,910	-128,713	-4,249	196,636	-27,060	-11,109	25,479	-162	54,776	110,754	87,373	123,488	126,019
ACCUMULATED	-1177,050	-1292,232	-1378,142	-1506,855	-1511,104	-1314,468	-1341,528	-1352,637	-1327,158	-1327,320	-1272,544	-1161,790	-1074,417	-950,929	-824,910

15	16	17	18	19	20	21	22	23	24	25	26	27
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	220,000	176,000	44,000	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105	47,105
29,715	12,735	21,225	33,960	29,715	25,470	59,430	63,675	50,940	59,430	55,185	29,715	4,245
51,990	50,257	64,121	55,456	72,786	69,320	84,917	79,718	109,179	105,713	129,975	129,975	152,804
5,600	9,800	15,400	10,500	10,500	11,900	18,900	16,100	15,400	16,100	28,700	26,600	23,800
50,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-	100,000
65,632	69,148	73,836	82,040	88,486	94,932	108,410	123,060	135,366	149,430	162,908	169,354	170,526
-	-	-	-	-	-	-	-	-	-	-	-	-
250,042	189,045	221,687	329,061	248,592	248,727	638,762	505,658	401,990	477,778	423,873	402,749	498,180
110,046	128,387	146,728	146,728	165,069	183,410	183,410	238,433	275,115	275,115	275,115	275,115	275,115
211,410	232,551	253,692	274,833	295,974	317,115	338,256	380,538	401,679	443,961	549,666	613,089	655,371
-	-	-	-	-	-	-	-	-	-	169,128	232,551	274,833
35,000	-	-	35,000	-	-	70,000	-	-	70,000	-	-	70,000
356,456	360,938	400,420	456,561	461,043	500,525	591,666	618,971	676,794	789,076	993,909	1120,755	1275,319
106,414	171,893	173,733	127,500	212,451	251,798	-47,096	113,313	274,804	311,298	570,036	718,036	777,139
-718,496	-546,603	-367,870	-240,370	-27,919	223,879	176,783	290,095	564,899	876,197	1446,233	2164,239	2941,378

Table 87. Protein bank - Grade cows - weaning rate 70%, stores sold at 2 to 3 years

A. Full Beef Production — Year:	0	1	2	3	4	5	6	7	8	9	10	11
Cows	-	-	-	18	22	13	18	24	27	28	30	33
Buy land: 980 ha ($ 3,000/ha)	2940,000	-	-	-	-	-	-	-	-	-	-	-
Buy cows: 15 ($22,000/ea)	330,000	-	-	-	-	-	-	-	-	-	-	-
Build corral and house	160,000	-	-	-	-	-	-	-	-	-	-	-
Build fences:	188,220	-	-	-	-	-	-	-	-	-	-	-
Fence repairs, living, cultivation	-	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722
Establish protein bank ($8,411/ha)	-	33,644	16,822	16,822	8,411	0	0	33,644	33,644	25,233	16,822	8,411
Maintain protein bank ($1,733/ha)	-	-	-	6,932	3,466	10,398	5,199	10,398	5,199	10,398	8,665	12,131
Buy bull: ea $50,000	-	50,000	-	-	50,000	-	-	50,000	-	-	50,000	-
Minerals: $ 586	-	12,892	18,166	22,854	25,784	26,956	24,612	27,542	31,058	35,746	39,262	42,192
TOTAL CASH OUT	3618,220	154,258	92,710	104,330	145,413	95,076	87,533	179,306	127,623	129,099	172,471	120,456
Receipts:												
Old cows: 290x$70 = $20,300	-	-	-	-	-	263,900	-	-	-	81,200	81,200	101,500
Store steers: 250x$70 = $17,500	-	-	-	87,500	87,500	70,000	105,000	122,500	70,000	105,000	140,000	157,500
Store heifers: 250x$70 = $17,500	-	-	-	-	-	-	-	-	-	-	-	-
Bulls: $35,000	-	-	-	-	35,000	-	-	35,000	-	-	35,000	-
TOTAL CASH IN	-	-	-	87,500	122,500	333,900	105,000	157,500	70,000	186,200	256,200	259,000
NET CASH	-3618,220	-154,258	-92,710	-16,830	-22,913	238,824	17,467	-21,806	-57,623	57,101	83,729	138,544
ACCUMULATED	-3618,220	-3772,478	-3865,188	-3882,018	-3904,931	-3666,107	-3648,640	-3670,445	-3728,069	-3670,968	-3587,239	-3448,695
B. 60% of Full Beef Production												
Total cash in	-	-	-	52,500	87,500	200,340	63,000	108,500	42,000	111,720	167,720	155,400
Net cash	-3618,220	-154,258	-92,710	-51,830	-57,913	105,264	-24,533	-70,806	-85,623	-17,379	-4,751	34,944
Accumulated	-3618,220	-3772,478	-3865,188	-3917,018	-3974,931	-3869,667	-3894,200	-3965,006	-4050,629	-4068,008	-4072,759	-4037,815

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
36	39	42	45	49	53	58	62	67	73	79	85	92	100	100	100	100	100
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722	57,722
8,411	50,466	42,055	42,055	25,233	25,233	25,233	67,288	58,877	67,288	42,055	50,466	50,466	95,521	84,110	84,110	50,466	50,466
10,398	13,864	12,131	17,330	13,864	20,796	15,597	24,262	19,063	27,728	22,529	32,927	25,995	38,126	31,194	43,325	36,393	46,791
-	50,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-	100,000	-	-	100,000	-
45,122	49,810	53,326	57,428	62,116	67,390	73,836	79,696	85,556	92,588	100,205	107,824	116,028	125,990	135,952	141,226	144,742	144,742
121,653	221,862	165,234	174,535	258,935	171,141	172,388	328,968	221,218	245,326	322,512	248,939	250,211	417,359	308,978	326,383	389,323	299,721
101,500	121,800	121,800	121,800	142,100	162,400	162,400	182,700	203,000	203,000	223,300	243,600	263,900	284,200	304,500	304,500	304,500	304,500
157,500	175,000	192,500	210,000	210,000	245,000	262,500	280,000	297,500	332,500	350,000	385,000	402,500	437,500	472,500	525,000	560,000	560,000
-	-	-	-	-	-	-	-	-	-	-	-	-	-	140,000	175,000	227,500	227,500
-	35,000	-	-	35,000	-	-	70,000	-	-	70,000	-	-	70,000	-	-	70,000	-
259,000	331,800	314,300	331,800	387,100	407,400	424,900	532,700	500,500	535,500	643,300	628,600	666,400	791,700	917,000	1004,500	1162,000	1092,000
137,347	109,938	149,066	157,265	128,165	236,259	252,512	203,732	279,282	290,174	320,788	379,661	416,189	374,341	608,022	678,117	772,677	792,279
-3311,348	-3201,410	-3052,344	-2895,079	-2766,914	-2530,655	-2278,143	-2074,411	-1795,129	-1504,955	-1184,167	-804,506	-388,317	-13,976	594,046	1272,163	2044,840	2837,119
155,400	213,080	188,580	199,080	246,260	244,440	254,940	347,620	300,300	321,300	413,980	377,160	399,840	503,020	550,200	602,700	655,200	655,200
33,747	-8,782	23,346	24,545	-12,675	73,299	82,552	18,652	79,082	75,974	91,468	128,221	149,629	85,661	241,222	276,317	265,877	355,479
-4004,068	-4012,850	-3989,504	-3964,959	-3977,634	-3904,335	-3821,783	-3803,131	-3724,049	-3648,075	-3556,607	-3428,386	-3278,757	-3193,096	-2951,874	-2675,557	-2409,680	-2054,201

APPENDIX C

SMALL FARMER CREDIT (LEY 5a.)

Limitations

- Farmer has to have less than $1,800,000 equity, 70% farm
- 75% of the income is generated from the farm.

Loan finances 80% of the total investment maximum per:

- beef cow. $22,000
- dual purpose. $35,000
- dairy purpose $65,000

The price of the animal can be somewhat higher, the above figure corresponds to the 80% financed by the bank.

Conditions

- 8 years loan
- 18% annual interest

Interest Payment

1 year: free of interest
2 year: 40% of interest of year 1
3 year: 60% of interest of year 1 and 20% of year 2
4 year: 80% of interest of year 2 and 20% of year 3
5 year: 80% of interest of year 3 and 60% of year 4
6 year: 40% of interest of year 4 and 100% of year 5 and 30% of year 6
7 year: 70% of interest of year 6 and 100% of year 7
8 year: 100% of interest of year 8

Repayment of Principal

Year 5: 15%
Year 6: 20%
Year 7: 30%
Year 8: 35%

Maximum loan equivalent to US$15,000 x 75 = US$1,125,000

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Paper presented in
the 5TH WORLD CONFERENCE ON ANIMAL PRODUCTION
Tokyo, Japan, August 14-19, 1983

COW-CALF SYSTEMS IN THE SAVANNAS OF TROPICAL LATIN AMERICA - A SYSTEMS DIAGN

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SUMMARY A major effort was undertaken to monitor prevailing cow-calf systems on acid, infertile soils of the Colombian and Venezuelan "Llanos" and Brazilian "Cerrados" to focus research on real system constraints. Farms differing in resources, management and input use were selected and closely monitored over a two year period. Ranches were large, had 600 heads of cattle and total investment ranged from US$210.000 in Colombia to US$900.000 in Venezuela. Weaning rates varied from 45% in Colombia to 57% in Brazil. It was concluded that productivity in these systems is determined largely by the quality and quantity of natural resources and can only be increased by introducing additional resources to the system (P, germplasm). Soil aluminium saturation is more important than nutrient availability or pH in determining present farming systems and potential developmental paths.

INTRODUCTION Herd management is considered a major constraint in extensive cow-calf systems of the infertile savannas of Tropical South America. Hoping to identify management practices presently used by more efficient farms with potential to be included in extension packages, a farming systems project was started, which covered savanna ecosystems of Brazil, Colombia and Venezuela.

MATERIALS AND METHODS In each of the selected regions (Cerrados, Brazil; Llanos Orientales, Colombia and Llanos Nororientales, Venezuela) 15 to 20 farms with varying levels of livestock management, resource endowment and input use were purposively selected and monitored over a period of two years by means of periodic visits by an interdisciplinary team collecting information on resource endowment, individual animal performance (weight gains by weighing and reproductive status by means of rectal palpations at six-month intervals), production, sales, use of inputs and labour. The large mass of individual animal data was handled by means of specifically developed computer programs to quantify herd performance indicators: calving rates, ages of first mating, weight gains of individual animal categories in the dry and wet season, etc. This information, as well as the farm-level data on input use, labour and resource endowment, was used to establish whole-farm budgets which were converted into US$ for the sake of across-region comparison.

RESULTS In all three savanna study sites the physical environment is characterized by the presence of clear-cut dry and wet seasons. Rainfall ranges from 1000 mm p.a. in El Tigre, Venezuela to 1800 mm p.a. in Brazilian Cerrado and 2000 mm p.a. in Carimagua, Colombia. Across all sites soils are very acid (pH 4-5) and low in phosphorus content; aluminium saturation is 80-90% in the Colombian Llanos, but only 25-35% in the other two sites. This and the differences in road infrastructure lead to a varying potential for crop production and thus for whole-system intensification. Dry season forage is provided by the shrubby vegetation in the Cerrado (50-70% farm area) and by lowlands in the Colombian Llanos. While the Colombian Llanos have only 1% of the country's population, the Brazilian Cerrados host 18%. Paved roads in the Colombian study region are absent, while 1200 km of roads are paved in the Cerrado and 3700 km in the Venezuelan Llanos. Agricultural policies also vary: Brazil has strongly subsidized agricultural development while no policies exist in Colombia. All three regions have ample land available and limited cattle. Labour use is significantly higher in Brazil (7 man units per farm) than in Venezuela (4.1 man units) and Colombia (3.2 man units). This is due to the presence of crops in Brazil and to milking of dual purpose cows in Venezuela. Total capital per farm and its structure shows remarkable differences between regions. Total investment is substantially higher in Venezuela than in Brazil with Colombia ranging lowest. This reflects the varying scarcity of resources in the different regions and leads to different degrees of entrepreneurial management efforts. Farms in the Llanos Colombianos, which require the smallest amount of capital and are more difficult to intensify, are managed by absentee landlords. The extensiveness of the system is further stressed by the fact that land and cattle comprise 82% of the total investment. Cow-calf systems predominate, but are variable. In Venezuela, 63%

of the cows were occasionally milked and as such received better treatment but were also used intensively. Cows in Brazil are preferentially treated around calving time and milked if they have a female calf. Males are sold at weaning in Brazil, and at 2-3 years of age in Colombia and Venezuela. Sown pastures vary from 30% in Brazil to less than 5% in Colombia. The close correlation between gain/animal and liveweight suggests that nutrition is still a major constraint. Biological performance (Table 1) is low but variable in all cases, reflecting differences in feeding patterns, management and land use. Higher values for Brazil are consistent with the more ample use of sown grasses, the utilization of rice stubbles and the more intensive care of the calving cows. Economic efficiency indicators are presented in Table 2. Use of inputs is significantly higher in Brazil than in the other two locations, mainly due to the crop enterprise. Livestock inputs are similar and low in all locations. Gross income levels per animal unit again show high levels for Brazil due to the rice crop. High Venezuelan values reflect high beef and milk prices. Internal rates of return are typical for extensive beef operations in most parts of the world. The low Venezuelan values are due to heavy investments in infrastructure and machinery undertaken under different conditions from those prevailing during the study period. It must be stressed that these internal rates of return refer to the total capital, but that the return to farmers' equity tends to be higher due to the use of subsidized credit, particularly in the Brazilian case.

