CATTLE YIELD PREDICTION FOR THE TRANSAMAZON HIGHWAY OF BRAZIL

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SUMMARY The Brazilian government is presently encouraging the rapid development of cattle pasture in large parts of the Amazon Basin through a massive program of financial and tax incentives. This has been encouraged by recent claims in Brasil that pasture improves soil quality, and therefore presumably could supply an indefinite yield of cattle to the ranchers that are responding to the incentives program. Calculation of beef productivity to be expected in areas such as Brazil's Transamazon Highway by a variety of means all lead to the conclusion that government expectations are over-optimistic. The present paper develops equations for prediction of cattle yields for a study area on the Transamazon Highway including the effects of both soil nutrients and competition from weeds. Low levels of soil phosphorus and invasion of inedible weeds soon reduce grass and cattle yields to very low levels. Results of a computer simulation of cattle yields based on the relationships developed linking yield to soil nutrients and weeds, and on the soil information gathered in the Transamazon Highway study area, are presented. The pasture simulation forms a part of a larger simulation of the agroecosystem of the Transamazon Highway colonists which is aimed at assessing the importance of various factors on the carrying capacity of the area for human populations. Although the carrying capacity study shows that agriculture based largely on annual crops is a risky business, it also casts doubt on the presumption of secure and sustainable yields from the pasture development schemes currently being promoted in the Brazilian Amazon.

This discussion of cattle yield prediction on Brazil's Transamazon Highway is a portion of a study aimed at the estimation of carrying capacity for human populations in a part of the colonization area near Altamira, Pará (Fearnside, 1978). The cattle yield prediction methods discussed here, when combined with the prediction of soil fertility changes under pasture (Fearnside, 1979), allow the simulation of cattle yields either as a part of the full carrying capacity model called "KPROG2" or separately in a smaller simulation for individual crop yields and soil changes called "AGRISIM". Subroutines dealing with cattle yields and soil changes under pasture are included in the program and documentation for KPROG2, together with a complete list of parameter values used in standard runs of the model (Fearnside, 1979). The hotly-debated questions in Brazil of 1) whether soil fertility is indefinitely sustainable under cattle pasture, 2) whether this implies that cattle yields are also sustainable, and 3) whether the conclusion follows from this that vast areas of the Amazon Basin should be converted to cattle pasture, makes this particularly timely. The findings of Falesi (1974, 1976) that pasture improves soil fertility lend support to the Brazilian government's massive financial incentives program encouraging the rapid conversion of much of the Amazon to cattle pasture. The pasture and soils debate has been discussed in a separate treatment of soil fertility changes under pasture (Fearnside, to be published). The importance of this debate dictates that the question of cattle yield prediction be examined carefully. With this in mind, the present discussion presents several possible ways in which cattle yield predictions can be calculated based primarily on disparate pieces of information gleaned from the literature on the subject, and from my own study of the Transamazon Highway based on two years of fieldwork in the area from 1974 through 1976 plus shorter visits extending the period of information from 1973 through 1978. All of the methods of calculation lead to the conclusion that cattle yields to be expected are far lower than official projections for the Amazon, and that for several reasons these yields cannot be expected to continue for the long periods that official statements imply.

Stocking Rates and Pasture "Carrying Capacity"

There are a number of statements in the literature giving values for the "average carrying capacity" in Amazon *terra firme* (high ground). Most of these statements are not accompanied by supporting data showing how the figures were derived. Presumably most of these come from observations (although unspecified as to sample size, sampling design, etc.) of the number of cattle per hectare which ranchers actually had stocked on their pastures at the time of an interview. This, of course, is not actually an estimate of "carrying capacity", since there is no indication, as through observations of changes in weed populations or soils, that the stocking rates observed could be maintained on a sustainable basis. In new areas, such as the Transamazon Highway, stocking rates can also often be misleading since the rate is often low due to a lack of availability of cattle or of money to purchase them, rather than any conviction on the part of the rancher that further increase in the stocking rate would cause deterioration of the pasture. There is also the problem of vagueness in most of these statements on the important question of whether the reported stocking rate refers to the density of cattle only on the area of pasture on which the cattle are actually grazing at the time of the interview, or whether the figure refers to the larger areas including second growth which are in a bush fallow between periods of use as pasture. The inclusion of the larger area can mean a difference of a factor of three or four, as in the case of two ranching operations for which both types of stocking rates are reported in the Amazonian portion of Peru: Tournavista with three head per hectare grazed and one head per hectare overall, and Granja San Jorge with 1.5 head per hectare grazed and 0.4 head

