Country Pasture/Forage Resource Profiles

PARAGUAY

by

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1. INTRODUCTION

Paraguay is a landlocked Central South American country (Figures 1 and 2) which has common frontiers with Argentina (to the south and west), Brazil (east) and Bolivia (north). The total land area is 406 752 km^2. The country is divided in two major geographical regions, with distinct topography and geology, by the south-flowing Paraguay River. Whereas the eastern region (Oriental) with 159 827 km^2 has an undulating landscape of rolling hills with abundant rainfall (up to 1 700 mm/year), the western part (Región Occidental or Chaco) is an extensive semi-arid to sub-humid alluvial plain with 246 925 km^2 (AHK, 1999). Paraguay's population was estimated to be 5 734 139 in July 2001 and 6 506 464 in July 2006 (World Factbook 2006, July 2006 est.), of which about 98% are in the eastern sector; the 2006 estimated growth rate was 2.45%. More than 50% of the population is considered urban. Agriculture and Forestry account for 26% of GDP and 90% of exports (70% of which goes into the neighbouring MERCOSUR [Southern Cone Common Market] countries). Total GDP is 8 273 000 000 US $. The contribution of livestock to the GDP is 8% (MAG, 1996).

Politically, the country is divided into 17 Departments of which the three largest ones are part of the Chaco, whereas the 14 most populated ones belong to the Región Oriental (Figure 3).

Land tenure is unbalanced. More than 80% of the farmers are small holders with properties of less than 20 ha, but they account for less than 7% of the total farming area, whereas farms larger than 1 000 ha (1% of farms) account for 77% of the total farm land (GTZ, 1994). There are reports of farm occupations, by a growing number of landless campesinos, particularly in the Oriental sector of the country.

Note: ---------- boundary of Paraguay

Figure 1. Biogeographic provinces of South America and location of Paraguay
Adapted from Tarso Zuquim and Lima Serrano (1997)

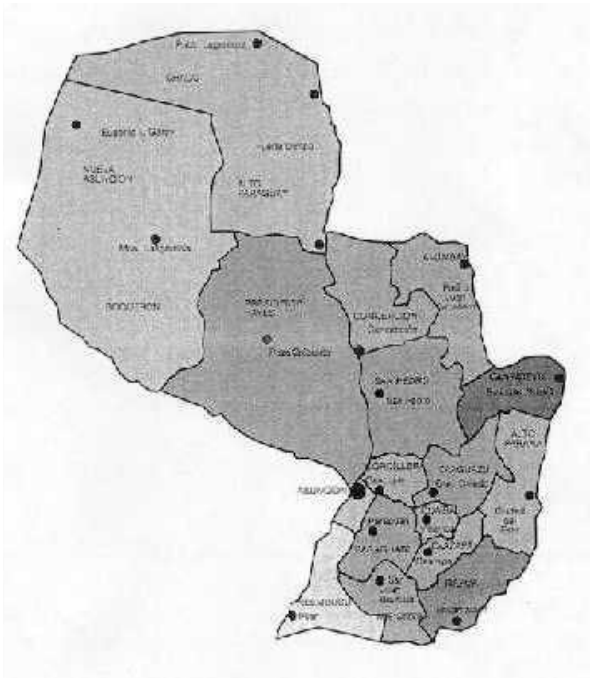

Figure 3. Republic of Paraguay: political subdivision, departamentos
(GTZ 1994)

Figure 2. Map of Paraguay
(from World Factbook 2006 Website)

2. SOILS AND TOPOGRAPHY

Paraguay has two distinct main physiographic regions, the relatively dry plain of the Paraguayan Chaco (Occidental Region) geologically young, with neutral to alkaline soils, and the humid Oriental sector with ferralitic and mostly acidic soils on old crystalline rocks (gneiss, granite, schists).

Landforms. Within the two main physiographic zones, the Chaco Paraguayo and the oriental region, there are further subdivisions to be featured (Figure 4):

A) The Chaco Paraguayo, which comprises about 60% of the country, is an alluvial plain with sediments from the Andes, naturally limited to the east by the Rio Paraguay and to the south and south-west by the Rio Pilcomayo. Altitudes range between 380 m in the north-west and 80 m in the south-east, where the Paraguay and Pilcomayo Rivers join, a distance of 750 km (Ramella and Spichiger, 1989). Mereles *et al.* (1992) distinguish two major zones of the Chaco:

- the Humid Chaco (Bajo Chaco), a plain liable to flooding, influenced by the Paraguay and Pilcomayo Rivers (annual rainfall 900 to 1 300 mm);
- the Dry Chaco (Chaco Boreal) with an annual rainfall range of 400 to 900 mm, which is further subdivided into 3 major sub regions (Glatzle, 1999):
- The Central Chaco is derived from a former inland delta with a mosaic of so called “campos” (old riverbeds with coarse sandy sediments) which contrast with the “monte” areas with fine textured soils (formerly temporarily inundated by flooding of the ancient river system). Campos areas comprise 15% of this region.
- Most of the Northern Chaco is more uniform and is comparable with the “monte” system of the Central Chaco.
- Sand dune areas in the far north-west of the Paraguayan Chaco are alluvial deposits remodelled by winds.

B) Eastern Paraguay (Oriental Region) comprises 40% of the country. Altitudes range from above 600 m in the north-eastern corner (Pedro Juan Caballero) and 55 m in the south-west (Pilar). The Oriental sector of Paraguay is a rather humid region of rolling hills with three major subdivisions (Bertoni and Gorham, 1973):

- The Rio Paraguay Valley is an undulating lowland with plains, parts of which are liable to flooding and with a few hills or strings of hills. Almost half of Paraguay’s population live here, where the capital Asunción is located.
- The Central Plateau with many low hills forms the “continental divide” between the watersheds of the Rio Paraguay and the Rio Alto Paraná.
- The Alto Paraná Valley is an undulating plain, rising to the west. As annual rainfall is high, this zone has many large and small watercourses, all draining to the Rio Alto Paraná, which runs through a deep gorge and is dammed as the Itaipu reservoir which powers the world’s biggest electrical power plant.

