ECONOMIC EVALUATION OF BEEF PRODUCTION SYSTEMS IN THE LLANOS ORIENTALES OF COLOMBIA

Gustavo A. Nores
Rubén Darío Estrada*

ABSTRACT

Using preliminary results obtained in a herd systems experiment, farm level adoption of alternative cow-calf production systems was evaluated through simulation using a computerized-activity-budgeting model. The same initial herd was developed over a 25-year period and the farm's net income flow was used to calculate the internal rate of return of each system using the discounted-cash-flow method. The experimental treatments considered as alternative systems were: (a) traditional system of grazing native savanna with salt supplementation, (b) *ad libitum* mineral supplementation, (c) same as above but early weaning all calves at three months of age, (d) breeding herd grazing *Melinis minutiflora* during the wet season and native savanna during the dry season, and (e) same as above plus early weaning. Two additional systems were simulated under a given set of assumptions: (f) the breeding herd grazing *Brachiaria decumbens*, and (g) grazing legume-based pastures. Of all the empirically-based alternatives considered, grazing native savanna with mineral supplementation is the most profitable system. Early weaning is not profitable with present costs and management; though it might become an economic alternative in case of widespread adoption of improved pastures. Grazing the entire breeding herd on *M. minutiflora* is substantially less profitable than the traditional system. Simulation results indicate that *B. decumbens*, in the absence of subsidized credit, would be as profitable as the traditional system, but that legume-based pastures could be significantly more profitable. Based on four years experimental results, fattening systems with *M. minutiflora* and *B. decumbens* pastures were evaluated at the farm level. In addition, fattening on legume-based pastures was simulated under conservative assumptions. Again, *B. decumbens* showed to be more profitable than *M. minutiflora*, and legume-based pastures with minimum inputs appear to be alternatives much more attractive from the economic standpoint. Results of sensitivity analyses indicate that the value of the inputs applied to pastures, as well as the frequency of application, affect the profitability levels significantly. Animal response to pasture fertilization has to be relatively high in order to be profitable. It is concluded that **minimum inputs** (low establishment and maintenance costs), appear to be the correct research strategy for systems in which the bulk of the herd grazes improved pastures. Higher levels of inputs might be afforded only by systems using a small pasture in a **strategic manner** (high animal response), or under highly subsidized conditions.

---

* Economists, Beef Program, Centro Internacional de Agricultura Tropical, Cali, Colombia.

Extensive cow-calf operations is predominant in the Llanos Orientes of Colombia*. Grazing native pastures, with stocking rates varying from 0.1 to 0.25 an/ha, and plain salt supplementation (not necessarily *ad libitum*) are the most common practices. Some farms have a small area in improved pastures, usually less than 3% of the total area. The species most commonly used are *Melinis minutiflora* Beauv. and *Brachiaria decumbens* Stapf. Herd productivity is in general quite low. Average calving rate is on the order of 45-55%, abortions are high, and reconception among nursing cows is very low (8, 11, 12). High calf mortality is another reason for the low extraction rate in the region (1, 7).

In this study, farm level adoption of alternative cow-calf production systems was evaluated using preliminary results of a partial life cycle experiment conducted in Carimagua. The experiment was conducted in the Centro Nacional de Investigaciones Agropecuarias—Carimagua of the Instituto Colombiano Agropecuario (ICA), as a cooperative project between ICA and CIAT. The objective of the experiment was to study the effects of several management techniques on reproductive and growth performance of breeding herds, and included the following variables: mineral supplementation, grazing native savanna and/or *M. minutiflora*, urea-molasses supplementation, early weaning, and two breeds of sire. Average results of four reproductive years (reported in 1) were used in this study to evaluate the profitability of selected systems at the farm level. Urea-molasses supplementation was not included as an alternative system since no effect on reproductive parameters was detected in the experiment (1).

SYSTEMS AND ASSUMPTIONS

The experimental treatments considered as alternative systems for evaluation at the farm level were:

Systems 1 and 2: Traditional systems with all animals grazing native savanna and *ad libitum* salt supplementation with an average intake of 12 kg/yr/AU of salt (as in Herds 2 and 3 of the experiment). In System 1, calf mortality was assumed to be 15% rather than the experimental result of 26%, since this latter value appears to overestimate actual farm losses. In fact, even a 15% calf mortality implies a decreasing herd over time. Thus, System 2 was included as a more representative case of the most common system prevailing in the area.

Systems 3 and 4: All animals grazing native pasture and receiving *ad libitum* supplementation of a full mineral mixture with an average intake of 16 kg/yr/AU (as in Herds 4 and 5).

