Agricultural Activities, Management and Conservation of Natural Resources of Central and South American Savannas

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Tropical savannas are one of the most important biomes of the world, covering around 20 million Km² of land surface in South America, Africa, Asia and Australia.
NEOTROPICAL SAVANNAS EXTEND AROUND 2,500,000 km²

BRASIL 76%, VENEZUELA 11%, COLOMBIA 6%, BOLIVIA 5%.
GUYANA 1%.
Smaller percentages in Central America and the Caribbean, French
Guyana and Suriname.
Neotropical savannas are very diverse, the Brazilian Cerrado, for example, has a rich and generally unappreciated biodiversity, the number of vascular plants exceeds 7,000 species. 45% of the Cerrado flora is endemic, which makes it:

THE RICHEST TROPICAL SAVANNA IN THE WORLD

The Orinoco plains are not as diverse as the Brazilian Cerrado. Riina et al. Report the existence of 3,219 species, with only 35 Endemic species (1.1% endemic).

for the Colombian Orinoquia, Romero et al. Report 2,692 plant Species.

This biodiversity is threatened by the expansion of the agricultural Frontiers, which has caused an intense fragmentation. In the Cerrado for example, cultivated African grasses cover more than 500,000 Km² and crops cover more than 100,000 Km². But only 33,000 Km² are protected.
Neotropical savannas are macrothermic and thrive in seasonal weather areas. Mainly under seasonal wet tropical climate: Köppen’s type Aw. Savanna climate

Figura 18
Climatograma de Calabozo, edo. Guárico
(tomado de Vareschi y Huber 1971)
Llanos de Venezuela

Western piedmont Llanos
1 Santa Bárbara
2 Guanare
3 Acarigua
Central Llanos
4 Calabozo-EQLI
5 San Fernán
6 Puerto Fáez
7 Toro Negro
Eastern Llanos
8 El Tigre
9 Temblador

Calabozo

Andes

Savannas
Orinoquia
Savannas come in contact with the Amazonia, the Chaco and the Caatinga.
The savanna soils are acid, highly meteorized, extremely poor, mainly Oxisols, Ultisols and Entisols, susceptible to degradation and compaction. These soils, categorized by Sarmiento as dystrophyc and hyperdystrophyc, present limitation for the agriculture production, mainly due to their natural low fertility, and the toxicity generated from the high Al saturation, that produces Aluminium-accumulating plants.

The Al saturation combined with low Ca volumes limits the radicular growth
Traditionally the savannas has been regarded as unsuitable for Agriculture, being reserved for Charcoal production (Brasil), the subsistence agriculture and the extensive cattle raising with native plants of very low nutritional quality.

combined with the use of fire
The savannas constitute a land extension with a great potential for agriculture and Forestry use, constituting the Main available agricultural Frontier.

Which has resulted in the deforested area of Brasilian Cerrado, being three times The deforested area in the Amazonia

Representing thus the Biggest threat for the Savanna Biodiversity
The physical conditions of the savanna soils demand a careful use; however, the savannas, specially those of the Cerrado were conceived among the most productive frontier of the world.

The cultivated area in the Cerrado tripled from 10 millions ha, in 1970, to 30 millions ha in 1985, and was expected to be doubled in the year 2000 !!!!

The single-crops system in the Neotropical savannas was very productive and very profitable, while the governments subsidized it. Especially in Brazil and Venezuela.

Which resulted in the introduction of: machineries, liming, high dose of fertilizer, agrochemicals, and the substitution of native grasses by pastures mainly from Africa.
BUT
these systems began to **deteriorate**, and to show losses of productivity, and problems of soil degradation.

Seminar on Technological and Scientific Development for the Agricultural Development

**Caracas 1975**

“No existe una Ciencia Agrícola Tropical”

“It Do not exist a Tropical Agricultural Science”

Montilla, J.J. y Vargas, R. - 1976
As a consequence of soil degradation, several international and national Agencies, were devoted to detect and select native species adapted to the savanna, to obtain germplasm of high genetic potential, and to carry out research on chemistry, physics and biology of the soil, pointing toward contributing by means of the technology generation to the development of an agricultural sector maintaining high levels of production, minimizing the environmental risks.