Figure 4. Paraguay: physiographic zones
(adapted from Bertoni and Gorham 1973)

Soils. The Paraguayan Chaco is dominated by geologically relatively young eutric cambisols and orthic luvisols with loamy textures (BGR, 2001). Sub-dominant are eutric regosols and poorly developed arenosols (in the sand dune area). Poorly drained eutric gleysols and

planosols are found in inclusions of the Central Chaco (so called "water-camps" with temporary water logging) and in the inundated areas of the Humid Chaco. As the distance from the Andes increases, soils tend to become finer in texture. The dominating soils in the Chaco have no major limitations in soil fertility, there are however big differences in water availability (drought and excess of water) over long periods (Fatecha 1989). Soil pH ranges from mildly acid to mildly alkaline.

The horizons are deep with relatively high salinity. From north-east to south-west, right across the Paraguayan Chaco, there is a belt of about 500 km long and 50 to 75 km wide with a shallow saline ground water table. This transitional zone between the Dry and Humid Chaco is prone to dry land salinity due to capillary ascension and salt enrichment at the soil surface, producing orthic solonetz and solonchaks in the "discharge area" of saline ground water. In eastern Paraguay, ferric acrisols with sandy to loamy texture are the main groups of soils in the rolling hills (Central Plateau). In contrast to the Chaco with greyish soils, for the Oriental Region a reddish soil colour is typical, due to sesquioxide formation in a rather humid environment. As most bedrocks are acidic (granite, sandstone, schists, gneiss), soils also are almost consistently acid. The depth of the soil profile and also the pedogenetic stage depends largely on its position in the relief of the landscape. Seasonally swampy, lower-lying areas in the Rio Paraguay Valley, particularly in the south-western corner (vicinity of Pilar) produce soils with hydromorphic properties (planosols). Intensively cropped basalt-derived ferric luvisols are the dominant group in the Alto Paraná Valley. Generally, the soils in the Oriental sector of Paraguay are considered to have high to medium potential for rainfed crop production (two crops a year), so long as there are no limitations of topography (steep slopes) or waterlogging in temporarily flooded areas. Contrary to the Chaco, the region has been settled and farmed for several centuries and little of the original vegetation remains undisturbed.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

There is a pronounced rainfall gradient right across Paraguay. Mean annual rainfall increases from about 400 mm in the north-west to 1 700 mm in the south-east (Sánchez 1973, Figure 5). In the Chaco, about 80% falls in summer, whereas in the south-east corner mean monthly rainfall is more equally distributed, with a slight depression in the driest months, July and August. The growing season lasts from October to March in the Chaco. Typical crops are sorghum, cotton and groundnuts. In eastern Paraguay, arable lands are often cropped twice a year under rainfed conditions, with soybean, cotton or maize, followed by a winter crop, such as temperate cereals.

Mean annual temperatures vary from 25.9 ^{0}C in the north (Bahía Negra) to 21.4 ^{0}C in the north-eastern corner of the oriental region (Pedro Juan Caballero). Summers are hot, even very hot. Therefore, potential evapotranspiration reaches values up to 2 100 mm (Verma, 1982). Absolute maxima range from 40.8 ^{0}C (Encarnación) to 44.0 ^{0}C (Mariscal Estigarribia). In winter, night frosts (to an absolute minimum temperature of –6.0 ^{0}C) occur, except in the extreme north east. Aerial parts of tropical grasses are generally burnt off by frost. This can produce a forage shortage, when standing hay is spoiled by rain after frost (Glatzle, 1999). Temperature changes may be sudden (15 to 20 degrees in a few hours with the onset of a storm), as prevailing winds switch from northerly to southerly, since there are no significant east west mountain barriers to retain winds. Wind speed exceeds 6 m/s for 14% of the year, resulting in wind erosion

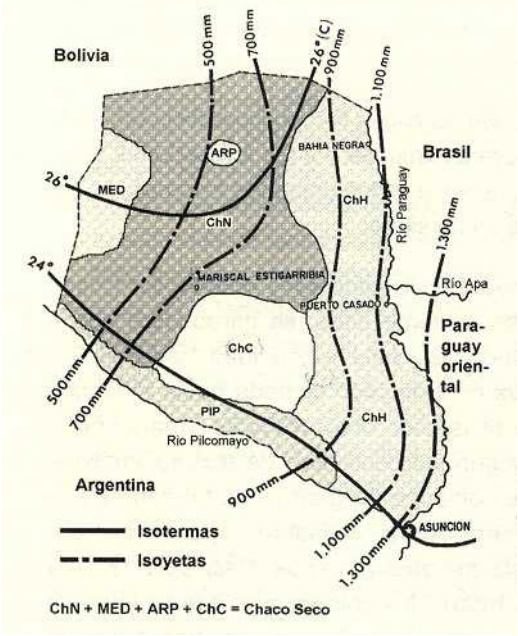

Figure 5. Paraguay (Chaco): rainfall and temperature

of cleared, bare land (Hacker *et al*., 1996). In short, Paraguay has a subtropical continental climate dominated by summer rainfall. It falls within the C climates of Köppen's classification (Eidt, 1969).

Vegetation. The dominant vegetation formations are xeromorphic, thorny, dry deciduous forests in the Chaco and subtropical rainforests in the East.

Dominant trees in the Dry Chaco are *Aspidosperma quebracho-blanco, Chorisia insignis* and *Schinopsis quebracho-colorado*. Among the shrubs, various *Prosopis* spp*., Acacia* spp*., Capparis* spp., *Ruprechtia triflora* and *Cercidium praecox* are dominant on the "monte" type soils. In contrast, the sandy "campos", along the ancient riverbeds, are characterized by a savannah-like open woodland with the dominant trees being *Astronium fraxinifolium, Schinopsis heterophylla, Tabebuia caraiba* and *Jacaranda mimosifolia*. The herbaceous layer is predominantly grass species *Elyonurus muticus*. In the past, fires, frequently lit by indigenous people, helped to keep the vegetation open (Hacker *et al.,* 1996). Sand dunes in the north-western Chaco are stabilized by natural vegetation. Their pronounced topography differs markedly from the flat, sandy "campos" in the Central Chaco, but their savannah-like vegetation is very similar. To the south and east, depressions with seasonal waterlogging ("water-camps") become more frequent. Here, the trees *Prosopis ruscifolia, Calycophyllum multiflorum* and *Bulnesia sarmienti* indicate cracking clay soils. The centre of the seasonal ponds, however, have no woody vegetation. An edaphic grassland with species tolerant of waterlogging like *Hemarthria altissima, Leersia hexandra* and *Paspalum* spp. covers the ground. In the humid Chaco, the vegetation is characterized by a mosaic with the irregular distribution of wetlands. The lower areas are seasonally waterlogged savannahs with a palm (*Copernicia alba*) and grasses like those in the "water-camps" of the Central Chaco, whereas drier areas typically support a tall *Anadenanthera colubrina* forest (Ramella and Spichiger, 1989). In the Oriental Region, the littoral of the Rio Paraguay Valley resembles the "Entre Rios Formations" of Argentina with open swampy grasslands and marshes. This region is suitable for cattle raising. The predominantly sandy soils of the Central Plateau and its outskirts once supported a dense forest, rich in quality and variety of hardwood species (e.g. *Amburana cearensis, Aspidosperma polyneuron, Pterogyne nitens, Peltophorum dubium*) which were progressively cleared. Besides timber species there are yerba mate (*Ilex paraguariensis*) and the tung-oil trees (*Aleurites fordii*) as well as the "coco"-palm (*Acrocomia totai*) grown in pure plantations or mixed cropping systems. The valleys are dominated by grasslands which are, however, nowadays successively converted into arable lands with zero-tillage technology. The undulating plain of the Alto Paraná Valley was also once covered by species-rich subtropical forest, much of which has been converted in recent years to intensively cropped arable lands (particularly for soy bean and temperate cereals).

