ALTERNATIVE BEEF PRODUCTION SYSTEMS FOR THE EASTERN PLAINS OF COLOMBIA

by

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"The Llanos Orientales," the eastern plains of Colombia, were first explored by the Conquistadores in 1523. Development since that time has been limited, and the agricultural potential of much of the area is debated. Some recent information obtained in the area relates to the present status of agricultural and livestock potential of the savannah region, especially in Meta and Vichada.

The term, "The Llanos Orientales," refers to the entire eastern three-fifths of Colombia, including the jungle to the south and the savannahs to the north. Using a broad definition, based on topography, the region is bounded on the north by Venezuela, on the east by Venezuela and Brazil, on the south by Ecuador and Perú, and on the west by the eastern cordillera of the Andean range. The total area approximates 670,000 square kilometers or 59 percent of Colombia's land area. The region's population is estimated at 325,000 or 2.1 percent of the nation's population.

Many of those 325,000 inhabitants live in towns in the foothills of the eastern cordillera, such as Villavicencio and Florencia, or in the surrounding piedmont farming and ranching regions. The population density for the entire Llanos is about one person per square kilometer. However, in the area comprised of Vichada, Guainía, Vaupés, Amazonas, and part of Caquetá (380,000 square kilometers), the density is less than one person per 10 square kilometers.

The northern savannahs account for about one-third of the Llanos. An abrupt transition from savannah to jungle occurs along the Guaviare river in the Department of Meta and roughly follows the Vichada river in the Comisaria of Vichada. Most of the savannahs north of the Meta river in Boyacá and Arauca (the region generally known as "Casanare") flood extensively during the rainy season from April through November. The savannahs south of the Meta river in Meta and Vichada are generally well drained, with little or no flooding even during the wettest months. Little is known of the jungle region; the northernmost part is probably well drained, while it is likely poorly drained in the extreme south. Unimproved trails, penetrating most of the savannah region, make it more accessible than the jungle. These trails are impassable during the rainy season in Boyacá and Arauca, but are open throughout the year in most of Meta and much of Vichada.

Villavicencio, known as Gramalote until 1850, is the largest town in the region with a population of approximately 60,000. It is the capital of the Department of Meta and is linked to Bogotá by 125 kilometers of modern highway which drops from an elevation of 3,000 meters just outside Bogotá to 500 meters at Villavicencio.

An all-weather main road continues from Villavicencio to Puerto López (90 kilometers), where a steel and concrete bridge spans the Meta river. Unimproved trails continue eastward along the right bank of the Meta river, and ferry service is provided at Puerto Gaitán, on the Manacacías river, 100 kilometers to the east of Puerto López. A spur of the main road terminates at El Porvenir, south of the Meta river across from Orocué, where ferry service is available.

At Carimagua, 25 kilometers south of Orocué, the road splits into two branches. One follows the right bank of the Meta river to Puerto Carreño, a small town, 100 meters above sea level, of approximately 1,500 inhabitants at the confluence of the Meta and the Orinoco rivers. The road is impassable during eight months of the year (roughly from April through November). The other follows the Muco and Vichada rivers to Santa Rita, a small village on the Vichada about 50 kilometers from the Orinoco river and the Venezuelan border, and some 800-900 kilometers from Villavicencio.

Commercial barge service, including livestock transport, is available on the Meta river and its larger tributaries between Puerto López and Puerto Carreño for eight to nine months each year. Smaller craft ply the lesser tributaries.

Violence erupted in the Llanos in the early 1950's when a wave of civil strife engulfed the entire country. It was initially political in nature, but by

1955 was not much more than banditry. The "Llaneros," tired of the "imported" guerrilla war, successfully eliminated most violence by 1957, and the region has known uninterrupted peace since that time.

Geology

The Andean uplift resulted in a geosyncline (zone of subsidence) between the new mountains and the ancient Guyana Shield of Venezuela and Brazil. This depression was gradually filled with massive sediments, mostly of Andean origin, during the tertiary and quarternary ages. The northern savannahs are situated on these thick sediments (terraces). The Meta river follows a fault line, the south bank being an estimated 30 meters higher than the north bank along much of its course. This explains in part the great difference in drainage and flooding in the two regions separated by the Meta river.

A relatively narrow strip (30 to 70 kilometers) of high, well-drained, smooth plains extends from Puerto López almost to the Orinoco river along the south bank of the Meta. This area is estimated at 3,000,000 hectares. South of this strip and along the major stream beds within the strip described is found the "serranía," formed by dissection of the uplifted plain. The "serranía" presents a landscape of rolling, grass-covered hills, with remnants of the original surface still apparent. The flood plains of Casanare, north of the Meta river, are generally quite smooth.

Climate

Few climatological data are available for the Llanos. Annual rainfall is known to decrease gradually from west to east along the Meta river. It is much higher in the piedmont, reaching 6,000 millimeters or more in the foot hills of the eastern Cordillera. It diminishes to approximately 2,000 millimeters at Puerto López, 1,700 at Orocué, and perhaps 1,200 millimeters at Puerto Carreño. Rainfall distribution is relatively uniform between early April and late November, with the exception of a short dry season usually during late July or August. There is little or no rain from December through March.

Temperatures vary from night lows of 15° to 18° C. to day highs of 38° to 40° C. (Average daytime temperature is probably about 32° to 34° C.). Mean temperatures for the savannah region are estimated at 26° to 27° C. decreasing as one approaches the Cordillera. Winds are common and strong, especially during the dry season. Prevailing winds are from the northeast. Blowing sand is common along the vast beaches of the Meta river and other major streams which are exposed during the dry season.

Vegetation

The area contains an abundant network of surface or spring-fed streams and several navigable rivers which drain eastward to the Orinoco river. These waterways support narrow gallery forests comprised of palm trees (Moriche and Royal) and deciduous trees, some of which provide wood suitable for posts, poles, and lumber.

The high, well-drained savannahs of Meta and Vichada are covered by native grasses and some legumes. The predominant grass species is Trachypogon vestitus (paja de savannah). Others present to a lesser extent include Paspalum pectinatum, Axonopus purpusii (Guaratara), Paspalum plicatulum (Pasto Negro), and Paspalum carinatum. The practice of burning off excess mature forage seems to have favored the predominance of the "paja" which is highly unpalatable to livestock when mature. Legumes are not abundant, but are found in greatest concentration in the lower-lying areas bordering streams.