Table 1. Biological performance of cow-calf systems

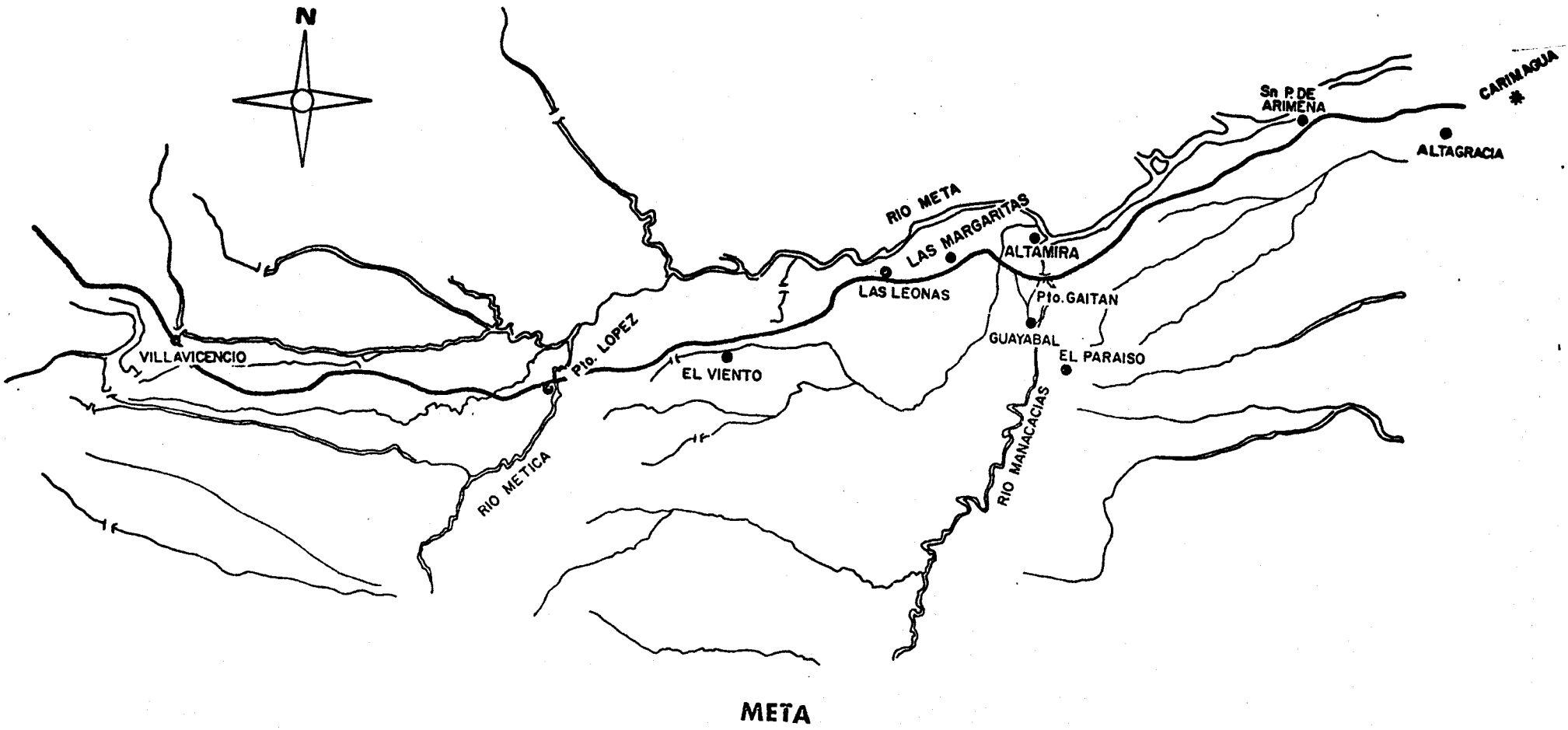
		Brazil	Colombia	Venezuela
Weaning rate	(%)	57	45	52
Weight gain:	(kg/AU/year)	65	58	55
	(kg/ha/year)	12	12	36
Average SR	(AU/ha)	0.23	0.17	0.32
Average cow weight	(kg)	310	305	301

Table 2. Economic performance of cow-calf systems

	Brazil	Colombia	Venezuela
Input use (US$/AU)	71.57	6.10	7.40
- Minerals	1.95	3.97	1.25
- Animal health	1.19	1.34	1.71
- Fertilizers	27.79	0.12	2.56
- Fuels	10.95	-	-
- Others	30.19	0.67	1.88
Gross income (US$/AU)	200.0	38.0	100.0
- Livestock	60.3	38.0	100.0
- Crops	139.7	0.0	0.0
Internal rate of return to total capital (%)	8	4	2

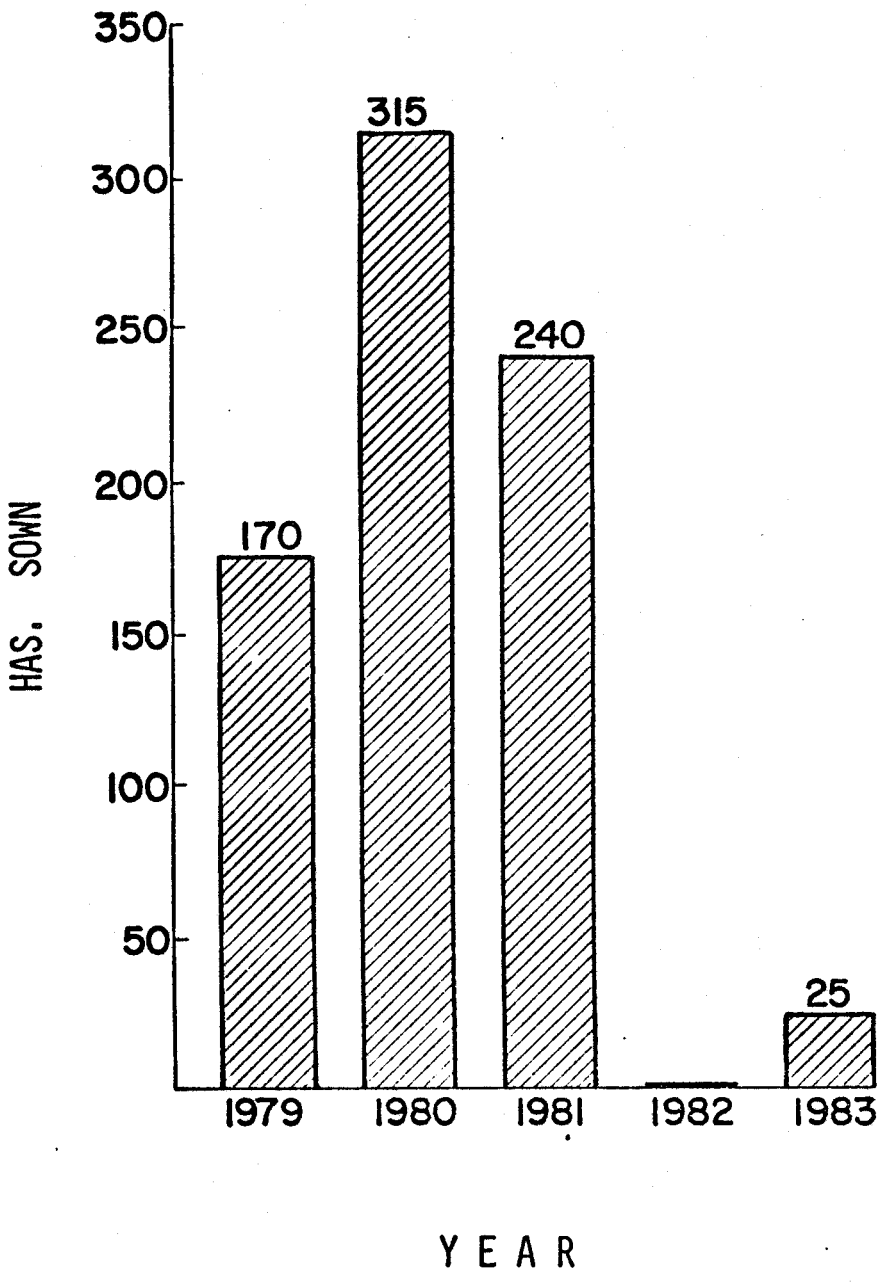
CONCLUSIONS Crops have played a major role in the recent development of these formerly pure beef systems, particularly in Brazil, where rice cropping introduced machinery and fertilization. Rotations with legume-grass associations could contribute to the nitrogen supply of the rice crop and legumes could improve the dry season fodder supply. Crops tend to increase gross returns and profitability while reducing risk and using subsidized credit. The advent of productive ley-farming systems would in turn demand specific germplasm with a lower emphasis on persistence. Higher nutrient requirements would be supplied by residual fertility of the crops. Thus, where aluminium saturation is lower, the potential for crop production opens up a wider range of germplasm options in comparison to those adapted to high aluminium toxicity environments such as the Llanos Colombianos. Related to the above is the interaction between infrastructure and germplasm requirements. The study regions in Venezuela and Brazil have good access to roads leading to a cheaper input supply, more production and specialized weaner production with special forage requirements. On the other hand, locations such as the Colombian Llanos with limited crop options and high transport costs suggest a strategic seasonal use of improved pastures, particularly to improve reproductive performance and to fatten cull cows as well as some steers. Reduction of agricultural subsidies will cause a drop of crop areas and increase demand for low-input pastures. Management practices had limited impact except in the Cerrado with larger areas of sown pastures. Thus, the latter may make improved management worthwhile.

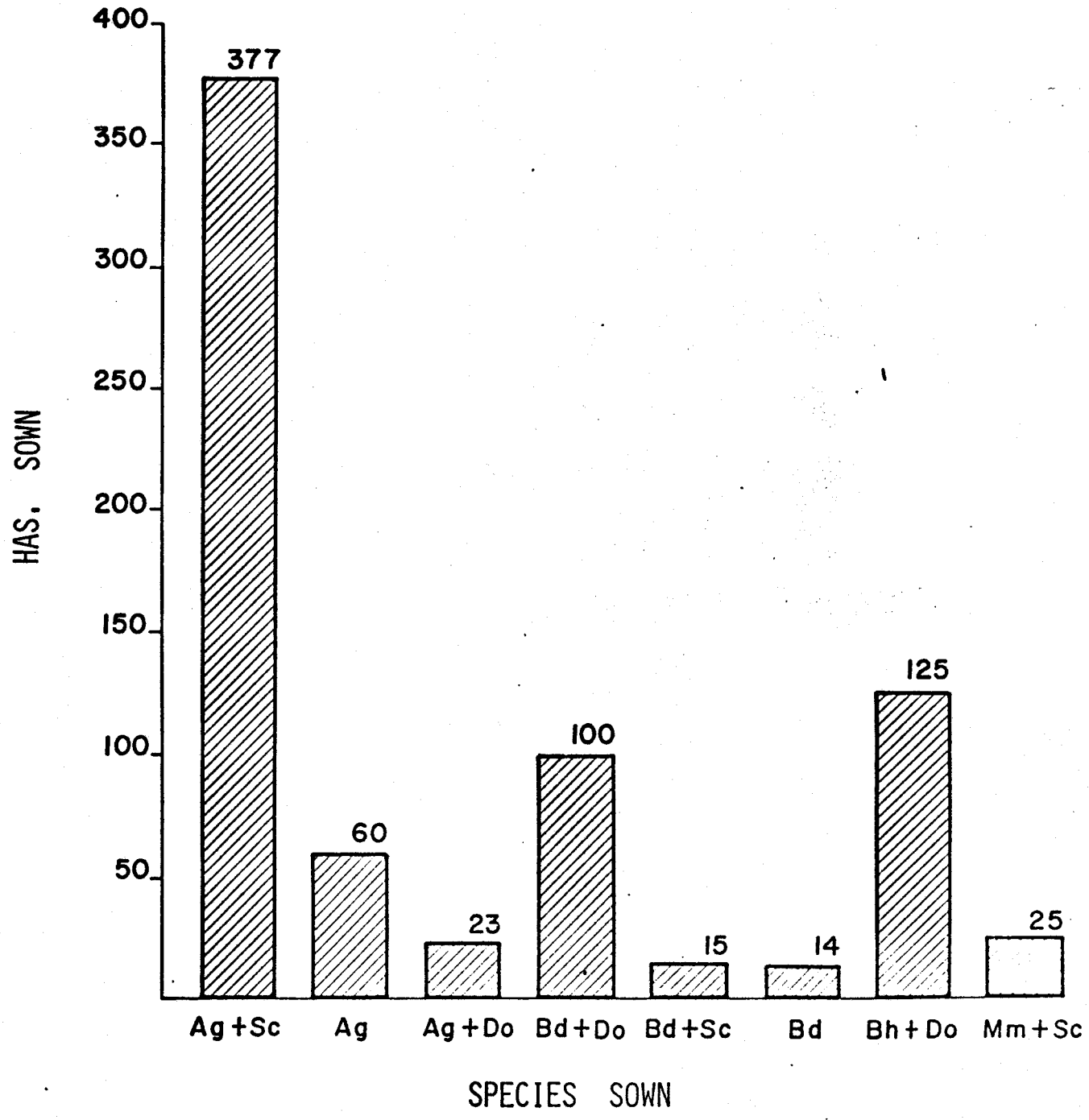
LOCATION OF COOPERATING FARMS


CASANARE
N
Sn P. DE ARIMENA
CARIMAGUA
ALTAGRACIA
RIO META
LAS MARGARITAS
ALTAMIRA
LAS LEONAS
Pto. GAITAN
GUAYABAL
EL PARAISO
VILLAVICENCIO
Pto. LOPEZ
EL VIENTO
RIO METICA
RIO MANACACIAS
META

