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1. INTRODUCTION

The Argentine territory, in the southern portion of South America, runs from the Tropic of Capricorn to the southern tip of the continent (55° 58’ S). Extending for 3 700 km north to south and covering 2 791 810 km², it is bordered by the Atlantic Ocean, Uruguay and Brazil to the east, Paraguay and Bolivia to the north and Chile to the west (Figure 1). Argentina’s population is estimated at 36 224 000 (2001) with an decadal increase rate of 11.1% (World Factbook July 2006 population estimate 39 921 833 and 0.96% annual growth rate). Population density for the whole country averages 10 inhabitants/km², ranging from 0.8 inhabitants/km² for Santa Cruz province to 59 inhabitants/km² for Tucumán province. At the country level, approximately 90% of the population is urban; only 10% live in the countryside. Almost two-thirds of the population are in the provinces of Buenos Aires, Córdoba, Santa Fé and Entre Ríos, 20% of the continental area (Figure 2).

Indigenous population, colonization, independence and national organization. The first humans migrated into the Argentine territory twelve or thirteen thousand years ago and settled in small groups of hunters and gatherers. By a thousand years ago people all over the territory had acquired some sort of agricultural/horticultural activity, using the fertile banks of some rivers after floods receded, irrigating some valleys in the arid west or burning patches in the forests of the humid northeast (Barsky and Gelman, 2001).

A great variety of human groups and living patterns were found in the native population at that time, estimated at half a million by the Spanish conquerors of this vast territory (in the sixteenth century). These groups were very diverse in terms of culture and organization and many were nomads. More advanced cultures had developed in the northwest, near the Andes, on the present border with Bolivia; these indigenous groups were dominated by the Inca Empire, which had an estimated population of 200 000 by the sixteenth century. They constructed organized settlements, irrigated their crops of maize and quinoa (Chenopodium quinoa) and used some medium-sized cameloids that had been domesticated (llama, alpaca) or were hunted (guanaco). In terms of size of population the group that occupied the Chaco area was also large, the Mocoví and the Chiriguano Chané groups being
the most important. The Querandíes and Charruas in the Pampas, the Charruas and Guararíes in Entre Ríos, Corrientes and Misiones provinces, the Tehuelches and Mapuches in Patagonia and the Onas and Yamanas in Tierra del Fuego were other large groups of, mainly, hunters-gatherers.

In the fifteenth century some of the present main cities were founded: Santiago del Estero (1553), Buenos Aires (1536–1580), Mendoza (1561), Santa Fe (1573) and Córdoba (1573). The viceroyalty of the Río de la Plata was created in 1776, extending over the present territories of Argentina, Uruguay and parts of neighbouring countries. In 1810 a strong commercial bourgeoisie, based in Buenos Aires, was the driving force behind the revolutionary movement that deposed the viceroy. Representatives of the provinces proclaimed independence from Spain at Tucumán in 1816 and created the United Provinces of Río de la Plata (Provincias Unidas del Río de la Plata). The Government of Buenos Aires forced a unitary policy, trying to maintain control over the rest of the territory assuming an inheritance of the Spanish rule. This position met vigorous opposition from the other provinces which favoured a federal system of government. Friction between the factions mounted steadily, leading to civil war in 1819. Meanwhile the national army led by General San Martín was fighting against the Spanish royalists and contributed decisively to the independence of Chile (1818) and Peru (1821).

Peace was restored in 1820, but the formation of a stable government remained unresolved. Throughout most of the following decade a state of anarchy prevailed in the United Provinces, further compounded by war with Brazil from 1825 to 1827. As a consequence of the conflict, Uruguay emerged as an independent state. The national political turmoil lessened appreciably after 1829 when Rosas, a federalist, was elected governor of Buenos Aires Province. He rapidly extended his authority over the United Provinces, which became known as the Argentine Confederation, and during his rule all opposition groups were crushed or driven underground. The dictatorial regime in Buenos Aires was overthrown in 1852 by a Federal Army led by General Urquiza who called a Congress that discussed and gave sanction to a Federal Constitution in 1853. The Province of Buenos Aires’ refusal to adhere to the new constitution flared into war in 1859. The Federal Army achieved a quick victory and in 1859 Buenos Aires agreed to join the federation. The province was, however, the centre of another rebellion that defeated the national army in 1861. In 1862 a national convention elected General Mitre to the presidency and designated the city of Buenos Aires as the capital of the nation. With these events, Buenos Aires Province achieved control over the rest of the nation.
One of the most important tasks for agricultural development during the late nineteenth century was the completion of the conquest of the Pampas as far as the Río Negro so the threat of hostile Native Americans from that direction was eliminated. This so-called War of the Desert (1879–1880) opened up vast new areas for grazing and farming. After this war Argentina made remarkable economic and social progress and the present borders of the nation were defined. The railroad network, developed mainly by British companies during the last decades of the nineteenth and the beginning of the twentieth century, played a fundamental role in the development of the territory by the central government. During the first decade of the twentieth century the country emerged as one of the leading nations of South America because of the export of primary products (mainly wheat and meat). European immigration from Spain and Italy transformed the social characteristics of the cities and the countryside. Many immigrants’ agricultural colonies were settled during that time, mainly across the Pampas.

Nowadays, Argentina is a Federal Republic divided into 24 provinces. The national government is a presidential democracy since 1853 when the Constitution was formulated. However, several non-democratic governments supported by military groups ousted the democratic ones. Democracy was reinstated in Argentina in 1983.

Initial herbivory and introduction of domestic livestock
Grazing lands and their dominant fauna originated in what is now Patagonia almost 45 million years (Ma) ago, as a consequence of the climatic disturbances that occurred during the mid- and last Tertiary Era (Miocene and Pliocene) and beginning of the Quaternary Era (Pleistocene). Fossil records in early Eocene (60 Ma) strata show early grasses and hypsodont-toothed mammals, while during the Oligocene (40–25 Ma) several new groups of non-ungulates appeared in the first open savannahs (Coughenour, 1985). Grasses (Poaceae) may have entered the region from Africa during the Palaeocene (70–60 Ma) or even uppermost Cretaceous (Stebbins, 1981). As disturbed climatic conditions continued, vast areas were occupied by grazing lands, dynamic ecosystems highly adapted to several types of disturbance events. Climatic changes caused the extinction of ancient herbivores, a consequence of the glacial period at the end of the Quaternary Neolithic Era. Equidae and Camelidae migrated from North to South America at the end of the Pliocene (3 Ma) or early Pleistocene (Stebbins, 1981).

There were neither herbivores of regular size nor their carnivorous predators in most of the Argentine territory when the Spaniards arrived. Such grassland steppes became an ideal open niche for the European cattle and horses whose population grew spontaneously into huge herds that roamed freely throughout the vast territory. The abundance of large herbivores changed the landscape, soil and grazing lands’ structure; high tussock canopies developed into more nutritious and softer forages and topsoil fertility increased.

Indians and the Spaniards easily hunted such cattle population on horseback. The possibility of exploiting their hides and salting some meat (biltong) marked the economic activity and allowed the growth of many settlements during the colonization period. Authorities of the principal cities of the region granted hunting permits and organized expeditions (“vaquerías”) throughout the seventeenth century, activities that stopped by the mid-eighteenth century because of the decimation of the wild cattle population. From then onwards, large cattle operations were developed for cattle raising (called “estancias” as Spanish government appointed people to “stay”). Significant areas were operated by the Jesuit Catholic Congregation who imprinted a strong cultural landmark in many regions. In the west and northwest of Argentina mules were produced and cattle raised to supply the silver mines in Potosí (actually Bolivia), an important economic development during the seventeenth century.

Land use
Throughout the country there are 332 057 properly delimited property units that comprise 172 million ha; the rest are properties whose limits are not adequately defined or fiscal lands whose occupants claim precarious property rights. This gives an average size of 518 ha, ranging between 74 ha in Misiones and 21 012 in Santa Cruz. A few holdings exceed a million ha in Patagonia or the dry west or 200 000 ha in the humid Pampas or Campos or Chaco. Only 20% of this area is cultivated (33 million ha) with cereals (29%) (wheat, maize, barley, oats and sorghum), oil crops (27%) (soybean, sunflower), industrial crops (2%) (cotton, sugar cane, flax, manioc, tobacco, coffee, tea and maté) or with other crops (41%) (timber,
orchards, pastures). Table 1 shows the croplands in Argentina.