Systems 5 and 6: Same as above but weaning all calves at 86 days of age. In the experiment, early weaned calves were fed 0.75 kg/day of a carbohydrate-protein supplement (20% protein) and *ad libitum* fresh chopped *Axonopus scoparius* (Flügge) Hitchc. during one month. During an additional period of two months they were fed 0.5 kg/day of the same supplement, while grazing in rotation *Paspalum plicatulum* Michx., *Stylosanthes guianensis* (Aubl.) Sw. (when available), and a mixture of *M. minutiflora* and *Hyparrhenia rufa* (Nees) Stapf. After six months of age, calves grazed native savanna and received only mineral supplementation. Given the location and conditions of the pastures used in the early weaning treatments of the experiment, and in order to extrapolate treatment results to farm level, it was assumed that such pastures need to be irrigated during the dry season. Hence, the cost of small irrigation equipment and the corresponding operating expenses and labor costs were charged to this treatment.

Systems 7 and 8: Cows, bulls and unweaned calves grazing *M. minutiflora* during the rainy season and native savanna during the dry season; all animals were supplemented *ad libitum* with a mineral

* For a detailed description of the environmental conditions as well as of the prevailing production system see 4, 5, 6, 7, 8, 9, 10, 11, 12.

mixture with average intake of 22 kg/yr/AU (as in herds 6 and 7).

Systems 9 and 10: Same as above but weaning at 86 days, with similar early weaning treatment as Systems 5 and 6.

System 11: Same as System 7, but grazing *B. decumbens* during the wet season with a stocking rate of 1.7 AU/ha, and savanna during the dry season. Reproductive as well as productive performance was assumed to be the same as in System 7. The only additional treatment assumed for this species, as compared to molasses grass, was 200 kg/ha of basic slag every two years.

System 12: Cows, bulls and unweaned calves all grazing a hypothetical legume-based pasture with a stocking rate of 2.0/1.0 an/ha in the wet and dry season, respectively. In this system, reproductive as well as productive parameters are given arbitrary values considered desirable as a target.

For each particular system based on experimental results (Systems 3 through 10), two cases were considered in terms of calving rates and mortality. In systems denoted by odd numbers, the experimental values of these parameters were directly extrapolated to the farm level. In systems denoted by even numbers, both parameters were assigned arbitrary values at the farm level that were lower than those obtained in the experiment. The lower values of calving rates were obtained in each case by subtracting one standard deviation from the corresponding experimental mean values. Calf mortality percentages were also arbitrarily set at lower levels under the assumption of good management of animals close to parturition.

The main biological parameters used to simulate herd development under each system are shown in Table 1. Since the frequency distribution of conception weights of the heifers at the beginning of the experiment had its maximum at 270 kg, that particular weight was used as the mating weight criterion for all systems. Mating age for each system was estimated, simulating heifer growth starting from average heifer weight at 18 months of age as obtained in the experiment for the corresponding treatment, and thereafter according to average annual weight gains as obtained in steer experiments with similar treatments (6), adjusted downward by 10% in order to account for male-female weight differences. In early versus normal weaning systems, it was assumed that absolute weight differences at 18 months of age were maintained over time.

Other parameters used in herd development for all systems were: bull:cow ratio of 0.05:1, culling rate of cows of 15%, culling rate of bulls of 20%, and an equal proportion of males and females at birth.

METHODOLOGY

On the basis of these parameters and assumptions, the same initial herd of 190 cows was developed for all systems over a 25-year period, for a commercial ranch of 2500-3000 ha. The net income flow of the ranch was used to calculate the internal rate of return of each system using the discounted-cash-flow method. All prices used correspond to average farm prices of 1976, which were assumed constant over time in real terms. The model used was a computerized activity budgeting model (HATSIM) developed at CIAT (2).

Pasture establishment costs used in the estimation were those of conventional planting in 1976; i.e.: US$120, 133 and 155 per ha for *M. minutiflora*, *B. decumbens* and the hypothetical legume-based pasture respectively. *M. minutiflora* was assumed to persist for 25 years without refertilization, *B. decumbens* was assumed to persist for 12 years and to require only 30 kg/ha of P_2O_5 at establishment and every two years thereafter. The legume-based pasture was assumed to persist for 12 years and to require 50 kg/ha of P_2O_5, 25 of K_2O, 20 of S and 20 kg/ha of Mg at establishment. The

Table 1. **Parameters used in herd development of alternative production systems.**