Soil composition in Carimagua and seven cooperating farms

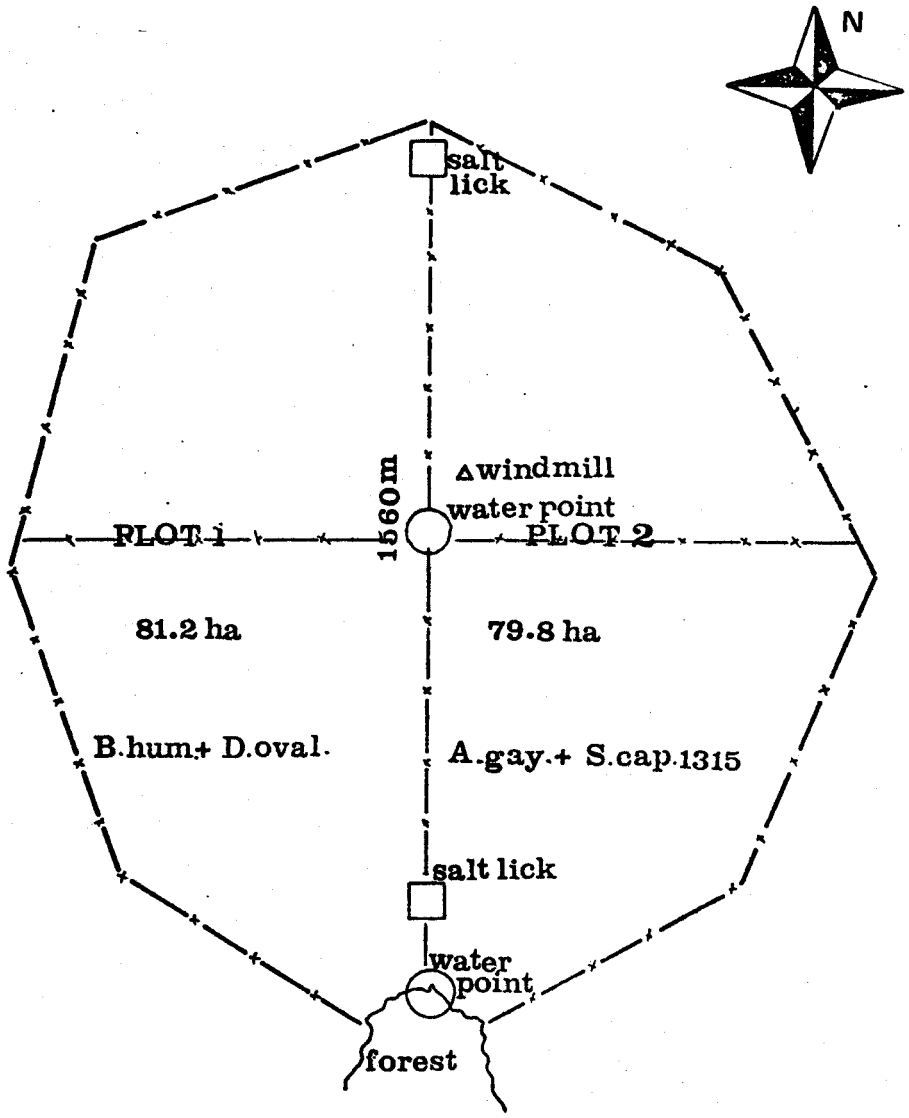
Location	Sand	Silt	Clay	pH	P (ppm)	Al	CEC	Al Sat.
		%		(1:1)H_2O	Bray II	mq/100 g		%
Carimagua	12	50	38	4.1	1.5	3.6	4.1	86.5
Altagracia	12	50	38	4.4	2.5	2.3	2.7	87.6
Leonas	17	36	47	3.7	2.4	2.9	3.2	92.9
Margaritas	20	32	48	4.3	1.6	3.0	3.3	90.3
Paraíso	38	23	38	4.5	2.2	2.0	2.1	94.9
El Viento	38	23	38	4.5	2.2	2.0	2.1	94.0
Guayabal	56	20	23	4.2	1.8	1.2	1.3	88.7
Altamira	70	12	18	4.7	7.4	0.9	1.1	83.0


350
300
250
200
150
100
50
HAS. SOWN
315
240
170
25
1979
1980
1981
1982
1983
YEAR


400
350
300
250
200
150
100
50
HAS. SOWN
377
60
23
100
15
14
125
25
Ag+Sc
Ag
Ag+Do
Bd+Do
Bd+Sc
Bd
Bh+Do
Mm+Sc
SPECIES SOWN

"ALTAGRACIA" FARM

"ALTAGRACIA"



TOTAL AREA: 161 ha

scale
100m

A L T A G R A C I A (15)

Owner:	Dr. Alfonso Jiménez
Manager:	Mr. Luis Suárez
Ranching system:	Cow-calf operation, replacement heifers, fattening of old cows and steers.
Inventory:	500 cows, 150 heifers, 150 steers, 250 calves and 30 bulls.
Total surfase area:	3850 ha (Stocking rate: 3.8 ha/Animal Unit)
Savanna:	3560 ha in 2 paddocks
Forest:	90 ha
Topography:	Flat and undulated savannas.
Soil analysis:	Similar to Carimagua (40% clay; 12% sand; pH = 40; P = < 1 ppm; Al Sat = 90%).
Sown pastures:	200 ha in 5 paddocks including 60 ha ETES-II in 2 paddocks.
Proportion of sown pastures:	4.3%. Date of planting ETES-II: June-July 1981.
	ETES-II project: Growth and performance of replacement heifers in sown vs. native pastures and fattening.

Planting and fertilization records:

A. 80 ha of *B. humidicola* 679 + *D. ovalifolium* 350.

February	1981:	Burning of original savanna + disking.
May-June	81:	2 additional diskings. Furrows made at 2 m intervals.
June-August	81:	Vegetative planting of *B. humidicola* + 1.25 kg/ha *D. ovalifolium* 70 kg/ha basic slag + 150 kg/ha rock phosphate + 20 kg/ha Sulpomag.

B. 80 ha of *A. gayanus* 621 + *S. capitata* 1315.

Land preparation similar to (A).

July 1981: 10 kg/ha *A. gayanus* + 4 kg/ha *S. capitata* 300 kg/ha basic slag + 20 kg/ha Sulpomag.

"ALTAGRACIA" AND "LAS LEONAS": THE ROL OF GRASS-LEGUME PASTURES IN IMPROVING GROWTH AND REPRODUCTIVE PERFORMANCE OF REPLACEMENT HEIFERS

"ALTAGRACIA" AND "LAS LEONAS": THE ROL GRASS-LEGUME PASTURES IN IMPROVING GROWTH AND REPRODUCTIVE PERFORMANCE OF REPLACEMENT HEIFERS

Traditional, savanna-based, ranching systems in the Plains of Colombia, Venezuela and Brazil are characterized by very low reproductive performance. Among several other parameters, age at first conception in heifers is late (only 50% have conceived at 3yrs of age, according to the ETES study), and thereafter remain in the herd for only 4-5 years.

The hypothesis that heifers with access to grass-legume pastures reach puberty and conceive earlier that those reared in the savanna, is being tested in two farms, where the control is heifers subject to the usual ranch management.

Tables 1 and 2 show preliminary results, which demonstrate that access to improved pastures, either continuously or seasonally, increases liveweight by about 100 kg over that of contemporary animals in savanna. This increase is responsible for improved fertility (Table 2 and Figure 1).

It remains to be established what, if any, are the carry-over effects of improved nutrition in early life on later performance, These aspects will continue to be studied both on-farm and in complementary on-station trials.

Table 1. Weight gains of heifers, in on-farm trials

Pasture	Altagracia		Las Leonas	
	$g.d^{-1}$	$an.ha^{-1}$	$g.d^{-1}$	$an.ha^{-1}$
Savanna	195 ± 33^{b}	0.13	118 ± 27^{c}	0.13
Brachiaria humidicola/ *Desmodium ovalifolium*	150 ± 60^{c}	1.69	-	-
Andropogon gayanus/ *Stylosanthes capitata*	330 ± 72^{a}	1.04	245 ± 36^{a}	1.33
Andropogon gayanus/ *Stylosanthes capitata* + Savanna[1]	-	-	218 ± 23^{b}	1.33

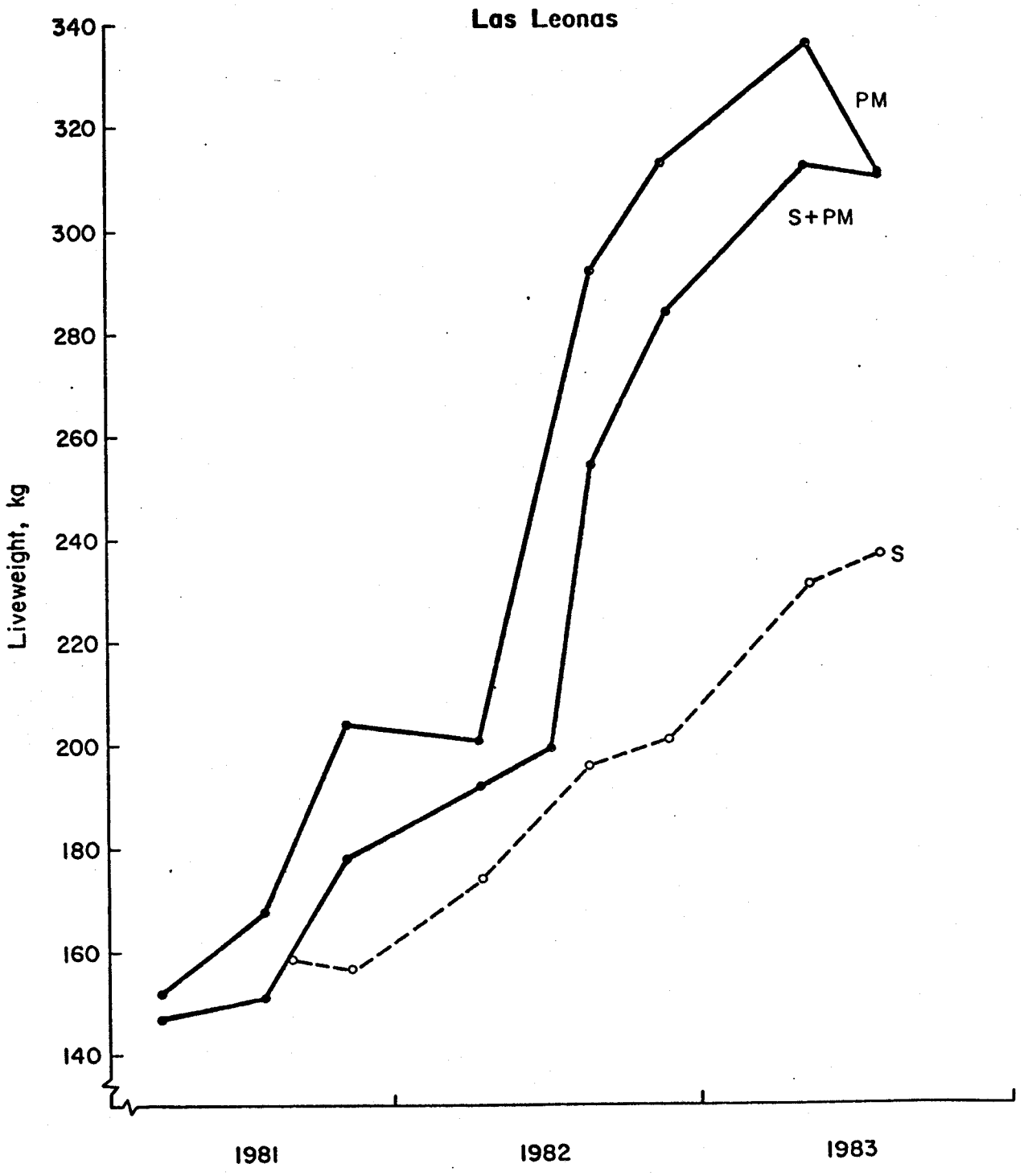
Means with different subscripts, within farms, are different ($P<0.05$)

1/ Sown pasture in the rainy season, savanna in summer

Table Conception rate of heifers on sown pastures and native savanna in on-farm trials.
Data for May 83

Pasture regime	Altagracia			Las Leonas		
	Conception, %	LW, kg	Age, mo.	Conception, %	LW kg	Age, mo.
Savanna	0	200±26	29±1	0	222±18	34±2
Brachiaria humidicola/ Desmodium ovalifolium	21.0	220±36	29±3	-	-	-
Andropogon gayanus/ Stylosanthes capitata	45.1	298±48	29±3	87.5	340±32	34±1
Andropogon gayanus/ Stylosanthes capitata + Savanna[a]	-	-	-	85.0	322±28	34±1

a Sown pasture during the rainy season; savanna in the dry season


Las Leonas
340
320
300
280
260
240
220
200
180
160
140
Liveweight, kg
PM
S+PM
S
1981
1982
1983

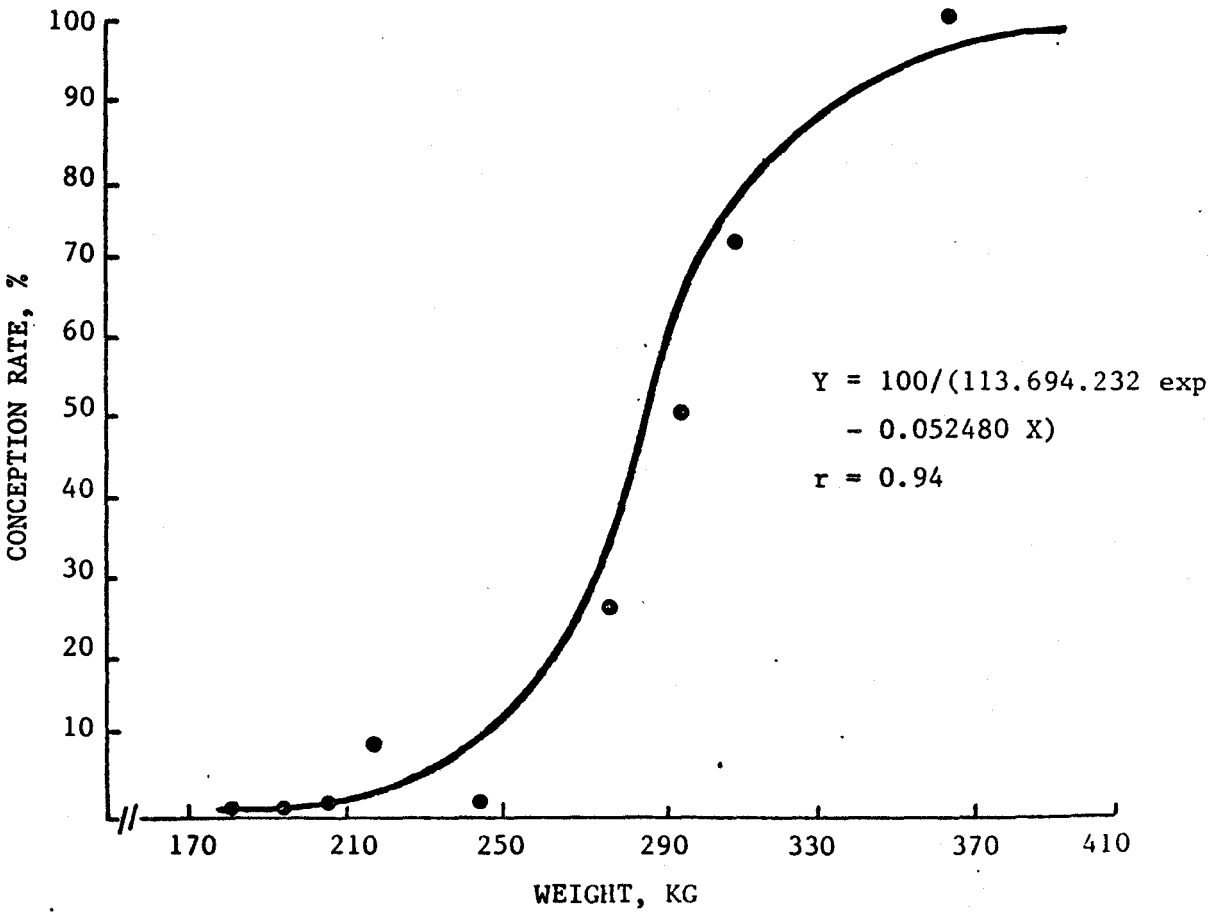


Figure 1. Relationship between conception rate and liveweight in heifers, in on-farm trials