Until recently, it has been usual to find mixed animal and crop production in Pampas ranching operations; this was meant to maintain soil fertility as three to five years of crops were followed by a similar period of pastures. In the past decade, the increases that occurred in principal crop prices, plus the possibility of minimum tillage of the soils, has determined the expulsion of cattle from the prime crop areas. As in many other parts of the world, Argentine producers became specialized either as farmers or as ranchers. Agricultural activity accounts for 30% of Argentina’s GDP and 50% of exports, including manufactured products (INDEC, 2001).

2. SOILS AND TOPOGRAPHY

Topography

Although bordered to the west by the high Andes, whose highest peak is Mount Aconcagua (6,959 m), most of Argentina is remarkably flat and 63% of the total area is less than 500 metres (m) above sea level (Table 2, Figure 3).

Major soil types

Soils in Argentina comprise eight orders from the Soil Taxonomy classification (Figure 4). The most abundant order is the Molisol, on which occur most of the cash crop agriculture and intensive cattle operations (beef and dairy). Dryland agriculture is significant in most humid areas, where this group comprise the most fertile soils of the Pampas. Entisols and Aridisols are undeveloped soils with low water holding capacity, important in arid and semi-arid areas. The fourth group in terms of the occupied area are the Alfisols, located mainly in the humid subtropical areas of northeastern Argentina. These four groups account for more than 80% of the country’s lands where graze the greatest part of the ruminant population (Table 3).

Table 1. Cultivated area and average yields for main crops in Argentina

<table>
<thead>
<tr>
<th>Crop</th>
<th>Cultivated area</th>
<th>Average yield (kg/ha)</th>
<th>Data for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>12 606 845</td>
<td>2 803</td>
<td>2002/03</td>
</tr>
<tr>
<td>Wheat</td>
<td>6 300 210</td>
<td>2 033</td>
<td>2002/03</td>
</tr>
<tr>
<td>Maize</td>
<td>3 084 374</td>
<td>6 477</td>
<td>2002/03</td>
</tr>
<tr>
<td>Sunflower</td>
<td>2 378 000</td>
<td>1 598</td>
<td>2002/03</td>
</tr>
<tr>
<td>Oat</td>
<td>1 368 400</td>
<td>1 666</td>
<td>2002/03</td>
</tr>
<tr>
<td>Cotton</td>
<td>410 905</td>
<td>-</td>
<td>2000/01</td>
</tr>
<tr>
<td>Sorghum</td>
<td>592 740</td>
<td>5 031</td>
<td>2002/03</td>
</tr>
<tr>
<td>Rye</td>
<td>337 640</td>
<td>1 402</td>
<td>2002/03</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>335 036</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Beans</td>
<td>292 800</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Barley</td>
<td>269 240</td>
<td>2 199</td>
<td>2002/03</td>
</tr>
<tr>
<td>Vineyards</td>
<td>209 000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Maté</td>
<td>201 600</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>157 326</td>
<td>1 412</td>
<td>2002/03</td>
</tr>
<tr>
<td>Rice</td>
<td>135 170</td>
<td>5 400</td>
<td>2002/03</td>
</tr>
<tr>
<td>Potatoes</td>
<td>119 165</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Tobacco</td>
<td>84 454</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Oranges</td>
<td>60 129</td>
<td>-</td>
<td>1996/97</td>
</tr>
<tr>
<td>Millet</td>
<td>49 850</td>
<td>1 844</td>
<td>2002/03</td>
</tr>
<tr>
<td>Tea</td>
<td>43 145</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Wheat (durum)</td>
<td>42 800</td>
<td>2 476</td>
<td>2002/03</td>
</tr>
<tr>
<td>Lemon</td>
<td>38 679</td>
<td>-</td>
<td>1996/97</td>
</tr>
<tr>
<td>Tangerine</td>
<td>36 770</td>
<td>-</td>
<td>1996/97</td>
</tr>
<tr>
<td>Onions</td>
<td>23 657</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Safflower</td>
<td>23 000</td>
<td>605</td>
<td>2002/03</td>
</tr>
<tr>
<td>Canary seeds</td>
<td>19 095</td>
<td>987</td>
<td>2002/03</td>
</tr>
<tr>
<td>Garlic</td>
<td>15 801</td>
<td>-</td>
<td>1997/98</td>
</tr>
<tr>
<td>Barley (forage)</td>
<td>14 450</td>
<td>1 732</td>
<td>2002/03</td>
</tr>
<tr>
<td>Flax</td>
<td>13 800</td>
<td>-</td>
<td>2002/03</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>13 458</td>
<td>-</td>
<td>1996/97</td>
</tr>
</tbody>
</table>

Empty cells mean lack of statistics. SAGPyA, 20

Table 2. Topographic distribution of Argentina’s territory

<table>
<thead>
<tr>
<th>Altitude (m)</th>
<th>Total area km²</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500</td>
<td>1 769 392</td>
<td>63.6</td>
</tr>
<tr>
<td>501–1 000</td>
<td>472 956</td>
<td>17.0</td>
</tr>
<tr>
<td>1 001–1 500</td>
<td>211 821</td>
<td>7.6</td>
</tr>
<tr>
<td>1 501–2 000</td>
<td>75 728</td>
<td>2.7</td>
</tr>
<tr>
<td>2 001–2 500</td>
<td>42 876</td>
<td>1.5</td>
</tr>
<tr>
<td>2 501–3 000</td>
<td>30 172</td>
<td>1.1</td>
</tr>
<tr>
<td>3 001–3 500</td>
<td>33 939</td>
<td>1.2</td>
</tr>
<tr>
<td>3 501–4 000</td>
<td>56 996</td>
<td>2.0</td>
</tr>
<tr>
<td>4 001–4 500</td>
<td>51 575</td>
<td>1.9</td>
</tr>
<tr>
<td>4 501–5 000</td>
<td>26 854</td>
<td>1.0</td>
</tr>
<tr>
<td>5 001–5 550</td>
<td>6 636</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt;5 551</td>
<td>1 455</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Based on a digital elevation model (Bliss and Olsen 1996)

Table 3. Land area by soil order in continental Argentina

<table>
<thead>
<tr>
<th>Soil order</th>
<th>Total area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfisol</td>
<td>205 851</td>
</tr>
<tr>
<td>Aridisol</td>
<td>555 686</td>
</tr>
<tr>
<td>Entisol</td>
<td>621 420</td>
</tr>
<tr>
<td>Histisol</td>
<td>872</td>
</tr>
<tr>
<td>Inceptisol</td>
<td>81 136</td>
</tr>
<tr>
<td>Molisol</td>
<td>871 569</td>
</tr>
<tr>
<td>Ultisol</td>
<td>737</td>
</tr>
<tr>
<td>Vertisol</td>
<td>15 679</td>
</tr>
<tr>
<td>Non classified (urban, rock, shallow water)</td>
<td>427 449</td>
</tr>
<tr>
<td>Total</td>
<td>2 780 400</td>
</tr>
</tbody>
</table>

Elaborated from INTA (1990)
Figure 3a. Topographic map of Argentina and surrounding areas
Elaborated from Bliss and Olsen (1996).

Figure 3b. Political divisions and the isohyets show humidity trend along the E-W gradient
In red, hydric index isohyets (Burgos, 1963) and temperature variation along a N–S gradient; in yellow, mean annual temperature.

Figure 4. Major soil types in Argentina according to soil taxonomy orders
Based on Atlas de suelos de la Republica Argentina (INTA 1990). Others soil types include urban, continental water and rocky areas.
3. CLIMATE AND AGRO-ECOLOGICAL ZONES

Climate
Argentina has a wide variety of climates and thus of biomes. Annual precipitation ranges from 150 mm in the driest parts of Patagonia and Western territory to more than 2 000 mm in the cold (SW) and subtropical (NE) rainforest. A large portion of the Arid South American Diagonal (Figure 5) covers the Western and Southern Argentine territory, determining dry forests in the North West, shrubby steppes in the Central West and a cool semi-desert in Patagonia.