Wildlife

Wild animal species present in the area include jaguars, tapirs, capybara, rabbits, deer, turtles, armadillos, several small rodents and marsupials, and numerous birds. Edible fish abound in the rivers and most of the larger streams. Several species of poisonous snakes and constrictors are present, along with stingrays and "pirañas" in the streams.

Soils

The soils of the smooth savannahs in Meta and Vichada are highly weathered, medium textured and welldrained, with little relief. They are quite acid (pH 4.5 to 5.0), highly aluminum saturated and low in bases (calcium, magnesium, potassium), and phosphorus. (Table 1.) Note the extremely high aluminum to base ratio. Organic matter content is surprisingly high in surface horizons, except in sandier soils, ranging to 4 percent or more. Sub-soils are bright red, iron rich, medium textured, with occasional occurrence of plinthite concretions. The clay fractions examined were composed of kaolinite, goethite, and traces of 2:1 intergrade mineral.

Soils in the "serranía" region are generally of coarser texture, with outcroppings of laterite stone and gravel common on side slopes and knoll tops.

Table 1. Typical chemical analysis of soils in the high plains of Meta and Vichada, Colombia.

pH	4.8	Ca^{++}	0.6 meq
Organic matter %	3.0	Mg^{++}	0.4 meq
Cation exchange capacity	12.0	K^{+}	0.05 meq
Phosphorus, ppm	1.5	Al^{+++}	3.5 meq

$$\frac{Al^{+++}}{\text{Total Bases}} = 3.5$$

Ranching and Agriculture

Commercial farming in the Llanos is confined to the narrow piedmont region, especially around Villavicencio. Most annual crops are grown on the flood plains where recent alluvium of cordillera origin usually provides sufficient fertility for acceptable corn, cotton, sorghum, and upland rice production. Plantain and bananas are grown as well as some sesame, oil palm, and citrus. Flooded rice is grown extensively with fertilizers on the less fertile but level terrace soils of the piedmont where topography is more favorable than in the floodplains. Rice is one of the few crops considered to be of high enough commercial value to warrant use of fertilizers.

Plant species other than pasture grasses which grow and produce to some extent without fertilization in the high plains of Meta and Vichada include "achiote," cashew, avocado, citrus, cacao, and mango trees, plus pineapple, cassava, watermelon, and "topocho" (a type of plantain). These are found in small acreages as "kitchen garden" crops on many ranches. They are frequently planted on old corral sites, taking advantage of the fertility-concentration process provided by occasionally penned range cattle. No domestic legume has so far been found which grows without fertilization. Pinto beans and peanuts have produced well with the addition of calcium and phosphorus (no nitrogen).

Ranching in the piedmont consists primarily of grass fattening of feeder cattle brought in from the savannahs of Meta, Vichada, Boyacá, and Arauca at 3 to 4 years of age. The proportion of improved pastures is increasing, with the introduced species Molasses grass (Melinis minutiflora) and Puntero (Hyphar-rhenia rufa) predominating at present although Brachiaria (Brachiaria decumbens and B. ruziziensis), Guinea grass (Panicum maximum), Elephant grass (Pennisetum purpureum), and some legumes show promise in the area. Pasto Negro (Paspalum plicatulum) is one of the best native species in this area.

Cattle for fattening may be fed on contract or purchased by piedmont ranchers as feeders. In many cases, they are produced by a rancher who owns land in both the piedmont and the savannah. The cattle are usually kept on improved pasture for 8 to 10 months, then shipped via truck to Bogotá for slaughter. Present local demand is for lean, grass-fed beef. Local prices are based primarily on weight rather than quality characteristics, with the heavier weights (450 to 530 kilograms) demanding higher prices.

Ranching in the high savannahs to the east of the piedmont is generally oriented toward the production of 3-4 year-old feeders under extensive rangetype management or no management at all. Some ranches are completely bounded by fences and rivers or creeks (which are used maximally for fencing), but few are cross-fenced.

Because land has long been available for the taking, ranches are extensive. Ranch size varies from 500 to 50,000 hectares or more, and cattle per ranch number from 100 or less to 5,000 or more. A 10,000-hectare ranch is not considered large. Stocking rates on native pasture are low, rarely exceeding 0.1 head per hectare and frequently as low as 0.05 head per hectare. These figures do not necessarily indicate the true carrying capacity of the range because increased grazing pressure and disking improve the native range by stimulating the better grasses, such as "Guaratara," to encroach on the "paja." There are few, if any, cases of over-grazing or of stocking rates which even approach the carrying capacity of the native range. Under present management practices, the availability of edible herbage during the dry season would undoubtedly be the major factor limiting carrying capacity.

Management of native range usually includes burning off excess coarse, dry herbage to permit regrowth of the more palatable, nutritious young shoots. The practice is condemned by some as being deleterious to the savannah soils. In reality, burning likely has little to do with soil characteristics. The burn is typically rapid and superficial. Soil temperatures are likely affected only to shallow depths as evidenced by the considerable organic matter content of soils on savannahs which have been burned for centuries. Calcium, magnesium, potassium, phosphorus, and other plant nutrients (with the exception of nitrogen and sulfur) remain in the ashes from which they are leached into the root zone by rain. They are not lost but rather are rapidly utilized in a new cycle of growth. Under the circumstances which presently prevail, burning is probably the only management practice available by which the rancher can provide edible forage for his livestock.

Under intensive management, with rotational grazing at or near the carrying capacity of the native range, it might be possible to eliminate burning or to replace it with an occasional mowing thereby reducing the risk to such improved species as Molasses grass which will not recover after burning, and to the less resistant native species, "Guaratara" and "Pasto Negro."

The native pastures are markedly deficient in calcium and phosphorus, and maximum protein content of native pastures (and probably of unfertilized improved pastures) is about 6 percent with the average being nearer 3 to 4 percent depending on the stage of maturity. These levels are barely sufficient to meet minimum needs for efficient growth and reproduction in cattle. Improved pastures are rare on the high savannah. Molasses grass (Melinis minutiflora), is one of the few species of improved grass which will grow without fertilization. Little data are available, but one study indicates that unfertilized Molasses grass will carry 0.5 to 1.0 animal unit per hectare per year in some areas and still maintain dominance over native species.

Puntero has been successfully established without fertilizer or lime in the same general area but on better soils, i.e. less acid soils of higher organic matter content and finer texture, but its development under these conditions is inadequate.

Most of the ranges in Meta and Vichada are well watered throughout the year, although animals frequently become mired in the mud when streams are low. Casanare ranges are frequently short of surface water during the dry season. The use of shallow wells (6 to 10 meters in many of the high savannahs) would be advisable in both areas during the dry season to avoid death losses in bogs and from diseases disseminated by stagnant water holes.