	Treatments			Parameters					
					Mortality rate		Heifers' mating rate[b]		
System	Pasture	Mineral supplementation	Weaning	Calving rate	Calves[a]	Adults	2-3 years	3-4 years	4-5 years
						%			
1[c]	Native	Salt	Normal	46	15	5	0	60	100
2[d]	Native	Salt	Normal	50	8	5	0	60	100
3[c]	Native	Full mixture	Normal	65	12	5	0	90	100
4[e]	Native	Full mixture	Normal	61	8	5	0	90	100
5[c]	Native	Full mixture	Early	87	13	4	0	80	100
6[e]	Native	Full mixture	Early	77	8	4	0	80	100
7[c]	*M. minutiflora* + native	Full mixture	Normal	64	10	5	10	90	100
8[e]	*M. minutiflora* + native	Full mixture	Normal	60	7	5	10	90	100
9[d]	*M. minutiflora* + native	Full mixture	Early	85	8	4	0	90	100
10[e]	*M. minutiflora* + native	Full mixture	Early	77	7	4	0	90	100
11[f]	*B. decumbens* + native	Full mixture	Normal	64	10	5	10	90	100
12[f]	Legume-based + native	Full mixture	Normal	77	7	3	20	100	-

a Up to one year of age

b Weight ≥ 270 kg

c Based on four-year experimental results

d Based on survey data

e Calving and mortality of calves are reduced by one standard deviation according with the estimate obtained in the experiment

f The values of the parameters are assumed.

annual maintenance cost assumed for this pasture was US$22 ha/yr, equivalent to applying 30 kg/ha of P_2O_5, 10 of K_2O, 5 of S and 5 kg/ha of Mg.

Since prices of inputs as well as of cattle vary according to distance from market, the economic evaluation was carried out for two regions: Region A between Puerto López and Puerto Gaitán, and Region B around Carimagua which is further away from the market (Bogotá). Region A averages 280 km from Bogotá while Region B averages 460 km from that city. Market prices of both inputs and cattle were corrected for transportation costs, to obtain prices at the farm level for each of the regions.

RESULTS AND DISCUSSION

Table 2 summarizes the performance of all systems for commercial ranches of 2500-3000 ha. The following analyses of the results use the return on capital and management as a measure of profitability.

Minerals

Systems 3 and 4, grazing native savanna with mineral supplementation are the most profitable of the alternatives considered with the only exception of System 12 which simulates the case of a legume-based pasture. These are followed by Systems 5 and 6 (which include early weaning), and by System 2 (native savanna supplemented only with salt).

Table 2. **Summary of simulated performance of alternative production systems in Colombian Llanos.**

	Area of improved pastures		Breeding herd size		Investment*		Annual net income*		Rate of return**	
System	Initial	Total	Initial	Total	Pasture	Total**	Year 4	Year 13	Region A	Region B
	ha		cows		'000 US$				%	
1	-	-	190	127	-	90	6.4	5.2	5.5	3.6
2	-	-	190	182	-	90	7.5	7.3	8.1	6.3
3	-	-	190	230	-	91	6.3	10.7	10.0	9.0
4	-	-	190	230	-	91	5.9	10.2	9.8	8.9
5	12	12	190	190	4	97	5.0	10.8	9.1	7.5
6	12	12	190	190	4	97	5.6	7.6	8.4	7.4
7	450	650	190	325	78	172	6.7	9.6	5.0	3.7
8	450	650	190	325	78	172	6.7	9.0	4.6	3.3
9	450	516	190	250	67	160	4.2	18.2	6.3	4.8
10	450	516	190	250	67	160	4.7	16.0	5.2	4.6
11***	100	190	190	325	25	118	6.7	9.6	8.5	n.a.
12***	95	162	190	325	25	121	7.5	27.9	14.0	n.a.

* Values correspond to year 8 and Region A

** Includes value of cattle and improvements, excludes value of land. Region A is between Puerto López and Puerto Gaitán; Region B near Carimagua

*** Based on assumed values for animal performance.

When analyzing the viability of adopting a new technology, the profitability of moving from the traditional system to new ones needs to be considered. The incremental rate of return may be used as an estimate of such profitability. That is, the return on the additional capital, including operating capital, required by the new system. Such incremental rate of return is defined as that rate which equals the discounted value of the increments in gross revenue with the discounted value of the increments in costs. In moving from System 2 to System 3, the incremental rate of return was found to be 25% (Table 3). Hence, mineral supplementation may be considered highly profitable for the Colombian Llanos. One of the reasons why such a profitable practice is not yet widespread in the region, may be the reduction in net income occurring during the first few years after implementation until the additional calf crop obtained is sold (Table 2). Since most farms in the region are large in area, within farm distances are also large. The lack of on-farm transportation causes difficulties in providing a regular supply of minerals to all animals. Irregular mineral supplementation probably reduces the impact of this treatment. Besides the delay in payoff and lack of on-farm transportation, other reasons such as absentee ownership, difficult access to the farm during the rainy season and irregular market supply of high quality mixtures may help explain why regular mineral supplementation is not yet a common practice in the region.