EX-ANTE ANALYSIS OF ALTERNATIVE STRATEGIC USES OF IMPROVED PASTURES IN COW-CALF OPERATIONS IN THE EASTERN PLAINS, COLOMBIA

EX-ANTE ANALYSIS OF ALTERNATIVE STRATEGIC USES OF IMPROVED PASTURES IN COW-CALF OPERATIONS IN THE EASTERN PLAINS, COLOMBIA

The use of pastures for early weaning, rearing of heifers and improved feeding cow was evaluated ex-ante by using information provided by the Program and assumptions based on the literature and qualified infromants. The main parameters used are to be found in Table 1. The weaning strategies differ in the age at weaning causing different impact on the cows' weight, calving rate and pasture requirement. The alternatives of strategic nutrition of the cows differ according to the duration of the period on improved pasture influencing the cows' weight, calving rate and due to the better feeding of female calves, their age at the first mating. Increases in the period on improved pastures imply a reduction in the number of cows fed per hectare of improved pasture.

The Alternative I of improved heifer feeding corresponds approximately to the results of on-farm trials reported by the Cattle Production Systems Section. The Alternative II refers to similar stocking rates, but higher weight gains. Alternative III, finally implies stocking rates and weight gains similar to those obtained with males under experimental conditions in Carimagua. In all cases it is supposed that the only effect of a better feeding of heifers consists in the younger age at first calving, without affecting the later repriductive life during which traditional management exclusively on savannas is assumed.

Based on these parameters and on prices of 1983 a marginal analysis of the impact of each of the strategies for an initial herd of 100 cows and their respective followers is made. Table 2 indicates the evolution of the areas in improved pastures for each strategy and the implications in terms of percentage of the total farm area with sown pastures.

Various efficiency indicators, the marginal rate of return, the relative increase of the cash-flow and the relative increase of the herd's value in the 25th year are shown in Table 3. Early weaning and strategic nutrition

Table 1. Strategic use of improved pastures in cow-calf operations: technical coefficients

Coefficients	Traditional	Early Weaning			Improved feeding of cows			Improved feeding of heifers		
		I	II	III	I	II	III	I	II	III
Calf mortality (%)	4	4	4	4	4	4	4	4	4	4
Adult mortality (%)	2	2	2	2	2	2	2	2	2	2
Mating of heifers (%):										
2-3 years	0	0	0	0	0	20	60	5	40	40
3-4 years	20	20	20	20	40	40	100	90	100	100
+ 4 years	100	100	100	100	100	100	100	100	100	100
Calving rate (%)	50	60	75	100	60	75	100	50	50	50
Culling rate (%)	16	16	16	16	16	16	16	16	16	16
Cow weight (kg)	310	340	400	500	340	400	500	310	310	310
Improved pasture requirements (head/ha):										
Calves		10	7	7						
Heifers								1.33	1.33	2.00
Cows					10	2.77	1.05			
Pasture persistence (years)		6	6	6	6	6	6	6	6	6
Refertilization frequency (years)		3	3	3	3	3	3	3	3	3
Mineral supplementation (kg/AU)		15	15	15	15	15	15	15	15	15

Table 2. Evolution of the required areas of improved pastures

Type of use[1]	Required areas of improved pastures			Relative area[2]
	Initial	10 years	20 years	
	ha			(%)
Early weaning:				
I	5	7	13	0.30
II	7	16	36	0.50
III	7	32	92	0.69
Improved feeding of cows:				
I	10	15	25	0.65
II	36	73	173	2.19
III	128	391	950	6.02
Improved feeding of heifers:				
I	20	27	50	1.42
II	27	41	60	2.09
III	18	27	40	1.38

1/ Alternatives I, II and II correspond to the coefficients reported in Table 18.6

2/ Area of improved pastures year 10 / total farm area (5 ha/AU)

Table 3. Expected performance of various strategic uses of improved pasture in cow-calf operations (100 cow unit)

Type of use	Marginal internal rate of return	Incremental cash flow [1]	Final value of herd [2]
Early weaning:			
I	37.96	54.45	73.16
II	45.50	146.07	236.31
III	51.71	403.40	707.72
Improved feeding of cows:			
I	34.87	60.20	75.81
II	29.02	172.70	297.50
III	22.22	359.16	787.50
Improved feeding of heifers:			
I	17.39	21.98	17.09
II	19.74	34.29	23.60
III	30.76	45.28	23.60

1/ Average of the years 10 to 15:

$$\frac{\text{Improved - traditional cash flow}}{\text{traditional cash flow}} \times 100$$

Traditional cash flow = $382,000

2/ $\frac{\text{Improved herd value - traditional herd value}}{\text{traditional herd value}} \times 100$

Traditional herd value (25 years) = 8'901,000

of cows always dominate the alternatives of strategic use for rearing heifers. Ever under conservative assumptions, attractive rates of return are obtained.

A large share of the production increase is capitalized in herd growth. This is the reason why the indicator of final value of the herd presents a higher variation among alternatives than the cas-flow in the years 10-15. Early weaning has the advantage of requiring only a very small investment in improved pastures while the growth of the herd constitutes the major investment. As cattle can easily be sold, this alternative offers a higher flexibility and less investment risk in pastures. On the other hand, early weaning requires more sophisticated management.

These results reveal the potential of the new germplasm, but at the same time document the importance of continuing systems experiments to evaluate these alternatives with more reliable data.

LAS MARGARITAS RANCH

LAS MARGARITAS

Area planted:	80 ha
Species sown:	*A. gayanus* 621 +
	S. capitata 1315
Date sown:	June/July 1981
Fertilization:	45 kg P_2O_5
	5.5 kg Mg
	11 kg K_2O
	11 kg S
Soil:	pH = 4.3
	P = 1.6 ppm
	Al Sat. = 90.3 %
	Clay = 48 %
	Sand = 20%
	Silt = 32%

RANCH LAS MARGARITAS

Dry matter, cover and chemical composition from a sward of *Andropogon gayanus* + *Stylosanthes capitata* 1019+1315

		1982 November	1983 April	1983 November
Availability DM/kg/ha^{-1}		2283±2170	785±428	1153±523
Botanical composition:				
Grass	%	28.5	54.5	69.0
Legume	%	71.5	45.5	31.0
Cover	%	34.5±30	21.5±10	19.0
Grass Chemical Composition:				
N	%	1.05±0.35	1.1±0.18	0.96±0.15
P	%	0.14±0.03	0.14±0.02	0.11±0.02
K	%	0.85±0.05	0.97±0.26	0.80±0.18
Ca	%	0.35±0.09	0.35±0.07	0.27±0.04
Legume Chemical Composition:				
N	%	1.85±0.21	2.47±0.18	2.15±0.11
P	%	0.13+0.03	0.16+0.01	0.18±0.02
K	%	0.41±0.03	0.76±0.17	0.68±0.06
Ca	%	1.78±0.37	1.22+0.20	1.06+0.09

"GUAYABAL" FARM

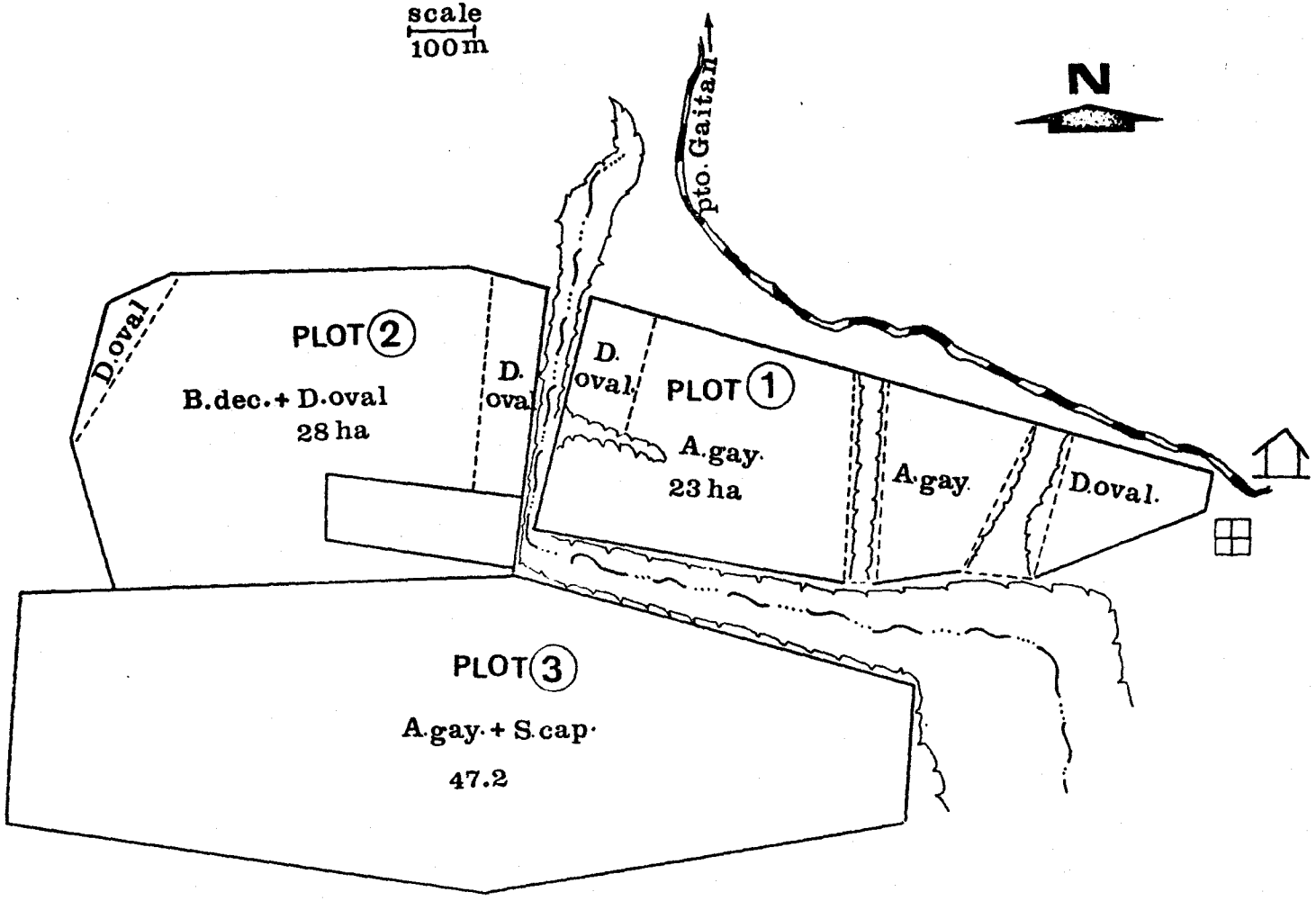
EL GUAYABAL (13)

Owner:	Dr. Jaime García
Manager:	Mr. Jesús Moreno
Ranching system:	Cow-calf, heifers, steers, fattening
Inventory:	120 cows, 100 heifers, 80 steers, 50 calves and 10 bulls
Surfase area:	1,412 ha (Stocking rate: 4.5 ha/AU)
Savanna:	1,262 ha in 2 paddocks
Forest:	50 ha
Topography:	Hills ("Serranía")
Soil analysis:	50% sand, 25% clay, pH = 4.5, P = 2-3 ppm, Al.sat. = 85%
Sown pastures:	100 ha in 3 paddocks
Date of planting:	May 1980

Project:

Strategic use of sown pastures for the breeding herd and temporary fattening

"GUAYABAL"


scale
100m
N
pto. Gaitan
PLOT 2
B.dec.+ D.oval
28 ha
D.oval
D.
oval
D.
oval
PLOT 1
A.gay.
23 ha
A.gay.
D.oval.
PLOT 3
A.gay.+ S.cap.
47.2

March 17, 1982
Estrada-Seré

PRELIMINARY ANALYSIS OF ONE YEAR OF FATTENING OF STEERS ON A 25 HA PASTURE OF BRACHIARIA DECUMBENS AND DESMODIUM OVALIFOLIUM AT THE "GUAYABAL" FARM

The present analysis is considered preliminary because only the first year of grazing has been completed and thus a series of assumptions had to be made. The approach followed was to estimate the marginal rate of return of shifting from the traditional land use of the area, extensive cow calf + feeder production on native savanna, to the fattening of steers on the improved pasture until finishing to be sold on the Bogotá market.

As far as possible actual data have been used and some alternatives are analyzed for the most sensitive or uncertain parameters.