It means: building “a Tropical Agriculture Science”

Some examples are:
In Colombia the International Center for Tropical Agriculture, CIAT,
In collaboration with Colombian Corporation of Agriculture Investigation, CORPOICA.
In Brazil the Brazilian Company of Agriculture Research, EMBRAPA
In Venezuela the National Fund of Agriculture and Cattle Research FONAIAP, today INIA.
Different varieties of unirrigated land rice were obtained, tolerant to Aluminium saturation and with high production potential. Some like *Oryzica sabana* 6 and *Oryzica sabana* 10 tolerate up to 90% Al saturation.

Soybean, Sorghum and Corn varieties, with different grades of Al Tolerance, were also obtained. Some Corn cultivars came from the Center of Improvement of Corn and Wheat, CIMMYT, México. This germplasms exudates Citric Acid by the roots as tolerance mechanism.

Cultivars for acid soils developed at Colombia. From Valencia & Leal (1999).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Variety</th>
<th>Al tolerance</th>
<th>Agreemen</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td><em>Oryzica sabana</em> 6</td>
<td>90 %</td>
<td>ICA-Ciat</td>
<td>1991</td>
</tr>
<tr>
<td>Rice</td>
<td><em>Oryzica sabana</em>10</td>
<td>90 %</td>
<td>ICA-Corpoica-Ciat</td>
<td>1995</td>
</tr>
<tr>
<td>Soybean</td>
<td><em>Soyica altillanura</em>2</td>
<td>70 %</td>
<td>ICA-Corpoica FAA</td>
<td>1994</td>
</tr>
<tr>
<td>Sorghum</td>
<td><em>Sorghica Real</em>40</td>
<td>40 %</td>
<td>ICA-Intsormil</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td><em>Sorghica Real</em>60</td>
<td>60 %</td>
<td>ICA-Intsormil</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td><em>Icaravan</em> 1</td>
<td>40 %</td>
<td>ICA-Intsormil-Alcaravan</td>
<td>1993</td>
</tr>
<tr>
<td>Corn</td>
<td><em>SikuaniV-110</em></td>
<td>55 %</td>
<td>ICA-Corpoica-Cimmyt</td>
<td>1994</td>
</tr>
</tbody>
</table>
Another results from the cooperation between agencies and Countries was the achieving of forrager legume, also tolerant to the soil acidity, especially: *Stylosanthes capitata* (Capica) and *S. guianensis* cv Mineirão *Centrosema acutifolia* (Centrosema vichada), *Arachis pintoi* (Arachis, perennial forrage Peanut).

New cultivation systems were organized:
In Colombia two systems were organized, one starting from dry-farmed rice intended to stablish gramineous-leguminous enchanced pastures, and other one using dry-farmed rice cultivation and a component of leguminous to recover degrades pastures.

In Brazil producers are using several integration systems, one of them is the Barreirão system: consisting of associating cultivations like rice, corn or sorghum with *Pennisetum typhoides* with forragers like *Brachiaria*, and leguminous like *Stylosanthes* or Arachis. Similarly in Venezuela these new techniques has been used with low input systems.
A significant advance toward more sustainable agriculture in the savannas, was the adoption of the conservationist farm systems. That is: minimum tillage and zero-tillage, those systems create conditions that allow for the functioning of the soil very close to that of the natural savanna. In both cases the compartments of the Organic Matter are favored and the soil erosion is minimized by the stability of aggregates.

In Venezuela it is estimated that between 1995 and 1997 there was an increment of 78% in the savanna area sowed under Conservationist Farming.

In 1980 it was calculated that in the Cerrado there were 150,000 ha under this saw system, and in 1990 there were 1,000,000 ha. Ten years latter it was calculated that they would have 10 million ha.
A highly successful strategy to intensify agricultural production in a sustainable way, and resolve problems of degradation, involves the integration of crop/livestock system in time and space: Agro-pastoralism

The strategy is based on the assumption that a beneficial synergistic effect on productivity and on soil occurs when annual and perennial species are combined.