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per hectare overall (Watters, 1971: 265-70). The following statements on cattle "carrying capacity" in Amazonian *terra firme* represent the range of opinions: 1) The Brazilian representative at a conference on the development of ranching in the American humid tropics held at Guayaquil, Ecuador in 1973 writes that the "mean carrying capacity" is one head per 2.5 ha/yr (0.40 head/ha) (do Nascimento and de Moura Carvalho, 1973: 111-B-32). 2) The director of EMBRAPA-IPEAN, the agricultural research institute in Belem, writes that "carrying capacity can reach four head/ha" in what he describes as "magnificent pastures" near Paragominas, Para (Falesi, 1974: 2.14). 3) The carrying capacity of *Brachiaria decumbens* experimental plantations at EMBRAPA-IPEAN in Belém is estimated at 1.5 head/ha/yr based on "quantitative and qualitative initial data and observations over several years" (Serrão and Neto, 1971: 26). 4) Using figures for the total number of cattle and the total area of pasture in the Northern Region of Brazil (which includes the flooded *várzea* as well as *terra firme*), a value of 2.7 ha/head (0.37 head/ha) is given in an EMBRAPA report on the National Bovine Project (Bercellos, 1974: 6,13). 5) The Superintendency for Development in the Amazon (SUDAM) in a background document for its massive fiscal incentives program for pasture, gives one head/ha as the "carrying capacity" of rainforest areas for breeding and two head/ha for fattening (Brasil. Ministério do Interior, SUDAM, Departamento de Incentivos, 1974: 45). 6) Nigel Smith estimates that the "carrying capacity" in upland Amazônia is one head/ha based on interviews on current stocking rates at four ranches (Smith, 1977).

Calculation of a "Three-Year Feeding Capacity" For Transamazon Pastures

Pasture Productivity under Average Conditions

Since sufficient information is not available to calculate a pasture "carrying capacity" which includes allowances for long-term changes in weed domination and soil compaction, some idea of what might better be termed a three-year feeding capacity can be estimated from a variety of disparate pieces of information taken from the literature.

The yearly productivity of dry weight for pastures under different soil conditions must be known if the feeding capacity of pastures on the Transamazon Highway is to be estimated. This must come from a variety of experiments done both on the Transamazon Highway and in Belém since no experiments have been run to make the particular measurement required. Virtually all of the pasture on the Transamazon Highway is "capim colonião" (*Panicum maximum*). Local data is unavailable for estimating the productivity of this pasture since the experiments done to date are variety trials using fertilized plots. Data from the local experiments can be used for a rough estimate of the difference in yield between this variety and another variety (*Brachiaria decumbens* Stapf) for which core extensive data are available: *Panicum maximum* produces better than *Brachiaria decumbens* by a factor of 1.12 (Viégas and Kass, 1974: 33). In these experiments, despite fertilization with superphosphate, ammonium sulfate, potassium chloride, and manure, *Panicum maximum* was described as showing "unsatisfactory vegetative development with visible symptoms of nutritional deficiency" (Viégas and Kass, 1974: 34). In addition to the fertilization, I observed these plots on the best soil type in the area, terra roxa (Oxisol) —the report, which was written by personnel at the headquarters in Belém who had not carried out the actual experiments, is apparently in error when it states that the soil type was the less fertile red yellow podzol (Utisol) (Viégas and Kass, 1974: 31).

If the relative difference in production between the two varieties can be assumed to hold at lower levels of soil fertility, some idea of the productivity of *Panicum maximum* in the Altamira area can be deduced from the performance of *Brachiaria decumbens* in Belém. The Belém experiments were done on a different soil type (yellow latosol —Utisol—), but the levels of the various nutrients are similar to those found in red-yellow podzol, the most common soil type in the "intensive study area" of the Transamazon Highway which was the focus of my study of human carrying capacity in the area (Fearnside, 1978). Soil nutrients for the area of the Belém experiments are given as: pH = 4.7, Al^{+++} = 1.2 meq/100g, Ca^{++} & Mg^{++} = 0.59 meq/100g, P = 4.0 ppm, and K=40.0 ppm (note: the report (Serrão *et al.*, 1971: 10) gives the units for P and K as "kg/ha", but the inconsistency with figures elsewhere in the report, plus knowledge of how EMBRAPA soil results are reported, lead me to believe that the units are actually ppm). The Belém experiments found a dry weight production of *Brachiaria* in unfertilized plots of 253 kg/ha in the first 342 days, which would correspond to approximately 270 kg/ha in a 365-day year. Correcting this for the difference in variety, an estimate of 303 kg dry weight/ha can be made for first-year *Panicum maximum* production.