Early weaning

In spite of the high increase in calving rate, this practice was not found to be profitable with present costs and management available in the region. As Table 2 shows, the rate of return of System 5 was lower than that of System 3. A substantial reduction in net income was observed during the first few years after implementation of this practice.

The relatively poor performance of early weaned calves, especially those weaned during the dry season (1), the high cost of carbohydrate-protein supplement and labor, and the cost of establishing and maintaining improved pastures contribute to this result, overshadowing the economic benefits from a larger calf crop. As pointed out in the CIAT Annual Report (1), "due to low soil fertility and rainfall distribution, there is presently

Table 3. **Incremental returns on capital and management, of moving from traditional system (2), to alternative systems.**

System	Treatment: Pasture	Treatment: Mineral supplementation	Investment	Rate of return	Incremental rate of return
			'000 US$	%	%
2	Native	Salt	90	8.1	
3	Native	Minerals	91	10.0	
2 to 3			1	-	25.0
11	*B. decumbens*+ native	Minerals	118	8.5	
2 to 11			28	-	9.4
12	Legume-based + native	Minerals	121	14.0	-
2 to 12			31		22.0

no technology available (for the region) to produce on farm at low input levels: (1) the components for an adequate concentrate; (2) year-round, high yielding cut forage species; and (3) pasture species with adequate feed value". Therefore, at present, early weaning is not profitable for continuous mating systems in the region, since the practice requires year-round availability of high quality feed.

Despite the delay in payoff, this practice was slightly more profitable than normal weaning in the intensive pasture systems (9 and 10 versus 7 and 8), by increasing breeding performance and thus reducing pasture investment per unit of output (sale of steers). Hence, rather than providing an indication of present profitability of early weaning, this result reflects the need for reducing pasture cost if the bulk of the herd is to graze improved pastures.

Since early weaning has been shown to substantially increase calving rates by reducing lactation stress, it merits further research not only in terms of a longer (than 84 days) lactation period to avoid the need for concentrate supplementation, but also in terms of improving post-weaning calf performance through an improved year-round forage base. This again emphasizes the need for pasture research.

Improved Pastures

Systems based on grazing *M. minutiflora* during the wet season (Systems 7-8) were found to be only half as profitable as systems based on native savanna (Systems 3-4, Table 2). Total investment nearly doubled in the former systems because of the low stocking rate of this pasture (0.5 AU/ha).

With a higher stocking rate (1.7 AU/ha) as in System 11 (a simulated case with *B. decumbens* assuming the same reproductive and productive performance as for *M. minutiflora*), the return on capital increases markedly. However, the estimate obtained for the incremental rate of return (9.4%) of moving from the traditional system to this one, suggests that for cow-calf operations, grazing the entire breeding herd on *B. decumbens* is not highly profitable. As will be seen later, subsidized credit would increase its profitability.

System 12, a simulation of a breeding herd grazing a legume-based pasture, appears to be a promising alternative from the economic standpoint. Both total as well as incremental rates of returns are attractive (Tables 2 and 3). Furthermore, if similar reproductive performance could be attained using a smaller area for strategic use (rather than grazing the entire breeding herd on such pasture), return on (the smaller) investment would increase substantially. In such a case, the probability of adoption by a wider base of producers would also be increased. Strategic use refers to grazing the legume-based pasture with animals when they have a high capacity of response. Such would be the case of grazing during the dry season, with cows which are under lactation stress, or to recover sick or weak animals in order to avoid capital losses.

Native pastures have a strong seasonal pattern in terms of both volume of DM production and quality (i.e.: digestibility, protein content, . . .). Since in general, in terms of volume, this is also the case of improved pastures (which make use of capital, or scarce resource), it is not a matter of substituting one for the other, but rather supplementing the native with the improved pastures, thereby capitalizing on their higher quality during the dry season.

Those improved pastures which are highly seasonal producers, both in volume and quality, but whose digestibility is low during the dry season, may still be attractive for fattening purposes in areas of high opportunity cost of land. Substitution of capital for land may be warranted in such a case due to high land values. Also, the possibility of obtaining high compensatory gains may allow for a rapid turnover of the capital invested in the animals.

