AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 72

1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AF00-1900-GG50

B. SECONDARY: Plant production--Pastures and feed crops--Tropics

2. TITLE AND SUBTITLE

Forage resources for ruminant livestock production systems

3. AUTHOR(S)

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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1976	12p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Fla.

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER

PN-RAB-616

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Beef cattle
Forage grasses
Guyana
Pasture
Production
Tropics
Animal nutrition

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-3684 211(d)

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Fla.
CSD-3684 211(d)
PN-RAB-616

Forage Resources for Ruminant Livestock Production Systems*

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Forages are frequently the only source of feed in beef cattle production systems in the tropics. Since the ruminant animal has a comparative advantage over other domestic animals in converting vegetation which now occupies large land masses of the world, into high quality food products, it seems highly probable that improvements will be made in forage-livestock production systems. Although animal products may constitute only a small part of the human diet, it is imperative that the agricultural scientist learn how best to exploit these vegetation resources to the greatest advantage to mankind.

The Natural Grasslands

In the modeling of livestock production systems, forages represent the point of beginning and the quality and quantity of available forage resources determines to a large extent the output of the livestock enterprise. The natural grasslands of the tropical and subtropical belt around the world represent very complex ecosystems with a wide range of plant species which are selectively grazed. The selective grazing is conditioned by stage of growth, regrowth after burning, the chemical and physical properties of the soil, the hydrologic cycle and the grazing pressure imposed. There is a phylogenetic similarity among the grasses associated with these natural grasslands. The savannas of Guyana are no exception. Most of the grasses occur in the subfamily *Panicoideae* and are represented by the genera *Trachypogon*, *Andropogon*, *Axonopus*, *Panicum* and *Paspalum*. The wide spectrum of microenvironments occuring in the savannas has resulted in the evolution of a large number of species many of which fit into very narrow niches of the ecosystem.

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* Report to the Ministry of Agriculture, Government of Guyana, George town, Guyana March, 1976.

The tropical legumes probably represent the most neglected forage resource of the savannas. Species of Stylosanthes, Desmodium, Aeschynomene, Calopogonium, Centrosema, Clitoria, Galactia, Indigofera, Phaseolus, Teramnus, Vigna and Zornia are to be found in the northern South American savannas. Very little if any exploitation of these herbaceous legumes has been made and researchers need to avail themselves of the opportunity of developing these legumes for livestock production.

Nutrient Requirements of Tropical Forages

The grasses and legumes of the savannas are present because they are adapted to the rigors of the environment to which they are exposed. The soils have an extremely low pH range, they are low in cation exchange capacity, extremely low in most of the major plant nutrients and many micronutrients, and high in exchangeable aluminum. In addition to a very poor soil environment they are tolerant of wet - dry cycles of rainfall. Many of the African grasses which have migrated to the American tropics will not survive under the soil environment of the savannas without a substantial input of plant nutrients.

Some chemical characteristics of the surface soils of the Intermediate Savannas are given by Drs. Downer and Ah Chu (Table 1). Some striking characteristics of these soils are:

1. low pH, mainly accounted for by exchangeable aluminum - exchangeable Al from 2 to 3 times as great as exchangeable H.
2. the organic matter content accounts for 90 to 100% of the variation in cation exchange capacity.
3. the extractable phosphorus is very close to zero.
4. Exchangeable bases account for less than 50% of the total exchangeable cations except for Tabela 6 which was 71 percent.

These findings suggest that any viable system of agriculture on these soils must include a strong emphasis upon increasing the organic matter content by the use of a long ley in the crop rotation or the use of permanent grasslands with ruminant animal production. It seems obvious that a suitable soil environment must be created in which adapted legumes will thrive, and which will extract the required nitrogen from the atmosphere by biological nitrogen fixation. The soil - plant - animal system offers some distinct advantages for the intensification of animal production in the tropics, the exploitation of added nutrients and their conservation in the system (Fig. 1). The Guyana soil scientists have shown that nearly all of the reservoir of nutrients in the savanna soils is in the organic matter fraction and almost none in the inorganic matrix. The residues, as indicated in figure 1 are the primary sources of nutrients for plant growth and in the soil - plant - animal system, provides a recycling mechanism which means that nutrients are utilized over and over again in the production of animal products. It follows that nutrients added to the system will also be recycled and as the organic matter fraction is increased, more exchange sites will be available to supply nutrients for plant growth. Research in other areas of the world indicate that the nutrient supply in such soils can be increased to a reasonably high level, and then the amount of nutrients added via fertilizer can be reduced to a level which only replaces those lost to the recycling stream through the harvest of animal products.