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

There are about 10 000 000 head of cattle, 400 000 sheep, 350 000 horses, 120 000 goats plus 1 800 000 pigs and some 15 000 000 poultry in Paraguay (DCEA, 2000). Figures in FAOSTAT for 2005 are 9.6 M cattle; 500 000 sheep; 360 000 horses; 155 000 goats; 1.6 M pigs and 17.9 M poultry (FAO, 2006). Hence, cattle raising for meat and milk is by far the most important livestock sector. Livestock numbers are shown in Table 1. There are about 310 000 individual producers (99%) or companies (1%) on the 24 000 000 ha of useful land (arable and grazing). On average there are 5.3 members per producer family.

Land and livestock tenure. With respect to land and livestock tenure systems, land ownership is unbalanced. Farms between 1 and 20 ha own less than 15% of the live-

Table 1. Livestock numbers

	1980	1990	1995	2000	2001	2002	2003	2004	2005
Cattle nos (,000)	5 854	8 254	9 788	9 737	9 889	9 260	10 128	9 622	9 622
Goat nos (,000)	115.0	148.2	122.6	123	124	125.5	105.5	159.5	155
Sheep nos (,000)	380	457	386	402	406	410	423	525	500
Horse nos (,000)	310	334.6	410.9	400	358	358	360	360	360
Pig nos (,000)	955.5	2 444	2 525	1 800	1 804	1 365	1 474	1 507	1 600
Poultry nos (,000,000)	12.4	17.6	14.9	16.1	16.2	16.3	17.7	17.9	17.9

(FAO databases, 2006)

stock and represent more than 70% of all producers/producer families. On the other hand, the producer class with more than 1 000 ha (1% of the farms) owns 77% of the farm land and 60% of the livestock population (Table 2).

Table 2. Land tenure system in Paraguay as analysed by most recent agricultural census

Farm size	Number of farms	Rel. no. of farms (%) per class	Total area (1000 ha)	Rel. no. of total ha (%) per class	Rel. no. of cattle (%) per class
Landless	7 962	2.6	0	0	0.7
< 1 ha	21 977	7.2	8.5	0.1	1.0
1 to 5 ha	92 811	30.2	222.8	0.9	3.7
5 to 10 ha	66 605	21.6	430.7	1.8	4.0
10 to 20 ha	66 223	21.6	806.8	3.4	5.9
20 to 50 ha	31 519	10.3	857.9	3.6	6.3
50 to 100 ha	7 577	2.5	502.6	2.1	3.5
100 to 200 ha	4 279	1.5	569.2	2.4	3.7
200 to 500 ha	3 503	1.1	1 050.0	4.4	6.0
500 to 1000 ha	1 525	0.5	1 011.0	4.2	5.3
1000 to 5000 ha	2 356	0.7	4 982.4	20.9	22.0
5000 to 10.000 ha	533	0.1	3 644.9	15.3	13.5
> 10.000 ha	351	0.1	9 730.9	40.9	24.4
Total	307 221	100	23 817.4	100	100

(MAG 1992)

Table 3. Distinctive characteristics of farms in the Oriental Region and the Chaco

Region	Number of farms	Total number of cattle	Average farm size	Non-national producers	Relative number of farms with			Avg. no. of cattle per farm
					Cattle	Pigs	Sheep	
Oriental	300 523	6.8 mil.	38 ha	7.2%	74%	69%	6%	30
Chaco	6 698	3.0 mil.	1 850 ha	11.5%	97%	29%	25%	450

(MAG, 1992 and DCEA, 2000)

About 25% of producers in Paraguay are involved exclusively in crop production. Of the rest, 89% run mixed farms (Molas *et al.,* 1996), combining, meat or milk production and crops, to diversify activities and minimize risk. The remaining 11% are exclusively livestock producers. Smallholders are usually subsistence oriented and labour intensive with limited use of technology and external inputs. However, farms at all production levels are commercially orientated, obviously with increasing market orientation, as the farm size gets bigger. Farms over 1 000 ha contribute more than three quarters of the agricultural exports of the country (GTZ, 1994).

The most striking difference between farming systems in eastern Paraguay and the Chaco is average farm size and average stock number per farm (Table 2\3). Whereas in the sparsely populated Chaco (1 inhabitant per 2 km^2) large farms (up to 50 000 ha) predominantly produce beef, in the more densely populated Oriental Region (32 inhabitants per km^2) farm size is much smaller and farms are much more oriented to mixed farming. Beef and milk production is highly commercialized, whereas small ruminants and pigs are predominantly kept for subsistence or have only local commercial importance (no exports). Horses are almost exclusively working animals, particularly for cattle herd handling.

There is practically no permanent housing of ruminants. Steer fattening in feedlots has shown marginal profitability. Animals are ranched on natural or improved pastures. Even in intensive dairy systems milking cows gain part of their feeding requirements on pastures near milking pens. Tethering is common among smallholders and landless campesinos, otherwise they keep their animals on public land between the fences at both sides of public roads. Stocking densities on range, bush land and sown pastures vary from about 10 (Alto Paraguay) to 0,2 ha (Central Department) per head of cattle, depending on the agro-ecological conditions and feed and supplement availability.