Rainfall events in the Argentine plains are determined by a continuous struggle of air masses: humid winds from the Subtropical Atlantic Ocean enter the Argentine Northern and Central territory while dry winds from the Patagonian region vary in relative strength according to the seasons. Dominant warm winds enter freely and deeply into the Northern and Central territory during the warm season releasing plenty of rain until desiccated in the west. In the cooler season a vast sector of Argentina lacks rain as the strength of southern dry winds increase and rainfall events occur only in the Eastern territory. Southerly winds always dominate the Patagonian territory. Because of this, the Northeast (Subtropical Campos and Chaco) and the Central East (Temperate Pampas) regions of Argentina are super-humid environments with evenly distributed annual rainfall of 1 200 mm. In the Mid-west rain become scarcer in the summer and nil in winter, causing subhumid continental environments in Central Subtropical Chaco and Central Pampas, with 600 mm spread over the summer, with a dry winter. Very little humidity reaches the far western region, as good rains are only found in the mountain slopes of the North West (Figure 3b).

Mean annual temperatures range from 5 °C in the southern continental extreme to 25 °C in the north. The 20 °C and 13 °C isotherms are used to separate the Pampas from the Chaco and Patagonian regions (Figure 3b). In humid Argentina the thermal environment is mild, allowing year-long grass growth and cattle grazing. In the Mid-west and South grass production is minimum during winter and protein has to be supplemented to cattle for better forage utilization. Peak temperatures increase towards the west.

Ecological regions
Around 75% of continental Argentina is occupied by vegetation of varied physiognomy whose herbaceous strata may be grazed by domestic herbivores. Annual isotherms of 13 and 20 °C are the limits of the mega-, meso- and micro-thermic grazing lands, while the estimation of partial fulfilment of the evaporative demands show the existence of arid, semi-arid, subhumid and humid grazing lands (Figure 6). Classified in this way, it is possible to differentiate major grazing land regions that show varied functional, production and foraging characteristics:

1. Campos and Espinal Forests (Mega thermic, Super Humid to Humid)
2. Chaco Forests (Mega thermic, Humid to Semi-arid)
3. Pampas (Meso thermic, Humid and Subhumid)
4. Semi-arid Grasslands, Dry Forest: Monte and Caldenal Shrubland (Meso thermic, Semi-arid)
5. Patagonia cold semi-desert (Micro thermic, Arid)
6. Puna and High Andes Grass steppes

Figure 5. Normalized Difference Vegetation Index (NDVI) derived from NOAA/AVHRR satellites for Southern South America in January 1995
Low NDVI areas (brown tones) show arid and semi-arid areas.
4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

**History.** After an initial period of exploitation of feral cattle, with the establishment of estancias, extensive, grazing-based commercial cattle raising began and became increasingly important. Sheep were added to cattle and horses during the nineteenth century; their population expanded rapidly and reached a peak in the Pampas at the turn of the twentieth century. Until the development of packing industries the main animal products marketed were hides, fat, wool and salt meat (biltong for slaves in Brazil). From there on British capital developed a modern cattle industry for provision of their citizens in the British Isles and some colonies. Such economic interest provoked an army campaign against the Indians to free more land, allowing a steadily increase in land occupancy and cattle numbers.

Although some native cameloids are exploited commercially for small quantities of hair/wool or for draught and “criollo” cattle are still found in many areas, almost all ruminants used for commercial purposes were absorbed by foreign breeds. An important work of selection and improvement of each breed occurred in the country and new breeds were designed. Breeder’s associations promote each breed, implementing national and local contests every year for showing and selling purebred animals. Ranchers attend these events in great numbers as they are very interested in the genetic improvement of their cattle.

Here we describe cattle population and productive parameters for five regions that partially fit the grazing regions (Figure 6, Table 4) Regions differ not only in their total stock but also in terms of their productive profile. The Pampas has about 62% of the national cattle stock. Patagonia has less than 2% of the national cattle stock but accounts for 59% of the national sheep stock. The highest proportion of cows are in the Campos and Eastern Chaco, showing the importance of cow/calf operations in this area.
The remaining 14% of cattle are in semi-arid regions of the country. Slaughter for human consumption is mainly of steers (Table 4).

Breed. The temperate grazing lands of Argentina are stocked with beef cattle of British breeds (Aberdeen Angus and Hereford) or others from continental Europe (Holstein and Charolais). In warmer subtropical areas Indian cross-breeds, derived from Bos indicus beef cattle (Brahman, Brangus, Braford), are used to increase adaptation to heat and pests of cattle of European origins. Dairy cattle are of Holstein origin, with a small number of Jerseys. Sheep are mainly Corriedale, Merino and Romney Marsh. The Pampinta breed was developed locally in 1990 for meat and milk in extensive operations, by crossing of Corriedale (25%) and East Friesian (75%) breeds. Today, more than 20 000 Pampinta animals are distributed in 40 dairy operations across Argentina.

Only some native cameloids continue to be used. Each breed is used depending on the environmental conditions and the productive goals of the commercial operations. Several non-governmental organizations are the local references for each breed.

Livestock numbers
In 2001 the country stock was composed of about 48 million cattle, 13.5 million sheep and 1.5 million horses (Figure 7). In recent decades sheep numbers decreased dramatically, principally due to low wool prices. FAOSTAT data for livestock numbers, meat and milk production and beef and live cattle exports are shown in Table 5, where it is noted that some figures (for example for number of horses) differ from those above.

In 2001, most of the beef (2.7 million tonnes/year), lamb (35 thousand tonnes/year – FAOSTAT figure is higher) and milk (10 000 million litres/year) produced was consumed domestically, as export to many countries is forbidden for sanitary reasons (e.g. foot and mouth disease). Cattle and dairying industries account for only 6% of exports (INDEC, 2001).

Distribution of stock-rearing areas
Argentina’s livestock production is in two sectors. The commercial farming sector is well developed, capital-intensive and export-oriented. In the subsistence and communal sector, production in the

<p>| Table 4. Cattle industry parameters for each Argentinian region and for the whole country |
|---------------------------------------|---------------|-------------|------------------|--------------|</p>
<table>
<thead>
<tr>
<th>Region</th>
<th>Stock (1000 head)</th>
<th>Cow %</th>
<th>Slaughtered (1000 head)</th>
<th>Offtake (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pampas (cropland and flooding)</td>
<td>34 200</td>
<td>35</td>
<td>10 600</td>
<td>31</td>
</tr>
<tr>
<td>II. Campos &amp; E Chaco (Espinal and wet Chaco)</td>
<td>12 500</td>
<td>45</td>
<td>1 220</td>
<td>10</td>
</tr>
<tr>
<td>III. W Chaco (Dry Chaco and Puna)</td>
<td>4 090</td>
<td>40</td>
<td>680</td>
<td>16</td>
</tr>
<tr>
<td>IV. Central Semiarid (Monte shrubland)</td>
<td>3 600</td>
<td>43</td>
<td>700</td>
<td>19</td>
</tr>
<tr>
<td>V. Patagonia (Shrub steppes, irrigated oasis and temperate forests)</td>
<td>760</td>
<td>44</td>
<td>190</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>55 150</td>
<td>39</td>
<td>13 390</td>
<td>24</td>
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</tbody>
</table>

Recalculated from Rearte (1996). The offtake represents the percentage of animals from the whole stock slaughtered each year.

<table>
<thead>
<tr>
<th>Table 5. Argentina: statistics for livestock numbers, meat and milk production, beef and live cattle exports for the period 1994–2005</th>
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<tr>
<td>Cattle (head) (million)</td>
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<td>Mutton and lamb prod. Mt. (thousand)</td>
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<td>Beef exports Mt (thousand)</td>
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<td>Live cattle exports (head) (thousand)</td>
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n.a. = not available

* In 2003 and 2004 milk equivalent imports were 76 242 and 57 488 Mt respectively (down from 219 551 Mt in 1993) As per FAOSTAT.
pastoralism and agro-pastoralism; in the majority of households it is subsistence-based and labour intensive, with limited use of technology and external inputs. The outputs and objectives of livestock ownership are much more diverse than in commercial livestock production and include draught power, milk, dung, meat, cash income and capital storage as well as socio-cultural factors.