Investment (Prices of 1981)

1)	Land Preparation, Fertilization and Seeding		
	a) 21 ha *B. decumbens* x $1,950/ha[1]		$ 40,950
	b) 4 ha *D. ovalifolium* x $1,950/ha		$ 7,800
2)	Fertilizers		
	a) Basic slag:		
	- 4 ha at 500 kg/ha x $3.9/kg . . .	$ 7,800	
	- 21 ha at 300 kg/ha x $3.9/kg . . .	$24,570	
	b) Sulpomag:		
	- 4 ha at 100 kg/ha x $15.2/kg. . .	$ 6,080	$ 38,450
3)	Seed		
	a) *B. decumbens*:		
	- 8 ha at 10 kg/ha[2] x $65/kg[2] .[3]. .	$ 5,200	
	- 13 ha at 2 kg/ha x $1,550/kg[3]. .	$40,300	
	b) *D. ovalifolium*:		
	- 4 ha at 4 kg/ha x $500/kg[4] . .	$ 8,000	$ 53,500
	PASTURE ESTABLISHMENT		$140.700
	PASTURE ESTABLISHMENT/HA.		$ 5.628
4)	Infraestructure		
	a) Fences: 25 ha x $1,789/ha	$44,725	
	b) Salt feeder: 1x $2,500	$ 2,500	$ 47,225
5)	Cattle		
	30 feeders weighting 263 kg each at a farm gate price of $45.63/kg liveweight		$360.000

1/ Actually the farmer was offered an attractive loan and bought a tractor. For the sake of comparability commercial prices of hiring machinery were used.
2/ Uncleaned seed as produced on farms.
3/ Commercial seed from Semillano, Villavicencio.
4/ Estimated.

Annual operating costs

30 head of cattle receiving mineral supplementation and vacines at $500/head/year	$ 15,000
Pasture refertilization (every second year)	
a) *B. decumbens*:	
Basic slag (100 kg/ha x 21 ha = 2,100 x 3.9/kg). .	$ 8,190
b) *D. ovalifolium*:	
Basic slag (100 kg/ha x 4 ha = 400 x 3.9/kg) . . .	$ 1,560
Sulpomag (68 kg/ha x 4 ha = 272 x 15.2/kg) . . .	$ 4,134
REFERTILIZATION.	$ 13,884

Output

At the end of the rainy season, 30 fat steers are sold every year weighting 375 kg liveweight.
A farm gate price of $41/kg is achieved.

30 steers x 375 kg each x $41/kg lw	$461,250

Opportunity cost incurred

a) Reduced investment:

As stated previously it was assumed that the farm had to reduce its traditional cow-calf + feeder production operation. Average prices and coefficients, typical of the Llanos were assumed.

Investment in cattle per animal unit (AU).	11,620
Stocking rate (AU/ha)	0.20
Size of the fattening scheme (has)	25
TOTAL investment reduction: 11.620 x 0.20 x 25. . .	$ 58,102

b) Reduced operating costs:

5 AU at $500/year mineral supplementation plus vaccines each.	$ 2,500

c) Reduced output:

In the traditional system $2,566/AU are sold of cull cows and feeders. ($2,566 x 5 AU)	$ 12,832

Assumptions underlying the present analysis

1. In spite of having only one-year data, the pasture was assumed to persist for 6 years with constant yields at the level of the observed year and to degrade to a pasture of a productivity of the same level of the savanna thereafter.

2. No value was attached to summer grazing with other animals due to the vast supply of high-quality forage from the lowlands (bajos) on this farm. This resource might be very valuable on other farms without "bajos", where mortality might be substantially reduced in particularly dry summer periods.

3. The analysis was undertaken in real terms using constant input and output prices of 1981. No access to subsidized credit was considered.
   Due to the use of an accounting period of one year, the exercise penalizes the internal return of the fattening process which ties most of the capital for only 9 months.

4. It was assumed that all 30 steers reached marketable weight within the 9 months fattening period in spite of the fact that, mainly due to the high variability of initial weight, only 2/3 of them were actually sold at the end of the rainy season.

Results

During the 9 months of rainy season the improved pasture produced:

111.6 kg lw/head
134.0 kg lw/ha
1.2 steers/ha

Actually the 4 hectares of *Desmodium ovalifolium* were not grazed. Considering only the 21 hectares of *Brachiaria decumbens*, the following performance was achieved during the rainy season:

111.6 kg lw/head
159.5 kg lw/ha

1.42 steers/ha

At Carimagua, assuming the same lenght of wet season (9 months), weight gains of 145 kg/head and 177 kg/ha were obtained in grazing experiments, if stocking rates are corrected on the basis of initial kg of liveweight per hectare. This comparison shows a gap between Carimagua and farm results, due to differences in soils, mineral supplementation, type of animals, herd management, etc. A better understanding of the relative importance of these factors would help to improve the technology design.

The economic performance is presented in Table 1, Alternative A. In spite of the lower physical performance, when compared to Carimagua, the marginal internal rate of return is acceptable and sensitive to the life of the pasture as shown by the increase from 9% to 12% when useful life is expanded from 6 to 20 years.

Due to the fact that *Desmodium ovalifolium* did not contribute to the production, an alternative was calculated where only the Brachiaria establishment costs were considered, i.e. the cost of the pasture actually grazed (Alternative B), a fact which raises IRRs by 2 percentage points.

Alternative C depicts the situation equivalent to Alternative A but assuming steers achieved the same gains per head as on Brachiaria in Carimagua. This raises IRRs substantially showing the potential benefits to be accrued if a more efficient technology transfer is achieved.

Finally Alternative D depicts the potential of straight Brachiaria, if the yield level of Carimagua were achieved, which shows very attractive economic performance (IRRs of 20% and 22%).

Conclusions

At the present stage only very preliminary conclusions can be drawn, and can only be stated for pure Brachiaria fattening activities.

Fattening on Brachiaria in the Llanos regions is moderately attractive

option, particularly for farmers with limited lowlands and not too far away from the market. At present the fattening of feeders in the Piedemonte is more attractive when paying agistment (IRR=31%) assuming weight gains similar to the ones of Carimagua.

Nevertheless this option is not open to many smaller farms, which produce only a low number of feeders. Here economies of scale in transporting store cattle on the hoof, and managing the fattening operation in the Piedemonte region, etc. make fattening on the own farm more attractive.

The sensitivity of the economic performance to weight gains achieved as well as the gap between the Carimagua and the "Guayabal" results points to the need for conducting fattening trials at various locations for a number of years. Part of them should be under complete control of the farmer, to identify the actual role of the improved pasture under farmer-conditions. This information, e.g. on relative value attached to dry and wet season forage supply is of utmost importance for the design of the pasture technology and specifically to determine the future role of legumes.

Table 1. GUAYABAL: marginal cash flow projection

a) **ALTERNATIVE A:** 25 ha pastures, 112 kg lw gains per steer

Item	1980	1981	1982	1983	1984	1985	1986	1987
Pasture establishment	-140,700							
Infrastructure	-47,225							23,612
Cattle		-360,000	-360,000	-360,000	-360,000	-360,000	-360,000	
Annual operating cost		-15,000	-15,000	-28,884	-15,000	-28,884	-15,000	
Output			461,250	461,250	461,250	461,250	461,250	461,250
Opportunity cost:								
Reduced cattle investment	58,102							
Reduced operating cost	2,500	2,500	2,500	2,500	2,500	2,500	2,500	-2,500
Reduced output		-12,832	-12,832	-12,832	-12,832	-12,832	-12,832	-70,935
Cash flow	-127,323	-390,332	75,918	62,034	75,918	62,034	75,918	411,427

IRR: 6 years pasture life 8.55
20 years pasture life 12.47

b) **ALTERNATIVE B:** 21 ha only *B. decumbens* pasture, 112 kg lw gains per steer

Pasture establishment	-111,020							
Infrastructure	-40,069							20,034
Cattle		-360,000	-360,000	-360,000	-360,000	-360,000	-360,000	
Annual operating cost		-15,000	-15,000	-23,190	-15,000	-23,190	-15,000	
Output			461,250	461,250	461,250	461,250	461,250	461,250
Opportunity cost:								
Reduced cattle investment	48,805							
Reduced operating cost	2,100	2,100	2,100	2,100	2,100	2,100	2,100	-2,100
Reduced output		-10,778	-10,778	-10,778	-10,778	-10,778	-10,778	-59,583
Cash flow	-100,184	-383,678	77,572	69,372	77,572	69,372	77,572	419,601

IRR: 6 years pasture life 11.21
20 years pasture life 14.49

Table 2. GUAYABAL: marginal cash flow projection

a) ALTERNATIVE C: 25 ha pastures, 145 kg lw gains per steer

Item	1980	1981	1982	1983	1984	1985	1986	1987
Pasture establishment	-140,700							
Infrastructure	-47,225							23,612
Cattle		-360,000	-360,000	-360,000	-360,000	-360,000	-360,000	
Annual operating cost		-15,000	-15,000	-28,884	-15,000	-28,884	-15,000	
Output		501,840	501,840	501,840	501,840	501,840	501,840	501,840
Opperating cost:								
Reduced cattle investment	58,102							
Reduced operating cost	2,500	2,500	2,500	2,500	2,500	2,500	2,500	-2,500
Reduced output		-12,832	-12,832	-12,832	-12,832	-12,832	-12,832	-70,935
Cash flow	-127,323	-390,332	116,508	102,624	116,508	102,624	116,508	452,017

IRR: 6 years of pasture life 16.58
20 years of pasture life 20.05

b) ALTERNATIVE D: 21 ha only *B. decumbens* pasture, 145 kg lw gains per steer

Pasture establishment	-111,020							
Infrastructure	-40,069							20,034
Cattle		-360,000	-360,000	-360,000	-360,000	-360,000	-360,000	
Annual operating cost		-15,000	-15,000	-23,190	-15,000	-23,190	-15,000	
Output			501,840	501,840	501,840	501,840	501,840	501,840
Opperating cost:								
Reduced cattle investment	48,805							
Reduced operating cost	2,100	2,100	2,100	2,100	2,100	2,100	2,100	-2,100
Reduced output		-10,778	-10,778	-10,778	-10,778	-10,778	-10,778	-59,583
Cash flow	-100,184	-383,678	118,162	109,972	118,162	109,972	118,162	460,191

IRR: 6 years of pasture life 19.63
20 years of pasture life 22.45

Economic analysis of fattening systems on improved pastures in the Colombian Llanos Orientales

Ruben Dario Estrada
Carlos Sere

ECONOMIC ANALYSIS OF FATTENING SYSTEMS ON IMPROVED PASTURES IN THE COLOMBIAN LLANOS ORIENTALES

The availability of 3 years experimental results from grazing trials with several pastures species and associations, have led to an assessment of the economic performance of these technologies in the area of interest of the Tropical Pasture Program at CIAT in Colombia: the Llanos Orientales. A preliminary analysis of some of these pastures used for fattening had been undertaken by Nores and Estrada in 1978.

The methodology used was similar to the one used by Nores and Estrada (1978). The internal rates of return were calculated at constant prices for a 300 ha model farm. The value of the land was not included, assuming the producer to be the owner of the land wishing to identify the best pasture alternative to use it for fattening purposes.

ASSUMPTIONS

The experimental results of the grazing trials are presented on Tables 1, 2 and 3. Table 4 presents the information on productivity is standardized for the economic evaluation. Uniform wet and dry season periods were used for all the alternatives and the stocking rates were corrected based on the initial live-weight per hectare to consider the difference between the initial live weight of 170 kg of the steers used in the grazing trials and the 250 kg live weight of the steers used commercially for fattening.

Table 5 shows the evolution of the weight of steers over time as a result of previous assumptions. The following animal management is assumed: fattening is iniciated in the dry season with low stocking rates and then the stocking rate is completed in the wet season with additional steers of 250 kg initial live weight. All the steers are sent to the market at the end of the rainy season.

In the evaluation of the different alternatives the levels of initial and maintenance fertilization every second year according to CIAT recommendations were assumed (Table 6). Due to the fact that the trials have been run for only 3 years, there is no empirical information about pasture persistence. Therefore pastures were evaluated at 6 and 12 years persistence assuming constant animal productivity until the last year at the same level

of the average for the first 3 years. Additional assumptions on prices and costs are reported on Table 7.

RESULTS AND CONCLUSIONS

The average production of all the grazing trials evaluated was 160 kg/animal/year and 220 kg/ha/year. With these levels of productivity the rates of return are attractive (between 10 and 30%) and present a low sensitivity to pasture persistence beyond 6 years (Table 8).

Due to the sample size of the experiments evaluated and the variability between years, it is not possible to infer about the statistical significance of the differences observed. Thus, observed differences are considered as certain estimates of the performance of each type of pasture.

The performance of *Brachiaria decumbens* alone (System 3) was used as a base for the comparison among alternatives. It should be pointed out that using this performance as a reference might to a certain extend bias the results due to the characteristics of the dry season on the last few years. Some rainfall during the dry season encouraged grass growth during this period, probably causing a reduction in legume consumption. More severe drought stress periods might have resulted in greater advantages for the strategies with legumes.

The associations *A.gayanus* + *S.capitata*, *B. decumbens* with *P.phaseoloides* in strips and the use of the savanna with 0.2 ha *P.phaseoloides* protein bank with low stocking rate (0.17 steers/ha) present internal rates of return substantially superior to *B.decumbens* alone. It should be pointed out that the real cost of the savanna with legume bank (Systems 4 and 5) might be somewhat underestimated due to :

- The level of fertilization for *P. phaseoloides* which in practice was above the recommended by CIAT. In the analysis only the recommended rates were included.
- The investment in fences and infraestructure per hectare, assumed for the alternatives with high stocking rate was not included in this case, because it was considered that a solution of extensive improvement of this type would be managed on bigger areas with minimum inputs of this category per hectare.

The superiority of certain strategies with legumes, leads to the question whether the increase in rate of return would be sufficient to make it attractive to the rancher. While the presently-used technology of pure *Brachiaria decumbens* involves serious risks due to photosensitation of cattle and spittlebug damage, the new legume-grass technology involves some additional costs due to:

- Higher risk of establishment due to the incremental seed cost of the legume.
- Risk of damage due to accidental burning of the pasture implying incremental costs of maintaining firebreakers, etc.
- More sensitivity to management, frequently requiring more fencing and water points, and the need to neglect fire and to some extent herbicides as management tools.

These are typical "second-generation" problems which will require a research input in future years.

At present the lack of use of legumes at commercial levels does not allow to estimate how the producer in the Llanos Orientales views the advantages and disadvantages of using legumes for fattening.