However, for areas with low opportunity cost of land, such as the Llanos, there is little advantage in replacing native savanna with improved pastures such as *M. minutiflora*, which are also poor in quality during the dry season. In cow-calf operations, there are no compensatory gains in the reproductive sense. Lack of conception, as well as abortions and higher mortality during the dry season cannot be "compensated" during the rainy season when the pasture is productive. Hence, emphasis in pasture research should be on finding ways of **supplementing** native savanna with improved pastures of high nutritive value during the dry season, rather than replacing one by the other.

Jarvis's (3) conclusion after a detailed analysis of the diffusion of improved pastures in Uruguay, supports this hypothesis: "Most producers find the artificial pastures to be highly profitable when planted on a small proportion of their ranches, this small proportion providing an improved nutrient base during the crucial winter months: . . . (improved pastures) have been used to supplement the traditional pastures, however, not to replace them . . . (they) have not been profitable for most ranches when planted to a large proportion".

Since improved pastures represent a sizeable investment, not exempt from risk, it is quite reasonable for producers to use them in a "strategic manner" as a supplement to forage available from native pastures. Improved pastures are thus first grazed with animals which have a high capacity for response. Further increases in the proportion of area planted with these pastures implies grazing with animals at times that have lower response capacity and, hence it may be unprofitable and risky. Moreover, unless forage conservation (i.e.: hay, silage, . . .) is economical, forage from the improved pasture will probably be wasted during the wet season. Burning native pastures is a very common practice in the region, but burning to remove inedible forage and to stimulate fresh regrowth of improved pastures is in many cases risky. Undergrazing, as well as overgrazing, is also risky in terms of pasture persistence, particularly in the case of legume-grass mixtures. As Jarvis (3) puts it, "the greater is the proportion of improved pastures on a ranch, the greater is the management sophistication and dedication required".

Thus, it seems logical to conclude that pasture research should emphasize good quality forage for the dry season, and animal management research on strategic use of the improved pastures rather than for the entire breeding herd.

Pasture persistence and establishment failures

Table 4 illustrates the effect of pasture duration on the return to capital. In systems using a limited area of improved pasture for early weaning (such as System 5), low persistence has a negligible effect. However, when the area planted is sizeable and the stocking rate is low (0.44 AU/ha), the returns on capital are quite sensitive to pasture duration (Systems 7 and 9).

Table 5 shows the result of a sensitivity analysis of pasture persistence and establishment losses. Two cases are considered: System 7 and System 7', the latter assuming 50% reduction in establishment costs of this particular pasture *(M. minutiflora)*. It may be observed that reducing establishment costs without affecting

Table 4. **Rates of return: sensitivity analysis with respect to pasture persistence.**

System	Pasture persistence (years) 24	12	9	6
	% return			
5	9.1	9.0	8.9	8.8
7	5.0	2.8	1.3	-*
7'**	7.1	5.9	5.0	3.7
9	6.3	4.2	2.7	0.9

* Negative value

** Assuming 50% reduction in establishment costs.

Table 5. **Rates of return from System 7: sensitivity analysis with respect to pasture persistence and establishment failure.**

Pasture establishment failures	Pasture persistence (years)					
	24		12		9	
	7*	7'**	7	7'	7	7'
% area	% return					
0	5.0	7.1	2.8	5.9	1.3	5.0
20	4.4	6.7	2.4	5.5	0.9	4.6
40	4.0	6.3	2.0	5.2	0.6	4.3
60	3.5	6.0	1.7	4.9	0.3	4.0
80	3.2	5.7	1.3	4.6	0.0	3.8

* Actual cost

** Assuming 50% reduction in establishment costs.

carrying capacity not only increases returns to investment, but also implies that these returns are less sensitive to establishment failures and to persistence risk. This is one of the reasons why a minimum input philosophy, and practices such as minimum tillage represent promising alternatives when the improved pasture is grazed by the entire breeding herd (10). They may not be as relevant when dealing with very small areas for strategic use only.