The great range of agro-ecological zones has led to the development of many livestock production systems adapted to the ecological and economic conditions in each zone. These systems have been described in Section 5 alongside details of the pasture resource, in order to simplify reading and avoid repetition.

Cattle ranches are settled on the periphery of the Pampas Region, in the Flooding Pampa or in any other place where cropping is not possible. Environmental, historic and economic reasons have determined such heterogeneous distribution of cattle throughout the country. Sheep are most important in Patagonia. Most subsistence producers are in northwestern Patagonia, the Puna and the Andes steppes. Dairying and fattening has traditionally been associated with the pampas, often in rotation with crops; high crop prices and new technology has led to increased specialization in crop production, and livestock (mainly cattle) are now being squeezed out of the cropping areas.

Marketing of animal products has strongly changed during the last decade. Central “on hoof” markets used to concentrate the greater part of the transactions (e.g. Mercado de Liniers). Today, direct trading between the ranchers and buyers (e.g. supermarkets, wholesale butchers) has the greater part of the market. However, on-hoof markets still determine the prices for several types of animals. For the milk market, dairy operations used to sell the milk directly to the factories. Three main companies concentrate 70% of the milk produced in the country. There are many medium and small factories, mostly in the Pampas.

**Principal constraints and problems in livestock production**

The principal constraints to pasture and fodder production, and to attempts at improvement, are as follows:

- Exportation problems (foot and mouth disease, etc.)
- Low national economic stability and high aversion to risk
- Environmental degradation: soil erosion, woody encroachment
- Difficulties with credit
5. THE PASTURE RESOURCE

(i) Campos and Espinal Forest
The humid to super-humid North Eastern territory of Argentina shows to the north marshes or pastures that grow on acid sandy (deep) and rocky (shallow) soils and, to the south, a savannah (known as the Espinal Forest) growing on strong clayish soils. These Mega thermic grazing lands are dominated by warm season grasses (C_{4}), progressively reducing the densities of both cool season grasses (C_{3}) or legumes. As cattle cannot graze down the low-quality forage biomass (60% digestibility or less) produced during the long warm season, a large biomass accumulates and senesces during autumn (April), loses quality further (up to 3% protein content) in winter (July) and has to be burned before the onset of the next growing season (September). Mass accumulation shades out the initial autumn growth of cool season grasses causing scarce forage production during winter that is heavily and continuously grazed. As low forage quality in the cold season affects cattle nutrition, stocking rates are low (Pizzio et al., 2000).

Grasses of the Panicoideae, Chlorideae, Andropogoneae and Oryzeae tribes dominate the grasslands that grow on these shallow and phosphorus deficient soils (less than 3 ppm), legumes present are of species of Adesmia sp., Desmodium sp. and Rhynchosia sp., while just a few C_{3} grasses of the Agrosteae and Stipeae tribes thrive for a few months.

Various grassland types are found in these Campos and Espinal Forest, classified according to the dominant species and physiognomy.

Tall grasslands: this is the typical vegetation of the Campos occupying humid to super-humid areas. Andropogon lateralis, the dominant species, is non-grazeable when the canopy is dominated by its wiry red flower stalks. When well grazed, this grass has a leafy appearance associated with medium and short grasses of acceptable forage quality as “Jesuits grass” (Axonopus compressus), Bahia grass (Paspalum notatum), Dallis grass (Paspalum dilatatum), some other Paspalum spp. (P. almum, P. plicatulum), Bothriochloa laguroides or Rottboellia selloana. When Andropogon is dominant and lightly grazed, biomass production may exceed 7 tonnes/ha/year. Other tall grasses dominate northwestern areas of this Campos Region and the Humid Chaco, such as Elionurus muticus (on well-drained sandy soils), Sorghastrum agrostoides and Paspalum intermedium.

Medium grasslands: in the open Campos and in-between the sparse tree canopy of Prosopis spp. and Acacia spp. of the Espinal Forest grows this herbage layer capable of producing 4-5 tonnes/forage/ha/year. In it soft grasses such as Axonopus argentinus, A. compressus, Bothriochloa laguroides, Paspalum notatum, P. dilatatum and Panicum milioiodes cover the soil densely and offer quality forage during the warm season. This grassland has a great capacity to recover its condition when moderately grazed, and when rests are allowed some cool season grasses appear (Stipa neesiana, Briza subaristata) and legumes (Adesmia punctata, Desmodium incanum, Rhynchosia senna, Medicago polymorpha and Trifolium polymorphum). When Andropogon is dominant and lightly grazed, biomass production may exceed 7 tonnes/ha/year. Other tall grasses dominate northwestern areas of this Campos Region and the Humid Chaco, such as Elionurus muticus (on well-drained sandy soils), Sorghastrum agrostoides and Paspalum intermedium.

Short grasslands: coarse grasses like Aristida jubata and Bouteloua megalotamica make a low density cover with infertile and alkaline soils; its forage productivity is low (1 tonne DM/ha/year). These grasslands are grazed by sheep.
Swamp grasslands: grasses and Cyperaceae with aerenchyma cover areas with 20–30 cm of standing water. Species like Echinochloa helodes, Eriochloa punctata, Paspalidium paludivagum, Leersia hexandra, Luziola peruviana dominate the dense canopy. These grasslands have good forage production (6 tonnes DM/ha/year) allowing heavy stocking and rapid weight gains of cattle during the warmer half of the year.

Cultivated pastures: a minimum area (200 000 ha) of native pastures has been replaced with Setaria anceps, Digitaria decumbens (Pangola grass), Brachiaria spp. and other improved forages. No legumes nor cool season grasses are successfully grown; a major drawback as there is much need to improve forage quality and winter production.

Extended degradation processes of both soil and vegetation are observable in this region. Different factors combine to cause such degradation: hilly terrain, sandy or clayish soils, intense rainfall events, overgrazing, deforestation or non-authorized fires. Almost 10% of the region’s area (840 000 ha) has been classified as severely eroded and another three million ha is degrading.

Cattle population and secondary production:
The existence of eight million cattle makes the Campos Region the second after the Pampas in terms of cattle numbers. Cow-calf operations are the exclusive activity for most large ranches (“estancias”). Weaners (160–180 kg) are trucked to the Pampas to graze oats, fescue or lucerne or to be fattened in yards. The Campos also produces lambs and wool from a large sheep population (1.5 million) in the southern savannahs. Year-round stocking rates in these grazing lands vary according to grassland types and winter productivity, between 1.5 and 3 ha/animal unit (450 kg) on native grasslands to 0.5 ha/animal unit on sown pastures. Phosphorus deficiency is a major cause of low calving rates (40–60%), averaging a secondary productivity of 30–40 kg/ha/year; leading ranches produce 100–120 kg/ha/year.

(ii) Chaco forests
[See also the paper on The Gran Chaco by Fernando Riveros available at http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Argentina/granchaco/GranChaco.htm.]
This subtropical savannah occupies the central northern territory of Argentina and continues north through Paraguay and Bolivia, comprising all together 80 million ha. Its southern limit is approximately the 20 °C isotherm or 30° 30’ South Latitude (Figures 3b and 6). In this region’s plain topography (from 100 to 200 m above sea level, see Figure 3a), forest patches alternate with extended grazing lands. Its physiognomy, plant density and species cover vary along a gradient of precipitation that allows the division of the Chaco into: Humid Chaco (East 1 000–1 250 mm), Sub-humid Chaco (Central 700–1 000 mm) and Semi-arid Chaco (West 450–600 mm). Further divisions of the Chaco (Oriental or Occidental, Arid, Alluvial, Hilly, Flooding) are usually considered.
**Humid Chaco savannahs:**

Patches of forest occupy the higher, most fertile and better-drained soils. Human activity has severely depleted most valuable woody species and caused shrub encroachment that denies cattle access. Characterized by the tannin-cored “quebracho colorado” (*Schinopsis balansae*), other majestic trees may be found in these forests such as *Aspidosperma quebracho blanco*, *Tabebuia ipe*, *Astronium balansae*, *Syagrus romanzoffianum*. Lower tree canopies, which surround these forest patches, comprise *Prosopis alba*, *P. nigra*, *P. algarrobilla*, *Geoffroea decorticans*, *Acacia praecox* and more.