Fattening on ranches on the well-drained savannas would be particularly attractive to small and medium sized producers due to economies of scale in the transportation of store steers on the hoof (it costs almost the same to herd a small lot or a large one) and in share-fattening in the Piedmont, opposed to lesser economies of scale in the fattening on farms and transportation on trucks to the market.

Improved pastures for fattening on farms also running cow-calf operations, could have a series of alternate uses during the dry season such as a reduction in mortality of weak animals, reconception of lactating cows, etc. There are evidences that, particularly in the case of reconception of lactating cows, the intake of forage legumes could be very important. If this is proved to be true, there would be more advantages to the alternatives of legume pastures compared to the quantified ones in the present

analysis. These benefits would however, be very variable between ranches, production systems, the amount of lowlands available on the ranch, etc.

The cost of seed and land preparation constitute a large proportion of total establishment costs. Once the initial investment on machinery and establishment of the first acreage of improved pasture have been undertaken, from which seeds could be harvested, the marginal cost of increasing the pasture area will substantially decrease.

The comparison of the internal rates of return to investment (without land) of regions in Llanos at increasing distances from the main market, Bogota, shows decreasing rates of return due to transportation cost of inputs and products. Due to the presently large decrease of land prices with increasing distance from Bogota, the internal rates of return to total capital are higher the more remote regions.

This static analysis shows a rent to the early adoption of technology, which within the usual tread-mill process will vanish due to an increase in land prices. Thus, on the long run the land use pattern of fattening at locations close to the market and producing store cattle at more distant locations can be expected to remain stable.

Table 1. Live weight gains of steers grazing on savanna + *Pueraria phaseoloides* legume bank[1], in Carimagua. Three years average. 1979-1981

Stocking rate steers/ha	Dry season 109 days		Wet season 258 days		Total annual 367 days	
	g/AU day	kg/AU	g/AU day	kg/AU	kg/AU	kg/ha
0.25	136	15	432	112	127	32
0.50	55	6	373	97	102	51

[1] 0.2 ha/steers

Fertilization

- Kudzu (*Pueraria phaseoloides*)
  - . Establishment : 100 kg/ha P_2O_5, 50 K_2O, 18 MgO, 21 S 1978
  - . Maintenance : 19 kg/ha P_2O_5, 22 K_2O, 18 MgO, 21 S 1980
    110 kg/ha of Sulpomag (October)..... 1981

Table 2. Liveweight gains of steers grazing *Brachiaria decumbens* + *Pueraria phaseoloides* legume protein bank in blocks and strips at Carimagua. Three years average. 1979-1981

Treatment	Stocking[1] rate steers/ha	Dry Season 103 days		Wet Season 250[2] - 230[3] days		Total annual 359[2] - 339[3] days	
		g/AU/day	kg/AU	g/AU/day	kg/AU	kg/AU	kg/ha
Grass	1.3/1.93	201	22	528	132	154	277
Grass + legume (30%) blocks	1.3/1.95	347	38	492	113	151	270
Grass + legume (30%) strips	1.3/1.87	468	51	568	131	182	316

1 Stocking rates dry/wet seasons, respectively

2 Days of grazing grass alone

3 Days of grazing grass with legume blocks and strips

Fertilization

- *Brachiaria decumbens* (all treatments)
  Establishment: 75 P_2O_5 kg/ha..... 1978

- *Pueraria phaseoloides* (in blocks and strips)
  Establishment: 100 P_2O_5, 50 K_2O, 18 MgO, 21 S.....1978
  Maintenance : 22 K_2O, 18 MgO, 22 S.....1979

Table 3. Liveweight gains of steers grazing *Andropogon gayanus* associated with different legumes in Carimagua. Three years average. 1979-1981

Treatment	Stocking rate[1] (steers/ha)	Dry Season 103 days		Wet Season 263 days		Annual total 366 days	
		g/AU/day	kg/AU	g/AU/day	kg/AU	kg/AU	kg/ha
Andropogon gayanus +							
. *Stylosanthes capitata* 1405	1.24/1.94	255[2]	24	636[2]	155	178	336
. *Stylosanthes capitata* 1019 + 1315	1.21/1.80	283	29	659[3]	165	194	335
. Zornia sp.	1.21/1.31	148	15	636	167	182	253
. *Pueraria phaseoloides*	1.21/1.83	371	38	596	157	195	330

1/ Stocking rates dry/wet seasons, respectively
2/ 94 and 243 days for dry and wet season, respectively
3/ 250 days for wet season

Fertilization

- *Stylosanthes capitata* (1019+1315) and 1405. Zornia sp.
  - . Establishment: 50 kg/ha P_2O_5, 22 K_2O, 18 MgO, 21 S 1978
  - . Maintenance: 11 kg/ha P_2O_5, 13 K_2O, 11 MgO, 13 S 1980
- Kudzu (*Pueraria phaseoloides*)
  - . Establishment: 100 kg/ha P_2O_5, 50 K_2O, 18 MgO, 21 S 1978
  - . Maintenance: 19 kg/ha P_2O_5, 22 K_2O, 18 MgO, 21 S 1980

Table 4. Productivity assumed for economic evaluation

System No.	DRY SEASON (3 1/2 months)				WET SEASON (8 1/2 months)				TOTAL ANNUAL	
	Stocking rate (steers/ha)		g/ day	Total (kg/ steer)	Stocking rate (steers/ha)		g/ day	Total (kg/ steer)	kg/ steer	kg/ha[2]
	A[1]	B[2]			A[1]	B[2]				
1. Savanna + Kudzu (0.17 steers/ha)	0.3	0.17	136	14.2	0.3	0.17	432	112.3	126.5	21.5
2. Savanna + Kudzu (0.34 steers/ha)	0.5	0.34	55	5.7	0.5	0.34	373	96.9	102.6	34.9
3. *B.decumbens*	1.3	0.88	201	21.1	1.9	1.29	528	137.3	158.4	195.7
4. *B.decumbens* + Kudzu-blocks	1.3	0.88	347	36.4	1.9	1.29	492	127.9	164.3	197.0
5. *B.decumbens* + Kudzu-strips	1.3	0.88	468	49.1	1.9	1.29	568	147.6	196.7	233.6
6. *B.decumbens* in ranches	-	-	-	-	-	1.26	430	112.0	112.0	141.1
7. *A.gayanus* + *S.capitata*	1.2	0.82	255	26.7	1.9	1.29	636	165.3	192.0	235.1
8. *A.gayanus* + Zornia	1.2	0.82	148	15.5	1.3	0.88	636	165.3	180.8	158.2
9. *A.gayanus* + Kudzu	1.2	0.81	371	38.9	1.8	1.22	596	154.9	193.8	220.1

1/ Stocking rate used in experiments based on steers 170 kg initial liveweight
2/ Stocking rate based on steers 250 kg initial liveweight adjusted for similar liveweight per hectare

Table 5. Number of steers fattened and liveweight changes by alternatives, 300 ha ranch

System No.	Beginning Fattening Dry Season				Beginning Fattening Wet Season			kg fatten steers sold/ha/year
	Number of animals	Weight (kg) Beginning dry season	Weight (kg) End dry season	Weight (kg) End wet season	Number of animals	Weight (kg) End dry season	Weight (kg) End wet season	
1. Savanna + Kudzu (0.17 steers/ha)	51	250	264.2	376	-	-	-	63.9
2. Savanna + Kudzu (0.34 steers/ha)	102	250	255.7	352	-	-	-	119.6
3. *B. decumbens*	264	250	271.1	408	123	250	387	517.7
4. *B. decumbens* + Kudzu-blocks	264	250	276.4	414	123	250	377	517.7
5. *B. decumbens* + Kudzu-strips	264	250	299.1	446	123	250	397	555.2
6. *B. decumbens* in ranches	-	-	-	-	378	250	362	456.1
7. *A. gayanus* + *S. capitata*	246	250	276.7	442	141	250	415	557.4
8. *A. gayanus* + Zornia	246	250	265.5	430	18	250	415	377.5
9. *A. gayanus* + Kudzu	246	250	288.9	443	120	250	404	524.8

Assumption: Fattening started during dry season with low stocking rate and adjusted to high stocking rate at the beginning of the rainy season

Table 6. Levels of fertilization for establishment and maintenance used per hectare

System No.	Establishment				Maintenance				
	Calfos	Sulpomag	Total value[1]	Total	Calfos	Sulpomag	Frecuency years	Total value[1]	Total
	------ kg ------		$	kg	------ kg -------		No.	$	kg
1. Savanna + Kudzu (0.17 steers/ha)	30	11.3	293	43	5.9	5	2	108	11
2. Savanna + Kudzu (0.34 steers/ha)	60	22.6	586	83	11.8	10	2	216	22
3. *B. decumbens*	468	-	1404	468	300	-	2	900	300
4. *B. decumbens* + Kudzu-blocks	514	68	2766	582	210	30	2	1170	240
5. *B. decumbens* + Kudzu-strips	514	68	2766	582	210	30	2	1170	240
6. *B. decumbens* in ranches	300	-	900	300	150	-	2	450	150
7. *A. gayanus* + *S. capitata*	300	100	2700	400	68	60	2	1284	128
8. *A. gayanus* + Zornia	300	100	2700	400	68	60	2	1284	128
9. *A. gayanus* + Kudzu	600	227	5886	827	118	100	2	2154	218

1/ Based on Bogotá prices: Col$ 3000/ton basic slag
Col$18000/ton Sulpomag

Table 7. Costs and prices assumed Col.$ 1.981

Description	Puerto Lopez	Puerto Gaitán	Carimagua
Transportation ($/ton)	980[a]	1.535[b]	2.110[c]
Steers[d]: ($/kg liveweight on farm)			
Lean	60.oo	59.40	58.80
Fat	57.60	56.17	54.73
Seed: ($/ha)			
S. capitata (3 kg/ha)	1.500	1.500	1.500
Z. latifolia (1 1/2 kg/ha)	750	750	750
P. phaseoloides (4 kg/ha)	2.400	2.400	2.400
A. gayanus (8 kg/ha)	3.200	3.200	3.200
B. decumbens (1 1/2 kg/ha)	3.000	3.000	3.000
Land preparation cost($/ha)	2.000	2.000	2.000
Investment: ($/ha)			
Fences	1.384	1.384	1.384
Infraestructure	1.666	1.666	1.666
Variable costs: ($/UA)			
Minerals	450	450	450
Labor	450	450	450
Other	200	200	200

a 196 km from Bogota

b 307 km from Bogotá

c 422 km from Bogotá

d Prices adjusted per cost of transportation, but without taking into consideration difference in body weight losses due to transportation

Table 8. Profitability[1] of fattening with different alternatives of improved pastures according to geographical location in the Colombian Llanos and pasture persistance

System No.	Geographical Location					
	Puerto López		Puerto Gaitán		Carimagua	
	Persistance		Persistance		Persistance	
	6 years	12 years	6 years	12 years	6 years	12 years
1. Savanna + Kudzu (0.17 steers/ha)	24.18	24.89	22.10	22.86	20.01	20.87
2. Savanna + Kudzu (0.34 steers/ha)	17.10	17.79	15.06	15.70	13.11	13.89
3. *B.decumbens*	22.58	24.65	20.55	22.69	18.48	20.69
4. *B.decumbens* + Kudzu-blocks	20.75	23.11	18.77	21.13	16.75	19.20
5. *B.decumbens* + Kudzu-strips	26.78	28.88	24.70	26.90	22.58	24.88
6. *B.decumbens* in ranches	14.04	16.23	12.47	14.73	10.69	13.04
7. *A.gayanus* + *S.capitata*	28.08	30.40	26.14	28.08	24.22	26.23
8. *A.gayanus* + Zornia	21.75	24.40	19.82	22.65	18.01	20.87
9. *A.gayanus* + Kudzu	21.02	23.79	19.03	21.61	16.89	17.78

1/ Internal rate of return (IRR) of 300 ha operation excluding land value.

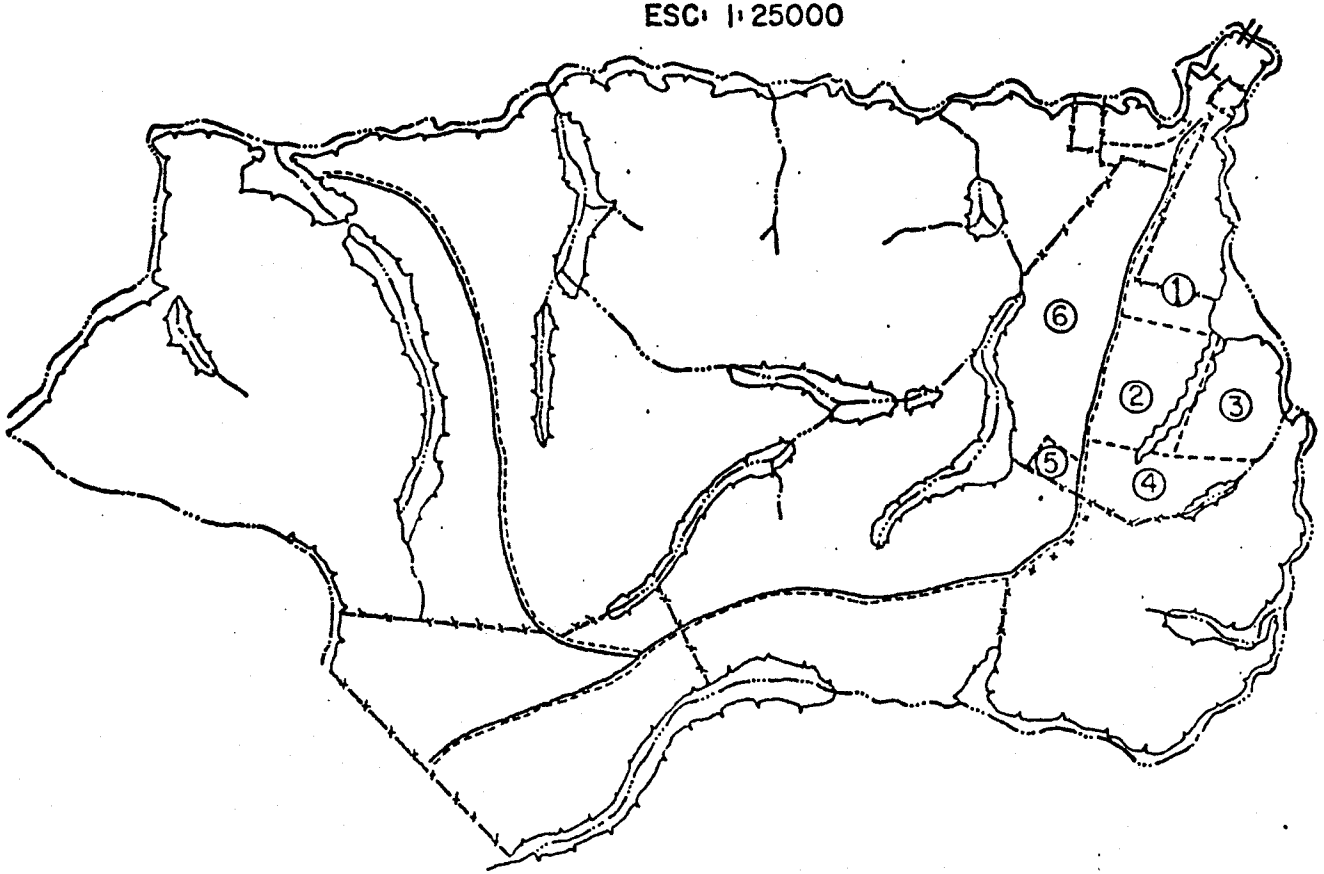
EL VIENTO

EL VIENTO (04)

