CASE STUDY

South American Livestock Farming Expansion

The Long Way to Sustainability

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AT THE BEGINNING of the 21st Century, South American countries, and in particular members of Mercosur, have become food providers on a global scale, particularly of animal products, i.e. meat, as well as soy beans and cereals. Commercial links, once mainly with Europe and the United States, now are increasingly directed towards emerging countries and other regions such as Russia, North Africa, and the Near East. Historically, the export market has grown at the same rate as agricultural production in South America. The export market always has been the driving force behind the growth of agricultural production, which is expected to continue to increase given the sector's strong potential in the region. Indeed, there are large areas of unused, arable land in South America which could be developed in the future in response to international demand. South American natural biomes, especially forests, also possess abundant natural resources which policy makers would like to exploit for national economic development.

However, the expansion of agriculture and livestock farming in South America presents several risks. Radical changes of native biomes cause serious

local and global disequilibrium in biodiversity and biomass dynamics, disrupt water cycles, and lead to erosion, especially in hilly zones. The deforestation of native forest areas is one of the main factors; the frequent use of slash and burn practices to establish pastures is another. The heavy use of fertilizers on annual and perennial crops and a lack of pasture management also render the expansion process unsustainable. For example, typical farmer applies mining when practices taking advantage of the soil natural productivity grown up by ashes and no using any fertilizers to recuperate the soil fertility.

According to Thompson (1997) and Hubert (2008), the functional integrity concept considers that any resource results from complex interactions between natural and human factors, or, in other words, between eco-

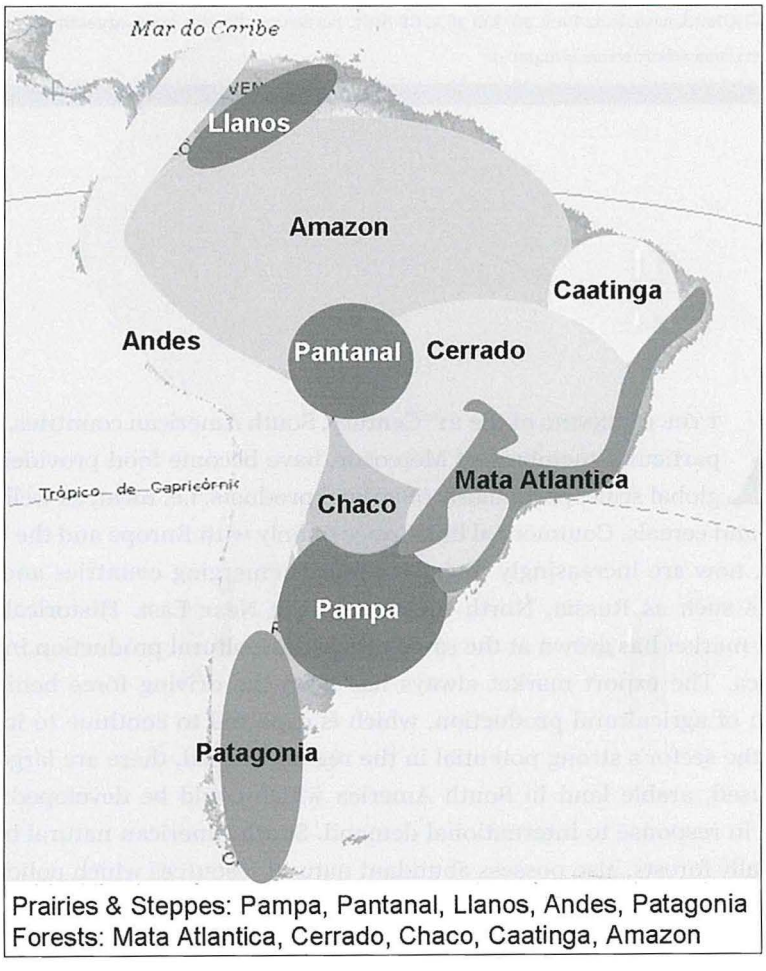

Figure 1. Location of the main South-American biomes

logical and social systems. A resource is not a given capital which each farmer can use, rather, it is the product of a combination of processes that depend on different natural and human uses on local to global scales. Resources and practices consequently cannot be evaluated from an economic angle alone. The diverse functions of a socio-ecosystem also must be considered, especially from spatial and long term perspectives.

