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~~THE SA~~VANNAS OF SOUTH AMERICA: TOWARDS A RESEARCH AGENDA FOR CIAT

(Summary of the rapid appraisals conducted in Brazil, Colombia and Venezuela, 1990-91)

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1.- Objectives and methodology.

The main objective of this document is to provide a framework for decision making in the form of an executive summary of the rapid appraisals carried out by CIAT in the savannas of Brazil, Colombia and Venezuela during 1990 and 1991 in close collaboration with national institutions. These surveys were conducted to identify global research issues in the fields of production and natural resource use and conservation of that important ecosystem. Bolivia and Guyana have not been surveyed as yet, but their savanna share is small in comparison. Each of the three surveys has its own document (Pacheco et al, 1990, Sanint et al 1990, and Sanint et al 1991), where detailed aspects are discussed. Here, a crisp synthesis is intended to facilitate the process of prioritization of the research agenda for the savanna program.

From the holistic and somewhat superficial rapid appraisals, special attention was paid to problems, opportunities and the role of CIAT components in the various production systems encountered; however, other components received increasing attention as new information collected suggested clearly the emergence of problems and opportunities linked to them. An example of this process was the mounting evidence of several problems related to decreasing productivity and degradation associated with continued soybean monoculture in the savannas.

The document presents some highlights of important policy issues that were likely to shape current events and national attitudes towards this ecosystem. An overview of natural resources in the savannas is then followed by the institutional setting that will facilitate the development of information and of the integrative and collaborative actions to be undertaken in research and training in and among interested countries. Chapter 5 summarizes the various savanna resource management approaches found in the three countries. In chapter 6, the document attempts to summarize the state of the arts in savanna research and its future prospects. Finally, some conclusions are drafted to compile the main issues expressed throughout the surveys.

It is understood that one goal of the savanna program is to identify and/or develop cropping alternatives for the savannas of Latin America that make possible higher levels of productivity in a sustainable manner, i.e., that avoid or reverse ecosystem degradation or even enhance the resource base through sound management practices. There are two contrasting realities that call the attention. In the disturbed, and often degraded savanna sites, watershed management is an important consideration for the choice of vegetation, water, and soil conservation, as well as resource degradation brought by improper management (chemical abuse, nutrient imbalances, etc.). The natural savannas, on the other hand, are major areas for the expansion and intensification of agriculture as they represent obviuos choices for the expansion of the land frontier and have a potential for a wide spectrum of agricultural and grazing uses (Tiessen). An exhaustive site selection process has to consider these contrasting options given the high complementarity and relevance of the knowledge generated in each case. The natural savanna will be a

benchmark which will supply information useful to compare with the knowledge generated in degraded savannas and, conversely, the information from the latter can provide useful guidelines to avoid mistakes.

The methodology of this exercise follows the basic guidelines stated in the document entitled "Program Plans and Resource Requirements, 1992-96" which proposes taht the selection of research sites for the agroecosystem programs should be guided by a set of criteria that includes:

* size of the area;
* perceived urgency of problems and opportunities;
* the extent to which possible solutions are researchable and can be extrapolated to other regions and countries; the issue of site specificity must be carefully considered at all steps.
* available knowledge about the region;
* "in house" expertise;
* presence of potential institutional partners; and
* logistical aspects such as accessibility and security.

2.- Natural resource overview of the savannas.

Tropical savannas[1] embrace the greater part of the world's underdeveloped lands with some 23 million km^2 or about 20% of the earth's land surface. They clothe 63% of Africa land, 60% of Australia, 45% of South America, and about 10% of India and South East Asia (Huntley and Walker, 1982).

The savannas of tropical South America extended over about 250 million hectares and include the Brazilian Cerrado (180 million hectares), the Llanos of Colombia (17 million hectares), Venezuela (28 million hectares) and Guyana (4 million hectares) and the savanna of Bolivia (14 million hectares) (Cole, M.M., 1987).

The current status of land use in savannas reflect the interplay of changing sets of environmental and socioeconomic conditions in space and time mainly through climate, and soil interactions as well as diverse economic policies, as will be seen later in the document. The greatest patch of disturbed savannas is found in Brazil (72 million hectares) on less acidic soils (with aluminum saturation lower than 50%) (Table 20 and WRI, 1990).