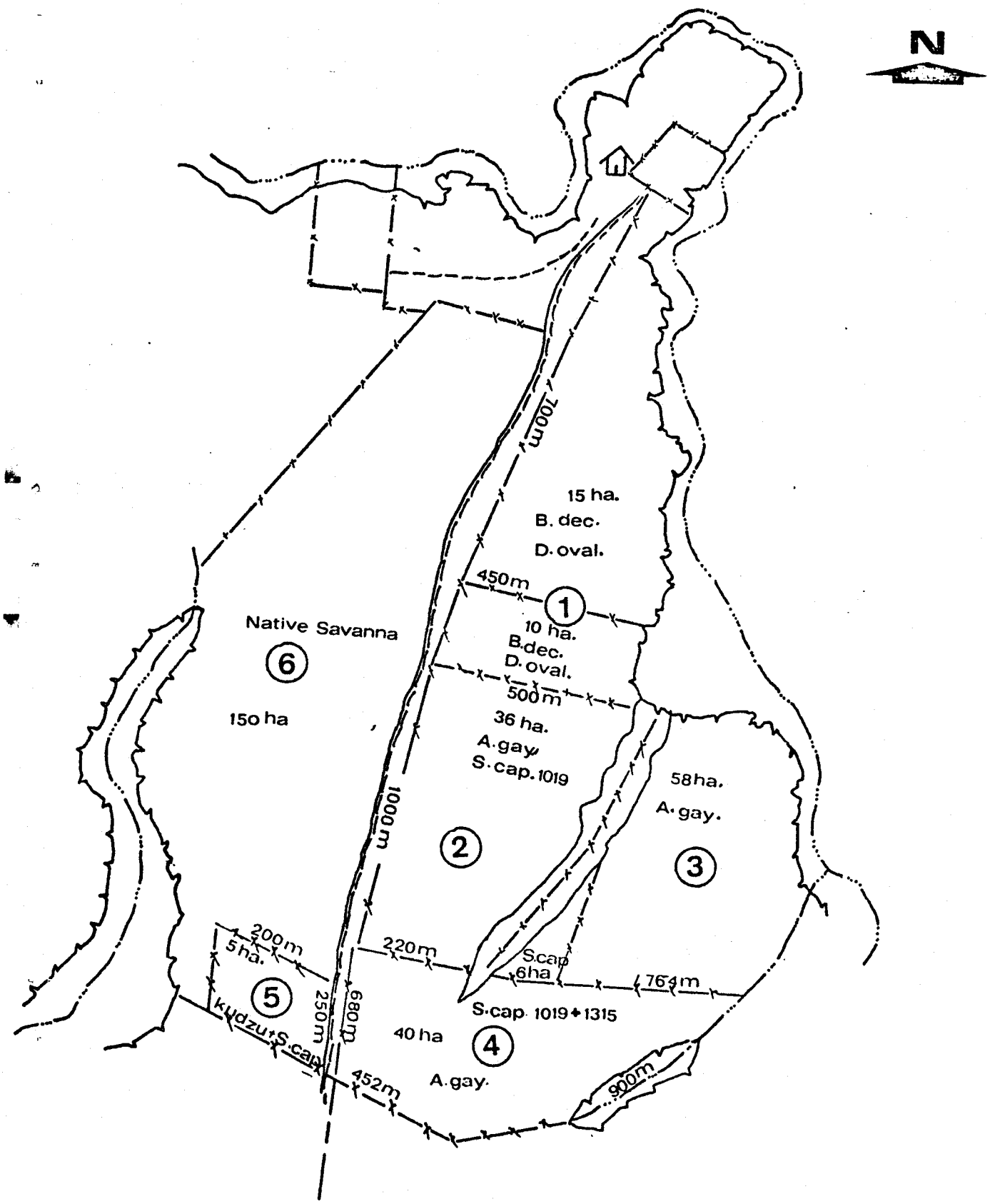
Owner:	Fundación Stroud
Manager:	Mr. Miguel Barreto
Ranching system:	Cow-calf
Inventory:	400 cows, 100 heifers, 20 bulls, 200 calves
Surface area:	3,052 ha (S.R.: 4.7 ha/AU)
Savanna:	2,810 ha in 10 paddocks
Forest:	72 ha
Topography:	Undulated savanna
Soil analysis:	40% clay, 40% sand, pH = 4.5, P = 1 ppm, Al sat. = 90%
Sown pastures:	170 ha in 6 paddocks
Proportion of sown pastures:	5.6%
Project:	Strategic use of sown pastures for the breeding herd

EL VIENTO

ESC: 1:25000



"EL VIENTO"


N
100m
15 ha.
B. dec.
D. oval.
450m
1
10 ha.
B.dec.
D. oval.
500m
36 ha.
A. gay.
S. cap. 1019
58ha.
A. gay.
3
2
100m
Native Savanna
6
150 ha
200m
5 ha.
220m
S.cap
6ha
764m
5
250m
680m
kudzu+S.cap
40 ha
4
S.cap. 1019+1315
A.gay.
452m
900m

"EL VIENTO": CASE STUDY

"El Viento" is a typical ranch of the Eastern Plains of Colombia. It is a cow-calf operation on poor savanna soils. Table 1 shows the factor endowment of "El Viento".

In early attempt to test the forthcoming pasture technology on commercial farms, 154 hectares of improved pastures were established in 1979 and 1980. The specific objective was to test the hypothesis that the improvement of a small percentage of the farm area, could significantly improve the productivity of cow-calf systems, which are the predominant land use in most of the South American savannas.

Table 2 gives the area of pastures established. It must be stressed that as early as 1979 little information was available on management and performance of associated pastures. Thus the performance of this farm has to be understood as the result of a notional technology managed by best-bet decisions. In the meantime substantial additional knowledge has accumulated.

The area improved only amounts to 5.5% of the grazing area of the farm thus pinpointing the focus of the program on the strategic use of improved pastures in cow-calf systems, consistent with characteristics of cow-calf systems: its capability to make use of distant and low-quality but also-low cost forage resources.

Table 1. "El Viento" factor endowment

Farm area:	3052 hectares
Savanna:	2810 hectares in 10 paddocks
Forest:	72 hectares
Sown pastures:	154 hectares
Soil analysis:	pH 4.5, P level ≃ 1 ppm, Al saturation ≃ 90% Texture 40% clay 40% sand
Type of operation:	
Cattle inventory (1979):	400 cows 100 heifers 20 bulls 200 calves

Table 2. Areas of improved pastures

Andropogon gayanus - Stylosanthes capitata	80 ha
Brachiaria decumbens - Desmodium ovalifolium	25 ha
Andropogon gayanus	40 ha
TOTAL area of improved pastures	154 ha
TOTAL pasture area	2810 ha
Percentage improved pastures	5.5 %

Impact of these pastures on whole herd performance is depicted in Tables 3 and 4. Changes are gradual over time and the situation is still dinamic after 4 years. This is mainly due to the larger amount of feed needed to increase cow weight of the whole herd, the driving force behind higher calving rates and weaner weights.

In spite of the very low percentage of the farm area improved, a marked increase in stocking rate can be observed (85%). This increase in stocking rate was accompanied by a significant ($P < 0.01$) increase in corrected live-weight of cows (Table 3). Reproductive performance also increased (Table 4); the actual weaning rate in 1982 was 63% and was due to a combination of improved nutrition as reflected in mean liveweight, and culling of cows for fertility. In these systems, culling for fertility is seldom practiced; it can be argued that the introduction of improved pastures induced more intensive management as well as the keeping of records, which then allowed culling. On the other hand, if sub-fertile cows had not been identified and had remained in the herd, the weaning rate would have been 57% (Table 4).

Table 5 describes the marginal benefits associated with the trial. In 1980 and 1981 the farmer sold 70 cull cows each year at higher weight. Higher weaning rates and higher calf weights lead to more kg of calf produced. Additional calves were also produced due to the introduction of 134 additional cows. Finally it was estimated that improved cow weights had led to a reduction of the cow mortality rate by two percentage points.

Benefits have changed both in absolute terms and in structure over time,

Table 3. Cow numbers and weight in "El Viento"

	1979	1980	1981	1982	1983	Change %
Number of cows	330	328	390	427	446	35
Uncorrected liveweight, kg	255	308	303	313	328	29
Corrected[1] liveweight, kg	229[a]	367[b]	299[c]	306[d]	326[e]	42
Stocking rate, AU/ha	0.13	0.17	0.17	0.22	0.24	85

1 Average cow weight corrected to the condition dry-empty and 6-7 years of age ($P < 0.01$)

Table 4. Weaning rate and weight

	1979	1980	1981	1982	1983	Change %
Weaning rate, %	50	53	53	57	57	14
Weaning weight[1], kg	109	129	129	144	162	49

1 Weaning at 9 months of age

Table 5. Marginal benefits of improved pasture use

	1980	1981	1982	1983
1. Sale of cull cows (No.of cows sold × kg incremental weight × price per kg)	(70)(70)(0.96) = **4.704**	(70)(70)(0.96) = **4.704**		
2. Incremental weaner weight (No.of weaners × incremental weight × price per kg)	(165)(20)(1.07) = **3.531**	(165)(20)(1.07) = **3.531**	(165)(35)(1.07) = **6.179**	(165)(53)(1.07) = **9.357**
3. Incremental weaning rate (No.of cows × increment × price per calf)	(330)(0.03)(126.5) = **1.252**	(330)(0.03)(126.5) = **1.252**	(330)(0.07)(154.3) = **3.564**	(330)(0.07)(173.6) = **4.010**
4. Reduction of mortality (No.of cows × reduction × value of cow)	(330)(0.02)(235.0) = **1.551**	(330)(0.02)(235.0) = **1.551**	(330)(0.02)(235.0) = **1.551**	(330)(0.02)(235.0) = **1.551**
5. Additional calves due to stocking rate increase (No.of additional cows × weaning rate × price per calf *)			(100)(0.57)(154.3) = 8.795	(134)(0.57)(173.6) = **13.259**
TOTAL	**11.038**	**11.038**	20.089	**28.177**

* Net value of a calf after deducting variable costs (minerals and drugs).

having more there doubled from 1980 to 1983 at constant 1979 prices. While in the first two years the incremental weight of the cull cows represented 42% of the total benefit, in later years the major benefits were the additional calves due to increased stocking rates and the incremental weight of the calves, only then followed by the benefit of the increased weaning rate.

The structure of the benefits is a reflection of management decisions by the farmer, particularly concerning the trade-off between higher body weights of cows and higher stocking rates, i.e. more cows on the farm.

The cash flow analysis (Table 6) shows an initial investment of US$27000 (1979 prices). After two years of negative cash flows positive values are achieved, which by year four lead to a positive cash flow of the size of the investment even if the investment is not terminated there as assumed in this example.

The initial investment necessary roughly corresponds to the gross income of one year of traditional production.

This leads to marginal internal rates of return between 19% and 35% according to the assumptions made on future persistence of the pasture (Table 7). These performance indicators as well as the large number of open questions clearly warrant further research in this area.

Table 6. Marginal cash flow (US$ 1979 prices)

	1979	1980	1981	1982	1983
Investment					
a) Pasture establishment	24347	11374			
b) Infrastructure	2679				
c) Cattle			23501	7990	
Inflows					
a) Production increase		11038	11038	20089	28177
b) Residual value pastures					28202
c) Residual value infrastructure					1598
d) Residual value additional cows					31492
Outflows					
a) Mineral feeds				116	164
b) Drugs				116	164
c) Pasture maintenance					1433
Net cash flow	27026	-336	-12463	12331	87708

Table 7. Marginal internal rate of return of "El Viento" pasture investment

Improved pasture scenario	IRR (%)
a) Worthless after year 4 of production	19
b) Worth 80% of initial investment at the end of year 4	31
c) 12 year persistence with refertilization every third year at 1983 level	35

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DEVELOPMENT OF IMPROVED GRAZING SYSTEMS IN THE SAVANNAS OF TROPICAL AMERICA

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1. Introduction

The savannas of tropical America constitute one of the largest, almost untapped, land resources of the world. High solar radiation, ample rainfall and soils of excellent physical properties as well as sociopolitical and economic pressures have made the development of appropriate land use systems for this region a major challenge.

This paper addresses some of the problems to be faced and presents strategies developed to overcome them.

2. Natural Resources

About half of tropical America is covered by Oxisols and Ultisols which occupy 850 million ha and extend from southern Mexico to northern Paraguay. Throughout the subcontinent, these soils are acid (pH 4 to 5), of medium to high in Al saturation (25-90%), low fertility (P <5 ppm; low in K, Ca, Mg, S, Zn) but have good physical characteristics. On a country-by-country basis they represent anywhere from 2% (Mexico) to 84% (Trinidad) of the area and therefore agricultural development on these soils is assigned varying priorities.