Using the concept of functional integrity, the expansion of South American livestock farming into particular biomes will be analyzed from a historical perspective in order to identify new ideas about relevant public policies and priority research topics.

In the prairie, the migrant and his herd replaced the Indian and his hunting

During the 16th, 17th, and 18th centuries, European companies exploited the soil and subsoil of South America to meet European demand. For example, gold and silver were mined in Peru and Bolivia, and sugar and coffee were grown along the Atlantic coast, especially in Brazil, the Caribbean region, and Central America (Alonso 1982).

Apart from llamas and alpaca in the Andean mountain range, livestock breeding does not seem to have been a widespread activity in pre-Columbian societies. Hunting and fishing appear to have been the main source of animal protein. Community boundries often defined hunting and fishing areas

Migrants initially brought European cattle to the Americas to provide the same products and services as in traditional European villages: dairy and meat for local consumption or for sale to provide income and savings, tillage and transport, dung and leather. Early in the 16th century, navigators noted the opportunities presented by the herbaceous savannas of the Pampa in the south and of the Llanos in the north (Castellanos 1972). Beginning in the 17th century, migrants developed specific bovine and ovine grazing systems based on practices already existing on European rangelands. Dried meat was exported to mining and sugar cane regions to complement local meat production to provide food for slave labour. Leather and wool also were exported, mainly to Europe.

A few Amerindian groups adopted similar extensive grazing systems. Other groups needed to move to regions far to the settlement zones because hunting

was complex in the new context, where migrants were starting to take possession of the land. In Northern Patagonia, Coronato & Tourrand (2009) show that Wales's settlements, which were limited to crop agriculture in the valleys, maintained good relationships with neighbouring Amerindians communities. Yet at the same time, competition over the use of rangelands between Indian hunters and cattle herders created serious conflicts. The Argentinean army's "Conquest" of the area, and the ensuing extermination of Indian communities, was the result. In a few years time, the steppes of Patagonia were populated by sheep under the impetus of British wool companies.

Until that time, migrants' farming systems had only a small environmental impact on natural resources because mixed farming systems were concentrated along the Atlantic coast and livestock grazing systems took advantage of the natural pasture without significantly changing the rangeland. However, from a social perspective, Amerindian communities were forced to either adapt to the new situation or to migrate farther away, for example onto the Patagonian steppe. The migrants' herds consequently were beginning to determine the Indians' hunting areas.

After the prairie, the ox, spearhead of colonization, entered the forest

Until the 19th century, the great part of South American forests had not been affected by colonization. Only the arable land of the Atlantic coast was occupied by settlements, first for sugar cane production, and later for coffee and cocoa plantations. In these biomes, livestock farming was limited to mixed agriculture – breeding systems, basing herd nutrition on sub-products and forage crops. As in traditional European systems, farmers created grassland areas around their villages for cattle breeding. However, some large herds migrated to Pantanal, a savannah covering one million km^2 located in the centre of South America. Livestock production contributed to the coastal productions, especially ox for tillage and transport in agricultural areas and meat and cheese for urban populations.

At the beginning of the 20th Century, zebu races — imported from India and adapted to tropical ecosystems — facilitated the expansion of cattle ranching into tropical forest biomes, deepening conflicts with Amerindian communities. The main advantages of zebu over European cattle in tropical areas are their resistance to high temperatures and some specific diseases,

especially parasitic diseases, and their better valorization of low-quality forages. Initially, zebus were used to transport the harvest from the field to the port on mountainous tracks at the end of the warm, dry season. However, within a few years herders began to use them to colonize new forest plots near their settlements, increasing their controlled area and prejudicing neighboring Amerindian communities.