The pasture yields in years after the first decline markedly, largely due to the invasion of weeds. The problem of weed invasion is greater with lower soil fertility. This is shown by comparison of the percent of the total dry weight of plant matter which is weeds as opposed to pasture at different fertilization levels in the *Brachiaria* experiments (Serrão *et al.*, 1971: 19). The *Brachiaria* experimenters conclude that the lower fertility makes it impossible for pasture to compete effectively with weeds which are adapted to low fertility conditions. In unfertilized plots of *Brachiaria decumbens*, 83% of the dry weight is weeds after 405 days, and in *B. ruziziensis* 73% of the dry weight is weeds after 368 days (Serrão *et al.*, 1971: 19). These figures contrast with 10% and 0% weeds for plots with a complete fertilizer treatment. One would expect even greater invasions of weeds in pastures with cattle since the cattle would be selectively eating the grass and not the weeds. Ignoring the effects of greater weed invasion at lower (realistic) fertility levels, and the effects of cattle, one can at least get a minimal figure for the decline in pasture yield after the first year from the results of a different *Brachiaria* experiment carried out over a span of three years at Belém. Here the plots benefited from chemical fertilizer and manure every year, as well as one weeding during the year. The results for *Panicum maximum* show a second year yield which is 63% of the first year yield, and a third year yield which is 49% of the first year yield (Neto *et al.*, 1973: 9).

Using the results of the foregoing experiments as the estimates for yield decline following the first year, the 303.0 kg/ha dry weight production in the first year would decline to 190.9 kg/ha in the second year and 148.5 kg/ha in the third year. This would give an average pasture productivity of 214.1 kg dry weight/ha/yr over the three-year period for unfertilized soils in this not unrepresentative fertility range. Since most of the assumptions that had to be made in deriving this figure were on the optimitic side, the actual feeding capacity could well be less than this.

Beef Productivity

Rough figures for the conversion of pasture grass dry weight into beef can be taken from a model of an African cattle raising system outlined by Howard Odum (1971: 109). Odum uses a figure of 4.5 kcal/gram dry weight for the energy content of pasture, and uses a value of 8000 kcal/day as the metabolic requirement of a 294.8 kg steer (citing Kleiber, 1961 for the latter value). This is the equivalent of 27.13 kcal/kg live weight/day, or 2.20 kg dry weight grass/kg live weight/year.

Average slaughter weight in Amazônia is given as 330 kg by do Nascimento and de Moura Carvalho (1973: 111-B-32), and as 350 kg by Smith (1977: 31) citing United Nations

F.A.O. (1973) and the Brazilian statistical institute figures (Brasil, IDESP, 1970). Mean age at slaughter is given as four years by all of these references, and as 4.5-5.5 years in the EMBRAPA report (Barcellos, 1974: 6.16).

Using the value for weight at slaughter of 330 kg as the weight of "adult" cattle on the range, the dry weight/kcal and metabolism figures used by Odum can be used to calculate the amount of pasture dry weight needed to support one head of cattle per year, resulting in a value of 726.8 kg dry weight/head/year. One must assume for lack of other data that this rate of consumption would result in the observed region-wide average growth rate corresponding to the attainment of a 330 kg slaughter weight in four years. Assuming optimistically that cattle could eat all of the grass produced, first year "feeding capacity" would then be the 303 kg dry weight produced divided by the 726.8 kg/head/year required, or 0.42 head/ha for the first year. The feeding capacity of the second and third years would be 0.26 and 0.21 head/ha respectively. The three year average feeding capacity would then be 0.30 head/ha.

There are several alternative sets of conversion factors available in the literature for converting pasture production figures into either "carrying capacity" or beef production estimates. These yield almost exactly the same result as the Odum conversion factors.