The landscape is completed by vast grazing lands that form a shallow network that drains excess water towards the east, extending over almost three million ha. In the intermediate slopes may be seen palms (*Copernicia alba*) and an herbaceous stratum dominated by tall grasses such as *Elionurus muticus* (on well drained sandy soils), *Sorghastrum agrostoides* (on periodically flooded soils) and *Paspalum intermedium* (on frequently flooded soils). The forage quality of these grasslands depends of the density of regular quality middle-sized companion grasses such as *Chloris ciliata*, *Setaria geniculata*, *Sporobolus indicus*. Within the drains (that are continually flooded) swamp grasses grow such as *Leersia hexandra*, *Luziola peruviana*, *Paspalidium paludivagum*, *Eriochloa punctata* and *Echinochloa helodes*, which form dense swards of good forage when leafy. Finally, marshes in deeper water are dominated by *Panicum prionitis*, a non-grazed tall grass.

A distinctive feature of this region is its herbaceous leguminous flora that varies according to soil phosphorus levels, ranging from very rich in forested soils to poor in saline soils bordering the drains. Species such as *Adesmia muricata*, *Aeschynomene rudis*, *Discolobium leptophyllum*, *Desmanthus virgatus*, *Desmodium canum*, *Dolichopis paraguariensis*, *Indigofera parodiana*, *Lathyrus nigricavlis*, *Neptunia* sp., *Phaseolus laxiflorus*, *Vicia graminea*, *Vigna luteola* and others improve forage quality and activate nitrogen circulation in these grasslands. Where nitrogen is fixed, cool season grasses such as *Bromus inermis*, *Agropyron scabrifolium* and *Phalaris angusta* grow, further improving forage quality. Unfortunately, continuous grazing and frequent fires have reduced these species heavily, and they are now found only in grasslands in good to excellent condition, mostly relics.

The southern area of this humid subregion is a vast basin of almost one million ha, characterized by frequent floods, saline soils and marshes dominated by *Spartina argentinensis*.

**Sub-humid and semi-arid Chaco grazing lands:**

The xerophytic forest of this subregion, characterized by small, hard leaves, decreases in height and density from east to west. The taller trees such as *Aspidosperma quebracho blanco*, *Prosopis nigra*, *Ziziphus mistol*, *Caesalpinia paraguariensis* and *Prosopis kuntzei* are mostly depleted. Shrubs such as *Acacia praecox*, *A. furcatispina*, *A. aroma*, *Schinus faciculatus*, *Mimosa detinens* and *Larrea divaricata* grow around and within taller trees, preventing herbage growth and cattle access. The lower and herbaceous strata of the landscape is rich in grasses of the *Aristida*, *Brachiaria*, *Bothriochloa*, *Chloris*, *Digitaria*, *Gouinia*, *Heteropogon*, *Neobouteloua*, *Pappophorum*, *Setaria* and *Trichloris* genera. Many open areas originated and have been maintained by fires, leading to the degradation of the grassland with dominance of *Elionurus muticus* and reduction of legumes of the *Cassia*, *Desmanthus*, *Desmodium*, *Galactia*, *Indigofera* and *Rhynchosia* genera.

**Cultivated forages:**

Exotic forages such as *Cenchrus ciliaris*, *Digitaria eriantha* and *Panicum maximum* are sown in areas where dominant shrubby or tall grass species have been eliminated, producing an important variation in cattle industry. Although the problem of lack of protein persists, the use of these improved species allows a more efficient harvest of the biomass produced, raising the carrying capacity of the area dramatically.

**Chaco’s potential and ecosystem fragility**

The Chaco occupies a significant area of the South America Continent and has great potential to be
developed. However its ecosystems are fragile and need rational use of their natural resources. The fine
texture of its soils and erratic drainage lead to floods, droughts, alkalinity, salt accumulation in soils hori-
zons and phreatic water tables. Severe erosion processes are evident and frequent, for degradation proc-
esses of both soils and vegetation are extensive. Desertification symptoms are observed in de-forested
and overgrazed areas. Availability of drinking water for cattle is erratic.

Forage production varies widely throughout the Argentine Chaco depending on precipitation, length
of the rainy season and domination of tree, shrub or tall grass canopies. Forage biomass production in
open spaces ranges from 5 to 1.5 tonnes/year in the east and from 2 to 0.5 tonnes/year in the west, being
almost nil in winter months. Forage quality depends of the presence of medium-sized warm season
grasses, herbage legumes and cool season grasses. As grasslands lose condition and are dominated by
tall grasses that overtop the best species, herbage accumulates during the summer losing digestibility and
protein content. The absence of cool season grasses further aggravates this problem in winter.

The cattle population of the Argentine Chaco is less than three million, giving a stocking rate of 10
or more ha per head. This is only justifiable in a 500 to 1 000 mm rainfall area because scarcity of water
points impedes adequate cattle distribution, and poor forage quality means that millions of tonnes of
course herbage remain ungrazed to be burned at the end of each winter.

(iii) Pampas

The Pampas Region occupies about 50 million ha, extending from the 2 °C to the 13 °C isotherm
(Figures 3b and 6), enjoying a temperate climate with mild winters without snowfall (Soriano 1991). Precipitation range decreases gradually from 1 200 mm in the northeast to 500 mm in the ecotonal
change to the Monte region. Rainfall is evenly distributed through the year in the eastern wettest areas,
while is just concentrated during the warm season in the west.

This region is characterized by its lack of native
trees, flat terrain, fertile soils, extended croplands
and native or cultivated pastures. As soils are fertile
and summers shorter and milder than in the north,
many C\textsubscript{4} grasses and temperate legumes species
grow during the cooler seasons in these grazing
lands. In this way, a seasonal alternation occurs with
species of one (C\textsubscript{4}) or the other (C\textsubscript{3}) photosynthetic
syndrome. Such sequential combination of species
characterizes its Meso-thermic grazing lands.

Species alternation maintains green grass year-
long and is ideal for resource utilization in a
seasonally variable climatic environment, where
mild water deficits during the summer are better
overcome by C\textsubscript{4} grasses. From the forage point
of view, temperate grasses and legumes of good
forage quality (above 20% protein and 70–80%
digestibility) allow total utilization during winter
of the remnant biomass of summer grasses.
Because of this, there is seldom accumulation of
forage during winter in these humid grazing lands.

Native humid grasslands cover the Flooding
Pampa, some parts of Entre Ríos Province and
most river and stream banks. The warm season
components of these grasslands are water-efficient,
nutrient-efficient and regular quality C\textsubscript{4} grasses
of the \textit{Panicoideae}, \textit{Chlorideae}, \textit{Andropogoneae}
and \textit{Oryzeae} tribes. Alternating seasonally with
them thrive C\textsubscript{3} grasses of the \textit{Agrosteeae}, \textit{Avenae},
\textit{Festuceae}, \textit{Phalarideae} and \textit{Stipeae} tribes. As soil

Aerial view of the Pampas

A hill grassland in the southern Pampas
fertility increases to the west of the Paraná River and south of the Río de la Plata, a myriad of herbaceous legumes grow (*Cassia* sp., *Crotalaria* sp., *Desmanthus* sp., *Phaseolus* sp., *Vicia* sp., etc.).

**Flooding pampa grasslands**

This subregion includes the lowlands known as the Laprida basin and the Salado river basin. The very slight slope of the plain in this area results in its low morphogenetic potential and its endoreic or areic drainage, in spite of a prevailing subhumid climate. These topographical characteristics result in extensive and lengthy flooding during periods of abundant precipitation (once every decade), causing severe damage and heavy losses where human influence has been prominent. Lesser floods occur at the end of winter and early spring, becoming the most remarkable features of this region.

Because of its flat relief and high water table, more than 60% of the soils of the Flooding Pampa are halo-hydromorphic complexes and associations. The commonest soils are natraquolls, associated with natraqualfs and natrabolls. The degree of sodicity of the soils depends on the depth and salinity of underground water, as well as soil denudation caused by continuous grazing. Soils in the higher parts (15% of the whole area) are deeper and have a higher productive capacity, being commonly used for the cultivation of cash crops or improved pastures of fescue (*Festuca arundinacea*), white clover (*Trifolium repens*) and *Lotus corniculatus*. The rest of the area is natural grassland, with the distribution of communities related to the excess of water and salinity. Summer droughts are frequent, with halomorphism and limited soil water storage.