**ANIMAL WEIGHT GAIN UNDER DIFFERENT CULTURE COMBINATION. UBERLANDIA BRAZILIAN CERRADO. AFTER AYARZA et al.(1999)**

<table>
<thead>
<tr>
<th>Production System</th>
<th>Input</th>
<th>Soil Type</th>
<th>Combination</th>
<th>Annual Production (Kg/ha/year)</th>
<th>Weight gain %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>Low</td>
<td>Sandy</td>
<td>Culture-grass</td>
<td>160</td>
<td>-</td>
</tr>
<tr>
<td>Pasture</td>
<td>Low</td>
<td>Sandy</td>
<td>Cult-grass-legume</td>
<td>254</td>
<td>58%</td>
</tr>
<tr>
<td>Pasture</td>
<td>Low</td>
<td>Clayed</td>
<td>Culture-grass</td>
<td>230</td>
<td>-</td>
</tr>
<tr>
<td>Pasture</td>
<td>Low</td>
<td>Clayed</td>
<td>Cult-grass-legume</td>
<td>354</td>
<td>54%</td>
</tr>
<tr>
<td>Culture</td>
<td>High</td>
<td>Sandy</td>
<td>Culture-grass</td>
<td>236</td>
<td>-</td>
</tr>
<tr>
<td>Culture</td>
<td>High</td>
<td>Sandy</td>
<td>Cult-grass-legume</td>
<td>267</td>
<td>10%</td>
</tr>
</tbody>
</table>
In the dry savannas of Bolivia a different orientation was carried out. Some farmers are integrating crops like rice or corn with pastures, but the CIAT/SC has not carried out research work in agro-pastoral systems, but it is advancing together with the British Mission of Tropical Agriculture, MBAT, in research in agro-silvo-pastoral systems.

Among utilized trees are: *Leucaena leucocephala*, *Flemingia congesta*, *Swietenia macrophylla* or *Schizolobium amazon*, and among pastures: *Brachiaria decumbens*, *B. brizantha* or another gramineus plants.

On the other hand, leguminous trees are being implanted in stablished grasslands, mainly: *Erytrina fusca*, *Samanea tubulosa* and *Prosopis sp.*. These systems are still in experimental phase.
In Venezuela, the oriental savannas were used for planting trees, on sandy soils, especially *Pinus caribea* and several species of *Eucalyptus*, since de hydric limitations for the cultivations did not affect the pines or the eucaliptus. However, the productivity was not the expected.

Pine forestation resulted in an accumulation of a thick Organic layer and the begining of podsolization in a relatively short time. In contrast, under eucaliptus the litter is rapidly incorporated and Organic Carbon content increases compared with natural savanna.

The perennial cultivation occupy a small space in comparison to the cultivation of grains and enhanced pastures. However, some cultiva-tions like rubber, fruit-bearing trees, forest plantations with pine, eucaliptus and other species, and plantations of coffe, in the specific case of Cerrado, constitute successful experience.
Regarding the conservation state of savannas we cannot be optimistic. Protected savanna areas are minimal.

The extreme floristic heterogeneity (beta diversity) of Cerrado vegetation has important consequences for conservation planning, since it will necessitate the establishment of many protected areas to preserve the biodiversity adequately.

A matter of urgency is to increase the area of Federal Conservation Units. In 1997 they represented only 1.5% of the Cerrado biome, and close to 5% in 2005. This area needs to be, at least, tripled.

Numerous animal and plant species are threatened with extinction, and an estimated of 20% of the endemic threatened species do not occur in protected areas.
“A partir dos resultados obtidos, podemos dizer que a situação do Cerrado é bastante crítica e preocupante. Mesmo os recentes esforços do Ministério do Meio Ambiente - MMA de identificar áreas prioritárias para a conservação e iniciar um processo de organização do conhecimento sobre a biodiversidade do bioma”.