In turn, the disturbed pockets of savannas in Venezuela reach less than 2 million hectares mostly on areas well drained. On the other hand in Colombia the area of disturbed savanna land is smaller and takes the form of extensive cattle ranching activities, matching

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1/ Typically, savannas comprise a continuum of plant communities varying from pure grasslands to woodlands and shrub vegetation.

the low priority given by agricultural development policies to an area of low nutrient and high acidity soils (saturation of aluminum above 80%) (WRI, 1990).

Looking at the savannas in the context of multiple criteria for sustainable development (i.e., growth, equity and enhancement of the resource base) helps to elicit the realtive contribution of the ecosystem to each of the aspects that need to be considered in the site selection process.

1) Growth: of the three major agroecosystems where RM research will focus, the savannas have the greatest potential to make significant contributions in this important aspect of sustainability. In Brazil, for example, several crops grown in the Cerrados have experience a growing share of total production over the past two decades and achieved important levels. Cereals (wheat, maize and rice), soybeans, beans, cassava, sugar cane, bananas, cotton and forestry products, along with meat and milk have been very dynamic. In Venezuela, cereal production (maize and sorghum) has also been important.

2) Equity: the most likely contribution here is at the consumer level (through cost reducing technologies for staple foods) and at the regional level. The latter aspect is quite important in a land abundant region with active colonization processes. Equity here works two-ways: by attracting resources from already developed areas into the newer savannas and by distracting the flow of resources into more fragile environments, like the Amazonia or even certain frail pockets in the savannas.

3) Enhancement of the resource base: one has to clearly distinguished different agroecological zones according to the degree and the characteristics of the frontier expansion process, since this distinction will be critical to design strategies that either try to correct problems in land use patterns ("older" savannas, from the viewpoint of years of exploitation) or propose a clean slate approach to savanna colonization (Colombia, Bolivia, parts of Venezuela and Brazil). The former is likely to be much more complex, but with a higher problem-solving impact, while the latter is more oriented to rational exploitation of opportunities and provides a contrasting dimension for enhancement and long term stability of the savanna, as well as guidelines for conservation and preservation of it.

Under this scenario, the Savanna Program appears to have its greatest potential for economic and ecological impact in Brazil. Besides the vast extent and wildlife resources, the savannas of Brazil represent every type of savanna likely to exist with the greatest present and future relevance in terms of agricultural output and resource enhancement across other countries.

3.- The policy environment for savanna development.

There are clear and sharp distinctions in the approaches followed by Brazil, Colombia and Venezuela from the 1960's to exploit these vast regions. In Colombia, agriculture plays

a key role in the economy, accounting for 17% of GNP; however, the process of colonization and expansion of the agricultural frontier for crop production has occured away from the acid savannas, into the more favorable interandean valleys and the lowlands of the caribbean region. There has not been a political will to develop the acid savannas. Those very acid soils of the Llanos are regarded as potentially good for cattle raising activities, where the lack of infrastructure (roads, electricity, communications, etc) is less critical (González, 1989). However, colonization processes in the forest margins of the Amazon (in the south eastern portion of the country and adjacent to the savannas) have been aggressive, placing the country among the leaders in deforestation activity in the world, after Brazil and Indonesia (Repetto, 1988). The Llanos can play the role of release valve ecosystem for the adjacent Amazonian forests.

In Venezuela, an oil rich country, agriculture represents less than 7% of GNP; yet most of the frontier expansion has occurred towards the acid savannas, following impressive infrastructure developments associated with the mining extraction activities along the Orinoco river, which crosses the acid savannas from west to east, and the energy projects implemented in the Guyana. The attention of the government towards agriculture has focussed in those acid savannas as well as in the lowlands of the northwest, around the Maracaibo lake, where better soils predominate. Currently, some 45% of cultivated areas are found in the venezuelan states with Llanos ecosystem along with 42% of the cattle inventory. Agriculture is seen as a net recipient of government funds: it is tax free, important input and output subsidies have been the norm, the state has intervened very actively in the land market, as well as in the commercialization (local, importation and exportation) of foodstuffs until the mid-eighties. Agricultural research activities by the state agency (FONAIAP) have focussed in developing technologies for the acid savannas, among a climate of abundant capital and cheap inputs emphasizing the approach of changing the adverse environment (by means of soil amendments and heavy chemical use) rather than trying to adapt germplasm to those conditions of poor soils.