One alternative method can be deduced from the calculations of Vicente-Chandler (1975: 424). Here "carrying capacity" for one 273 kg steer is given as equivalent to 3.86 kg of total digestible nutrients per day. Total digestible nutrients has been calculated from kg dry forage for both star grass (*Cynodon plectostachyum*) and pangola grass (*Digitaria decumbens*) using a figure of 0.54 kg total digestible nutrients as equal to one kg dry matter. (The actual method of calculation used by Vicente-Chandler is the reverse, as is common in the range management literature: the weight gains of the cattle are measured and the total digestible nutrients and dry matter which they must have eaten are calculated). Using these figures, 9.56 kg dry weight pasture/kg live weight of cattle per year would be required. The problem of pasture grown on soils deficient in minerals such as phosphorus being less nutritious than equivalent weights of pasture grown on more fertile soils (eg. Kamprath, 1973: 143) must be ignored here. The feeding capacities for 330 kg steers using the previously estimated production figures for Transamazon Highway pasture under average conditions, would be 0.37 head/ha for the first year, 0.26 head/ha for the second year, and 0.20 head/ha for the third year. This gives a three-year feeding capacity average of 0.28 head/ha.

TABLE 1

REGRESSION OF PASTURE YIELD ON PHOSPHORUS

Regression	Y	=	4.84 A
Standard Error			1.27
t statistic			3.82
Significance			< 0.01
Partial correlation			0.82
	R-Squared = 0.44	F statistic = 14.55	
	N = 8		

Abbreviations: Y = (yield with phosphorus / yield without phosphorus) — 1.0
A = ppm phosphorus — 2.0
Note: phosphorus range is $0 < A < 8$ ppm.

A third method of calculation also produces a similar figure. An estimate of the feeding capacity can be obtained from the rate of weight gain that would be required to reach 330 kg by the average slaughter age of four years, coupled with a conversion factor relating amounts eaten to amounts gained. Vicente-Chandler (1975: 424) has used a formula involving body weights, days of grazing, and weight gains to make the reverse calculation from weight gains to amount eaten. He does not give the formula, but credits it to the "Pasture Research Committee (1943)" without giving a bibliographic citation. Of 17 such conversions made in Vicente-Chandler's paper, the conversion factors are all quite close to the average of 0.14 kg weight gain/kg total digestible nutrients consumed (the range is 0.12-0.16, SD=0.01). Using the conversion factor of 0.54 to convert dry matter to total digestible nutrients, the average yearly production of total digestible nutrients over a three year period can be estimated at 187 kg/ha. The potential cattle weight gain from this, assuming the cattle eat all of the grass, is therefore 26.2 kg weight gain/ha/year averaged over three years. Since a steer must gain an average of 82.5 kg/year in order to reach a weight of 330 kg in four years, the three-year feeding capacity can be estimated at 26.2 divided by 82.5 or 0.32 head/ha.

It is no surprise that the value of 0.32 head/ha from weight gains is close to both the 0.30 head/ha figure derived from Odum's calorie conversions and the 0.28 head/ha figure derived from Vicente-Chandler's "carrying capacity" conversion factor. The fact that these three-year feeding capacity figures are lower than most of the stocking rate figures underlines the unreliability of using current stocking rate as an estimate of pasture "carrying capacity".

The three year feeding capacity of the pastures should correspond roughly to the maximum stocking rate which would pay on a short-term basis for pastures of the type which are actually in use at any point in time and pastures from which cattle are temporarily excluded to allow re-growth, but not second growth areas which are recovering between use periods as pasture. A stocking rate would have to be lower than this were the rancher concerned about preventing degradation of the pastures, as well as obtaining the maximum short-term yield.

Probable Pasture Management Cycles on The Transamazon Highway

The question remains as to what becomes of pasture yields after the third year. My interviews with ranchers in the much older area of colonization in the area north of Altamira which had been settled long before the construction of the Transamazon Highway revealed that pastures are burned approximately every three or four years following the exclusion of cattle for a few months. They are left in second growth after highly variable longer periods. Pasture grasses such as "jaraguá" (*Hyperrhenia rufa* Nees-Stapf) and later "colonião" (*Panicum maximum*) have only been in the Altamira area since about 1968. These grasses have made it possible to keep areas in pasture without following for much longer periods than was previously possible when the only varieties available had to be planted from cuttings rather than seeds, were very sensitive to draught in the period following burning, and would only last four to five years before a bush fallow period was required. Even with resistant grasses such as *Panicum maximum*, fallow periods appear to be the best way of dealing with the relentless increase in weed populations. Numbers of pasture can be seen reverting to woody second growth both on the Transamazon Highway and the older Belém-Brasília Highway. I have also seen several old pastures (cleared at various times from 1912 to 1955) near Altamira which have not been fallow for many (10-20) years and which now have been completely invaded by inedible mints. These pastures also have extremely hard compacted soil. The process of soil compaction under pasture and rates of recovery under second growth are discussed separately (Fearnside, to be published).