Ranch facilities are generally limited to housing (often primitive), corrals (some with chute), and a tack room. Salt is provided infrequently and minerals rarely. Preventive medicine is almost non-existent except for aftosa vaccination programs on some ranches. Horses are small (600 to 800 pounds) and able to work but one or two days per week without excessive loss of condition when maintained exclusively on native pasture.

Castration of calves is not practiced widely, and young bulls run with the cow herd until they are sold. Thus the impact of purebred bulls (mainly Zebu) is greatly diluted. The cows are predominantly "Casanare" (of mixed European origin) or cross-bred Zebu. Roundups are held once or twice a year to count, brand, ear mark, and select market animals. Few females are sold; steers or bulls are sold for fattening at 3 to 5 years of age; few are fattened in the area because of a lack of adequate quality pastures. Calving occurs year-round at rates varies from 30 to 40 percent; mortality in calves is between 10 to 15 percent generally, but reaches 25 to 30 percent in some areas; calves are weaned by their dams; the weaning rate is between 26 and 36 percent. Adult mortality probably varies between 5 to 10 percent.

Diseases and Pests

Mosquitoes, flies, ticks, wasps, ants, chiggers, and termites (which swarm in April) abound. Malaria occurs where mosquitoes are not controlled, and yellow fever and Chagás disease exist.

The economically important livestock diseases known to be present include piroplasmosis, trypanosomiasis (in cattle and horses), anaplasmosis, tetanus, anthrax, pasteurellosis, blackleg, aftosa, equine encephalomyelitis, equine infectious anemia, hydrops amnii, infectious calf scours, leptospirosis, a low incidence of brucellosis, external parasites (including ticks, mites, fungal infections, and screw worms), and internal parasites (including Onchocerca), especially in horses. The present low fertility rates and high frequency of bone fractures are attributed primarily to nutritional deficiencies, especially in calcium and phosphorus. Snake bite, death in bog holes during the dry season, and poisonous plants are the other major causes of death.

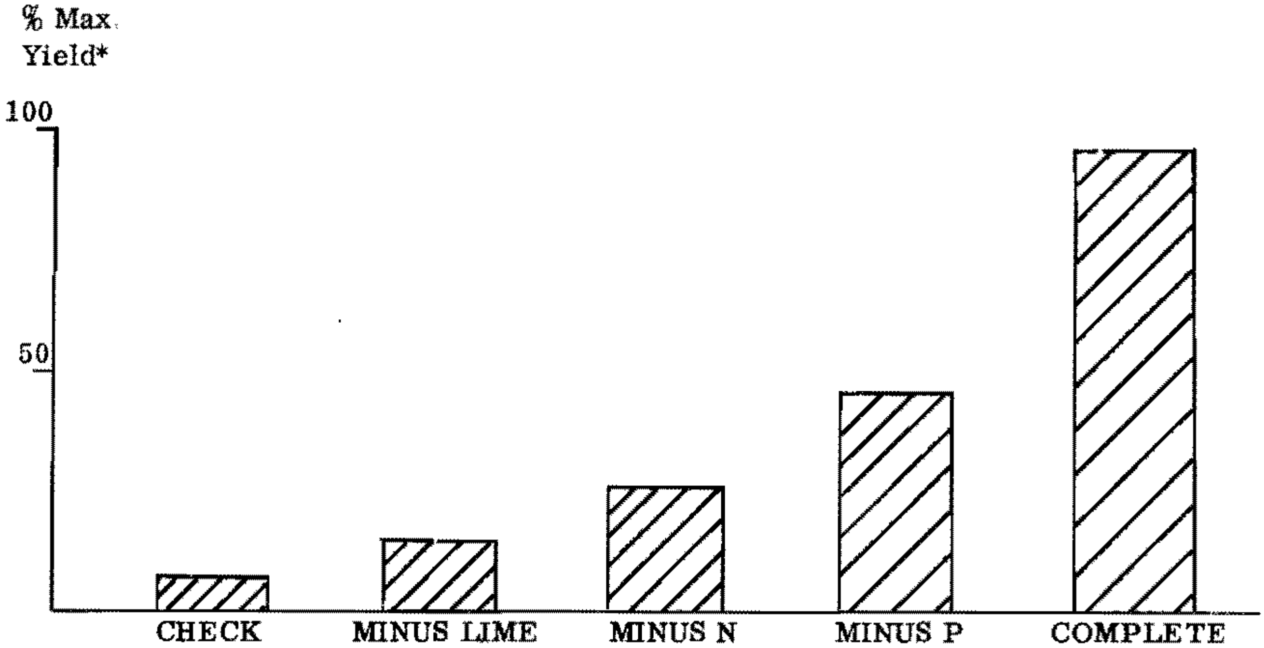
A few of the more progressive ranchers vaccinate for control of foot and mouth disease, blackleg, anthrax, hemorrhagic septicemia, and brucellosis, depending on the region and suspected presence of the disease. Most ranchers dip or spray their herds as necessary to control ticks. It is reported, and has been observed, that cattle grazing on Molasses grass remain relatively tick-free; the grass is waxy and highly aromatic, but the mechanism of tick control is unknown. Nuche warble (Dermatobia hominis) is serious in most of the piedmont but almost unknown in the open, high savannahs.

Agronomic Research

With the cooperation of area ranchers, the Instituto Colombiano Agropecuario (ICA), initiated agronomic research in the savannahs of Meta and Vichada early in 1966. The first experimental plots were planted in May and June at "El Piñal," a ranch located south of the Meta river near Orocué, some 300 kilometers from Villavicencio. Corn (H-104) was planted in small plots and treated with different levels of lime, phosphorus, and nitrogen in all combinations. Figure 1 is based on results of the first and second plantings. Note the striking response to each of these nutrients. Yields of best treatments were disappointing when compared with those obtained in traditional corn growing regions of Colombia. In subsequent experiments, with better insect control, yields increased markedly. Some 1968-A experiments using H-253 corn yielded 6 tons of grain at the experiment station "La Libertad" near Villavicencio. Experiments currently in progress (1969) near Vichada with this same hybrid indicate that similar yields may be obtained on high savannah soils.