Consequently, from the second half of the 19th century, tropical forests and savannahs gradually were occupied first by beef herds, then by zebus herds due to the latter's better capacity to adapt to a tropical bioclimatic context. Settlers used slash and burn practices to transform natural forest plots into rural space following a number of successive steps. First, the vegetation was slashed and burned to enrich the soil with minerals contained in the ashes. Second, cereal food crops such as rice, corn, bean or manioc were established. After this first crop, if other inputs were not added, the second annual crop was jeopardized due to a lack of soil fertility. The first crop used up the nutriments and weeds invaded the fields which farmers had great difficulty getting rid of. For these two reasons, after a first crop on slash and burn soils, the plot usually either was left fallow, planted with a permanent culture such as coffee, or used as pasture land. In the latter case, failing strict management, the fodder cover gradually deteriorated and the soil became less and less fertile.

A huge area of deforested land in South America thus had been established as pasture but, the percent of this land, used for grazing, after some years was significantly lower because of its gradual degradation (Veiga et al. 2004). However, Over the decades, much degraded pasture has been recuperated and turned into productive fields. From these historical and socio-spatial points of view, livestock farming appears to be a driving force behind the colonization of forest land, as it was for prairies and steppes. It led to the creation of new frontiers and offered, over the last centuries, real perspectives to migrants who often were excluded from the land system in their own areas and countries of origin.

Until today, South American landscape kept livestock farming footprint

Today, South American prairies and steppes are not the same as they were prior to the arrival of the Europeans. Information about pre-existing natural vegetation is not available (Pereira 2002). There probably were more small trees, especially on the riverbanks, and also more high grasses as *Andropogon sp.* Wildlife, such as small harts, rodents, and birds, have been mentioned as normal inhabitants before the arrival of the big ruminants, as well as their predators. Livestock practices probably have modified the herbaceous composition of rangeland, adapting it to bovine and ovine nutrition and reducing spontaneous burnings. Livestock breeding today takes advantage of a ready-made resource which has been both partially modified from what once existed and partially created though the presence of migrants over several centuries. In Pampa, a big change was the adoption of a mixed farming system based on wheat and forage crops for cattle grazing beginning at the end of the 19th century. More recently, this biome is the theatre of a huge expansion of agribusiness using mechanized, high level, no-tillage cropping, genetically modified crops, and efficient market chains, in response to international demand for food and biofuels.

Under the influence of man and herds, tropical forests and woody savannas evolved into grasslands, following the same process as that of herbaceous steppes and savannas some time before. The Mata Atlantica was the first forest to be colonized due to its location nearest to the Atlantic coast where the first settlements were established. In response to the local demographic dynamic and new European migrations, especially at the end of the 19th century and beginning of the 20th century, the agricultural frontier gradually advanced into the Mata Atlantica, transforming natural forest plots into rural and urban areas. Settlers developed mixed farming systems based on annual and perennial crops (coffee, cocoa ...) according to local conditions and international market demand. The landscape now is dominated by pasture planted for beef and dairy production, especially the slops and hilly areas. At the end of 20th century, only 7% of the original Mata Atlantica forest remained intact. A similar process took place in the Caatinga biome in north-eastern Brazil. At the same time, there was a systematic exploitation of the natural resources available: wood, non-wood forest products, animal skins, etc.