Some of the tropical legumes and grasses which are very tolerant of soil acidity, high exchangeable Al and Mn have been found to be highly responsive to low rates of lime application (Fig. 2). This suggests that the factor limiting production may be the lack of adequate calcium as a nutrient, rather than a low pH and possibly toxic levels of Aluminum and Manganese. The data plotted in figure 2 were taken from the CIAT annual report in Colombia. Most of the yield response was obtained from 150 Kg/ha of lime equivalent and very little response above that level. The calcium concentration in the Stylo continued to increase and the Mn level decreased as the level of lime was increased up to 4000 kg/ha.

Table 1. Some chemical characteristics of surface soils from the Intermediate Savannas (after Downer and Ah Clu)

Soil	pH	Exchangeable H	Exchangeable Al	Organic Matter	Extractable P	CEC*
		---me/100g---		%	me/100g	me/100g
1. Ebini	4.9	.40	1.20	2.06	.02	2.14
2. Ebini	5.1	.25	.66	1.72	.02	1.45
3. Kasarama	5.3	.16	.48	1.21	.05	1.10
4. Kasarama	5.1	.16	.54	1.32	.04	1.16
5. Tabela	5.6	.19	.29	.74	.02	.90
6. Tabela	5.7	.07	.14	.72	.02	.72

Soil	Exchangeable bases Total	Ca	Mg	K	Na	Percent Saturation H	AL	Bases
	----------me/100g----------					--------%----------		
1. Ebini	.54	.18	.04	.15	.17	19	56	25
2. Ebini	.54	.19	.10	.03	.23	17	46	37
3. Kasarama	.46	.18	.04	.07	.17	14	44	42
4. Kasarama	.46	.17	.06	.03	.20	14	47	39
5. Tabela	.42	.07	.03	.07	.25	21	32	47
6. Tabela	.51	.17	.05	.03	.26	10	19	71

* Cation Exchange Capacity

If this proves to be the pattern with other tropical legumes the amount of lime required to improve tropical pastures on the heavily leached soils of the savannas may be relatively small. Phosphorus is probably the most critical element, but nutrient calcium, magnesium, sulphur and several of the micronutrients including a generous supply of molybdenum may be needed.

Components of forage Quality

The performance of the animals grazing the pasture, whether they be brood cows with calves, growing-fattening steers or replacement heifers, is dependent upon their intake of digestible energy. There are however, a multitude of factors which affect forage quality, and many more than are included in figure 3. Those illustrated show in very simple fashion the main relationships which exist but do not indicate the interactions and the feed - back mechanisms. Forage quality and consequently animal performance are closely related to nutritive value and rate of voluntary intake. Of these two, intake probably accounts for at least two - thirds of the variation in animal performance and nutritive value one - third. Under grazing conditions, intake is very difficult to measure and especially the intake of the components of the very complex botanical flora of the natural grasslands. Merely sampling the individual species, determining their chemical composition and digestibility *in vitro* does not supply very reliable information for prediction purposes.

Rate of forage consumption is dependent upon the selectivity exerted by the grazing animals, the rate of digestion, retention time in the rumen and the grazing pressure imposed by the manager. If high stocking rates are imposed upon the pastures, the animals may be forced to consume forages which they would otherwise reject and almost surely reduce their rate of intake.

Before we discuss some alternative methods for solving some of problems associated with forage quality, an examination of figure 4 indicates how forage quality is related to animal production/unit area of land. The production per unit area of land is associated with three factors; 1. the forage produced per unit area of land which can be utilized as represented by the carrying capacity. 2. the quality of

forage as represented by animal performance and 3. the animal potential. The prediction of animal output per unit area of land is dependent upon the precision attained in estimating the three components. Biomass yield is of little use unless accurate estimates are available for percentage use of that biomass. For many of the natural grasslands the percentage use is very low.

An alternative for estimating yield and forage quality.

Intuitively, it seems feasible to estimate the digestible energy intake per unit area of land from an inventory of the land and cattle resources in a fixed area. This means we must work from right to left in the two charts (Figs. 3 and 4). By obtaining estimates of the stocking rates in a given region we can predict the usable biomass. Since animal performance is a function of animal potential and digestible energy intake, animal output in terms of a unit of breeding females, in the case of a cow herd, will serve to estimate the quality of forage on offer. Such estimates, say on a monthly basis, can serve as base - line data for predicting changes in output if modifications in the system are imposed.