In Brazil, agriculture represents 8% of the GNP; the sector is a vital generator of foreign exchange (over 40% of exported commodities are of agricultural origin) in a country that is suffocated by the debt service burden. The frontier expansion process in Brazil reached the acid savannas in the 1960's after the capital was moved to Brasilia (in the midst of the Cerrados) in 1962. Infrastructural policies, mainly road construction, were instrumental for the change. Critical inputs were heavily subsidized, particularly lime (which is abundant in that region), and credit which was amply supplied, generally at negative real interest rates. Direct government involvement in commercialization increased (EGF and AGF programs). Minimum prices were established and transport costs were subsidized. A substantial investment in agricultural research produced important results, such as the adaptation of the soybean to the Cerrados conditions. The import substitution policies of the 1950's and early 1960's (following the Prebish theses) gave way to an export promotion plan, fueled by foreign endebtment and infrastructure expansion into the Cerrados. New activities took the lead in that development process which was accompanied by the growth in agroindustry, as the plan called for an increase in value added in export goods through a series of tax exemption mechanisms that encouraged

agroindustrialization instead of exporting raw materials (soybean oil and cake, frozen concentrated orange juice, poultry, cocoa butter and products, freeze dried coffee, refined sugar, etc). At the same time, an ambitious energy replacement program for renewable resources (alcohol) and an import substitution program for wheat also meant added resources for the Cerrado expansion process. Crop insurance programs, along with abundant agricultural credit and inflation, accelerated the colonization of the agricultural frontier, reaching the Amazon by the late seventies and placing Brazil as the leader in the opening of tropical forests in the world. Cattle activities have been at the *forefront* of the expansion, and currently it is easy to find pockets of degraded pastures where a few years ago there were recently colonized areas. After the debt crisis of the early eighties, the country entered an era of reduced subsidies (mainly in credit) and a call for greater efficiency in the already colonized areas. Research focus is shifting towards better adapted germplasm and more efficient and sustainable systems, rather than frontier expansion and heavy input use for soil amendments, plant protection, etc. The frontier expansion process is shifting to a slower but more rational exploitation of the natural resource base in the Cerrados and the Amazon basin.

Future prospects, as the Latin American countries go through a process of opening their economies, point towards higher efficiency in agriculture with intensification of the exploitations. Attention will increasingly focus on the deterioration of the resource base, as second generation problems of the earlier technologies become more evident. Ecological and environmental concerns will coexist with the urgency to continue to acknowledge the growing demand on agriculture to supply food, feed and fibers, as well as energy. The savanna ecosystem will increasingly be perceived as a key region for enhancement and conservation of the resource base. It can act as major source of production for the region, thereby releasing market pressures for increased deforestation. Within the savannas, important degradation processes in the most exploited regions need to receive attention, while exploitation of currently unused ones has to be rationalized to protect the important stock of flora and fauna.

4.- Institutional setting.

National agricultural research and development institutions working in the savannas are quite numerous and heterogenous in terms of aim, coverage and resource endowment, both within and among countries.

The most remarkable institutional setting is found in Brazil, a fact highly correlated with the overall importance that the Cerrado plays in its economy. Government programs like CONDEPE, PCI, PRONAP, SUDECO and POLOCENTRO are leaders in the area. Coexisting with a strong public extension (EMBRATER) and research systems (EMBRAPA with specific centers located in the Cerrados like CPAC, CNPAF, CNPMS and others like NMA not located in the region but with an interest in it), a number of non-governmental organizations and producer associations have been working in germplasm development and crop management aspects for the past three decades. Agroecological studies are more recent and limited to the participation of EMBRAPA

and a few universities in the region (USP, UFV).

In Venezuela, the institutional presence is less than that of Brazil in number and in resources but relatively abundant given the area of the exploited savannas in that country (about 4 million has). The emphasis is more on quantification and preservation of the resource base than in its exploitation (CVG, UNELLEZ, UCV, UDO, USB, IVIC). The national research institution (FONAIAP) has a deficient integration and coordination with other research organizations, mainly the private ones, and among the different regions of the country.