Financing

In Colombia, as in some other Latin American countries, the nominal interest rate on loans is lower than the inflation rate. This implies financing under subsidized conditions. Table 6 is included to illustrate the effect of this type of incentive on the return to the cattleman's own capital. The following conditions are assumed: an annual expected inflation rate of 30%, 18%

Table 6. **Rates for return on producer's own capital and management from alternative systems receiving credit under subsidized conditions.**

System	Percent financing of initial investment				
	0	20	40	60	80
	% return				
2	8.1	(n.a.)*	(n.a.)	(n.a.)	(n.a.)
3	10.0	10.8	(12.8)	(15.1)	(18.8)
7	5.0	5.6	6.3	7.2	(8.8)
7'**	7.1	7.9	8.9	10.2	(12.0)
11	8.5	9.6	11.0	13.1	(16.8)

* Figures in parentheses are improbable cases included only for illustration

** Assuming 50% reduction in establishment costs.

nominal interest rate and a four-year grace period on a 12-year loan. These conditions are presently found in the Llanos, though they may not necessarily prevail over the long run. As the proportion of initial investment financed under these conditions increases, so does the profitability of all systems. But, even under 60% financing, System 7 (grazing *M. minutiflora)* is not as profitable as Systems 2 and 3 (native savanna plus salt and minerals, respectively) without financing. However, such is not the case of System 11 which simulates grazing of *B. decumbens*. Beyond 30-40% financing under such subsidized conditions this system becomes more profitable than Systems 2 and 3. This may explain why many producers in the Llanos are adopting this particular improved pasture.

Land values

When analyzing the profitability of alternative production systems which are relatively similar in intensity of land use, the value of land is not included in the amount of initial investment. The relevant question is: which of the production systems is more profitable, considering that the producer has already invested in land?

However, when comparing the returns on capital of a given technology in two ecologically similar regions which face different input-output prices, because of distance to markets, the value of land has to be incorporated in the analysis in order to explain profitability differences between two regions. If the same technology is adopted in both areas, land prices are expected to compensate for the difference in profitability due to different input-output prices. The regions further away from the market, and hence with the least favorable prices, will have a lower return on capital when the value of land is not included in the amount of initial investment. This explains the difference in returns between Region A and Region B, as shown in Table 2. For example, comparing normal weaning systems (3 and 7) against early weaning systems (5 and 9 respectively) it may be observed that the regional differences in return are larger in the case of systems incorporating early weaning. This indicates that technology using a larger volume of inputs has a lower probability of adoption in regions further away from the market, due to transportation costs.

Table 8 illustrates the effect of a land-saving technology (improved pastures) on the total return to producer's own capital (including land value). It was assumed that the real price of land increases at an annual rate of 2%. The area below the line

Table 7. **Rates of return* from System 3 (native pasture and mineral supplementation): sensitivity analysis with respect to land values and percent financing of initial investment under subsidy conditions.**

Land value		Percent financing on initial investment**				
		0	20	40	60	80
Col$/ha	US$/ha	% return				
0	0	10.0	10.8	12.8	15.1	18.8
500	14	6.9	7.2	7.9	8.6	9.4
1000	28	5.5	5.7	6.1	6.4	6.8
1500	42	4.7	4.8	5.1	5.3	5.6
2000	56	4.2	4.3	4.5	4.7	4.9

* Rates of return on producer's own capital and management, and on total investment including land value

** Excluding land value.

Table 8. **Rates of return* of System 11 (*B. decumbens* plus native pasture and mineral supplementation): sensitivity analysis with respect to land values and percent financing of initial investment under subsidy conditions.**

Land value		Percent financing of initial investment**				
		0	20	40	60	80
Col$/ha	US$ha	% return				
0	0	8.5	9.6	11.0	13.1	16.8
500	14	6.5	7.0	7.0	8.5	9.5
1000	28	5.4	5.8	6.2	6.7	7.2
1500	42	4.8	5.1	5.3	5.7	6.0
2000	56	4.3	4.6	4.8	5.0	5.2

* Rates of return on producer's own capital and management, and on total investment including land value

** Financing of initial investment excluding land

represents situations in which System 11 (*B. decumbens* plus minerals) is preferable to System 3 (native pasture plus minerals; Table 7), using total returns on capital as the criterion. This explains in part why land-saving technology (improved pastures with high carrying capacity), even under similar ecological conditions, are adopted first in areas closer to the market which have higher land values, as is observed in the case of the Llanos Orientales.

In summary, the fact that in the Llanos many producers are planting *B. decumbens* although it is not more profitable than the traditional system, could be explained by: (a) subsidized financing, (b) higher land values in regions close to the market, (c) lower establishment costs than those assumed in this study, and (d) use of improved pastures for fattening purposes, as discussed next.

Fattening systems

A 1000 ha fattening farm in Region A was simulated, based on four years of experimental results conducted in Carimagua (1, 6). As in previous cases, the economic analysis was carried out for a 25-year period. Prices of 1976 were used and were assumed constant over time and expressed in real terms. The net income flow was used to calculate the internal rate of return using the discounted-cash-flow method.