Paraguay has a multicultural rural population with strong minorities (native Indians of at least eight different ethnicities and languages, groups of settlers of Brazilian, German or Japanese origin and foreign investors) which differ considerably in their production systems, production levels and organizational structures. While the native Indians live predominantly by subsistence agriculture on communally owned land, most of them showing little affinity for animal husbandry, typical Paraguayan campesinos and foreign groups of settlers generally apply mixed farming systems on privately owned land, being predominantly market oriented. Foreign investors, representing a fairly high proportion in the Chaco (Table 3), are exclusively commercially oriented and frequently grow monocultures, such as beef, soy bean or cotton.

The organizational structure of Paraguayan campesinos and foreign investors is relatively weak. However almost all emigrant settlers communities are organized into marketing co-operatives. Among

them are so called "colonies" of Japanese and Mennonites (a religious community of German origin which settled in the Chaco and in eastern Paraguay mainly in the first half of the past century). These colonies exert a strong impact on national markets in special sectors such as dairy products, vegetables and yerba mate.

Table 4. Comparison of traditional and present production parameters of beef cattle herds and grazing lands in the Chaco

Production system:	Traditional	Modern
From the most important production parameters.....		
Calving rate (%)	50	90
Mortality calves (%), first year	25	5
Mortality adults (%)	10	1
Fattening period till 450 kg LW (months)	48	28
Proportion of cows in the herd (%)	38	34
..... result in the following production indices:		
Extraction rate (%)	7	28
Energy efficiency (kg LW GJ-1 ME)	2.8	5.3
Liveweight production (kg LW ha/a) from ME consumed:		
2.5 GJ ME ha/a (native bushland)	7.1	13.3
25 GJ de ME ha/a (sown pasture)	71	133

(Glatzle, 1999)

Herd productivity and breeds. Beef is commonly produced in extensive systems on the 165 000 km^2 of native pastures and grazed bush land plus 33 000 km^2 of cultivated pastures. Main capital investments refer to fencing, establishment of herd handling facilities, construction of dams or so called "Tajamares" (basins for rain water collection) and pasture establishment and maintenance. Traditionally, there was little veterinary care and infrequent herd mustering, no seasonal bull service, no weaning control and little genetic improvement. Therefore, traditional herd productivity is low compared to production figures which are regularly achieved nowadays by a growing number of cattle farmers (Table 4).

The energy efficiency of forage was modelled on the basis of the production parameters of both traditional and modern systems. The improved herd productivity results in almost twice as much liveweight being produced from a unit of fodder energy consumed. Moreover, up to a tenfold rise in liveweight production per area (across the whole herd) is achieved by improving the forage base. Hence, improved pasture establishment results in a better land use efficiency (Table 4) as long as the production system is ecologically compatible. More efficient beef production technologies are increasingly adopted by cattle farmers, as indicated by an increase by 66% of the nation-wide extraction rate in the past 20 years (Table 6).

As far as the milk sector is concerned, 40% of the farms own milking cows (in the average 3.6 per farm). Only part of them (estimated at 25%) have access to milk collection and processing systems. The remaining 75% are either subsistence oriented or depend on local markets for fresh milk or homemade cheese. There is a big variation of production levels, taking into account all (not only the commercial) milk producers. Whereas the nation-wide average production parameters are poor, specialized commercial milk producers achieve remarkably high production levels (Table 5) applying high technology, and covering up to 75% of the daily feed requirements with concentrates and silages, in order to raise milk yields and to achieve a more balanced production across the seasons.

The Criollio breed, derived from Spanish and later British cattle importations, is a well adapted, small framed and robust, double purpose breed, highly fertile but otherwise low in production. This traditional breed forms about 70% of the Paraguayan cattle population (MAG 1992). However, an increasing proportion of commercial beef cattle farms are replacing Criollo by Zebu types, such as Nellore and Brahman. Frequently a high level of Zebu-genes is maintained in the herds, served by bulls of British (Angus, Hereford) or European continental (Gelbvieh, Fleckvieh, Limousine) breeds in order to produce a fast growing, environmentally adapted and resistant industrial cross. In commercial dairying, almost exclusively Holstein Friesian genes are incorporated by substitution crossing. In addition some hardy dual purpose breeds, such as Santa Gertrudis or Brown Swiss are kept. Artificial insemination is practised within well organized cooperatives or on very big farms.

Table 5. Milk production parameters in Paraguay comparing the national average with data from a commercial farm and a Mennonite cooperative

Parameter	National average	Granja Guarapí	Colonia Menno
Heifer age at first service (months)	36	20 - 24	24
Calving interval (days)	450–500	380–400	400
Lactation period (days)	< 180	305	305
Average production (kg milk/cow/year)	650	4 500	2 500

(Molas et al. *1996)*

Table 6. Paraguay statistics of production, exports and consumption of animal products and important agro-industrial by-products used as animal feeds

Item	1980	1990	1996	1997	1998	1999	2000	2004	2005
Beef production (1000)	107	189	226	226	231	246	239	215	215
Extraction rate (% cattle slaughtered)[1]	8.7	13.0	12.8	12.8	13.2	14.2	13.9	13.3	n.r.
Live cattle net export (1000 head)	0.8	–0.01	–108.0	–36.0	9.8	–52.2	33.0	–1.7	n.r.
Net beef export (1000 tonnes) incl. offal	1.0	97.5	23.0	22.7	33.9	18.9	41.5	82.3	n.r.
Mutton and goat meat production (1000 tonnes)	2.8	3.4	3.1	3.1	3.4	3.4	3.2	3.9	3.7
Pig meat production (1000 tonnes)	85.2	118.1	115.7	117.4	118.8	120.0	114.0	156.0	105
Poultry meat production (1000 tonnes)	14.7	24.7	34.1	36.6	37.6	41.6	34.7	38.8	38.8
Production of cattle hides (1000 tonnes)	15.8	29.4	35.0	35.0	35.8	38.4	37.8	34.4	34.4
Production of greasy wool (tonnes)	486	721	848	845	850	850	699	850	850
Milk production[2] (1000 tonnes)	163.0	225.8	403.8	444.2	445.0	445.0	329.8	362.0	372.4
Milk production[2] per milking cow (kg/yr)	1 890	1 900	2 320	2 400	2 410	2 410	2 400	2 310	2 370
Net milk product imports (1000 kg milk equiv.)	4.7	15.2	51.8	41.5	30.5	9.4	22.6	29.1	n.r.
Human consumption:									
Bovine meat supply (kg/cap/yr)	34.1	20.3	40.1	39.0	36.9	42.0	34.4	n.r.	n.r.
Total meat supply (kg/cap/yr)	67.3	55.0	71.3	70.2	67.9	72.4	73.0	n.r.	n.r.
Milk supply (kg/cap/yr)	49.7	52.7	87.1	89.9	86.1	83.9	n.r.	n.r.	n.r.
Agro-industrial by-products for concentrates:									
Wheat[3] bran (1000 tonnes)	21	65	100	75	45	58	63	n.r.	n.r.
Seed cake[4] (1000 tonnes)	51.1	107.2	94.0	215.5	191.4	213.0	n.r.	n.r.	n.r.