In Colombia, the low priority of the Llanos region is reflected in a reduced institutional presence in that region of ICA and of a few producers' associations, particularly when compared to the levels of activity observed in the Brazilian and Venezuelan savannas.

In terms of research partners for CIAT and for a potential network of savanna research, the brazilian institutions appear to be the most qualified in their operating capacity and the resource endowment of the system as a whole (private, public, NGO's, universities). These partners will be most interested in applied research issues such as pasture renovation, crop management with rotations, soil preparation, fertility, etc.

Venezuela seems to be the best prepared partner in the area of natural resources, where an important research base exist in IVIC, CVG, and several universities (UNELLEZ, Central, Simon Bolivar, Oriente). UNELLEZ, for example, has graduate programs in natural resources and wild fauna. An important portion of the training component of the network can be decentralized easily in this country.

In Colombia, besides the traditional involvement of cattle growers associations in savanna research activities, the recent interest of FEDEARROZ in the acid tolerant rice lines constitutes an opportunity to share responsibilities with the private sector, beyond the traditional work with ICA. Where they exist, producer associations in Colombia are generally strong and reliable research partners. Other international centers in the country, like CIMMYT and INTSORMIL , constitute also ideal CIAT partners for component research for the savanna environment.

The new winds of change towards more open economies in the region imply a change of attitude towards private and NGO's research institutions. International centers need to reposition themselves as actors that have specific advantages in catalyzing efforts and in disseminating regional knowledge through research and training but their place is not at the top of a hierarchical organization; rather, they have to interact at the same level. They should identify rent seeking activities for the research consortiums that they can foster (Biggs, 1990). This implies stronger links with the private sector and with the end users of the technologies. The monopoly for research activity devolves from the hands of the public sector. PROCITROPICOS (an IICA initiative) deserves special consideration due to the clear complementarities with CIAT of that important international initiative, which considers savanna research as one of its main action thrusts.

5.- Savanna resource management.

The physical resources of the savannas have been described above. Land use has clearly been dominated by extensive grazing of natural pastures mainly using Zebu and Zebu crossbred cattle for beef production. Among the technically viable options, this is the one best suited to the factor proportions of the region.These are characterized by:

- ample availability of land and natural pastures of low carrying capacity and quality,
- marked seasonal fluctuations of feed supply both in terms of quantity and quality,
- low product prices due to high transport cost to larger urban markets
- limited access to capital for on farm investments,
- relatively scarce supply of labor, particularly skilled labor.

The basic characteristics of savanna farming systems across the American tropics have been modified to a varying degree by policies of individual governments. This reflects each country's overall resource endowment, the relative importance of the savanna resources versus other ecosystems, and specific development policies (see section on policies and tables).

Table A presents selected indicators of the savanna farming systems of the Savannas of Brazil, Colombia and Venezuela. This information was produced by a joint project undertaken by CIAT, the Technical University of Berlin and national agricultural research institutes of the involved countries with the objective of characterizing the predominant farming systems and identifying bottlenecks for system intensification. The data is about 12 years old and does come from a small, purposively selected sample. The Brazilian systems were clearly the more intensive ones, with an important crop component and with heavy subsidies leading to the highest rates of return. At the other extreme Colombian Llanos farms were the most extensive ones with the lowest technical efficiency and low returns. High transport costs due to poor road infrastructure and distance to markets make input-output price ratios particularly unfavourable, leading to very extensive, specialized ranch operations, which are higly vulnerable to the booms and busts of the beef industry. In terms of rates of return the Venezualan cases presented the lowest level, largely related to heavy machinery investments, which had been done at subsidized exchange rates, but which were not being used because policies made crop production unattractive at the time the study was undertaken.

The lumpiness of many of the investments needed to operate a beef ranch in an environment almost without infrastructure and the lack of crop options represent a serious constraint to the viability of small farms and settlement schemes. Land ownership is more geared to capturing potential capital gains, should production conditions improve, than to generate a continuous flow of income. This gives particular advantages to absentee owners, who do not need continuous income from the ranch operations, since these owners generate their cash flow in other sectors of the economy.

Colombia has an ample supply of higher potential land, closer to the major urban concentrations in the Andean region which is still underdeveloped.