During 1968, experiments were initiated at Gaviotas, a government-sponsored development center just inside Vichada on the road to "Santa Rita." Work in pastures and soils continues at "El Piñal" and at other sites between "El Piñal" and Puerto López. Results to date indicate that the most promising crops for the soil and climate include rice, peanuts, cowpeas, sorghum, sesame, and soybeans. Corn can be grown but has relatively high fertility and lime requirements.

Figure 1. Response of corn to nitrogen, phosphorus and lime in savannah soils, the eastern Llanos, Colombia.



*Yield of complete treatment is taken as 100 percent. Response to each factor is indicated by the difference between the "minus" plot and the "complete" plot.

Livestock Research

Several trials were initiated by ICA in 1966 at La Libertad and on various ranches in the area to demonstrate the effect of mineral supplementation and simple disease control programs on growth, fertility, calving percentages, calf mortality, and weaning weights. Some of the results are indicated in Table 2.

Table 2. Short term increases in cattle production through the application of an improved production system.

Production Factors	Percentage		
	1966-67 (Conventional Management)	1967-68 (Improved Management)	Production Increase
Calving rate	40	65	62
Death losses from birth to weaning	25	Less than 5	400
Excessively thin cows	30-50	Less than 15	100-230

Return on investment: 444 percent

Preliminary data indicate an increase in growth rate of 15 to 20 percent with mineral supplementation alone (see Table 3 for mineral formulation recommended).

Table 3. Complete mineral mixture recommended for livestock in the Llanos*

A.	Trace mineral mix		1 part
	Compound	Percentage	
	Copper sulfate	1.95	
	Iron sulfate	7.47	
	Zinc oxide	1.24	
	Magnanese sulfate	3.09	
	Cobalt sulfate	0.24	
	Potassium iodide	0.07	
	Wheat middlings	85.94	
		100.00	
B.	Steamed bone meal or the equivalent as fluoride-free dicalcium phosphate		5 parts
C.	Common salt		10 parts

*Average daily consumption per cow per day has been found to be approximately 50 grams.

Grazing trials to determine beef production per hectare on native range are in process on several ranches. Indications are that, with proper management rates of 1.0 animal unit per 2 to 4 hectares are feasible on native grass.

Production Potential

Agronomic research indicates clearly that the soils of the eastern prairies of Colombia can be made highly productive with adequate lime and fertilizer applications. Many fertility and management problems undoubtedly remain and will require major research efforts.

Under present market conditions, some crops could be produced economically while others would be marginal. As access routes are improved and costs of inputs decrease, the region should be able to compete in domestic and world markets in the production of rice and other grains as well as other crops including certain grain legumes.

Livestock production levels can be greatly improved with rather simple measures including supplemental feeding of minerals, basic animal health programs, controlled breeding, and improved range management. It is estimated that the application of these measures could result in short-term production increases of up to 300 percent.

Development of this area of the Llanos, including the establishment of cow-calf operations, requires operators with capital resources sufficient to sustain them for 3 to 5 years after setting up operations. Soil fertility is such that production of cash crops as an interim income source is not feasible unless lime and fertilizers are used at high levels of management.

ALTERNATIVE BEEF PRODUCTION SYSTEMS

Given the physical, economic, and social environment which characterize the area, there are many alternatives for investing resources. Rational decision making requires an analysis of the probable outcomes of alternative organizational patterns or systems of production. Indeed, given constantly changing technologic and economic environments, continuing evaluations of alternatives are essential to taking decisions and actions which maximize earnings or other goals and objectives. The analysis presented here is intended to assist in making rational management decisions.

The physical and biological information which provides the basis for analysis of alternatives represents estimates of experienced agricultural scientists familiar with the area. The prices used for resources and products are essentially current. In general, the data employed apply to the high savannah area south of the Meta river extending eastward from Puerto López through the Department of Meta and into the Comisaría of Vichada for a distance of some 200 kilometers. Although these data are thought to be representative of the area, they are obviously not necessarily directly applicable in any particular situation. However, an individual may adjust the analysis to his particular situation by appropriate correction of the technical information and prices.

Basic Assumptions of the Analysis

In the area of the study, the production of certain crops may be an economic alternative. However, the present study considers only beef production. Specifically, three beef cattle production systems are budgeted:

I. An extensive, minimum input system typical of present operations.

II. A medium intensive system, including controlled breeding involving some cross breeding, an improved animal health program, and a limited amount of improved pasture.

III. An intensive system based on improved pastures and including intensive animal breeding and health programs.

The basic production unit in all three systems is a 500-head brood-cow herd (consisting principally of Casanare-Zebu breeding). The 500-cow unit is an arbitrary assumption, but research in the United States suggests that such a herd is large enough to benefit from any size or scale cost-economies to be realized in a beef herd. (It should be noted that this result has not been verified under conditions in the Llanos). The amount of land used varies from system to system depending on the needs to support a 500-cow unit under the assumptions made.

Few of the current beef operations in the Llanos castrate males, and there is no market price differential between the two classes of animals. Hence, in each of the three systems budgeted, it has been assumed that the rate of gain in uncastrated males is sufficiently greater than otherwise to warrant the additional fencing cost and management problems. In all three cases, the on-farm sale price for animals is used for calculations.

In the three systems, the production and input requirements, and the cost-return estimates, assume a normal year with respect to production rates, death losses, and other technical and economic variables. Obviously, results will vary from year to year; hence the data presented are considered representative of long term averages or norms.

Summary of Detailed Assumptions for the Various Systems

System I is extensive, based on current production practices in the area. It assumes a 40 percent calving rate and a 34 percent weaning rate which implies a 15 percent death loss from birth to weaning. Breeding and calving are assumed to occur year-round and calves are weaned by the cow. Bulls are sold on the ranch at about 4 1/2 years of age at an average weight of 400 kilograms. These animals may go directly to slaughter or more likely will be fattened on another ranch.

Cattle do not have access to improved pasture, and no wells are used. The major items of equipment are a jeep or a pick-up truck and a small electric generator. Cattle are sprayed or dipped for ticks and vaccinated against aftosa twice each year. Salt is supplied periodically, but no minerals are provided.

In System II, calving and weaning rates of 75 and 70 percent, respectively, are assumed. Purebred Zebu bulls are used and the breeding season is April through July with calving occurring during the dry season (January through April). Calves are weaned at 7 to 9 months of age (in October or November) and before the end of the rainy season to insure that they have access to good pastures. Bulls are sold on the ranch at 4 years of age ready for slaughter at an average weight of 500 kilograms.