1 Sources: MAG (1992), DCEA (2000) and FAO (2006)
2 Only commercialized milk
3 Bran yield: about 25% of wheat production - wheat exports
4 Seed cakes (production - exports) of soy bean, cotton, sunflower and groundnuts
n.r. = no record

Production, marketing and consumption of animal products. Since the early 1980s the cattle population grew by about 50% from approx. 6 500 000 to almost 10 000 000 (MAG, 1992 and DCEA, 2000). In the same period, beef and milk production more than doubled, and indicators of production levels, such as average extraction rate of slaughter animals and milk yields per milking cow, increased by about 65% and 25% respectively (Table 6). These higher production levels can be attributed to better herd handling, improved veterinary care and the use of adapted and productive breeds, but also to the expansion of the area sown to improved pastures. Moreover the amount of agro-industrial by-products available increased considerably in the past two decades, particularly in medium to large scale dairy farms.

In 2000, total agricultural imports reached a value of US$ 383 241 000 and exports a value of US$ 647 699 000 (FAO 2005) by 2003 figures were US$ 207.7 for imports and US$ 1.02 billion for exports. Net beef exports accounted for 4 to 9% of the total beef production in the past years (Table 6). Beef exports vary from year to year and depend very much on the outbreaks of Foot and Mouth Disease and a positive immunological status of the animals due to compulsory vaccinations; meat exports beyond South America are insignificant. Beef imports are negligible, like imports and exports of other meats. Almost all wool and hides are processed locally or discarded.

There is only commercial milk production where an efficient and reliable collection system and a processing plant have been built up. This is the case in the Central Department (around the capital Asunción) with about 1 000 000 inhabitants, in the Boquerón and Presidente Hayes Departments (Chaco) and the Departments Caaguazú and Alto Paraná (Oriental Region). Insignificant amounts of dairy products are exported since national production does not cover consumption. Imported milk equivalents (predominantly from Argentina) account in recent years for 7 to 13% of the national production of commercialized milk (Table 6).

More than half of the meat consumed is beef. As stated in Table 6, total meat consumption is high in Paraguay. On the other hand the supply of processed milk is unsatisfactory (less than 2/3 of the 150 kg/head/yr recommended by the FAO).

5. THE PASTURE RESOURCE

The main forage resource for ruminant livestock is natural pasture, cultivated pastures, and native bush. The total area dedicated to livestock production is 19 900 000 ha, distributed in the Oriental and Occidental Regions as shown in Table 7.

Table 7. Areas (millions of hectares) of native and cultivated pastures and extensively grazed bush land in Paraguay

Forage resource	Native pasture	Sown pasture	Bush land	Total
Oriental Region	4.7	2.0	1.7	8.4
Occidental Region	5.5	1.3	4.7	11.5
Paraguay	10.2	3.3	6.4	19.9

(Molas et al. *1996)*

Native Grazing Resources in Eastern Paraguay. Most of the grazing lands in the Oriental Region are marginal for agriculture due to natural constraints such as poor drainage, shallow soils, and rocky soil. Basically there are two types of native pastures in Eastern Paraguay.

- **Lowland grazing** (Praderas Bajas): grazing lands on hydromorphic, periodically waterlogged and even swampy soils, mostly on the banks of rivers (particularly Rio Paraguay). However, there are also extended stretches of plains with hydromorphic planosols with an impermeable clayey subsoil towards the central Oriental Region along riverain zones. Within these grazing lands, the dominant herbaceous species are large tussock grasses generally with low palatability and nutritive value *Sorghastrum agrostoides, Panicum prionitis, Andropogon lateralis*, and *A. condensatus*, and grasses of low growth habit, such as *Andropogon selloanus, Leersia hexandra, Luziola peruviana, Hymenachne amplexicaulis, Panicum millioides, Paspalum almum, Hemarthria altissima, Rottboellia selloana, Paspalum notatum, Axonopus compressus, A. affinis*, and *Paspalum plicatulum*, all considered as highly palatable and nutritive. Moreover, herbaceous legumes such as *Desmodium canum, Aeschynomene americana, Macroptilium lathyroides* and *Arachis* spp. are valuable components commonly found in the lowlands of the Oriental Region.
- **Hillside grazing** (Praderas Altas): These are grazing lands in the rolling hills of eastern Paraguay, predominantly at sites, sub-optimal for cropping in the Central Plateau and the Alto Paraná Valley. Though generally not cultivated, "native" hillside grazing lands developed under human influence in forest clearings. Most of them maintain the aspect of a savannah or open woodland with varying densities of trees (even the planted "coco"-palm *Acrocomia totai*). In the Central Plateau, grazing lands are often restricted to sandy soils with rocky outcrops (granite, sandstone, schist) and of limited fertility (high acidity, high aluminium and low phosphorous contents). In the Alto Paraná Valley, fertility characteristics of the basaltic soils are better, however, grazing lands frequently present slopes marginal for agriculture. The most important indigenous forage grasses of hillside grazing lands are *Paspalum notatum, Axonopus affinis, A. compressus, Paspalum plicatulum* and *Andropogon lateralis*. Common valuable native legumes are *Chamaecrista rotundifolia, Stylosanthes guianensis, Arachis* spp., and *Alysicarpus* sp.. Among the grasses of low stock acceptability are *Imperata brasilensis* and *Aristida* spp.. Weedy dicotyledoneous species commonly found are *Vernonia chamaedrys, Baccharis* sp.*, Psidium araca, Butia yatay* and *Campomanesia obversa*.