In the recent past, the prospects for the Colombian llanos, and particularly the region closer to the Andean piedmont, have improved. Research has led to the development of crop and pasture cultivars highly adapted to the low fertility soil conditions, particularly upland rice, tropical grasses and forage legumes. Roads have been improved, oil has been found in the region. New entrepreneurs are attracted to the region due to the novel options being made available.

Brazilian systems have become much more intensive than the Colombian ones. This has been induced by both the natural resources and the Brazilian policies. The Cerrados have immense pockets of soils with substantially lower Aluminum saturation than those typically found around Carimagua, for example, making crop production feasible. Brazilian policies have clearly fostered the development of the Cerrados. The incentives have made it attractive for immigrants, particularly of the South to migrate to the Cerrados. The systems that have evolved under these conditions have a *heavy crop* component, mainly corn, rice and soybeans. Sown pastures, particularly Brachiaria species are an important source of animal feed, crop by-products are to some extent used as animal feed during the long dry season. Animals are frequently finished in feed lots during the dry season to benefit from the higher prices during that part of the year. Perennial crops are gradually being incorporated into the system, such as sugar cane, coffee, oranges, and recently rubber trees. Large scale afforestation mainly with eucalyptus was undertaken with heavy specific subsidies.

Brazil's macroeconomic difficulties, (foreign debt, public spending level, inflation) led to the drastic reduction in the 1980's of these subsidies to Cerrados agriculture. The central issue for the future of Cerrados systems is how they will adapt to a significantly deteriorated external environment. This should lead to more input efficient systems, more complex systems involving crop pasture rotations, which will require more and new managerial skills. Clearly not all Cerrado farmers of today will manage to survive these changes as viable operations.

Venezuela has in the past had access to ample foreign exchange due to oil and mineral exports and has therefore relied heavily on imported food. The country nevertheless had a number of policies to favor agricultural development, particularly input subsidies, favorable exchange rates to import agricultural machinery, subsidized credit, etc.

These distortions in relative prices led to systems making heavy use of inputs, particularly fertilizers to establish crops and pastures based on non-adapted germplasm. High labor costs and subsidized machinery prices led to over-mechanization. For a time, policies promoted food import substitution. The high prices led to a substantial expansion of crop areas in the Venezuelan savannas. Surpluses developed rapidly in the interior of the country while the agroindustrial sector had its infrastructure located close to the ports to process imported raw materials.

Policies have now shifted to be more aligned with international prices and subsidies have been reduced substantially. This has led to a situation similar to the one of Brazil, where the production capacity and intensity level are beyond what is feasible at international prices.

Land cropped in the recent past is now left over to weeds and has a productivity lower than the one of the initial savanna vegetation, large investments in agricultural machinery and infrastructure are idle. Clearly this situation makes the search for appropriate intensive production technology very relevant in the present macroeconomic context.

6.- State of the art and future prospects of savanna research

The focus of savanna research at CIAT has been to develop new germplasm, well adapted to low fertility conditions and to respond to short term solutions to declining yields/higher unit costs related to problems of resource degradation problems as they appear in the most disturbed savannas: pasture degradation, monoculture, soil erosion, water contamination, fertility loss, etc. Little has been done to understand the basic mechanisms accompanying the applied production oriented recipes for soil preparation, rotations and agropastoral systems management. This is where CIAT's advantage at the strategic level will reside: (i) in soil/ water/ plant relationships, specifically providing guidelines for ecosystem development and stability, based on the understanding of those interactions and on the importance of organic matter and nutrient transformations resulting from them (Tiessen) and (ii) their relation to with selected farmer behavioral patterns.

CIAT's comparative advantage at the outset lies in the availability of key components (pastures, rice, sorghum, cassava, maize) and some knowledge of farmers behavioral patterns. The new savanna program will have to build from that experience and start phasing in activities of strategic research as the portfolio of components changes and the critical watersheds are identified. The process for the selection of priority problem/process combinations to work on should, to a large extent, be based on the congruency with the economic importance of the items (the demand side, which includes topics like expected net social value of impact, numbers of people and farms affected, interest by potential beneficiaries) as well as on the characteristic of the research involved (the supply side, i.e., the types of intervention envisaged, the probability of success, lags to adoption, comparative advantages, resources needed, etc.).