The typical physiognomy of the Flooding Pampa is extended, treeless grasslands (except where trees are planted) and its community is dominated by Dallis grass (*Paspalum dilatatum*), *Bothriochloa laguroides* and *Briza subaristata*. *Paspalum quadrifarium* and *Stipa trichotoma* are bunch grasses which dominate the southwestern part of the area. Where water covers the land during the cooler months, the plant community is dominated by *Leersia hexandra*, *Luziola peruviana*, *Paspalidium paludi vagum*, *Echinochloa helodes* and *Glyceria multiflora*.
Communities on halomorphic soils show a low steppe aspect, with sparse cover; the dominant grasses are: Distichlis scoparia, Sporobolus pyramidatus, Chloris barroii, Hordeum stenostachys, Paspalum vaginatum and Diplachne univiria.

Non-saline grasslands produce about 5 tonne DM/ha/year with a clear summer peak, a pattern that contrasts with the small variation in standing crop greenness. Forage productivity in winter (July) is 5 kg DM/ha/day, being 30 kg DM/ha/day in December and January (Sala et al., 1981, Paruelo et al., 2000). Scarce winter production is caused by the depletion of cool season grasses caused by continuous overgrazing of domestic cattle, after windmills and fences were developed 100 years ago. The dominance of warm season grasses and loss of nitrogen fertility further prevent the establishment of cool season grasses every autumn. Low winter productivity controls the carrying capacity and determines the production system of the area: cow-calf operations. Almost 3.5 million cattle roam the six million ha of the Flooding Pampa, with two million calves exported annually to be raised on pastures in cropland or feed yards. Annual secondary production may be estimated at 90 kg/ha.

Winter productivity may be significantly increased by hard early autumn grazing or herbicide spraying of the warm season grasses, followed by nitrogen fertilization. This promotes the establishment and growth of annual ryegrass (Lolium multiflorum), an excellent quality exotic grass that thrives well in intermediate communities. Phosphate fertilization may also increase cool season grass production by promoting the density of herbaceous legumes (Lotus tenuifolius and Trifolium repens) that enrich soil nitrogen through fixation. With higher winter forage production, heifers and yearlings may be raised on this subregion’s grazing lands, increasing annual secondary production three-fold.

**Cropland Pampas cultivated pastures**

The most renowned Pampa is this sector extending in a circle around the Flooding Pampa (Figure 8). Constituting the main cropping area of Argentina with 77% of the cattle stock and 70% of the human population, it contains the major cities and industrial development. The original tussock grasslands are now rainfed croplands that produce soybeans, maize, wheat and sunflower as the main cash crops. After several years of cash crops, improved pastures are sown in a 4–5 year cyclic rotation designed to maintain soil fertility. When pastures are grown, the seasonal forage production alternates between lucerne, which grows in the warm season, and grasses and clovers that grow in cooler weather.

Cultivated pastures are grazed by steers, yearlings or dairy cattle. Forage legumes like lucerne (Medicago sativa), clovers (Trifolium repens, T. pratense) and birdsfoot trefoil (Lotus corniculatus) fix nitrogen that is transferred to grasses such as tall fescue (Festuca arundinaceae), canary grass (Phalaris...
aquatica), brome (Bromus catharticus), cocksfoot (Dactylis glomerata), rye grasses (Lolium perenne and L. multiflorum) or Agropyron elongatum. ANPP of these non-fertilized sown pastures during the first and second year is higher than those given above (8–10 tonnes DM/ha/year), although plant death and depletion of soil nutrient availability significantly reduces such productivity during following years (Oesterheld and León, 1987). When pastures are adequately fertilized (principally with P), primary production may achieve 12 to 15 tonnes DM/ha/year or even more. This primary production allows 500 kg/ha/year of beef production or 200 kg/ha/year of milk fat.

Nowadays, cash crop prices and the higher profits of agriculture have led to a decrease of cattle numbers in this area; to this add genetically modified soybeans and modern non-tillage practices that reduced the need of pastures/cash crops rotation to maintain soil fertility.

iv) Semi-arid grasslands, dry forest and Monte shrubland

This region extends along the centre west of Argentina between the 13 and 20 ºC isotherms. Its climate is characterized by a serious water deficit, as average annual precipitation ranges between 200 and 550 mm. Rainfall events occur between October and March (spring and summer); severe drought occurs in summer due to high evapotranspiration. Soils in this region are mainly Aridisols and Entisols, sandy and of low organic matter content. These soils have a very low nitrogen content but some are high in phosphorus. Climate and soil produce a wide variety of vegetation types. We refer here to the most important for livestock production:

Caldén forests

The caldén forest is a temperate semi-arid region that borders the Subhumid Pampa to the west and covers four million ha. Domestic livestock were introduced in the early 1900s, causing overgrazing and preventing fire; thereafter the physiognomy changed from a sparse forest of isolated shrubs and trees with dense grasslands underneath, to a shrubland with visible signs of soil erosion. Currently, stocking rates range from 5 to 7 ha/cow/year (Busso, 1997).

The landscape is hilly and vegetation is open forest dominated by caldén, a leguminous tree (Prosopis caldenia). Other woody species in this forest are chañar (Geoffroea decorticans), jarilla (Larrea sp.) and molle (Schinus fasciculatus). The herbaceous stratum is a group of short grasses with good forage quality, as the unquillo (Poa ligularis), flechilla negra (Piptochaetium napostaense), flechilla fina (Stipa tenuis), gramilla cuarentona (Sporobolus cryptandrus) and pasto plateado (Digitaria californica). Medium-sized tussock grasses of low or very low forage quality increase as grasslands deteriorate: Stipa tenissima, S. gyneryoides, S. brachyphaeta and Elionurus muticus. Forage productivity is estimated at 1.7 tonnes DM/ha/year.

Grass steppes are interspersed within the Caldén forest and on higher topographic sites, usually associated with sand dunes. The wind from the west and southwest has formed the topography in the past. Today wind is mainly from the north and is an important cause of soil erosion. From August to November, the driest period, fires and dust storms occur. Chañar tree patches can occur inside these grass steppes. Summer grasses with an acceptable quality are the most important grasses (Bothriochloa springfieldii and Schizachyrium plumigerum). In good areas Sorghastrum pellitum is still present, a grass
with a remarkable forage quality and production when grazed. In degraded areas *Elionurus muticus*, a very low-quality grass became dominant. Forage production in a good condition grassland can achieve 1.5–2.2 tonnes DM/ha/year, mainly in summer.

**Monte shrubland**

The Monte phytogeographic province is a strip that surrounds the Calden and Semi-arid Chaco regions up to the Atlantic coast of Chubut province, covering 50 million ha. Its physiognomy is dominated by a tall shrub stratum with *Prosopis alpataco*, *P. flexuosa* (Fabaceae), *Larrea divaricata*, *L. cuneifolia* and *L. nitida* (Zygophyllaceae). Fodder shrubs include the genus *Atriplex*. To the northern tip of the Monte province *Prosopis* spp. are dominant in the shrub layer, while the southern extreme is dominated by *Larrea* spp. The grass layer, which is the most important forage source, is composed of a mixture of C4 and C3 species. Towards the north the C4 group (*Panicum urvilleanum*, *Chloris castilloniana*, *Pappophorum caespitosum* and *P. phillippianum*) dominate and to the south the C3 (*Stipa tenuis*, *S. speciosa*, *Poa ligularis* and *P. lanuginosa*) increase in importance. *Prosopis* spp. are widely browsed by small ruminants like goats, as their shoots and pods are rich in protein.

Forage production is both spatially and temporally variable (Figure 9). In piedmont communities of *Larrea divaricata* (1500 m) in Mendoza, total litter yield varied from one to more than 5 tonnes DM/ha/year. (Martinez Carretero and Dalmasso, 1992). The herbaceous stratum accounts for 130 to 500 kg DM/ha/year of the total productivity (Braun Wilke, 1982). Because of low wool prices, sheep were displaced by cattle as the main domestic ruminant in this area. Nowadays, cattle numbers continue to grow because of their displacement from agricultural areas.