Native Grazing Resources of the Chaco Region. The Occidental (Chaco) Region is an extended alluvial plain with a gradient of rainfall and soil texture from north-west to south-east (more rain and finer texture as the distance from the Andes Mountains increases). The agro-ecological conditions are good for permanent pastures. However cropping faces some limitations and risks from the quantity and distribution of rainfall (Dry Chaco) and temporary waterlogging (Humid Chaco) respectively (Figure 4). The native grazing resources in the two major physiographic sub regions of the Chaco can be described as follows:

- **The Humid Chaco (Bajo Chaco)**: The grazing lands of the Humid Chaco are predominantly palm savannahs with *Copernicia alba* on poorly drained, hydromorphic gleysols and planosols. The palm *Copernicia* tolerates fires and temporary waterlogging. It is found in densities of up to 100 trunks per hectare and its spread is promoted by livestock (Degen, 1996). These natural grazing lands contain many grasses of medium to high nutritive value and palatability, such as *Leersia hexandra, Hemarthria altissima, Panicum elephantipes, Diplachne uninervia, Hymenachne amplexicaulis, Paspalum lividum, P. alcalinum, P. almum, Cynodon dactylon, Pennisetum nervo-*

sum and *Eriochloa montevidensis*. Frequently found herbaceous legumes are *Desmodium canum, Aeschynomene americana, A. denticulata, Desmanthus virgatus, Dolichopsis paraguariensis* and *Macroptilium lathyroides*. Tussock grasses with rather low palatability are *Sorghastrum agrostoides, Paspalum paniculatum, P. plicatulum* and *P. conspersum.* Reported carrying capacities are one American Livestock Unit (454 kg LW) per 2 to 4 ha (Ramírez and Laneri, 1989). Besides mechanical or chemical treatments or burning of the shrubby weeds (*Acacia curvifructa, Prosopis ruscifolia* and *Geoffroea decorticans,* and *Tessaria dodoneaefolia*), there are practically no interventions for the maintenance of good grazing economically feasible or necessary (Glatzle, 1999). Periodically and episodically flooded areas with waters from the Pilcomayo river in regions with rather low rainfall (below 750 mm) are to be considered as a transitional zone between the Humid and the Dry Chaco. This zone along the left side riverbanks of the upper Picomayo-river is exposed to an extremely varying water regime, which may cause seasonally flooded grasslands to be reconverted into xeromorphic bush and vice versa within a few consecutive years.

- **The Dry Chaco**: Traditionally the most important natural grazing resource in the Dry Chaco are the **"**espartillo" grasslands ("campos") on the regosols or arenososls in old riverbeds of the former inland delta which shaped the landscape of the Central Chaco. These grasslands are characterized by abundance of the grass *Elyonurus muticus* (espartillo), not particularly palatable. Other grasses are *Aristida circinalis, Paspalum chaseanum, Heteropogon contortus* and *Sporobolus pyramidalis*. The espartillo-grasslands present a wealth of native legumes as soon as fire frequency is reduced and disturbance by grazing increased. Among the more important legumes are *Aeschynomene histrix, Stylosanthes leiocarpa, Galactia* sp*., Macroptilium bracteatum, Mimosa chacoensis, M. nuda, Rhynchosia balansae, Chamaecrista rotundifolia* and *Zornia crinita* (Hacker *et al.,* 1996). Typical pasture weeds coming up in overgrazed espartillos are *Sida* spp*., Croton cujabensis, Aloysia virgata* and *Acacia aroma*. In former decades, a relatively high proportion of the campos was used for cropping by early European settlers and indigenous horticulturalists. Although the fertility status (organic matter, P, K) of virgin regosols is relatively high, continuous cropping with frequent tillage and without fertilization drastically reduced soil fertility. Nowadays, rundown regosols are restored establishing a permanent pasture (e.g. with Pangola grass) and introducing a suitable legume (e.g. *Stylosanthes hippocampoides* or *Alysicarpus vaginalis*).

Towards the sub-humid parts of the Central Chaco (south and east), inclusions of edaphic grasslands on poorly drained gleysols (so called **water-camps**) are found with increasing density. The forage species occurring in the water-camps are essentially those listed for the *Copernicia* savannahs in the Humid Chaco.

Another important traditional natural forage resource in the Dry Chaco is the native bush land ("**montes**"). Browsing the mostly thorny woody plants, such as *Acacia praecox, A. aroma, Caesalpinia paraguariensis, Ruprechtia triflora, Capparis tweediana* and *C. retusa* and eating the pods of various *Prosopis* and *Acacia* spp. (Morello and Toledo, 1959) supports an average stocking density of about one bovine animal unit to 10 to 15 ha of bush (Fretes *et al.,* 1969). Understorey grasses are virtually absent: *Setaria globulifera, S. fiebrigii* and *Digitaria sacchariflora* are practically the only grasses found, but in very low frequency. There are studies demonstrating a severe degradation of the "monte" soils due to overgrazing under traditional grazing regimes. However, Adámoli *et al*. (1990) estimated the area affected by soil degradation in Chaco bush land to be less than one% of the total area. Abril and Bucher (2001) reported that soil organic carbon losses are much lower under cultivated pastures than in over utilized bush land.

6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

Sown pastures with introduced forages. The establishment of pastures with selected grasses and legumes on cleared land raises herd productivity per unit area about ten fold (Glatzle and Cabrera,

1996, and Table 3). Hence it is not surprising that the area of cultivated pastures increased five to six fold since 1980, mostly at the expense of native forests and bush. Large scale land clearing and pasture establishment obviously has adverse effects on landscape and species diversity and carbon sequestration. Therefore it is indispensable to take into account a number of land clearing regulations in order to maintain or create a healthy and diverse agro-ecosystem. A steadily increasing number of farmers leave at least 25% of the forest, woodlands or bush of a property intact (Ley Forestal 422/73).

- Leave intact a bush strip of 100 m width in east-west orientation, perpendicular to the prevailing wind (north-south) every 500 m and around the property (Resolución No. 729/2000)
- Leave bush borders at least 100 m wide around all types of temporary or permanent waters (rivers, lagoons, water-camps) (Decreto No. 18.831/86).

A significantly higher biodiversity was found when pastures contained a large number of native bush niches (strips and "islands") and when the use of fire as a management tool was restricted or avoided (Glatzle, 1999). Moreover, at sites with an elevated dry land salinity risk (high water table of saline ground water in a semi-arid climate, such as the Chaco), native bush fulfils the important role of preventing salinity due to the very high suction forces produced by many Chaco woody species, capable of keeping the ground water at a low level (Glatzle *et al*., 2001). Bush clearing at sites prone to salinization has resulted in the loss of valuable pasture land.