This system assumes the establishment of sufficient Molasses grass pasture to fatten slaughter bulls. The improved pasture will be stocked at the rate of one animal unit per hectare and will be maintained by hand-cleaning when necessary, thus eliminating the need for a tractor. Three wells, with either windmill or gasoline power pumps, are assumed. Cattle are sprayed every 90 days and vaccinated against aftosa three times each year. Routine annual vaccinations include blackleg, hemorrhagic septicemia, pasteurellosis, and anthrax. Sufficient fencing for control of breeding and weaning, as well as fattening of slaughter animals, is provided.

In System III, a calving rate of 85 percent and a weaning rate of 81 percent are assumed. Breeding and calving periods are somewhat shorter than in System II; weaning dates are the same. Bulls are sold for slaughter at 2 1/2 to 3 years of age, weighing an average of 500 kilograms. A cross-breeding program using Casanare-Zebu and San Martinero or Brown Swiss breeds is contemplated. Production testing will be employed with weaning and 18-month weights to be determined as a guide to production efficiency and selection.

Improved pastures include Puntero, Molasses grass, and a small amount of Brachiaria mixed with a legume such as Kudzu, all fertilized sufficiently to carry three animal units per hectare. In addition, 5 hectares of forage as a source of greenchop will be used for calves during corral weaning.

Grazing intensity and selective use of a rotospeed (rotary mower) will be used to maintain pastures, thus eliminating the need to burn.

Calves are weaned on improved pastures or greenchop to minimize weaning setbacks. Heifer calves may use the native pasture at one year of age if there is a shortage of improved pasture. However, given average conditions, males and females will be maintained permanently on improved pasture from birth to marketing.

The herd health program in System III is essentially the same as that of System II except that livestock are sprayed each 21 to 30 days, and all heifers are vaccinated against brucellosis. Bulls are fertility tested 2 to 3 months prior to the breeding season, cows are pregnancy tested 45 to 60 days after the breeding season, and non-pregnant cows are fattened and sold. Salt and a balanced mineral mix are provided year-round to all livestock.

Because less experience has been gained with a system such as System III, the input-output coefficients used are considered to be subject to greater error than those in Systems I and II. Further, in the event of adverse weather conditions, there is probably more inherent risk in System III than in the other two systems. A reserve of 1,500 hectares of native pasture is maintained to provide emergency grazing and reduce this type of risk.

As has been indicated earlier, resources in the study area could be used to produce commodities other than beef cattle. In a similar fashion only three of an essentially infinite range of beef cattle production alternatives have been budgeted. Other alternatives include extensive use of irrigation and utilization of pastures only for fattening purchased animals.

Estimated Input Requirements, Production, Costs and Returns of Three Systems

Table 4.0 presents estimates of the livestock inventory and livestock capital requirements for System I. The total inventory includes 1,201 head of beef cattle and 30 horses, making 1,015 animal units, requiring an investment of $1,202,660 pesos.

Table 4.1 presents the non-livestock inventory and capital requirements of System I. Land prices vary considerably in the Llanos and, in general, decrease with distance from Villavicencio. The houses include a reasonably substantial building for the owner and minimum housing for the work force. The stables include a tack room and other basic necessities. Fencing would vary depending on natural fencing in the form of canyons, streams, etc. The annual depreciation for buildings and other permanent fixtures is based on straight-line depreciation over a 10-year period. Equipment is depreciated at a more rapid rate.

Table 4. 2 presents estimated annual production and income for System I. Only slaughter bulls and cull cows are sold, all heifers being required to replace cull cows. On-farm prices are used and represent net prices to the rancher.

Table 4. 3 presents annual input requirements and cost estimates for System I. As this is an extensive or minimum input system, major input items are more or less fixed expenses in terms of labor and depreciation.

In the tables that follow, detailed estimates are presented for Systems II and III. The format for these tables is the same as for System I.

Table 7. presents a summary analysis of the three beef production systems. In terms of resources, the cow input is the same for each. The number of animal units on the ranch is higher for II than for I, primarily because of a much higher weaning rate. On the other hand, despite the fact that the weaning rate is higher in III than in II, the animal unit inventory is lower because the animals are sold at younger ages. This of course is made possible by a larger investment in improved pasture. Native pasture inputs are higher in I and lower in III. Contrarywise, no improved pastures are used in I and inputs for this item are higher in III.

Estimates of labor input are necessarily arbitrary, particularly in the case of System III where no operating experience has been accumulated. However, it is thought that the requirements budgeted for the three systems are correct in a relative sense. The cost of labor per man varies between systems because of the differing skills required.

Animal production, in terms of animals sold and pounds of beef produced and sold, increases rapidly between I and II, and the production in III is somewhat higher than in II. The contrast between I and II arises from the much higher weaning rate with II as well as heavier sale weights made possible by improved pastures.

Cow productivity, in physical terms, may be measured in several different ways, such as calving rate, weaning rate, animals sold per cow, and beef production per cow. Cow productivity is much greater in II than in I, somewhat higher for III than for II. Land productivity for III is much higher than for the other two systems, and a great deal higher for II than for I. In terms of beef production per man, III is less productive than II, but both are more productive than I. When measured in terms of cows as well as animal units per man, labor productivity is highest in I and lowest in III.

The potential rate of herd increase for various systems is important to individuals who are interested in expanding their herds and it is likewise important to the area and nation. Under System I, all heifer calves are required to replace death losses and the cull cows, leaving no possibility for natural herd increase or expansion. Thus, if all herds in the region operate at this level, any increase in cow numbers or total production of the region would necessarily come from purchased breeding stock. On the other hand, System II permits an increase of 11.6 percent per year in the cow herd, while System III permits an increase of 12.8 percent. Since each system involves the sale of cull cows, it could be argued that in each case the potential rate of herd increase has been underestimated. If the culling rate is reduced, however, calving rates and weaning rates would presumably be adversely affected.

Financial Analysis

Capital inputs are highest in System II and lowest in I. This of course arises from the much higher weaning percentage which results in a greater livestock investment in System II. On the other hand, the earlier sale date in III results in lower animal investments than in II. Most of the other capital investment differences are due to varying land requirements.

Both estimated gross income and estimated costs, not including interest, are highest in III and lowest in I. However, the residual return to capital and risk is negative in III, while the expected return in II is more than five times that of I. Furthermore, when interest charges are included in costs, they exceed estimated income in I and III.

Gross income per cow is highest in III, and the gross income per cow in I is much lower than for the other two systems. However, gross income per man is highest in II, with gross income per man in I being much lower than in the other two systems.