Pasture management can be viewed as a response to three types of degradation-regeneration cycles. First, there is a short-term degradation resulting from the removal of grass through grazing and the invasion of some low weeds. This can be countered by periodically excluding the cattle from the pasture for a month or two using a system of rotation between fenced subdivisions on the ranch. This allows the re-growth of grass and shading out of weeds. Second, there is a medium-term degradation resulting from invasion of woody second growth. This requires burning the pasture, either by cutting the second growth and burning in the pasture every three to four years, or leaving the pasture in a short period of bush fallow followed by cutting and burning. The third type of degradation is a possible longer-term deterioration of soil nutrient levels and soil structure. Much longer periods of fallow would be needed to counter this type of degradation.

The important question with respect to fallowing of pasture land is not how often and how long a colonist ought to fallow his land, but how often and how long he will actually do so. There is little reason to expect that his decision will be based on consideration of long-term benefits rather than the immediate trade-off of meat production from keeping a given patch of land in pasture for one more year versus the labor required to control the invading weeds. Since adequate data on such behavior is unavailable, one must be content only with a rough guess of what grazed and fallow times are likely. My guess is a grazed period of about five years. A fallow period of a minimum of about two years would be needed to allow sufficient re-growth to facilitate cutting. Such a short fallow, however, could only be followed by use as pasture since a longer fallow period, of say five years, would probably be required to allow pasture seeds in the soil to die if the colonist wished to plant annual crops following the cutting and burning of the second growth. The actual length of time a patch of land is left fallow beyond these estimated minimum values would depend on the amount of labor available to the colonist after allocating his labor effort to any other tasks of higher priority.

One can only guess at the pasture dry weight yields that could be expected in the fourth and fifth years, since there would be competing influences operating from improvement resulting from burning and continued deterioration resulting from further weed invasion, as well as compaction and other problems. For lack of other data, one might best make the probably optimistic assumption of continued productivity at the third year level during the fourth and fifth years. Using the third year estimate from Odum's value this would give two additional years of feeding capacity at 0.21 head/ha, which would bring the average for a five-year feeding capacity down to 0.26 head/ha. If the shortest practical fallow period of two years is also included, then the average feeding capacity over the seven year cycle is further reduced to 0.19 head/ha.