Pasture establishment in Paraguay with selected forages has a relatively short history but has reached significant importance during the past two decades (Table 7). Probably with the introduction and multiplication of buffel grass (*Cenchrus ciliaris*) by an American agricultural advisor of the Mennonite colonies in the Central Chaco, Robert Unruh, in the early nineteen fifties, cultivated pastures attained economic importance for the first time. Later on, a number of other introduced grasses gained commercial importance and were multiplied on a national level (Table 8). When the German-Paraguayan Project "Estación Experimental Chaco Central" started in the early 1990s, a new era started for the commercial use of introduced pasture legumes (Table 8).

In order to maintain productivity, cultivated pastures require, even more than native grazing lands, a correct adjustment of stocking rates. Typical stocking rates range from about 0.5 to 2 bovine units per hectare along the rainfall gradient across Paraguay, from north-west to south-east. Maximum energy conversion from *Panicum maximum* cv. Gatton and *Cynodon nlemfuensis* pastures in the Central Chaco

Table 8. Commercially important pasture grasses and legumes in Paraguay

Botanical name	Cultivar or/and common name	Importance
Cultivated grasses		
Panicum maximum	Gatton	Since 1990 most important grass for newly cleared lands. In the Chaco, many 100 000 ha of highly productive Gatton pastures.
Panicum maximum	Colonial and Tanzania	Grown on the more fertile basaltic soils in East Paraguay. Less important in the Chaco.
Cenchrus ciliaris	Buffel grass, Texas 4464	Since the 1950s. Several 100 000 ha in the Dry Chaco. Otherwise replaced by Gatton.
Cynodon nlemfuensis	Estrella	Several 100 000 ha along the limit of the Dry and Humid Chaco, in the Humid Chaco, and on the fertile soils in East Paraguay.
Brachiaria brizantha	Marandú	Wide spread in East Paraguay predominantly on infertile sandy soils. In the Chaco not frequent. Tolerant to spittle bug.
Digitaria eriantha var. pentzii	Pangola	Several 10 000 ha on sandy soils and at shortly inundated sites in East and West Py.
Urochloa mosambicensis	Nixon	Important since 1995 in the Chaco to restore rundown Gatton and buffel pastures.
Cultivated legumes		
Alysicarpus vaginalis	Alyvag	Restores rundown arable regosols in the Chaco. Combines well with Pangola. Also used as a summer active ley legume.
Stylosanthes hippocampoides	Oxley	Excellent to restore rundown arable regosols. Combines well with Pangola.
Desmanthus virgatus	Filadelfia	Cultivated legume, native to the Chaco. Adapts well to heavy textured soils. Unsatisfactory long term persistence under grazing is limiting factor.
Leucaena leucocephala	Cunningham and Tarramba	Used as a fodder bank by an increasing number of smallholders and big farms.
Trifolium repens	Haifa	Winter active, to be mixed into permanent pastures in the Alto Paraná Valley, East Py.
Melilotus alba	Sweet clover	Winter active ley legume, relatively rare.

by grazing steers (into animal liveweight per ha) was attained by a stocking rate of 1.8 AU/ ha (Stosiek *et al.,* 1997). This figure exceeds, however, the recommended long term ecological optimum stocking rate for this zone (0.8 to 1.2 AU/ha). Maintenance interventions, such as woody weed control, are necessary to maintain long term profitability of sown pastures.

Other grasses cultivated on a commercial scale, but of much less importance than the ones mentioned in Table 8, are: *Chloris gayana* cv. Callide, *Panicum coloratum* cv. Bambatsi, *Brachiaria decumbens, B. mutica, B. humidicola, Cynodon* sp. Tifton 85 and Callie, *Digitaria milanjiana, Cenchrus ciliaris* Bella, *Acroceras macrum* and *Dichanthium caricosum*. Pasture legumes of secondary importance are: *Macroptilium atropurpureum* Siratro, *Lotononis bainesii, Stylosanthes scabra* cv. Seca and Siran, *S. hamata* cv. Amiga, *Clitoria ternatea* cv. Milgarra and *Chamaecrista rotundifolia* cv. Wynn.

Other Fodders. Among the most important cultivated forages is Silage Sorghum for dairy enterprises. In the Central Chaco (accounting for about 50% of the national milk production), the area cultivated with Silage Sorghum is estimated at over 10 000 ha. At smallholder level in Eastern Paraguay some silage is made from *Pennisetum purpureum* (Cameroon grass). Part of the grain Sorghum (23 000 tonnes 16 000 ha in Paraguay) and maize (900 000 tonnes 370 000 ha in Paraguay) is used for concentrates, to be mixed at farm or at small commercial enterprise level with the agro-industrial by-products obtained predominantly from oilseeds (Table 6). No statistics are available on total concentrate feed production, nor on the proportions used to feed dairy cows, pigs, horses or poultry. However, concentrates used for beef production are negligible.

A typical emergency feed is sugar cane, grown on a small area on many farms and harvested in the dry season. During prolonged drought periods (about one in 10 years), whole sugar cane (produced in more humid Eastern Paraguay) is sold to cattle farmers in the Dry Chaco to enable them to maintain at least their breeding herd. There is little haymaking in Paraguay.

Similarly, there is virtually no irrigated fodder production due to

- the absence of irrigation water in the Chaco (and poor external drainage)
- the high rainfall reliability in Eastern Paraguay
- the high opportunity costs (irrigated vegetables are more profitable than forages).

Constraints. The main constraints to pasture establishment, grassland management, forage and ruminant production and product marketing in Paraguay are the following:

- Shrubby weed invasion in cultivated pastures and native grasslands (requires interventions every two to three years)
- Soil compaction due to overstocking and loss of soil plasticity (loss of organic matter)
- Reduced pasture productivity due to nitrogen deficiency in older pastures
- Uncontrolled fires entering from neighbouring properties, destroying fodder reserves
- Wind erosion on sandy, denuded soils
- Increasing pests and diseases, such as leaf cutting ants (*Acromyrmex landolti* and *Atta vollenweideri*), grasshoppers (*Staurorhectus longicornis*), caterpillars (*Spodoptera frugiperda*), spittle bugs (*Zulia* sp.), red spider mite (*Tetranychus sp.*), buffel blight (*Pyricularia grisea*), ergot (*Claviceps maximensis*) etc.
- Unexpectedly prolonged droughts, particularly in the Chaco
- High risks of dryland salinity within a belt of about 500 km long and 50 to 75 km wide with a shallow saline ground water table, right across the Paraguayan Chaco from north-east to south-west
- Long distances to the slaughter houses (reduces profitability for beef)
- Absence of milk collection systems in many parts of the country.