After crossing Mata Atlantica and Caatinga, the agricultural frontier entered the Cerrado. However, bioclimatic conditions and the distance to the

Atlantic coast, where the major consumption centres and export ports were located, incited the development of livestock farming systems. Until the middle of the 20th century, cattle ranching was the main activity in these biomes. After the 2nd World War, the Brazilian government decided to better integrate the Cerrado into the national economy. The integration program was based on the establishment of a public agency, the construction of roads and other infrastructure, and loans to attract the migration of southern farmers and companies. Extensive breeding systems gradually are being replaced by export agriculture, especially of cereals (corn and rice) and legumes (soybean), supported by credit and mechanized practices, and involving many industrial inputs. The hilly areas and lowlands remain the field of pastoral activities. However, breeding was far from eliminated. It retains a dominant position in every landscape. Thus the Cerrado, known worldwide for its production of soybeans and cereals, continues to be covered mainly by grasslands. In addition, it has profited from the new context to move to intensification of crops.

The colonization of South American forests and woody savannas biomes has continued through the end of the 20th century and has reached the Amazon in the north and the Chaco in the south, although this biome already was involved at the same time as the Cerrado. Today these biomes hold nearly 200 million cattle, which added to the approximately 50 million in the Pampa, account for about 20% of world livestock.

Environmental impact and social consequences of agricultural dynamic

The Amazon, with a deforestation rate of about 15 to 25%, according to different countries, is the focus of media attention. Yet little mention is made of the Cerrado and the Chaco, which respectively have lost nearly 70% and 50% of their surface to deforestation. Joined together, these two biomes, combined with the natural Mata Atlantica area, cover a surface almost equivalent to the Amazon and present a biodiversity which is among the most remarkable on the planet.

The environmental impact also affects the water cycle. The deforestation of Chaco, Cerrado, and Mata Atlantica is directly responsible for the intense floods in the whole Plata-Parana-Paraguay basin, one of largest on the planet.

The deforestation of the Oriental Amazon has resulted in irregular water cycles with climatic consequences which remain little known but are potentially very important.

At the local scale, the establishment of livestock breeding often resulted in a random occupation of available land without taking into account the potential of the above ground, pre-existing ecosystems. In woodland and forest ecosystems, pastures were established in an ill-considered way along riverbanks, around water sources, and on steep slopes. The result was serious erosion resulting in the changing of courses, the silting of the streams and rivers, and the draining of the sources and of ground water. The consequences were not as serious for herbaceous savannahs due to their gentle relief, which resulted in less erosion, and due to the original herbaceous cover.

At present, people distinguish between "friendly" animal production and industrial animal production. In general, "friendly" animal production is seen and understood as not being sufficiently productive to meet the high global demand for meat, while industrial animal production is highly natural resources consumer and more productive, as can be seen at bovine feed-lot, poultry and swine production. The called "friendly" production system si based on management practices that take account of the environmental/ecological demands, as the water and soil natural cycles. It takes more time to be implemented, compared to "industrial" production, that is not in every cases environmentally worried and is based on commercial inputs, such as supplementary grains, and takes less to complete the meat production cycle.. The factors that can lead to one or the other depend on market pressures, thus the occidentalization of habits in Asia, for example, and the usual meat consumption in Europe and USA, determine South American production modes.

In all cases, a mining style exploitation of natural resources has resulted in a genuine waste of these resources and seriously damaged the environmental functions of the forest and herbaceous ecosystems concerned, although the situation is not always irreversible. Regarding the marginalization of most of the Amerindian population, livestock breeding was an important factor in producing social differentiation in South American colonial societies. Also, a transformation of the society has been going on during recent decades, and the agrarian sector has lost its relevance. So, the social function of breeding, which was the foundation of colonial societies are irrelevant for the management of the large ranches, which are real human deserts.

Reasons for the expansion of livestock farming in South America

"*Livestock farming is a good business*" is an idea shared around the world in rural areas, even though it is not the best business depending on the region and period. The South American case study gives some specific points of view due its biological and social context.