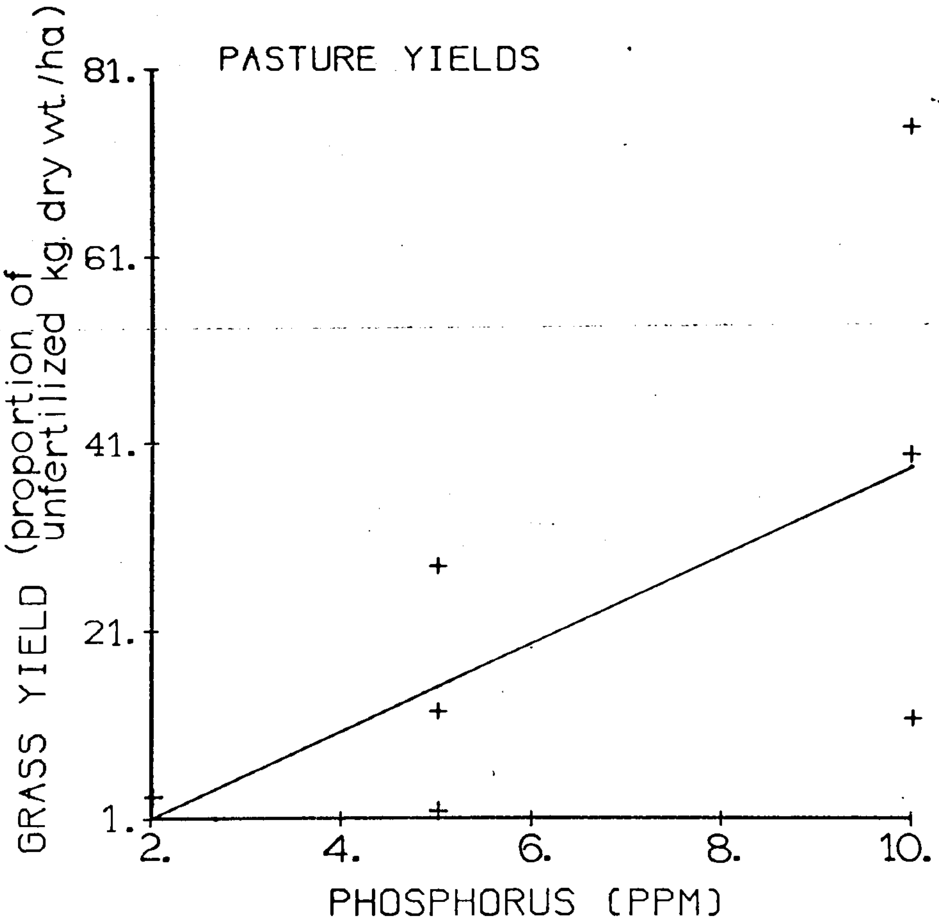

Fig. 1: - Regression of pasture yields on phosphorus. (N = 8).

Predicting Pasture Production From Soil Fertility

Fertilizer experiments with pasture grasses have made it clear that great differences can be expected in productivity depending on fertility, aside from any other problems such as weed invasion and soil compaction. In fertilization experiments done on *Brachiaria* in Belém, phosphorus fertilization was found to have the greatest effect on productivity, followed by potassium (Serrão *et al.*, 1971). Since phosphorus levels are very low on the Transamazon Highway, usually but not always much less than the values reported for the fertilized plots in Belém, the relations between phosphorus and yield found in Belém may well hold for the Transamazon Highway. One must assume that the *Panicum maximum* in use on the Transamazon Highway responds to phosphorus in the same way as the *Brachiaria decumbens* used in the experiments. Strong responses to phosphorus have been found for *Panicum maximum* in Paragominas, Pará (Koster *et al.*, 1977).

One would expect the response of pasture to phosphorus to follow the linear response and plateau pattern characteristic of most crops. In estimating the critical value for soil phosphorus above which further increases in yield could not be expected, the results of a different *Brachiaria decumbens* fertilization experiment, done in the cerrado zone of Brazil, were used. Dry matter production at three levels of four different phosphate fertilizers were estimated from graphs of response to different fertilization levels (North Carolina State University Soil Science Department, 1974: 198). These production values were plotted against soil phosphorus levels from samples which had been taken about midway through the experiment (North Carolina State University Soil Science Department, 1974: 101). The critical levels of soil phosphorus were estimated graphically using the linear response plateau method described by Waugh *et al.* (1975). Two of the fertilizer types were estimated to have critical values of 10 ppm, one of 17 ppm, and one of 22 ppm, one of optimistic value of 10 ppm (corresponding to a sharper response to phosphorus) was chosen for use in estimating *Panicum maximum* responses in Altamira. An "optimum" concentration of phosphorus of 25 ppm was found for *Panicum maximum* in one experiment in Pucallpa, Peru, but this value was not used since the soil was described as an unusual soil with abnormally low phosphorus fixation capacity (North Carolina State University Soil Science Department, 1974: 44).

I estimated the relation between pasture yields and soil phosphorus levels using data extracted from the results of the *Brachiaria* fertilization experiments done in Belém (Serrão *et al.*, 1971). In the *Brachiaria* experiments, soil samples were taken at the time of each of the eight cuttings reported, and approximate values for phosphorus can be taken from the graphs presented in the report. The yields of dry weight of grass can be compared for the plot which received a complete fertilizer treatment and the plot which received the complete treatment minus phosphorus. The plot which received no phosphorus through fertilization had soil phosphorus levels constant throughout the experiment at about two ppm, while the concentrations in the plot with the complete treatment varied from two to 15 ppm. If one calculates the yield for each cutting for the plot which received additional phosphorus as a proportion of the yield for that cutting in the plot with no additional phosphorus, a trend can be seen linking higher phosphorus levels to higher relative yields.

Using the estimated critical value of 10 ppm phosphorus as the beginning of the plateau part of the response curve, a regression can be performed on the eight yield values. Phosphorus levels over 10 ppm were assigned values of 10 ppm as would be predicted from the linear response plateau model. All phosphorus values were then converted to values of phosphorus in excess of the two ppm in the control plot (here the complete minus phosphorus plot), and all yields were expressed as proportions of the control in excess of 1.0. These manipulations allow the regression to be forced through the origin. The regression is shown in Table 1.