The cost of production per kilogram of beef, excluding interest charges, is estimated at 3.35, 1.93, and 4.48* for Systems I, II, and III, respectively. When interest charges are included, the total cost of production per kilogram of beef is estimated at 8.90, 4.23, and 6.29* for the respective systems.

The rate of capital turnover, measured in terms of the number of years required for gross receipts to equal capital investment, is fastest in III and slowest in I. These data suggest that in the case of System I, 10.4 years are required for gross receipts to equal capital investment. This compares to 4.2 and 3.5 years, respectively, for II and III.

Estimated returns to capital can be calculated by expressing the return to capital as a percentage of the capital investment. The rate of return in System I is estimated at 2.4 percent per year, and for System II at 13.5 percent per year, while returns to capital in System III are negative. In appraising these data it should be noted that these estimates assume no appreciation in capital value of assets, including land. Thus, if land prices in the area of the study are expected to increase over a period of years, it is clear that estimated rates of return on capital are underestimated. In System I, for example, a 1 percent per year increase in land value would imply an additional 0.3 percent per year return on all capital if this inventory increase is included as a receipt; in System II it would be an additional 0.2 percent.

In the case of System I, there is a 1.33 peso gross income per peso expense. This compares to $2.34 for II and $0.95 for III. The annual cost of maintaining a cow for one year, not including interest, is estimated at $303, $525, and $1,492 for the three systems, respectively. When interest charges are included, these costs rise to $804, $1,150, and $2,092 pesos, respectively.

Summary and Conclusions

Three beef production systems for the eastern Llanos of Colombia, and more specifically the high plains area south of the Meta river, are budgeted and analyzed. In general, the three systems may be characterized as involving extensive, medium intensive, and intensive systems of organization and management. The extensive system is considered to be typical of current cattle management in the region. It involves no improved pastures and no control or

* pesos

management of breeding. System II involves a limited amount of improved pastures but includes managed breeding and an improved animal health program. System III is dependent almost entirely on improved pastures, and includes a breeding program and an animal health program somewhat more advanced than in System II.

In terms of kilograms of beef produced per cow per year, III is the most productive of the three systems analyzed. However, in terms of financial results, System II appears to be, by a considerable margin, the most profitable. Thus, to the extent that these analyses are adequate, it would appear that adoption of improved pastures, primarily for fattening of market animals, is profitable. However, these results suggest that extensive substitution of improved pastures for native pastures is not profitable under present conditions.

Stated differently, reducing land extension by increasing fertilizer inputs is not profitable given present raw land prices and fertilizer costs. Whereas the number of hectares per cow is 23, 17, and 4 in Systems I, II, and III, respectively, the annual per cow pasture costs (including depreciation and interest on fences) are $178, $184, and $398, respectively. This difference of 220 percent between the first two systems and System III is due entirely to pasture maintenance costs, of which fertilizer purchase alone accounts for $266 or 67 percent.

It should be emphasized that the three systems budgeted are only several of an infinite number of possibilities. The technical coefficients used in budgeting System III are probably more subject to error than in the other two systems because of lack of experience with such a system.

The results presented here are not necessarily applicable to any specific ranching operation in the Llanos. Present and potential operators may find it profitable to budget alternatives under the specific circumstances surrounding their cattle enterprise. This could involve somewhat different technical coefficients such as weaning rates, as well as prices more specific to the local area.

Although this analysis is primarily directed to questions of the economics of the individual ranching units, certain conclusions relative to potential macro effects seem appropriate. Although the Llanos are generally thought to have an enormous potential for cattle production, they now account for only approximately 10 percent of the nation's cattle inventory. It should be noted further that if the typical system (System I) budgeted here is, in fact, typical of the Llanos, current weaning rates and production levels do not permit expansion of breeding stock through natural increase. On the other hand, the improved system budgeted in System II permits a fairly rapid increase of approximately 12 percent per year in female breeding stock. These data suggest that cattle production and management systems are of interest not only to the individual ranchers, but to the welfare and growth of the nation as well.

Table 4.0 Estimated Livestock Inventory and Capital Requirements, Beef Production System I[1] (Typical Extensive), Colombian Llanos

Item	Number	Value (Pesos)		Animal Units (A.U.)	
		Each	Total	Each	Total
Brood cows	500	$1,200	$ 600,000	1.0	500
Bulls	5[2]	3,000	15,000	1.0	5
Calves less than 1 year old	170	350	59,500	0.2	34
Young stock, 1-2 years old	160	640	102,400	0.5	80
Young stock, 2-3 years old	151	860	129,860	1.0	151
Young stock, 3-4 years old	143[3]	1,100	157,300	1.0	143
Slaughter bulls 4 years old	72	1,300	93,600	1.0	72
Horses	30	1,500	45,000	1.0	30
Totals	1,231	XX	$1,202,660	XX	1,015

(1) Year-round breeding; calving rate 40 percent; weaning rate, 34 percent; death loss birth to weaning, 15 percent; death loss in all other ages, 6 percent; sell at 4 1/2 years of age.

(2) One improved bull is purchased each year despite the fact that there is no formal breeding system.

(3) Of the 70 heifers, 30 replace cows that die, and 40 replace cows culled for sale.

Table 4.1 Estimated Non-Livestock Inventory and Capital Requirements, Beef Production System I (Typical Extensive), Colombian Llanos

Item	Amount	Value (Pesos)		Annual Depreciation (Pesos)
		Each	Total	
Native pasture (ha.)	11,673 (1)	$ 50	$583,650	$ XX
Houses	XX	XX	100,000	10,000
Stable	1	15,000	15,000	1,500
Fencing (km.)	20	4,500 (2)	90,000	9,000
Power plant	1	10,000	10,000	2,000
Corrals	1	10,000	10,000	2,000
Sprayer	1	8,000	8,000	1,600
Pickup	1	65,000	65,000	13,000
Saddles	3	800	2,400	480
Miscellaneous tools	1	2,000	2,000	400
Totals	XX	XX	$886,050	$39,980

(1) Ten hectares per animal unit plus 15 percent loss of pasture in streams and forests.

(2) Cost per kilometer of 4 strand fence:

250 posts at $6.00	$1,500
Labor	600
Wire and staples	2,375
Corners and braces	25
	$4,500

Note: A swing fence, with brace posts every 300 meters, at a cost of $2,500 per kilometer might be adequate. (See "Long Span Fences" So. Dakota State University, Agricultural Experiment Station Bul. 546, June, 1969).