The stock of knowledge in the three countries covered in this report with respect to savanna research is highly correlated with the economic importance assigned by each one to the ecosystem, as can be inferred by the crop areas: modest in Colombia (around 100,000 has per year), intermediate in Venezuela (close to 1 million has per year) and abundant in Brazil (over 10 million has per year). By specific items, pasture research is considerable in all counties, with Colombia having an edge in legumes. Animal research is mainly found in Brazil. Crops for this environment have little attention in Colombia, more in Venezuela, where the private sector has vested interests, and much more in

Brazil. A similar situation can be found for forestry research . In the area of natural resources, there is some research in Venezuela and Brazil, with the main emphasis on characterization rather than management.

The demand for forages that are more aggressive at the establishment and that respond efficiently to moderate fertilizer applications has grown as a result of the increasing attention that crop pastures systems are getting. The Tropical Forages Program at CIAT should quickly adapt selection criteria for grasses and legumes to better fit the new demands for pastures in the savannas of Latin America.

The holistic approach required to do research in natural resources demands a more integrated approach of public and private interests that has to go beyond the national boundaries. The role of catalyzer, as played by international centers, is critical to efficiently accomplish compatible environmental effects in common watersheds.

In terms of methodology, this type of research can be evaluated ex-ante, in a similar way as done with conventional research, but with some modifications. Dimensions beyond yield increases, particularly environmental costs, need to be incorporated in the evaluation. Within the savannas the major cost seems to be erosion, for which some stock of methodologies exist. It is proposed, as a first approach to concentrate efforts on the soil dimension, both due to its importance in relation to other problems and the availability of in-house expertise to work with it.

A further methodological issue is the definition of the unit of analysis. This choice is related to the magnitude and way to measure externalities. If we are looking for the development of methodologies to deal with savanna resource enhancement issues, then results should be very extrapolable. If this is so, then the regional importance of the specific problem should be a better criterion than the problem by watershed benefit. Taken to the extreme, this criterion would imply that the choice of specific watershed is almost irrelevant.

Once the broad selection of problems to tackle in the field has been ranked, eg.g. erosion in annual crops in the light textured Cerrados, poor persistence of grass pastures, lack of perennial crops for the savannas with more than 60% aluminum saturation, by social rate of return, the more operational aspect has to be defined mainly by the appropriate biological scientist.

The next issue is the division of labor between CIAT and its partners. It seems that local partners will tend to favor the more applied research with a shorter term pay-off, than CIAT and other international donors. Among the latter, CIAT have a comparative advantage in production-related aspects and will seek partners to tackle the more environmental issues. At this stage solid specialist research on specific components will be the main output.

Within the systems perspective, once these outputs start being produced, a phase of

synthesis is needed. This may involve both hard and soft systems modeling, policy analysis, etc. The interaction with CIAT's Land Use Program will be key at this stage. After a number of iterations, an assessment will be needed of the cost-effectiveness of the approach and, if acceptable, a strategy for its broader use by the society will need to be defined.

This will have to be linked with on-the-job training, combined with more formal training in natural resource management at universities. CIAT should probably focus on very specific aspects, mainly those related directly to production, where it can develop a comparative advantage due to the existence of strong commodity programs.

7.- Conclusions

1. The savanna ecosystem has to be viewed as an ecosystem with a potential for ecologically sound production versus the option of merely preserving it. This is due to the fact that the environmental risks of its use seem manageable by comparison to other ecologies of the continent. There is considerable potential for sustainable growth. The land has clear ownership rights and the present owners are already using it. Thus preservation is a realistic option only for the parts owned by the government. These nevertheless include substantial areas of savanna land, such as the Tuparro reserve in Vichada, ...(completar con datos de P.Jones sobre magnitud de areas de reservas en sabanas).

2. The savanna regions vary in the degree to which they have been intervened both in terms of the time span and the intensity of intervention. Given the fact that very extensive ranching seems to be quite appropriate in terms of resource conservation although not very productive, it is stated that the study of more intensively used savanna regions will be more productive in terms of:

   - Identifying sustainability issues of concern to stakeholders, particularly farmers
   - Attracting the interest of potential partners for collaborative research

   The macroeconomic scenario of limited public funds for infrastructural investments further support the argument of concentrating efforts in sites of "older" savanna use (tose that have been more intensively used). However, the contrasting nature with the natural sites offers complementary and relevant information for the degraded savannas as well as for a proper development of the land frontier. If this reasoning is accepted, at least two contrasting sites will have to be chosen.