The resulting equations for prediction of pasture yield from soil phosphorus are:

$$Y = B\,(4.84\ P - 8.68)W_t \quad \text{for } P < 10 \text{ ppm}$$
$$Y = 39.72\ B\ W_t \quad \text{for } P \geq 10 \text{ ppm}$$

where:

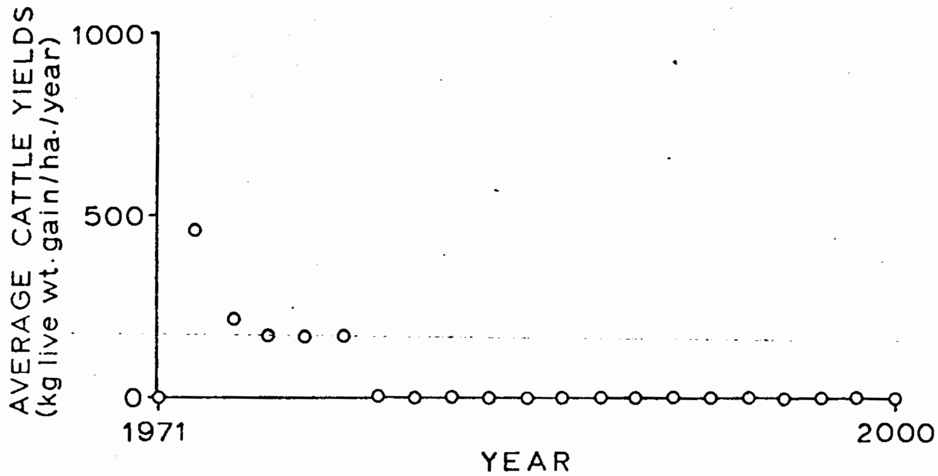

Fig. 2: - Cattle yields from AGRISIM simulation. Yields are expressed in kg live weight gain of cattle per hectare per year. Yields decline sharply due to weed invasion.

Y=pasture yield in kg dry weight/ha/year

B=base yield (expected first year yield in kg dry weight/ha for variety at two ppm phosphorus) (the value here is 303 kg/ha/year).

W=year factor (proportional decrease from first year yield due to invasion of weeds). The values are:

$W_1 = 1.00\ W_2 = 0.63\ W_3 = 0.49$

t=the year.

Figure 1 presents the data from the regression of Table 1, showing the effect of phosphorus, with appropriate adjustment of the axes to express the yield as a proportion of the unfertilized (two ppm phosphorus) yield and to express phosphorus as ppm.

Simulation Results

The pasture yield prediction procedure from soil nutrients with the year effects resulting from weed invasions discussed here have been incorporated into computer simulations which have been used both as a part of the full model for estimation of carrying capacity in a part of the Transamazon Highway (Fearnside, 1978) and as separate simulations of cattle yields alone. The soil changes taking place under pastures (Fearnside, to be published) are also included in the same simulations. Pasture grass production is converted into kg live weight gain per year of beef cattle. The results of a deterministic run of the AGRISIM program simulating cattle yields is shown in Figure 2.

The warning must be heeded in interpreting simulated results such as those shown in Figure 2 that such results are not intended in any way to represent projections of yields in particular years. The years shown in the figure are intended only to orient the reader with respect to the time horizon used in the simulation.

The sharp decline in cattle yields indicated by Figure 2 is the result of invasion of the pasture by weeds. If weed effects are arbitrarily excluded from the simulation, the result is a constant yield at levels near the first year yields of Figure 2. The low soil phosphorus levels restrict pasture grass growth, resulting in cattle yields substantially below official projections even ignoring the effects of weeds. The effects of weeds cannot be ignored in the real world however. Several assumptions inherent in the simulation, such as the assumptions that the cattle consume all the pasture grass produced and that the rancher maintains the stocking rate at the pasture's feeding capacity, mean that actual yields could be even lower than those indicated.

In the simplified run shown here where only one patch of land is examined without the added complexity of the land use allocation procedures, etc. in the full carrying capacity model, the simulated patch is not re-planted after the pasture has been choked out by invading weeds. In the full model such re-use as pasture is permitted after an appropriate fallow period under second growth.