Alternative to the current livestock production system.

An analysis of the systems currently in use in the Rupununi and intermediate savannas suggest that less than 500 lbs/acre of dry matter are harvested each year. This forage must have less than 50% digestibility. Some questions which might be asked are these:

1. What affect would a relatively small area of improved pasture, *Stylosanthes* - *Digitaria* pasture, have upon the output of the system if such pasture were available during stress periods.
2. What would be the effect upon herd composition if an alternative source of pasture or feed were available for early weaned calves.
3. What would be the impact of supplemental energy, protein and/or minerals upon herd performance.

For modeling purposes by the Texas A & M team estimates were made of the monthly digestion coefficients and the protein contents of the forage apparently consumed (Table 2). This gives only a very rough ap-

proximation of the quality of forage available and if more reliable coefficients can be generated, then the output of this system can better be predicted.

Table 2. Estimated coefficients of digestibility and crude protein contents of forage consumed by cattle herds in the Rupununi and Intermediate Savannas.

Month	Rupununi		Ebini			
			Native Pasture		Improved Practice	
	DMD *	CP +	DMD *	CP +	DMD *	CP +
	Percent					
Jan	44	4.5	47	5.0	47	5.0
Feb	42	4.0	42	4.0	42	4.0
Mar	37	3.5	35	3.0	35	3.0
Apr	35	3.0	30	2.5	30	2.5
May	52	8.0	47	8.0	52[1]	8.0[1]
June	58	9.0	55	10.0	58[1]	10.0[1]
July	52	7.0	45	6.0	50[1]	6.0[1]
Aug	50	7.0	42	5.0	48[1]	5.0[1]
Sept	50	6.5	40	4.0	52[2]	10.0[2]
Oct	48	6.0	35	3.0	50[2]	9.0[2]
Nov	47	5.5	32	2.5	48[2]	8.0[2]
Dec	46	5.0	37	3.5	44[2]	7.0[2]

* DMD = Dry matter digestibility +CP = Crude Protein

[1] Regrowth after controlled burning

[2] Improved pasture (Stylosanthes for example)

Suggestions

In the area of forage production, one of the most promising areas of research and development is the selection of promising tropical legumes adapted to the Guyana environment. Their requirements with respect to lime and fertilizer, and grazing management systems which will allow them to persist must be determined. Caribbean Stylo *Stylosanthes hamata* is one of the most promising tropical legumes possibly adapted

to the savannas which has minimum input requirements. Australia has a cultivar (Verano) which is already in commercial production and a collection was made on the east coast of peninsular Florida which appears superior to Verano under Florida conditions. It would not be surprising to find some ecotypes of this species in Guyana. There are many tropical legumes which have been catalogued in Guyana which may have potential as forage crops.

Another possibility for exploitation are the native grasses of the savannas. There must be species present which have a much higher nutritive value than species of Trachypogon and Andropon since these two genera cannot possibly furnish the nutritional requirements of the grazing animals. Studies which would determine the diet of the grazing animals should indicate the species which are being selected. Combinations of some of these grasses with compatible tropical legumes could furnish a ration far superior to that now available.