Four fattening systems were evaluated: (A) grazing *M. minutiflora* for 274 days with a stocking rate of 0.44 AU/ha, (B) same as above but with a stocking rate of 0.88 AU/ha, (C) grazing *B. decumbens* during a similar period, at a stocking rate of 1.3 AU/ha, and (D) same as above but with a stocking rate of 1.7 AU/ha. Results for the four systems are reported in Table 9. Using return on capital (excluding value of land) as the criterion, it may be seen that although System B yields more output per ha, it is less profitable than System A which has a lower stocking rate. Only in areas with high land values would System B become more profitable than A.

A similar conclusion could be reached comparing Systems C and D. That is, although the capital invested in pasture is producing more in the systems with higher stocking rates, capital invested in animals is producing substantially less, overshadowing such benefits and yielding an overall lower rate of return. Thus, under these conditions, the optimum stocking rate appears to be closer to maximum production per head than to maximum production per ha.

System C is substantially more profitable than the other systems. This result tends to support those obtained in the simulation of System 11 with the breeding herd grazing *B.*

Table 9. **Animal performance and rates of return on capital[1] and management from finishing cattle on improved pastures in the Colombian Llanos.**

System	Pasture	Stocking rate	Production			Rate of return
			Per-head		Per ha	
		an/ha	g/day	kg/yr	kg/yr	%
A[2]	*M. minutiflora*	0.44	416	114	50	7.2
B[2]	*M. minutiflora*	0.88	277	76	67	4.8
C[3]	*B. decumbens*	1.3	376	103	134	12.1
D[3]	*B. decumbens*	1.7	292	80	136	8.0
E[4]	Legume-based	2.1/0.9	411	150	270	19.3
F[4]	Legume-based	2.1/0.9	500	182	328	25.2

1 Excluding value of land

2 Based on four year experimental results

3 Based on three year experimental results

4 Parameters on animal performance are assumed values.

decumbens. As already indicated, it was assumed in the calculations that this particular species could persist for 12 years without a loss in productivity and needs no refertilization except for 30 kg of P_2O_5 every second year. It should be pointed out, however, that there is no conclusive evidence regarding maintenance of productivity of this species without periodical N applications beyond the fourth year.

In addition, two systems for fattening (E and F) on a hypothetical legume-based pasture were simulated for the same region. Weight gains assumed as well as the resulting return on capital and management are reported in Table 9. Preliminary research results, because of lack of persistence of the legume—*S. guianensis* in this case, lead us to believe that the assumed liveweight gains per head and per ha are feasible, if not conservative (1, 6). Comparing the returns on investment of the systems using grass species (A through D) with those of the systems using legume-based pastures (E and F), the expected superiority of the latter two is confirmed, thus reinforcing the need to continue seeking persistent legume-based pastures for these savannas.

Table 10 is included to illustrate the type of economic results which could be expected from different pastures needing different levels of inputs with different frequencies in order to achieve similar animal production. Each cell in the table represents a different pasture requiring application of a given amount of fertilizer, with a given frequency, in order to yield the same output per ha with the same stocking rate as in System C (Table

Table 10. **Returns of investment* for simulated fattening systems having identical animal performance with the same stocking rate, but requiring application of inputs with different frequencies.**

Frequency	Value of inputs (US$/ha)			
	0	28	42	56
	% return			
Every year	12.1	4.6	1.0	**
Every 2 years	12.1	8.5	6.7	5.0
Every 3 years	12.1	10.2	8.7	7.6
Every 4 years	12.1	10.4	9.7	8.9

* Excluding land value

** Negative return.

9). In Carimagua (Region B) and at 1976 prices, the amounts indicated in Table 10 would buy the following amounts of N or P_2O_5:

Nutrient	Source	US$28	US$42	US$56
			kg	
N	Urea	50	75	100
P_2O_5	Basic slag	67	101	135
P_2O_5	TSP	39	58	78

As may be seen in Table 10, other things being equal, pastures needing frequent fertilization (at even low levels) are markedly less profitable than the ones needing only low establishment rates. Pastures needing the same fertilization with higher frequency are also substantially less profitable. In order to compensate for such differences in returns, animal response to fertilization of the pasture needs to be rather high. For example, if a pasture requires a maintenance rate of 75 kg N/ha every year (costing US$42), it is estimated that animal production has to be at least 50% higher in order to be as profitable as System C *(B. decumbens)*.

Thus, it seems logical to conclude that, in the case of the Carimagua region, pastures needing high and frequent fertilization could become economic alternatives perhaps only for strategic grazing by those animals with rather high response capacity.