Conclusions

The cattle yields to be expected from pastures such as those being planted along the Transamazon Highway can be roughly predicted from available information on soil changes under pasture, relation of soil nutrient levels to pasture grass growth, conversion factors for converting pasture grass dry weights into cattle growth gains, and information on the effects of invading weeds on pasture. Many claims of high "carrying capacity" for pasture in the Brazilian Amazon are based on short-term observation of stocking rates rather than information which would indicate long-term sustainability. A simulation incorporating both weed and soils effects gives serious reason to doubt the potential of pasture to provide the sustained yields which Brazilian planners currently anticipate.

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LA PREDICCION DEL RENDIMIENTO DE GANADO PARA LA CARRETERA TRANSAMAZONICA DE BRAZIL

PHILIP M. FEARNSIDE

RESUMEN *El Gobierno brasileño está en la actualidad alentando el desarrollo rápido de pastos para el ganado en grandes superficies de la Cuenca Amazónica mediante un programa masivo de incentivos fiscales. Esto ha sido estimulado por la pretensión de que en Brasil el pasto mejora la calidad del suelo, y, por tanto, presuntamente podría llevar a un rendimiento indefinido de ganado para los hacendados que respondan al programa de incentivos. El cálculo de productividad de res que se puede esperar en zonas como las de la carretera transamazónica del Brasil, hecho de diversas maneras, lleva a la conclusión de que las esperanzas del gobierno son demasiado optimistas. El presente trabajo desarrolla ecuaciones para la predicción de rendimiento de ganado para una zona de estudio en la carretera transamazónica, incluyendo el efecto tanto de los nutrientes del suelo como de la competencia por parte de malezas. Los niveles bajos de fósforo del suelo y la invasión de malezas no-comestibles reducen pronto el rendimiento de hierba y de ganado a niveles muy bajos. Se presentan los resultados de una simulación por computadora de rendimiento de ganado basada en la relación entre el rendimiento y los nutrientes del suelo y la maleza, así como sobre la información acerca de los suelos reunida en la zona de estudio de la carretera transamazónica. La simulación de pastos forma una parte de una simulación más amplia del agro-ecosistema de los colonos de la carretera transamazónica, la cual apunta a la evaluación de la importancia de varios factores sobre la capacidad de sustento de la zona para las poblaciones humanas. Aunque el estudio de la capacidad de sustento muestra que la agricultura basada principalmente en cosechas anuales constituye un negocio riesgoso, del mismo surgen dudas sobre la suposición de rendimientos seguros y sostenibles a partir de los esquemas de desarrollo de pastos que se promueven en la actualidad en la Cuenca Amazónica.*

PREDIÇÃO DO RENDIMENTO DA CRIAÇÃO DE GADO NA RODOVIA TRANSAMAZÔNICA DO BRASIL

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RESUMO *Atualmente, o Governo Brasileiro está encorajando o rápido desenvolvimento de pastagens para o gado, em grandes extensões da Bacia Amazônica, através de um maciço programa de financiamento e incentivos fiscais. Isto tem sido estimulado no Brasil por recentes pretensões de que as pastagens melhoram a qualidade do solo, e portanto, presuntamente, poderiam levar a um rendimento indefinido da criação de gado para os fazendeiros que estão respondendo ao programa de incentivos.*

O cálculo da produtividade de carne bovina, que pode ser esperada nas áreas da Transamazônica, feito de diversas formas, leva à conclusão de que as esperanças do Governo são demasiado otimistas. Este trabalho desenvolve equações para a predição do rendimento da criação de gado para uma área de estudo na Rodovia Transamazônica, incluindo tanto o efeito dos nutrientes do solo como a competição das ervas daninhas.

Os baixos níveis de fósforo no solo e a invasão de pragas reduzem rapidamente o rendimento das pastagens e do gado a níveis muito baixos.

São apresentados os resultados de uma simulação computarizada do rendimento da criação de gado, baseada na afinidade entre o rendimento dos nutrientes do solo e as pragas, e na informação obtida na área da Rodovia Transamazônica.

A simulação do agro-ecossistema dos colonos da Rodovia Transamazônica, que aponta para a avaliação da importância de vários fatores sobre a capacidade de sustento da área para as populações humanas. Ainda quando o estudo da capacidade de sustento mostra que a agricultura, baseada principalmente em colheitas anuais, constitui um negócio arriscado, do mesmo surgem dúvidas sobre a presunção de rendimentos certos e sustentáveis a partir do desenvolvimento das pastagens que está sendo atualmente promovido na Amazônia Brasileira.