3. The savanna systems are exposed to varying degrees of pressure to adjust to a changed macroeconomic environment, e.g., how to adapt the system to higher input prices and lower product prices, how to operate with capital costs at market rates, etc. It is posited that these dynamic situations of change should be actively sought because they create particular windows of opportunity for new technology

design and its adoption. There is therefore a clear role for social sciences to contribute to the process of site selection.

4. Farmers and institutions in several of the countries involved in savanna management have been actively searching for alternative commodities and technologies to manage the resources. It will be critical for the efficiency of the proposed strategy that this knowledge be actively researched and incorporated into the design of alternatives (In-reach activity). It is most probable that the components for the future systems are already in place and the contribution of the research process will be to identify their more efficient combination, the reasons for that efficiency, and to add flexibility and more alternatives to the stock of knowledge accessible by savanna farmers. In this context, we should remind ourselves of the past adoption experience: farmers seldom adopt packages or complete solutions, but single components or approaches (Biggs, 1990). The research thrust should be focused accordingly. It should aim at generating knowledge that facilitates adoption of concepts of land use by farmers (from isolated practices, to integrated management, to sustainabilty). This naturally implies that adoption and impact will be difficult to measure because it will not be linked directly to specific commodities.

5. The study has shown the very peculiar nature of resource degradation in Venezuela. It is more linked to exploitation of non-renewable resources than to agriculture. Venezuela fits into a "developed country resource management scenario and not to the typical agriculturally driven resource depletion to be found in poorer countries. It is therefore appropriate not to select the country for one of the key work sites. Nevertheless, it seems very attractive to actively seek Venezuela's participation due to vast experience in utilizing savannas to grow a range of crops and trees and because of the existence of a strong interest in understanding the ecology and resource management of the savannas.

6. Contrary to the initial version of the operational plan, we consider that within the two envisaged countries for field activities, Brazil (and not Colombia) should host the main part of the savanna program and its leader. This is based on considerations of potential impact, congruence across both countries, strength of potential partners, and logistical aspects of locating the major part of the team close to the farming system they are trying to understand and influence. (The Brazilian cerrados have a series of intermediate cities which allow "for adequate" living conditions and closeness to the problem at the same time). The holistic understanding and close relationship with different types of partners requires very intense interaction. The track record of CIAT in Brazil supports the hypothesis of trying a different institutional set-up.

   A change in approach is also needed in the way the program relates to national institutions. In the past, relations were monopolized by EMBRAPA, which "de facto" insulated the program from the interaction with farmers and other

institutions. This was negative for the TPP in the past, but would be even worse for a new program which requires interaction with additional new partners, which are under no circumstances adequately represented by EMBRAPA. For the above reasons, and to avoid the internal difficulties between CPAC and CNPAF, it is proposed to work in close collaboration with a large producer cooperatives, universities, etc. thus having the interaction with other institutions in "neutral territory". (The working group should consider the possibility of establishing CIAT as a legal entity in Brazil).

7. The Colombian Llanos should host the smaller part of the savanna team. For the above stated reasons of the small relevance of the colombian savannas, plus the isolation and limited representativeness of Carimagua in terms of presently used savannas in the Cerrados, the team should work in the region around Pto. Lopez. This allows for easy operation out of existing infrastructure (Sta. Rosa, La Libertad, CRECED Pto. Lopez) and allows staff to live in Villavicencio.

8. The research strategy will require a careful balance in terms of division of labor with the national partners and in terms of the time horizon of the projects tackled. In general terms, the partners will be more interested in the adaptive research focusing production problems while CIAT will, in collaboration with other IARCs, be more interested in strategic research with a sustainability perspective. It is suggested that CIAT should focus around the commodities in which it has experience and should attract external expertise if other commodities are of importance. To gain credibility, the savanna program should initially involve several team members (perhaps equivalent to two staff persons or 25% of its resources ??) in collaborative work with national partners on applied topics related to its commodities. It is important that the research portfolio has not only long term projects, but also some short term ones to insure political support from the producers for the main objectives.