**Animal production**

Land use in this area is grazing, except for some 200 000 ha. of intensive irrigated cropping (vineyards, lucerne, orchards and horticulture). Only a small part of the irrigated area is used for livestock, despite animal products...
having to be imported to these populous areas. The production system is mainly suckler operations. Calves are weaned at six months weighing 140 kg. Average stocking rates for the whole area range from 7 to 28 ha/cow and meat production ranges from 4 to 20 kg/ha/year. In the wettest eastern areas the natural vegetation is replaced by *Eragrostis curvula* or *Digitaria eriantha*. Drinking water for cattle is one of the more important problems: low-quality sources, very deep aquifers and competition for water from surface sources are the main conflicts.

**Central semi-arid region’s potentiality**

There are many possible ways to improve the stocking rates and meat production of this region. A key operation to determining stocking rate is frequently approached by trial and error. Potential cattle production in the plain of Mendoza was estimated from rain use efficiency (RUE). Guevara et al. (1996) suggested that through the incorporation of available production technology, cattle productivity could be 70% above the actual productivity. The use of RUE gave carrying capacities that vary from 16 to 100 ha/animal unit.

**(v) Patagonian cold semi-desert**

Argentinean Patagonia lies between 39° S and 55° S and comprises 770 000 km². It includes the Andes on the border with Chile, the plateaux and hills up to the Atlantic Ocean. A west–east topographic gradient from 1 600 m in the Andes descends to the Atlantic coast. The plateau sequence starts in the north on the border between Mendoza and Neuquen and continues to Santa Cruz in the south. Several hill chains interrupt the plateaux, like in Chubut the Sierra de Tecka (1 500) and Sierra de San Bernardo.

The Andes determine the climate of Patagonia. The north–south axis of the Andes forms an orographic barrier for humid air masses that blow from the Pacific Ocean. The air discharges a great part of its humidity on the Andes, generating the Valdivian rainforest and the subantarctic temperate forest, with mean annual precipitation above 2 000 mm. East of the Andes the climate is drier. Mean annual temperature in Patagonia varies between 15 °C in the north and 5 °C in the south. Minimum average monthly temperature is above 0 °C for almost the whole of Patagonia. Precipitation in most of the Patagonian steppes ranges between 125 mm in the centre to 500 mm in the west and falls mainly in winter (April to September). Strong and dry west winds, principally in summer, are a principal feature of the Patagonian climate.

Extra-Andean Patagonia is dominated by plateaux and plains composed of basalt, sand and clay. Soils development is low, with low water holding capacity and organic matter levels. The ranges are grazed by sheep, with the largest population in the country. Four districts are distinguished in Extra-Andean Patagonia (León et al., 1998): a) Central shrub steppes, b) Western shrub grass steppes, c) Sub-Andean grass steppes and d) Magellanic grass steppes. As in most desert regions, oases form in riparian areas, providing abundant, fresh and palatable forage during spring and early summer.

**Shrub steppes in the Central District** extend over 15% of the region, from Río Negro to Santa Cruz provinces and from the occidental district on the west to the ocean and the San Jorge gulf district to the east. This corresponds to a transition zone between the semi-desert and the shrub-grass steppe. The most representative vegetation is a low shrub steppe; species are *Chuquiraga aurea*, *Nassauvia glomerulosa*, *Nassauvia ulicina* and *Chuquiraga avellanedae* (quilenbai) and *Acantholippia seriphioides* (tomillo). Depending on latitude and topographic position different proportions of grass mainly of the genera *Stipa* and *Poa* can be found. Forage production is estimated at 490 kg DM/ha/year with the peak in November.
Shrub steppes of the San Jorge gulf district extend on the plateaux adjacent to the gulf. Two main vegetation types can be found in this district: the tall shrub steppes dominated by Colliguaja integerrima associated with other shrubs such as Senecio filaginoides, S. bracteolatus and grasses of the genus Stipa (S. humilis and S. speciosa). The second vegetation type is a grass-shrub steppe dominated by Festuca pallescens and F. argentina and shrubs like Senecio filaginoides, Nardophyllum obtusifolium, Mulinum spinosum and Adesmia campestris.

Shrub grass steppes of the occidental district are widely distributed between 38º to the north and 46º 30’ to the south. The 70º meridian is the eastern limit. The shrub component of this steppe is 60–180 cm tall while the tussock grasses are 10–50 cm tall, covering approximately 50% of the soil. One of the most important communities is dominated by grasses of the genera Stipa (S. speciosa; coiron amargo, S. humilis; coiron llama) and Poa lanuginosa (pasto hilo). Good forage quality grasses that are less frequent include Bromus setifolius (cebadilla patagónica) and Hordeum comosum (cebada patagónica). The shrub layer is dominated by Senecio filaginoides (charcao o mata mora), Mulinum spinosum (neneo) and Adesmia campestris (manuel choique). Berberis heterophylla (calafate) and Schinus polygamus (molle) are other less important shrubs: average primary production is 560 kg DM/ha/year, ranging from 210 to 750 kg DM/ha/year (Fernandez et al., 1991; Jobbagy and Sala, 2001). Primary production is on average equally divided between grasses and shrubs.

Shrub grass steppes of the Sub-Andean district occupy a narrow portion on the eastern slope of the Andes and constitutes the ecotone between the forests and the shrub grass steppes from Neuquén in the north to Tierra del Fuego in the south. Annual precipitation is over 300 mm. The physiognomy is very homogeneous grassland with a very low shrub cover, except in highly degraded sites. Festuca pallescens (coiron blanco), Rytidosperma picta and Lathyrus magellanicus are the dominant species of this area. Forage production may reach 900 kg DM/ha/year with a peak production in December (Bertiller and Defosse, 1990).

Grass steppe of the Magellanic district is located in southern Santa Cruz and northern Tierra del Fuego with a cold and oceanic climate. Vegetation physiognomy is a grass steppe dominated by Festuca gracillima 30–40 cm. tall.

Meadows – wherever water flows from springs or aggregates in very different topographic positions (slopes and valleys), it is associated with meadows that occupy less than 5% of the whole territory. These are dominated by grasses and cyperaceous species and are highly productive, forage production reaching 7 000 kg DM/ha/year. Overgrazing on these areas induces denudation and salinization and gully formation from water and wind erosion.

Land use and animal production
Environmental heterogeneity and history determines the size of the operations and the land tenure situation in Patagonia. Three social groups can be distinguished:
1. Small producers, usually from indigenous communities of the Mapuche group that have grazing rights in fiscal lands. They herd their flocks from the Andean slopes to the shrub grass steppes practicing transhumant seasonal grazing in northwestern Patagonia (mainly Neuquén province).

   Goats are as important as sheep in this group.

2. Large sheep and cattle operations ("estancias") in the most productive areas, as in the sub-Andean and occidental districts. These operations were started in most cases by Europeans (mostly British) in the early 1900s. Sizes range between 20 000 and 200 000 ha.

3. Operations smaller than 20 000 ha. These are usually not economically feasible Many owners abandoned them during the last ten years.

   Grasslands are grazed continuously in Patagonia as paddocks are very large and usually include more than one grazing site. Carrying capacity for Patagonia ranges from 0.18 sheep/ha/year for the shrub-grass steppes of Central District to 1.2 sheep/ha/year in the more humid grass steppe of the Magellanic District. Wool production may reach 4 to 7 kg/head depending on the area. There are many possibilities for increasing carrying capacity in these areas with technological improvement. For example, the use of urea supplementation to stimulate the utilization of low-quality grasses and improve their digestibility has been reported (Golluscio et al., 1998).

   A hundred years of continuous grazing by domestic herbivores hampered the ecological sustainability of the Patagonian steppes. Several authors consider that grazing had a main role in the environmental and productive degradation in Patagonia. The Patagonian sheep population has declined over the last decades from 20 million in 1952 to 11 million in 1993. Highly selective sheep foraging has reduced the density and vigour of the highest quality plant species.