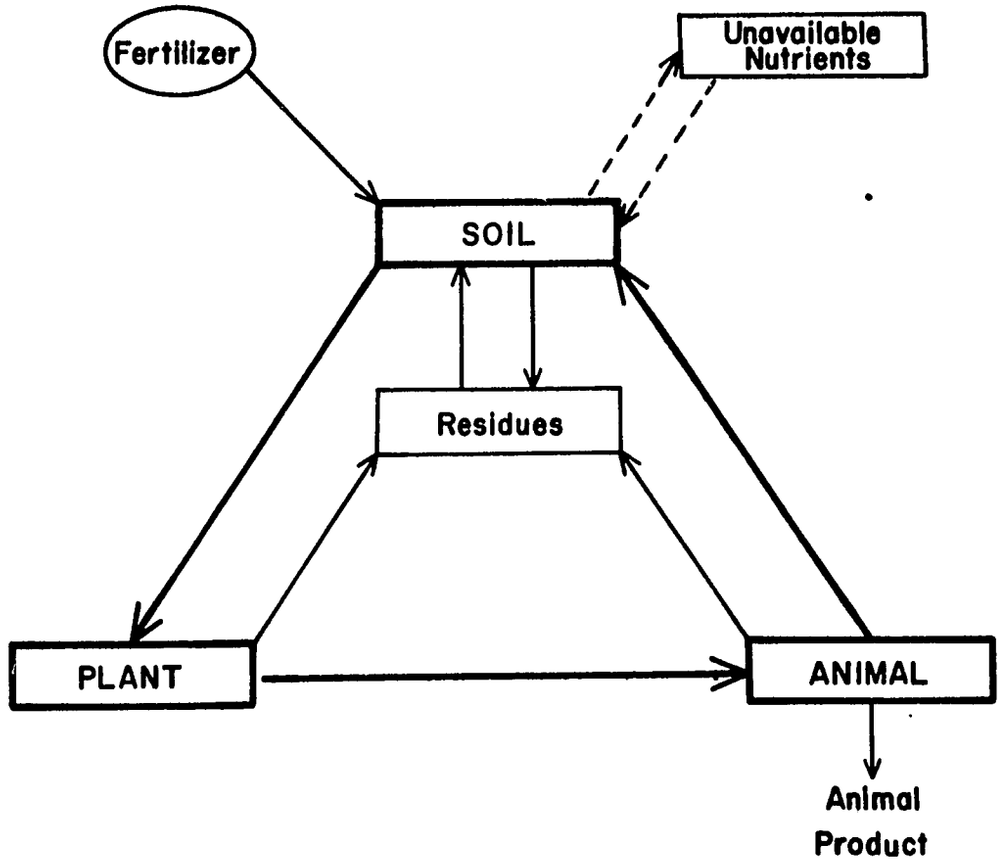


Figure 1. Nutrient recycling in grazed grasslands.