Table 4.2 Estimated Annual Production and Income, Beef Production System I (Typical Extensive), Colombian Llanos

Item	No. Sold	Weight (kilos)	Kilos Beef	Price/Kilo (Pesos)	Value (Pesos)	
					Each	Total
Slaughter bulls	72	400	28,800	$4.70	$1,880	$135,360
Cull cows	41	400	16,400	4.00	1,600	65,600
Totals	113	XX	45,200	XX	XX	$200,960

Table 4.3 Estimated Annual Input Requirements and Costs, Beef Production System I (Typical Extensive), Colombian Llanos

Item	Number	Value (Pesos) Each	Total
Salt (A.U.)[1]	1,015	$ 2.60	$ 2,639
Drugs and vaccines (A.U.)	1,015	5.00	5,075
Bull, purebred[2]	1	6,000.00	6,000
Labor:[3] Manager	1	12,040.00	12,040
Cowboys	2	7,990.00	15,980
Laborers	4	6,370.00	25,480
Cook	1	6,370.00	6,370
Horse depreciation	30	150.00	4,500
Building and equipment depreciation	XX	XX	39,980
Building and equipment repair	XX	XX	7,689
Fuel and lubricants	XX	XX	7,500
Tax (A.U.)	1,015	18.00	18,270
Totals	XX	XX	$151,523

(1) A.U. = Animal Unit.

(2) Buy one bull each year at $6,000.

(3) Labor cost includes food and social security.

Table 5.0 Estimated Livestock Inventory and Capital Requirements, Beef Production System II[1] (Medium Intensive), Colombian Llanos

Item	Number	Value (Pesos)		Animal Units	
		Each	Total	Each	Total
Brood cows	500	$1,200	$600,000	1.0	500
Bulls	20	4,500	90,000	1.0	20
Calves less than 1 year old	350	360	126,000	0.2	70
Young stock 1-2 years old	336	720	241,920	0.5	168
Young stock 2-3 years old[2]	322	980	315,560	1.0	322
Young heifers 3-4 years old	60	1,100	66,000	1.0	60
Young bulls 3-4 years old	160	1,100	176,000	1.0	160
Horses	30	1,500	45,000	1.2	36
Totals	1,778	XX	$1,660,480	XX	1,336

(1) Improved pastures; calving January-April; calving rate, 75 percent; weaning rate, 70 percent; death loss birth to weaning, 9 percent; death loss in bulls, 2 percent; death loss in all other groups, 4 percent; sell at 4 years of age.

(2) Of the 161 heifers, 95 move to the breeding herd to replace 20 cows that die and 75 that are culled.

Table 5.1 Estimated Non-Livestock Inventory and Capital Requirements, Beef Production System II (Medium Intensive), Colombian Llanos

Item	Amount	Value (Pesos)		Annual Depreciation (Pesos)
		Each	Total	
Improved pasture (ha.)	250[1]	$ 490	$122,500	$ XX
Native pasture (ha.)	8,200[2]	50	410,000	XX
Houses	XX	XX	100,000	10,000
Stable	XX	XX	15,000	1,500
Fencing (km.)	30	4,500[3]	135,000	13,500
Power plant	1	10,000	10,000	2,000
Corrals	1	10,000	10,000	2,000
Windmills	3	16,000	48,000	4,800
Tanks	3	2,000	6,000	600
Salt feeders	11	800	8,800	1,760
Sprayer	1	8,000	8,000	1,600
Pickup	1	65,000	65,000	13,000
Saddles	5	800	4,000	800
Miscellaneous tools	1	3,500	3,500	700
Totals	XX	XX	$945,800	$52,260

(1) Utilized by 160 slaughter bulls and 75 cull cows.

(2) Six hectares per animal unit plus 15 percent for loss in streams and forests.

(3) Cost per kilometer of 4 strand fence: (See table 4.1).

Table 5. 2 Estimated Annual Production and Income, Beef Production System II (Medium Intensity), Colombian Llanos

Item	No. Sold	Weight (Kilos)	Kilos Beef	Price/Kilo (Pesos)	Value (Pesos)	
					Each	Total
Slaughter bulls	154	500	77,000	$4.70	$2,350	$361,900
Cull cows	75	460	34,500	4.00	1,840	138,000
Heifers	58	420	24,360	4.70	1,974	114,492
Totals	287	XX	135,860	XX	XX	$614,392

Table 5.3 Estimated Annual Input Requirements and Costs, Beef Production System II (Medium Intensive), Colombian Llanos

Item	Number	Value (Pesos)	
		Each	Total
Salt and minerals (A. U.)	1,336	$ 15.00	$ 20,040
Drugs and vaccines (A. U.)	1,336	12.50	16,700
Veterinary and management service (A. U.)	1,336	1.00	1,336
Bull depreciation	20	820.00(1)	16,400
Labor:(2) Manager	1	28,240.00	28,240
Cowboys	3	8,800.00	26,400
Laborers	6	7,180.00	43,080
Cook	1	7,180.00	7,180
Horse depreciation	30	300.00	9,000
Building and equipment depreciation	XX	XX	52,260
Building and equipment repairs	XX	XX	10,273
Fuel and lubricants	XX	XX	7,500
Tax (A. U.)	1,336	18.00	24,048
Totals	XX	XX	$262,457

(1) Buy at $6,000, 2 percent death loss each year and sell at $2,500 after 5 years service. Thus $6,000 - $2,500 ÷ 5 + (6,000 x .02) = $820.

(2) Labor Cost includes food and social security.

Table 6.0 Estimated Livestock Inventory and Capital Requirements, Beef Production System III[1] (Intensive), Colombian Llanos

Item	Number	Value (Pesos) Each	Value (Pesos) Total	Animal Units Each	Animal Units Total
Brood cows	500[2]	$ 1,200	$ 600,000	1.0	500
Bulls	22	4,500	99,000	1.0	22
Calves less than 1 year old	405	400	162,000	0.2	81
Young stock 1-2 years old	389	800	311,200	0.5	195
Young stock 2-3 years old	373[3]	1,100	410,300	1.0	373
Horses	15	3,000	45,000	1.2	18
Totals	1,704	XX	$1,627,500	XX	1,189

(1) Improved pastures; calving January-March; calving rate, 85 percent; weaning rate, 81 percent; death loss birth to weaning, 5 percent; death loss in bulls, 2 percent; death loss in all other groups, 4 percent; sell at 3 years of age.

(2) Breed 500 cows plus 105 heifers and pregnancy test 60-90 days after breeding season to cull infertile cows for sale.