Alternatively, for systems in which the bulk of the herd is on improved pasture (fattening farms, or grazing the entire breeding herd), the above results clearly indicate the appropriateness of selecting species and varieties based on minimum input criteria, and therefore again reinforces the need for seeking legume-based pastures.

CONCLUSIONS

In the case of the Llanos Orientales of Colombia, full mineral mixture supplementation is highly profitable. Factors such as delay in payoff, lack of on-farm transportation, absentee ownership, difficult access to the farm during the rainy season and irregular market supply of high quality mixtures may restrain the adoption of this practice in the region.

In spite of a striking increase in calving rate, early weaning was not profitable at present costs and management requirements in the region. However, this practice merits further research in terms of a longer (than 84 days) lactation period to avoid the need for concentrate supplementation, and in terms of improving post-weaning calf performance through an improved year-round forage base.

Field research has clearly identified poor quality of native forage, particularly during the dry season, as the second major constraint to increased beef production in the region. Systems based on grazing the entire breeding herd on *M. minutiflora* during the wet season and native savanna during the dry season were half as profitable as year-round grazing on native savanna. This is due to the poor quality of this particular species during the latter season. Thus, the importance of developing a good quality forage base for the dry season is confirmed. This is not a matter of substituting native with improved pastures, but rather supplementing the former with the latter, thereby capitalizing on their higher quality during the slack season. Furthermore, given the absence of compensatory gains in reproduction, emphasis in animal management research should be given to strategic use of improved pastures rather than to grazing them with the entire breeding herd irrespective of the physiological status and/or condition of each animal.

Comparisons of economic results obtained from simulating performance of legume-based pastures vis-a-vis the two grasses considered *(M. minutiflora* and *B. decumbens)*, reinforce the need to continue seeking legume-based pastures. Finally, results of sensitivity analyses clearly indicate the appropriateness of selecting species and varieties based on a minimum input strategy. Reducing establishment and maintenance costs without affecting carrying capacity not only increases returns to investment but also implies that these returns are less sensitive to pasture establishment failures and to persistence risk.

LITERATURE CITED

1. Centro Internacional de Agricultura Tropical. 1978. Annual Report 1977. CIAT, Cali, Colombia.

2. Juri, P., N.F. Gutiérrez and A. Valdés. 1977. Modelo de simulación por computador para fincas ganaderas. CIAT, Cali, Colombia. (Mimeographed).

3. Jarvis, L. 1977. Predicting the ultimate diffusion of new technologies under varying profitability: Artificial pastures in the Uruguayan livestock sector. University of California, Berkeley. (Mimeographed).

4. Mullenax, C.H., J.S. Plaxico and J.M. Spain. 1969. Alternative beef production systems for the Eastern Plains of Colombia. Special Report No. 1, CIAT, Cali, Colombia.

5. Paladines, O. 1975. Management and utilization of native tropical pastures in America. p. 25-47. *In* Proceedings of the Seminar on Potential to Increase Beef Production in Tropical America. Series CE-no. 10, CIAT, Cali, Colombia.

6. ——— and J. Leal. 1978. Manejo y productividad de las praderas en los Llanos Orientales de Colombia. *In* Seminario sobre Producción de Pastos en Suelos Acidos e Infértiles del Trópico. CIAT, Cali, Colombia. Serie 03SG-5.

7. Raun, N.S. 1968. Producción de ganado de carne en los Llanos Orientales. Agricultura Tropical 24:643-650.

8. ——— 1976. Beef cattle production practices in the lowland American tropics. World Animal Review 19:18-23.

9. Rubio, E. y A. López U. 1968. La explotación ganadera en los Llanos Orientales. Agricultura Tropical 24: 616-641.

10. Spain, J.M. 1978. Establecimiento y manejo de pastos en los Llanos Orientales de Colombia. *In* Seminario sobre Producción de Pastos en Suelos Acidos e Infértiles del Trópico. CIAT, Cali, Colombia. Serie 03SG-5.

11. Stonaker, H.H. J. Salazar, D.H. Bushman, J. Gómez, J. Villar and G. Osorio. 1975. Influence of management practices on productivity. p. 63-81. *In* Proceedings of the Seminar on Potential to Increase Beef Production in Tropical America. Series CE-no. 10, CIAT, Cali, Colombia.

12. ———; J. Villar, G. Osorio and J. Salazar. 1976. Differences among cattle and farms as related to beef cow reproduction in the Eastern Plains of Colombia. Tropical Animal Health and Production 8:147-154.