(vi) Puna and High Andes grass steppes

This region extends from northern Neuquén to Jujuy and continues to Bolivia and Peru. The landscape is characteristically mountainous, with snow capped peaks, mountain pastures, high lakes, plateaux and valleys. Topography is characterized by plateaux, hills and valleys ranging between 3 000 and 4 300 m. and the high Andes between 4 300 and 6 600 m (Figure 3a). Soils are sandy and stony. The dry climate varies from temperate to cold, with an average temperature between <0 and 15 ºC. Precipitation varies between 250 and 500 mm per year.

   The vegetation is characterized by grass and shrub-grass steppes, halophyte steppes and meadows (Ruthsatz and Movia, 1975; Cabrera, 1976). In terms of vegetation, the Puna is close related to Patagonia, because of the common dominant genera. Grasses primarily belong to the genera Calamagrostis, Agrostis and Festuca and shrubs of the genera Fabiana, Lepidophyllum, Chuquiraga, Nardophyllum, Mulinum and Adesmia. Characteristic formations include five main communities:

   1. Shrub steppe dominated by Fabiana densa, Baccharis boliviensis and Adesmia horrida;
   2. Cardonales, dominated by Trichocereus pasacana
   3. In the wettest areas, small forest dominated by Prosopis ferox (fabaceae) or Polylepis tomentella (rosaceae).
   4. Meadows with Scirpus atacamensis, Helocharis atacamensis, Juncus depauperatus, Plantago tubulosa, Hypsela oligophylla
   5. On saline and temporally wet soils, Festuca scirpifolia, Juncus balticus and Hordeum halophilum.
6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

Argentina’s pastoral country circumscribes the fertile croplands of the Chaco and Pampas regions. In the 4 000 km long by 300 km wide semi-arid-strip that borders the Andes, there are a variety of rangelands where more than five million cattle graze. Provided adequate infrastructure is developed to improve animal distribution, those grazing lands may carry 8–10 million head of cattle. North of the cropland is the humid region where present stocking (10 million) may be tripled if sound management is applied and soils are adequately fertilized with phosphorus. A large proportion of the cattle population that graze cultivated pastures in the croplands (35 million) will be displaced by cropping activity. In this way the cattle population will be redistributed, remaining at 50 million head. Argentina may specialize in providing a healthy product (grass-fed animal products), produced in ecologically-sound systems (well-managed rangelands). The climate allows yearlong grazing and large ranches reduce costs of these ranching systems.

Several technologies may improve the carrying capacity in the semi-arid rangelands, such as
(i) water development,
(ii) nitrogen supplementation,
(iii) fire management,
(iv) stock distribution
(v) multi-species stocking,
(vi) sound grazing management
(vii) establishment of improved forages.

Several of these technologies are already used successfully on many ranches and are ready to be extended to the rest of the properties in the region. This will happen rapidly as the increased specialization that is occurring in the croplands expels cattle, which move together with management and capital to the surrounding rangelands. This will assure the implementation of appropriate technology. Humid Argentina (Chaco, Campos, Espinal and Pampa Regions) is a climatically gifted region that is home to 10 million cattle and could triple its carrying capacity. Rainfall is high and fairly even while the temperature is mild and peak-less, allowing grass to stay green year-round when well-maintained and grazed. There is no climatic constraint that could affect animal comfort when grazing the extensive native pastures year-long. Heat stress is overcome by crossbreeding zebu to British breeds. With these conditions and the possibilities of improving grassland productivity through (i) adequate fertilization, (ii) the establishment of adapted forages and (iii) controlling the way of grazing, the future is promising.

Improvements in forage production and utilization will not increase beef output from Argentinean rangelands without an adequate nutritional management of the grazing animals. The lack of nitrogen and phosphorus supplementation to satisfy animal requirements determines the nationwide inefficiency of beef cattle production and low weaning percentage (barely 60%). Prolonged dry winter periods reduce protein content in the forages provided by the semi-arid rangelands. Senesced summer grasses that overtop the winter ones (and prevent their growth) determine the need for autumn and winter nitrogen supplementation in the humid grazing lands. As the soils of this humid region lack phosphorus, good conception rates and fast animal growth are hampered. Nutritional limitations of P may be overcome through an adequate supplementation programme and by soil fertilization. Energy deficiencies in winter are overcome easily by grain supplementation and grassland cultivation.

Pasture seed production and marketing

About 23 000 tonnes of pasture seeds were marketed during the 2000/2001 season. Most of the seed sown in Argentina is produced in the country. However, more than half the marketed amount of lucerne seed is imported.

<p>| Table 6. Pasture seed production and importation for 2000/01 |
|-------------|-------------|-------------|-------------|</p>
<table>
<thead>
<tr>
<th>Forage</th>
<th>Produced</th>
<th>Imported</th>
<th>Marketed</th>
</tr>
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<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>11 213</td>
<td>6 987</td>
<td>23 350</td>
</tr>
<tr>
<td>Bromus catharticus (brome grass)</td>
<td>3 357</td>
<td>0</td>
<td>3 300</td>
</tr>
<tr>
<td>Festuca arundinacea (tall fescue)</td>
<td>1 495</td>
<td>2</td>
<td>2 100</td>
</tr>
<tr>
<td>Medicago sativa (lucerne)</td>
<td>1 292</td>
<td>4 647</td>
<td>7 000</td>
</tr>
<tr>
<td>Lolium perenne (perennial ryegrass)</td>
<td>1 186</td>
<td>85</td>
<td>1 500</td>
</tr>
<tr>
<td>Lolium multiflorum (annual ryegrass)</td>
<td>1 097</td>
<td>821</td>
<td>4 000</td>
</tr>
<tr>
<td>Dactylis glomerata (orchard grass)</td>
<td>962</td>
<td>85</td>
<td>1 200</td>
</tr>
<tr>
<td>Trifolium repens (white clover)</td>
<td>354</td>
<td>228</td>
<td>650</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>230</td>
<td>160</td>
<td>no data</td>
</tr>
<tr>
<td>Others</td>
<td>1 240</td>
<td>959</td>
<td>3 600</td>
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</tbody>
</table>

The eight named forages in the table represent almost 90% of the seed produced. [NB. only certified seed is considered for produced and imported seeds, but non-certified seed is an important part of the market, thus the discrepancy between totals].
(Table 6). There are some projects on native plant breeding. The native C₄ grass *Paspalum dilatatum* was studied for soils with low drainage. Other species bred abroad like *Plantago lanceolata* are now being tested for introduction to pastures.

### 7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

#### Institutional structure
The National Secretary for Agriculture, Livestock Production, Fisheries and Food leads the national politics on the area. Each of the provinces has its own federal secretary for the area. Several national institutions such as the INTA, the SENASA and the universities (see links below) are important for local research and development.

#### Links
The key organizations and their current areas of activity/interest with relevance to pasture and animal production are as follows:

- **National Secretary for Agriculture, Livestock Production and Fisheries.** [www.sagpya.mecon.gov.ar/](http://www.sagpya.mecon.gov.ar/)
- **National Institute for Agriculture and Animal Production Technology (INTA).** [www.inta.gov.ar](http://www.inta.gov.ar)
- **Institute for Arid Zones Research.** [www.cricyt.edu.ar/institutos/iafrica/default.htm](http://www.cricyt.edu.ar/institutos/iafrica/default.htm)
- **Faculty of Agronomy, Universidad de Buenos Aires.** [www.argobra.ar](http://www.argobra.ar)
- **Faculty of Agronomic Sciences, Universidad Nacional del Litoral.** [www.fca.unl.edu.ar/](http://www.fca.unl.edu.ar/)
- **Darwin Institute.** [www.darwin.edu.ar/](http://www.darwin.edu.ar/)
- **Argentine Association of Regional Consortiums for Agricultural Experimentation (AACREA).** [www.aacrea.org.ar/](http://www.aacrea.org.ar/)
- **Argentine Association for Animal Production (AAPA).** [www.aapa.org.ar/](http://www.aapa.org.ar/)
- **Laboratory for Regional Analysis and Remote Sensing.** [www.agro.uba.ar/lart](http://www.agro.uba.ar/lart)
- **Argentine Rural Association (SRA).** [www.ruralarg.org.ar/](http://www.ruralarg.org.ar/)

#### Contacts for information on pasture and fodder production and management:

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