“Não têm sido capazes de conter a atual tendência ao desaparecimento do Cerrado.”

“Estimamos que o bioma deverá ser totalmente destruído no ano 2030, caso as tendências de ocupação continuem causando uma perda anual de 2,2 milhões de hectares de áreas nativas.”

The future: African grasses

Trachypogon savanna

Hyparrhenia savanna “Yaraguá Brasilero”
Hyparrhenia savanna
“Yaraguá Brasilero”
The future:
Agricultural expansion?

- Oil Palm
- Sugar cane
- Petroleum exploitation
- Biofuels
Soy Bean
Policy changes, “Revolutions” encouraging:
the violence, the dismembrement of properties,
the abandonement of exploitaitions,
the invasion of productive exploitaitions !!!!
The Neotropical savannas hold still high potential for sustainable production, but to reach this objective it is necessary to develop appropriate systems for the soil management.

The construction of an “Arable Layer” should be the main objective of the management of tropical soils. Once one arable, consistent and productive layer is obtained; it is possible to perform on it a sustainable agriculture. (Amézquita et al., 1999).

Technologies for recovering pastures has been developed. In 1999 it cost was between US$ 86 and US$ 499 per ha.

“The research must pay greater attention to seek solutions to the small agricultural systems (Lopes et al., 1999)
The agro-pastoral and agro-silvo-pastoral systems visibly improve the soil chemically, physically and biologically, due to the synergistic effect of the association of annual and perennial cultivations, but they still require the use of fertilizers, herbicides and pesticides.

It is necessary to continue investigating and improving the production systems, as well as selecting and developing new germplasm.

The sustainability of a system begins by the deep knowledge of the components that integrate it. The sustainability of the soils must be monitored through sustainability or degradation indexes, that must be build. These indicadors should be easy to understand and to be handled by the producers.

“It is necessary to have a bigger effort of the scientific community to dialogue with the farmers, extensionists and authorities” (Lopes et al., 1999)
Among the topics with very little research are the soil microorganisms.

Studies of bacterial diversity have been performed in many different environments. However, little is known about the bacterial community associated with cerrado soil (Quirino BF, et al. 2007).

Lineage-through-time plots show that the expected richness of bacteria species present in the cerrado sensu stricto soils is approximately 10 times greater than that of a Cerrado converted to pasture. (Quirino BF, et al. 2007).

Endotrophic vesicular-arbuscular mycorrhizae, VAM, exploit large soil volumes and exert an important influence in the structure and the mineral nutrition of the communities (Harnet & Wilson, 2002).
Termites are treated as plagues that are feeding on foragers' grasses, and the termite mound considered as obstacles.

However, it is known that the termite mound is richer in nutrients than the soils of the savannas.

Zech et al., (1999) showed that in the Cerrado, in loamy soils, the termite mound had 100 g/Kg of Carbon against 26 g/Kg in the soil, and they had three times more N than the surrounding soil.
Fortunately, in Brazil, the widespread transformation of the Cerrado landscapes, and the threatened status of many of their species, have led to an upsurge in conservation initiatives from government, Non Goverment Oganization (NGOs), researchers, and the private sector.

A network of NGOs (Rede Cerrado) has been established to promote sustainable-use practices.

The Brazilian Ministry of the Environment established a working group that in 2004 produced the Program Cerrado Sustentável.

Some state governments such as Goiás, organizations like the World Wide Fund for Nature, The Nature Coservancy, all have conservation programs in the Cerrado (Klink & Machado, 2005).
For the Colombian and Venezuelan Llanos The Nature Conservancy (TNC), WWW-Colombia, the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, from Colombia, and the Fundación para la Defensa de la Naturaleza FUDENA, from Venezuela, signed an agreement of technical cooperation for working on the conservation of Orinoco basin.

TNC está colaborando con sus socios, incluida la Asociación colombiana Red de Reservas Privadas de la Sociedad Civil, para incrementar la conservación en tierras privadas mediante la creación de nuevas reservas privadas en lugares críticos de Los Llanos.