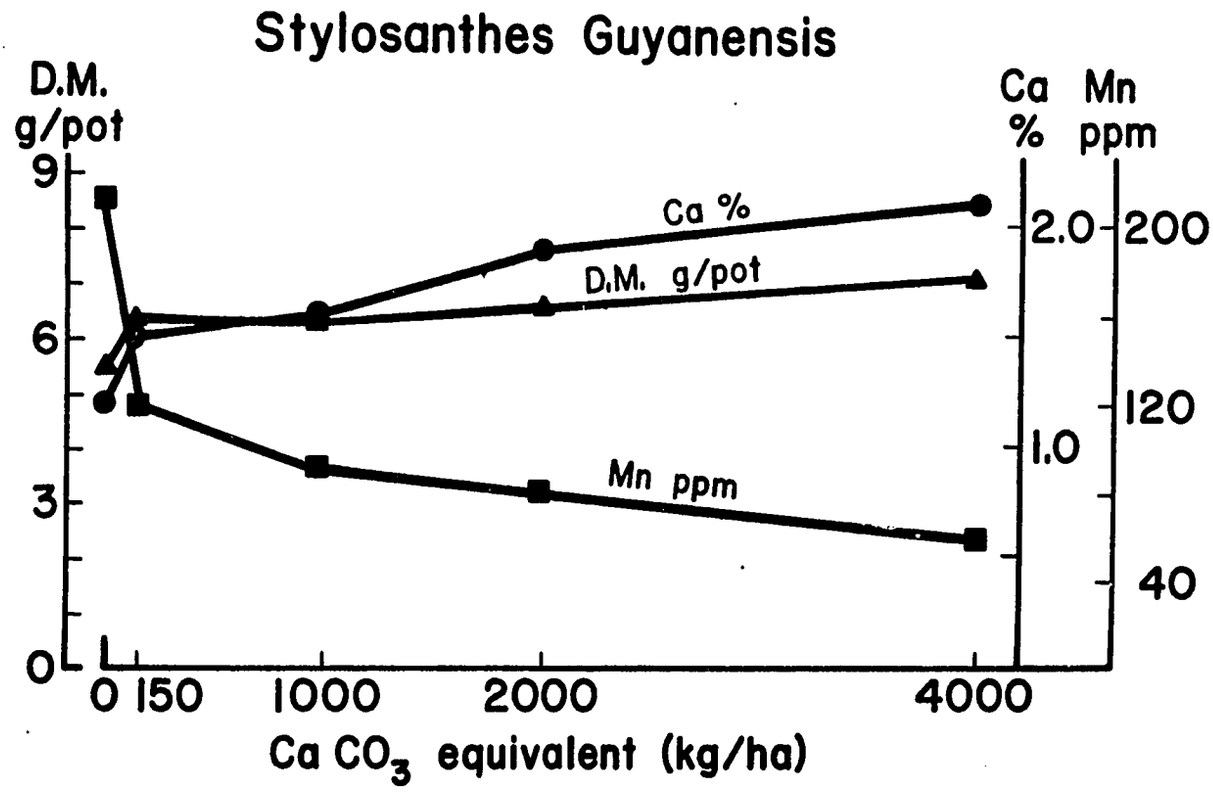
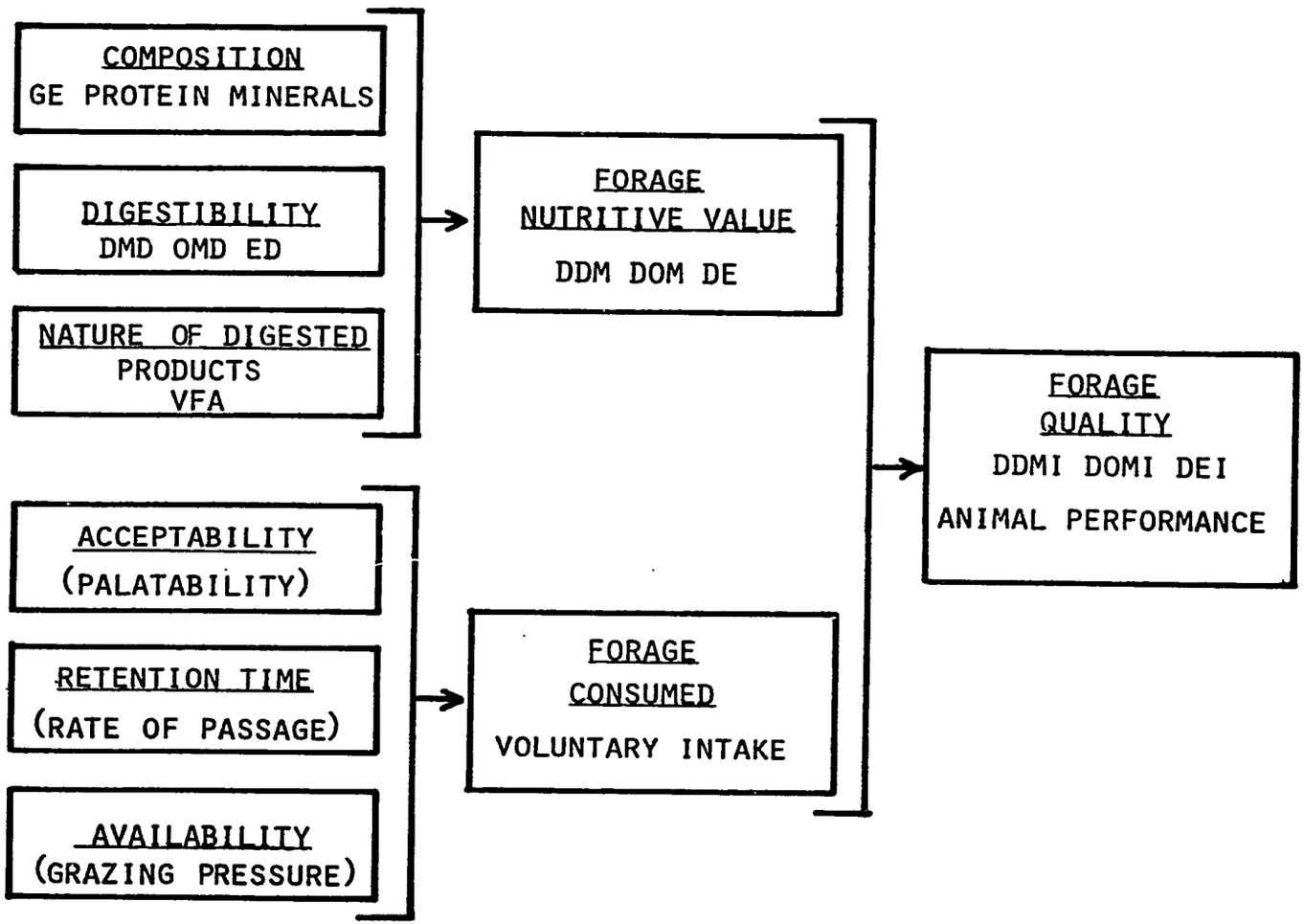


Figure 2. Effect of lime upon dry matter production and Ca and Mn concentration of Stylosanthes guyanensis.