The colonization process is a major factor. Amerindians societies did not find a way of impeding the migrants' expansion. And today, for many South American people, land is still available and could be colonized for agricultural and livestock production, especially in the Amazon basin. Natural resource opulence is another major factor. Prairies and steppes provide good rangeland for migrants' herds. Transformed into grassland through slash and burn practices, forests also provide excellent food for ruminants, especially in rainy tropical area, according to the climatic conditions (water, temperature, and sun). Over the last few decades, macro policies always have supported the colonization process, including the expansion of cattle ranching, to valorise soil and subsoil natural resources and meet national and international demand for livestock production – meat, dairy products, leather, and wool. Agricultural research and technology progress also have been relevant factors in the development of efficient livestock systems and increasing herd productivity. Brazilian zebu ranching is a good example of how diversified livestock may be adapted to different levels of social and economic conditions.

However, this "success-story" could not exist without the diverse and complementary functions of livestock in rural societies, as mentioned previously. Savings and income, meat and dairy products for auto consumption by small breeders, tillage and dung in mixed crop-livestock systems, the valorisation of marginal zones and cropping sub-products, social position at the local level and cultural aspects... these elements combine to justify farmers' interest in livestock activities and contribute to their resilience despite market risks.

Finally, in rural areas, land and cattle are two property signs. Furthermore, the 1st is valorized by the 2nd, which itself contributes to proving the ownership of the 2nd. The singular and strong relationship between cattle and land consequently must be analyzed within the context of the culture of migrant societies, acknowledging that many migrants were landless before migrating.

The battle for land possession is finishing and a way of sustainable management of grazed agro-ecosystems is arriving

Despite the renewal of deforestation in the Amazon in 2007, for which cattle breeding continues to be regarded as one of the main driving forces, and the increase of biofuel expansion in other biomes, there is a real environmental awakening within the South American societies concerned. Although the fight for land at any environmental and social price is still likely to continue, in particular in the Amazon, it is no longer the most frequent scenario.

Livestock farming will be regarded as the destroyer of natural ecosystems for a long time. However, far from disappearing from the landscape of intensified farming, it is integrated into it by adopting new rules and international standards, i.e. less environmental impact, maintaining soil fertility, permanently protecting riverbanks, sources, and steep slopes. Moreover, land valuation and productivity will pass more and more to tree planting within the fodder parcels, as has occurred during recent years for perennial crops, even if this is due to a lack of valuable wood in previously exploited forests.

In conclusion, livestock farming, spearhead of the colonization of most of the South American continent, was based on the mining of natural resources which transformed the natural ecosystems into pastoral spaces. The market demand for livestock products and the prospect of land accumulation sustained the advance of colonization. This first pastoral wave was followed by a second wave made up of vegetable production, also promoted by market forces. The combined environmental and social impact of these two waves has led those currently involved to imagine other ways of developing rural ecosystems which are less degrading, more respectful of their integrity, and make it possible to recover part of the functions of these ecosystems.

Natural resources are not just a gift from Nature, but construct themselves, considering that they are the result of the interaction of a diversified and complex web of physicial-chemical biological social and cultural processes. In this sense, they are not just inputs to productive process, but the result of an intricate process.

From a scientific point of view, in the face of uncertainty and a growing number of stakeholders, the research community seeks to improve (i) its insertion into social networks to construct shared perceptions with the potential of improving action. Also, and in a collaborative manner, it is necessary to continue to (ii) observe and monitor changes in livestock systems that are

underway throughout the whole region, (iii) understand these changes as a joint human – environmental system, (iv) spatially and explicitly model ongoing transformations and associated changes in land use, and (v) assess system outcomes, such as vulnerability, resilience, and sustainability.

If one considers ecological economy postulates (Martínez Alier & Jusmet 2000), it is imperative to take multi-criteria decisions, identify the tools that can support these decisions and, most importantly, present the role and responsibilities of all consumers in relation to the kind of animal production being developed around the word, knowing that demand - in terms of quantity and quality - impacts supply and thus the rhythm, volume, scale, time, and space of production and natural resources consumption - mainly of water and biomass.

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