(3) Of the 184 heifers, 105 are retained to replace 20 cows that die and 85 that are culled.

Table 6.1 Estimated Non-Livestock Inventory and Capital Requirements, Beef Production System III (Intensive), Colombian Llanos

Item	Amount	Value (Pesos) Each	Value (Pesos) Total	Annual Depreciation (Pesos)
Improved pasture (ha.)	425[1]	$ 490	208,250	$ XX
Native pasture (ha.)	1,500[2]	50	75,000	XX
Houses	3	XX	100,000	10,000
Stable	1	15,000	15,000	1,500
Fencing (km.)	20	4,500[3]	90,000	9,000
Power plant	1	10,000	10,000	2,000
Corrals	1	10,000	10,000	2,000
Windmills	8	16,000	128,000	12,800
Tanks	8	2,000	16,000	1,600
Salt feeders	14	800	11,200	2,240
Sprayer	1	8,000	8,000	1,600
Pickup	1	65,000	65,000	13,000
Tractor and equipment	1	110,000	110,000	22,000
Saddles	10	800	8,000	1,600
Miscellaneous tools	1	5,000	5,000	1,000
Scales	1	14,850	14,850	1,485
Totals	XX	XX	$874,300	$81,825

(1) Calculated at the rate of 0.33 hectare per animal unit, including fattening of cull cows prior to sale, plus 1 hectare per horse, plus land for forage production.

(2) 1,500 hectare reserve.

(3) Cost per kilometer of 4 strand fence: (See Table 4.1).

Table 6.2 Estimated Annual Production and Income, Beef Production System III (Intensive), Colombian Llanos

	No. Sold	Weight (Kilos)	Kilos Beef	Price/Kilo (Pesos)	Value (Pesos)	
					Each	Total
Slaughter bulls	184	500	92,000	$4.70	$2,350	$432,400
Cull cows	85	460	39,100	4.00	1,840	156,400
Heifers	84	420	35,280	3.50	1,470	123,480
Totals	353	XX	166,380	XX	XX	$712,280

Table 6.3 Estimated Annual Input Requirements and Costs, Beef Production System III (Intensive), Colombian Llanos

Item		Number	Value (Pesos)	
			Each	Total
Salt and mineral (A.U.)		1,189	$ 25	$ 29,725
Drugs and vaccines (A.U.)		1,189	18	21,402
Veterinary and management service (A.U.)		1,189	8	9,512
Pasture maintenance (ha.)		425	860 (1)	365,500
Greenchop production (ha.)		5	600	3,000
Bull depreciation		20	820 (2)	16,400
Labor: (3)	Foreman	1	15,280	15,280
	Manager	1	50,920	50,920
	Cowboys	4	10,420	41,680
	Laborers	8	7,180	57,440
	Cook	1	8,800	8,800
Horse depreciation		15	300	4,500
Building and equipment depreciation		XX	XX	81,825
Building and equipment repair		XX	XX	14,125
Fuel and lubricants		XX	XX	7,500
Tax (A.U.)		1,189	18	21,402
Totals		XX	XX	$745,911

(1) Tractor and equipment -------------- 60.00
Fertilizer (Urea plus 10-20-20)-------800.00
$860.00

(2) Buy at $6,000, 2 percent death loss each year and sell at $2,500 after five years. Thus 6,000 - 2,500 ÷ 5 + (6,000 x 0.02) = $820.

(3) Labor cost includes food and social security.

Table 7. Summary Analysis of Three Beef Production Systems, Colombian Llanos

Item	Unit	I Typical Extensive	II Medium Intensive	III Intensive
Resources used:				
Brood cows	Number	500	500	500
Animal units	Number	1,015	1,336	1,189
Native pasture	Ha.	11,673	8,200	1,500
Improved pasture	Ha.	XX	250	425
Supplementary feeding	Ha.	XX	XX	5
Labor	Man-years	8	11	15
Annual Production:				
Animals sold	Number	113	287	353
Beef sold	Kilos	45,200	135,860	166,380
Productivity:				
Calving rate	Percent	40	75	85
Weaning rate	Percent	34	70	81
Animals sold per cow	Number	0.23	0.57	0.71
Beef production per cow	Kilos	90.4	271.6	333.6
Beef production per ha.	Kilos	3.9	16.1	86.4 (1) 391.5 (2)
Beef production per man	Kilos	5,650	12,345	11,120
Animal units per man	Number	127	121	79
Cows per man	Number	62.5	45.5	33.3
Potential rate of cow herd increase (3)	Percent	XX	11.6	12.8

(1) Production for total land holdings.

(2) Potential production using only the improved pasture.

(3) Heifers sold as a percentage of the cow herd.

Table 7.
Page 2

Item	I Typical Extensive	II Medium Intensive	III Intensive
Sale Ages: (Months)			
Slaughter bulls	52	48	39
Heifers	XX	36	36
Sale Weights: (Kilos)			
Slaughter bulls	400	500	500
Breeding bulls	XX	XX	XX
Cull cows	400	460	460
Heifers	XX	420	420
Investments: (Pesos)			
Livestock	$1,202,660	$1,660,480	$1,627,500
Other	886,050	945,800	874,300
Total	2,088,710	2,606,280	2,501,800
Income and Costs: (Pesos)			
Estimated income	200,960	614,392	712,280
Estimated costs (1)	151,523	262,467	745,911
Returns to capital and risk	49,437	351,925	neg.
Interest at 12 percent	250,645	312,754	300,216
"Total" estimated costs (2)	402,168	575,221	1,046,127

(1) Not including interest on capital.

(2) Including interest on capital.

Table 7.
Page 3

Item	I Typical Extensive	II Medium Intensive	III Intensive
Financial Analysis:			
Gross income per cow	$ 402	$ 1,229	$ 1,425
Gross income per man	$ 25,120	$ 55,854	$ 47,485
Investment per cow	$ 4,177	$ 5,213	$ 5,004
Cost per kilo beef(3)	$ 3.35	$ 1.93	$ 4.48
"Total" cost per kilo beef(4)	$ 8.90	$ 4.23	$ 6.29
Rate of capital turnover (Ratio)	10.4	4.2	3.5
Return to capital (%)	2.4	13.5	neg.
Income per peso cost	$ 1.33	$ 2.34	$ 0.95
Cost per cow(3)	$ 303.00	$ 525.00	$ 1,492.00
"Total" cost per cow(4)	$ 804.00	$ 1,150.00	$ 2,092.00

(3) Not including interest.

(4) Including interest.

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