Pasture seed production. There is a strong small to medium scale pasture seed production in the Central Chaco of Paraguay at farm level. The seed produced are *Panicum maxium* cv. Gatton, *Cenchrus ciliaris* cv. Texas 4464 and Bella, *Urochloa mosambicensis, Chloris gayana* cv. Callide, selections of *Digitaria milanjiana*, *Panicum coloratum* cv. Bambatsi, *Sorghum sudanense, Leucaena leucocephala, Alysicarpus vaginalis, Desmanthus virgatus* cv. Filadelfia and *Stylosanthes hippocampoides* cv. Oxley. Total seed production attains several hundred tons a year. Although there is no pasture seed certification, seed

quality commonly competes with certified Argentine or Brazilian seed. Most seed is locally marketed directly between farms or via the co-operatives of the zone. Bigger seed producers also export Gatton Panic seed to neighbouring Argentina and Bolivia. However, practically all *Brachiaria* spp. seed and most *Panicum maximum* cv. Tanzania and cv. Colonial seed which are used in Paraguay, are imported from Brazil, because seed yields are too low under local conditions.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

At present little research is carried out actively in Paraguay in the fodder and pasture sector. However, in the past, international or bilateral programmes and projects introduced and screened pasture species, initiated trials on pasture and herd handling and grazing management, and disseminated innovations in the forage and livestock sector. For example:

- an American agronomist employed by the MCC (Mennonite Central Committee) who introduced buffel grass and initiated pasture cultivation in the Chathe "Servicio Técnico Interamericano de Cooperación Agrícola (STICA)" who evaluated for the first time cattle breeds, native and introduced to Paraguay
- a Swiss project in connection with the "Instituto Agrario Nacional (IAN)" in Caacupé
- a USAID project in connection with PRONIEGA ("Programa Nacional de Investigación y Extensión Ganadera") in Pozo Colorado
- a French project in connection with the Fondo Gandero in La Patria
- a German project in co-operation with DIA (Dirección de Investigación Agrícola) in the Central Chaco (Estación Experimental Chaco Central, Cruce de los Pioneros).

Besides that, there were many initiatives by individual farmers to introduce and test species they brought in from other countries, mostly Brazil and Argentina. Most of the *Brachiaria* species and a number of *Cynodon* cultivars came in through this channel and were spread from farmer to farmer.

More recently, livestock farmers interested in applied experimentation became privately organized in the "Consorcio Ganadero para la Experimentación Agropecuaria (CEA)". CEA holds a highly appreciated international congress on technology transfer every year in Asunción at the headquarters of the "Asociación Rural del Paraguay (ARP)". CEA members even organized an information travel of farmers to Queensland, Australia, from where a lot of new ideas and aspects on cattle breeds and grass cultivars came into the country. Moreover, the ARP is the organizer of a big annual Agricultural Trade Fair, where regularly cattle breeds and adapted pasture seed are exposed and marketed. On a regional level, farmers conscious of sustainable and profitable production systems organize themselves in so called CREA-groups ("Consorcio Regional de Extensión Agropecuaria"). Some private CREA groups work very efficiently, and sometimes contrast favourably with public extension services, such as divisions of the Ministry based "Dirección de Extensión Agrícola y Ganadera (DEA)" or even services offered by credit institutes, such as CAH, BNF and Fondo Gandero. Only about one in ten farms is reached by a pubic extension service at a nation-wide average (Molas *et al*. 1996). However, many producers' co-operatives provide competent technical assistance to their members.

A new programme has started in October 2001 at Loma Plata, Chaco, the "Iniciativa para la Investigación y Transferencia de Tecnología Agraria Sostenible (INTTAS)", initiated by the private foundation DeSdel-Chaco ("Fundación para el Desarrollo Sostenible del Chaco"), and sponsored by the Swiss foundation AVINA ("Acción para la Vida y la Naturaleza"). This programme integrates, co-ordinates and complements the on-farm-experimentation and technology dissemination activities carried out by various co-operatives and their extension services, and private farmer groups within the Paraguayan Chaco. Furthermore, INTTAS is to reactivate a virtually paralysed public research station in the Chaco Region, implementing joint research programmes, and to promote regular exchange of experience with private and public entities of interest from the other Chaco countries, Argentina and Bolivia.

The "Dirección de Investigación Agrícola (DIA)", part of the Ministry of Agriculture, carries out research mainly in the cropping sector in 9 research stations spread over the country. However, little importance is given to research in pastures and forages. The mandate of another Ministry-dependent research unit, the "Dirección de Investigación de Producción Animal (DIPA)", is to conduct research in the animal production sector in three stations across the country. Again, the products of cooperative based and other private initiatives on animal breeding, animal selection and improvement of herd handling are more obvious than public efforts in this field. The low efficiency of public research in Paraguay is primarily due to the lack of operational funds. More than 80% of the small budgets available (including revenues generated on the research stations) are used to cover the personnel costs.

In contrast to many other countries throughout Latin America efforts to revamp public-sector agricultural research and development agencies in Paraguay have yet to come to fruition. Major change was proposed in the mid-1990s in the form of the establishment of a national agricultural research institute, the Paraguayan Institute of Agrarian Technology (IPTA), as a joint public-private venture with multiple funding sources. The proposal for the creation of IPTA is still pending, however, and it now appears that no legislative decision will be made until at least 2002, following a public reform process that is currently underway in Paraguay Beintema *et al*. (2000). On the other hand meanwhile, a strong negative selection process is being observed, by skilled technicians and scientists moving away from the public sector (DIA and DIPA) into private research and development entities.

Some kind of extension work and small scale experimentation in the forage and livestock sector is done by institutions of higher education which are:

- Facultad de Ciencias Agrarias (FCA) - Universidad Nacional de Asunción (UNA)
- Facultad de Ciencias Veterinarias (FCV) - Universidad Nacional de Asunción (UNA)
- Facultad de Ciencias Agrarias (FCA) - Universidad Católica "Nuestra Señora de Asunción" (UCA)
- Facultad de Ingeniería Agronómica Ciencias Agrarias (FCA) - Universidad Nacional del Este (UNE)

Distinguished Technicians currently engaged in public or private research programmes in the pasture and forage sector are:

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