Grasses are the main contributors to both biomass production and cattle diet; the Trachipogon spp. savannas predominate in the well drained soils of the Orinoco basin (Blydenstein, 1967), while Paspalum notatum, Paspalum spp., Panicum spp. and Aristida spp. dominate the grass cover of the Cerrado (Rodriguez et al., 1979). Legumes contribute only a small proportion of the total vegetation although many species are native to the region, some of which have been used commercially.

The nutritional value of most native pastures is low, particularly in the Orinoco basin, and management practices to improve their value such as burning have only short-term effects (see 3.2). As a consequence of poor forage quality year-round and low dry season productivity carrying capacities are very low and thus very extensive ranching systems predominate.

3.2 Cattle Production Systems

Traditional cow-calf ranching systems of the region have been studied in detail (Vera and Seré, 1983). Ranches tend to be large (1500-3000 ha), in inverse proportion to land value (US$30 - 230/ha). Average herd size is about 600 head and therefore stocking rates vary between 0.1 to 0.2 AU/ha. The availability of other resources varies between countries due to different agricultural policies. Heavy subsidies in Brazil stimulated the introduction of well-fertilized cash crops, mostly rice, leading to heavier use of labour, fertilizers and machinery. Low (subsidized) costs of mechanization, infrastructure and fertilizers in Venezuela, led to heavy use of machinery and the planting of well-fertilized and high

nutrient-requiring grasses such as Digitaria decumbens, while use of costly labour remained low. On the other hand, in the Colombian plains the existing ranching systems are least intensive due to the high cost of all inputs, low land values and lack of specific development policies.

Animal productivity in all three countries is low (Table ?) and is clearly associated with poor, year-round nutrition. Nevertheless, physical productivity of the system is substantially higher in Brazil and Venezuela due to the presence of annual crops and, in the latter country, of limited milk production. Not surprisingly, the economic performance is modest (Table 3) and heavily influenced by crop production.

Options for improving cattle productivity without the use of external inputs are extremely limited. Despite fairly high rainy season forage yields from native vegetation, rapid deterioration of nutritional quality (Table 4) makes much of the forage effectively unavailable (Paladines and Leal, 1979). Temporary improvements in forage quality and animal productivity can be obtained by sequential burning of the savannas but not through rotational grazing, and other management practices (Paladines and Leal, 1979). Nevertheless, these improvements in weight gain (40 vs. 80-90 kg/head.year in unburned and sequentially burned savanna respectively) can only be realized if animals are consistently supplemented with mineralized salt, a high-cost input which in the Colombian plains accounts for 65% of the value of all purchased inputs in traditional systems. Case studies conducted on ranches applying various "improved" management practices, have clearly shown that techniques such as the use of subdivisions, controlled mating, separation of different animal categories and

others do not result in improved production per animal or per hectare, at present nutritional levels (Habich and Kleinheisterkamp, 1983). On the other hand, improvement in nutrition brought about by introduction of sown pastures and more diversified forage resources may be responsible for the apparent higher returns to management observed in ranches of the Brazilian Cerrado (Minhorst and Weniger, 1983; Serê, Carrillo and Estrada, 1983). In view of the above, and considering the limitations of existing introduced grasses (see 4.2), new forage species are required which are adapted to acid, infertile soils, have higher nutritive value, and are compatible with existing level of resources and management.

4. Improved Cattle Production Systems

4.1 Supplementation with Legumes (Protein Banks)

The use of pure legume pastures is not a new idea, but it is especially attractive for savanna ecosystems due to the low quality of the native grasses and low opportunity cost of land. Weed and grass invasion is controllable. Under these conditions some exotic legume species such as Pueraria phaseoloides and possibly Desmodium ovalifolium persist with low fertilizer inputs. An experiment has shown that the availability of 2000 m^2 of Pueraria phaseoloides per head as a supplement to the regularly burned savanna results in increases in weight gain ranging from 6 to 24% per head and 58 to 168% per hectare (Table 5). The effect of the legume on animal performance is especially marked during the dry season, during which, and contrary to what is observed in the wet season, animals showed a marked

selectivity towards the legume. Legumes that remain green longer into the dry season are being investigated both in the Orinoco basin and the Cerrados by CIAT (1981) and others (Vera et al., 1981). In the latter region, legume pastures may play an additional role in restoring soil fertility to rice stubbles, while benefiting from the residual effect of fertilizer and lime applied to the crop; in this case the range of adapted legumes is larger.

These simple protein bank-savanna systems have also produced attractive economic results. Internal rates of return between 13 and 24% p.a. were obtained in whole-farm-simulations of Pueraria phaseoloides - savanna systems using experimental results (Estrada and Seré, 1982). The same concept applied to cow-calf systems is currently being tested, while its use for milk production in dual-purpose systems also resulted in 10-20% increases in individual performance and 60-80% in production per hectare (Paterson et al., 1981) during the dry season. This concept is especially attractive for milk production since in traditional dual-purpose systems milking is discontinued during the dry season, the period of the year when milk prices are highest. In some cases, dry season production determines the year-round milk delivery quota.

Implications of the above results in a whole-system context have yet to be fully analyzed. It is unlikely that steers could be finished in these simple systems, but it is reasonable to anticipate that weaners could be raised successfully to 250-280 kg liveweight in less than two years for later transfer to a finishing pasture. Extrapolation of the available results to the rearing of replacement heifers suggests that age at mating could be diminished by about one year. Assuming no other improvements in reproductive performance, the

use of such a supplement would result in a 25% increase in calf production per cow over its lifetime. It remains to be established what, if any, are the effects of protein banks on the fertility of breeding cows, a subject currently under investigation.

While savannas are burnt the traditional way in conjunction with the use of protein banks, another strategy is to introduce the legume in strips in the native pasture without burning to improve the degree of utilization of the forage produced by the savanna thus making possible increases of stocking rates. This approach is at a very early stage of experimentation but early results are very promising.

4.2 Introduced Grasses

The introduction of improved grass species in the savannas of tropical America has a long history. With some species, such as Digitaria decumbens or Panicum maximum, success has depended heavily on the intensive use of fertilizers. Otherwise very few species have persisted in the Oxisols and Ultisols; in the Cerrados and parts of Central America, Melinis minutiflora and Hyparrhenia rufa are naturalized, while they have persisted without spreading in the Orinoco basin.

More recently, Brachiaria decumbens has spread rapidly in the Brazilian Cerrados where it is planted following rice. Case studies of farms in that region (Minhorst and Weniger, 1983) have shown that it is the main sown species and covers 10-15% of the area; it is estimated that 1 million ha exist in Brazil alone. It has also spread successfully in the Orinoco basin where it represents 3-4% of the area in parts of the Eastern Plains of Colombia (Habich and

Kleinheisterkamp, 1983; Seré and Estrada, 1983) and 10-12% in the Venezuelan Plains (Plessow, 1983). It is frequently planted without fertilizers and therefore its productivity is limited. Problems such as its susceptibility to spittlebug, lack of compatibility with available legume cultivars and occurrence of the photosensitization syndrome in cattle have led to the search for other species. The recent release of Andropogon gayanus in several countries is the product of its adaptation to acid soils, good resistance to the dry season, resistance to spittlebug and greater potential compatibility with legumes.

Both grasses have shown roughly similar productivity levels (100-120 kg/head and 300-350 kg/ha) (Tergas et al., 1982; CIAT, 1981), and additionally offer farmers the opportunity of fattening their own steers rather than having to sell store cattle. Returns to fattening are high throughout the region; specialized fattening operations obtain between 17% and 28% p.a. of return to total capital (excluding land). Due to transportation costs, highest returns are achieved at locations close to the main markets, thus explaining their concentration in regions like the Piedmont of the Colombian Andes which supplies 60% of the beef consumed by the city of Bogotá.

The use of these grasses for the breeding herd in late pregnancy and during the mating season have led to significantly reduced calving intervals, improved weaning weights, and increased calving percentages while still allowing access to improved pastures of other animal categories (CIAT, 1983) during the remaining six months.

4.3 Grass-Legume Pastures

Productive and persistent legume cultivars adapted to acid, infertile soils have been difficult to identify, although several species are native to the region.

The introduced Pueraria phaseoloides has been successful as a protein bank as well as in association with Brachiaria decumbens and Andropogon gayanus. The native Stylosanthes capitata associates well with Andropogon gayanus while several Centrosema spp.; Desmodium ovalifolium and others are promising.

Results available so far for sown grass-legume pastures have shown increases over straight-grass pastures in terms of weight gain per head (183 vs. 145 kg/head) but not per hectare (Tergas et al., 1984). This makes legume-grass pastures particularly attractive where cattle are expensive relative to land such as is the case in most of the Latin American savannas. On the other hand the incremental production due to the legume has to offset the additional costs of legume seed, additional fertilization and weeding in some locations as well as the requirement of more careful management. Persistance of the legume component in legume-grass associations is still not fully understood and quantified. Simulation analyses have shown the high sensitivity of the return on pasture investment to persistence of pastures of less than six years, particularly for the Colombian Eastern Plains.

On-farm trials have shown highly favorable biological and economic results following the introduction of improved grass-legume pastures in cow-calf systems. Over a four year-period, the carrying capacity of a ranch increased 30%, calving rates increased from 50% to

63%, liveweight of weaners at 9 months of age increased from 109 to 160 kg, and the adjusted weight of dry, empty, 5-year-old breeding cows rose from 280 to 330 kg when 6% of the farm was planted to grass-legume pastures. These changes have also, for the first time, allowed selection among the available replacement heifers and culling of breeding cows for fertility. Therefore, further improvements in reproductive performance are expected, as well as changes in the structure of the animal population. Economic performance is difficult to quantify in these systems at the present stage, due to limited availability of empirical evidence on pasture persistence, maintenance fertilization needs and other maintenance requirements as well as herd production coefficients beyond the first few years. During the initial years, the main benefits are increased weight of culled cows and calves; over time, increased reproductive efficiency and carrying capacity gradually become more important.

On-farm trials have up to now, emphasized the use of grass-legume pastures for the breeding herd. Pioneer farmers, using associated pastures, are integrating steer-fattening and cow-calf operations, and in some cases, even dual purpose milk production, thus maximizing economic gains from the improved pasture technology.

5. Outlook and Perspectives for Savanna Development

Land is not a scarce resource in Latin America as a whole. Historically, pressure to colonize the savannas has been low and when effective, it was determined more by sociopolitical reasons than economics. The low productivity of native pastures and the serious

limitations to crop growth impose a very low ceiling to the population density that the region can support.

The last few decades have seen a series of changes in this formerly static scenario. Population growth has increased pressure on land in more fertile areas displacing livestock with crops. This has led to rising beef prices and thus pressure on policy makers to promote beef production. The discovery of oil and minerals in the savannas has made the development of transportation infrastructure more attractive in some areas of Venezuela and Brazil. The location of Brasilia, in the midst of the Brasilian savannas, has greatly stimulated the development of productive farming systems in that ecosystem. The identification and in some cases actual exploitation of lime and rock phosphate mines in or near savanna regions have further enhanced the prospects for their development. In response to this changing setting, national and international development agencies have launched ambitious research projects; some initial results have just been presented.

Range improvement is a long-term process all over the world. In the Latin American savannas this process is just starting. Its potential is impressive but requires a persistent steady research effort only achievable through continuous support by far-sighted policy markers.

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Table 1. Above-ground production in the tropical savannas of America.

Country	Type of Savanna	
Brazil[a]	Cerrado, well drained savannas,	g DM/m^2.year
	at stocking rates of	
	0.2 AU/ha	195
	0.3	153
	0.4	118
Colombia[b]	Trachypogon, well-drained savannas	210 - 310
Venezuela[c]		g OM/m^2.year
	Trachypogon, well-drained savannas	200 - 570
	Flooded savannas	430 - 910
	Paspalum fasciculatum savannas	1000 - 2500

a/ Vilela, H. (1982).

b/ Paladines and Leal (1979). Available DM, average of 3 stocking rates.

c/ Medina, E. (1980).

Table 2. Animal productivity of existing cow-calf systems in the tropical savannas of America[a].

Production Parameter	Brazil	Colombia	Venezuela
Average SR, AU/ha[b]	0.23	0.17	0.32
Heifer weight at 36 mo, kg	283	255	290
Age at 1st. conception, mo.	40	35	38
Weaning rate, %	57	45	52
LWG, kg/AU.year	65	58	50
LWG, kg/ha.year	12	12	32

a/ Seré, C. and R. Vera (1983).

b/ Unweighted means.

Table 3. Economic performance of prevailing cow-calf systems in the savannas of tropical America (US$/AU.year).

	Brazil	Colombia	Venezuela
Gross income			
Cattle	60.3	38.0	100.0
Crops	139.7	0.0	0.0
Total	200.0	38.0	100.0
Expenses			
Purchased inputs			
Mineral salts	1.95	3.97	1.25
Animal health	1.19	1.34	1.71
Fertilizers	27.79	0.12	2.56
Fuels	10.95	0.0	0.0
Others	30.19	0.67	1.88
Total purchased input	72.07	6.10	7.40
Labour	22.32	7.67	24.21
Depreciations	18.01	5.90	35.66
Total expenses	112.60	19.67	67.27
Net income	87.40	18.33	32.73
Farm capital	1262	442	1490
Rate of return, %	7	4	2

Source: Vera, R. and Seré, C., 1983.

Table 4. Nutritive value of the native vegetation in the savannas of tropical America.

Brazil - Cerrado[a]

	CP, %	IVOMD, %
March	10.08	29.8
May	10.03	35.8
July	9.66	41.1
August	10.85	30.2

Colombia - Eastern Plains[b]

Days of regrowth	CP, %	P, %	Zn, ppm
10	10.5	0.21	30
20	8.0	0.16	22
35	6.4	0.11	19
90	6.4	0.09	17
365	4.4	0.06	12

a/ Rodriguez et al. (1979).

b/ Paladines and Leal (1979); Vera (unpublished).

Table 5. Productivity of savannas with and without complementary grazing of legumes.

	kg/an	kg/ha
Savanna, best management	95	19
Complementary grazing of Kudzu (*Pueraria phaseoloides*) at stocking		
rate of 0.25 an/ha	118	30
0.50 an/ha	101	51

Sources: Paladines and Leal, 1979 (means of 5 years)
Tergas *et al.*, 1983 (means of 4 years)

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