FIGURE 3. COMPONENTS OF FORAGE QUALITY

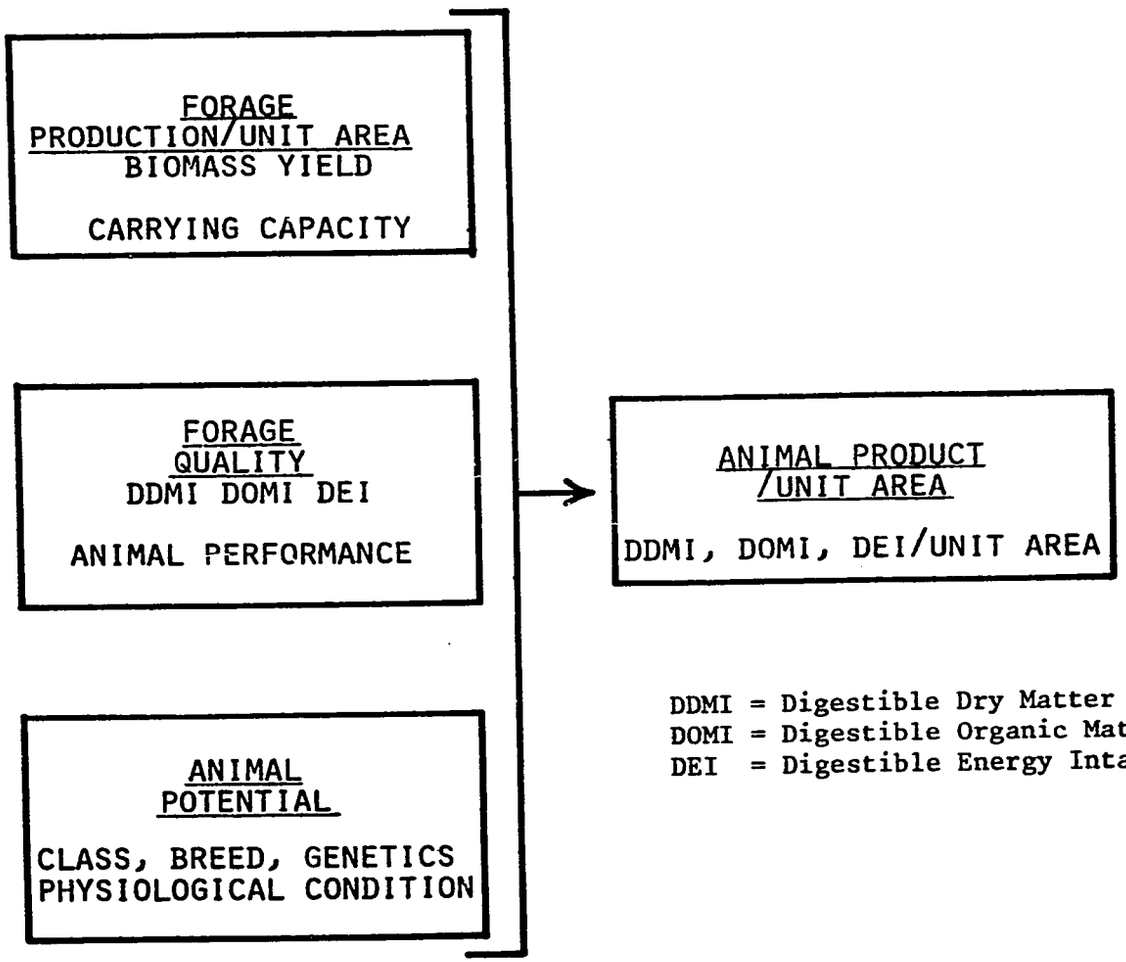


DMD = Dry Matter Digestibility
OMD = Organic Matter Digestibility
ED = Energy Digestibility
VFA = Volatile Fatty Acids

DDM = Digestible Dry Matter
DOM = Digestible Organic Matter
DE = Digestible Energy

DDMI = Digestible Dry Matter Intake
DOMI = Digestible Organic Matter Intake
DEI = Digestible Energy Intake

FIGURE 4. COMPONENTS OF ANIMAL PRODUCTION/UNIT AREA



DDMI = Digestible Dry Matter Intake
DOMI = Digestible Organic Matter Intake
DEI = Digestible Energy Intake