9. Institutional strengthening and training will be key to the new strategy of resource management. Given the limited expertise at CIAT, the peculiarities of the four agroecosystems programs and the synergism between these activities and the research to be undertaken, it is key that the main responsibility for these activities rests with the individual programs.

10. The site selection process can be seen in a iterative fashion where larger sets are subsequently reduced into smaller subsets that meet certain criteria. Starting with the savannas as a whole, the country condition narrows down the set to Brazil and, possibly, Colombia. Then the subset of "older" savannas (from the viewpoint of years of intervention) calls the attention. Relevant areas are the next criterion: technology demand aspects need to be examined (congruency, net return of research, number of farms and area of impact, etc.). Logistic considerations, such as access, infrastructure, security, etc. further constraint the subset. At this stage, the institutional setting becomes relevant: an inventory of institutions working in

the area of the subset needs to be ellaborated. Then, the supply aspects of the technology, such as technical feasibility, probability and years to success, magnitude of resources needed, representativeness versus site specificity, etc., determine the last subset from which to make a final joint decision with the interested partners already identified a few steps earlier.

11. The follow up of this report should be to initiate the following activities:

a) Subcontract the mapping of land use, resource endowment, etc. of the Venezuelan savannas. A collection of the wealth of information already existing but disseminated in the hands of many institutions can be efficiently compiled by a local researcher. The understanding of the resource endowment will be instrumental to understanding the technologies developed and to better target collaboration with local institutions of appropriate regions.

b) A similar effort should be undertaken for the Bolivian savanna regions. This information would be useful to assess the extent to which the Brazilian site can be selected to increase the probability of spill over effects for Bolivia. *This would* contribute to a better international distribution of the benefits of the proposed strategy.

c) Produce an institutional inventory of the narrowed-down Brazilian Cerrados, particularly paying attention to institutions interested in environmental and resource management issues. The agricultural production side is somewhat better known to CIAT. This institutional inventory starts with a catalog of institutions, researchers, professionals, activities, databases, bibliography, etc. Subsequently, CIAT should select prime partners to (i) foster integrative initiatives among them, (ii) foster definition and adoption of standard research methodologies, protocols and priority setting criteria, and (iii) promote training and communications activities in the savannas.

d) If the Brazilian Cerrados are considered the major short term impact area of the savanna program, and legumes are considered a major innovation to be incorporated into the systems to make them more sustainable, at present the forage program of CIAT has very limited germplasm to offer. It is thus suggested that this forage program immediately initiate screening activities with a different set of criteria from those used in the past. The new set of criteria includes selecting for more aggressive establishment, reduced emphasis on high palatability and persistance, abundant nitrogen fixation, cheap seed production feasibility, possibility of selecting annual plants, etc. This is the key contribution required from the forage program; it will take some time and therefore should start immediately. It will also be needed for the other regions (forest margins and hillsides) but some materials are already available for those regions. This process of selection criteria will be interactive with the new resource management programs.

e) Observational yield trials for the new savanna rice lines need to be aggressively expanded to cover representative watersheds in the ecosystem; both, national rice programs together with CIAT's rice program, have to coordinate with the new savanna program these initiatives to quickly screen successful rice varieties, given that this is a crucial component in the system.

f) Staff recruited for new positions should be hired on the condition that they accept outposting to the respective savanna sites, to avoid later difficulties when implementing the strategy.

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9.- Tables (see attached set)

Table A. Selected indicators of savanna farming systems of Brazil, Colombia and Venezuela.

	Brazil	Colombia	Venezuela
Total farm assets (000 US$)	587	210	906
-Land (as %)	48	39	36
-Cattle (as %)	22	43	27
Herd size			
-Head of cattle (no)	538	526	684
cows (as %)	40	41	38
1 year + old steers (as %)	7	16	15
Technical efficiency indicators			
-Stocking rate AU/ha	0.23	0.17	0.32
-Age at first conception (months)	40	35	38
-Weaning rate (%)	57	45	52
-Annual weight gain (Kg.)			
per AU	65	58	50
per ha	12	12	32
Economic performance indicators			
gross returns/ha (US$)	65.0	6.6	40.2
gross returns/AU (US$)	200.0	38.0	100.0
gross returns/man equivalent (US$)	14257	5344	15040
return to total farm assets (%)	7	4	2

Source: Vera, R. and C. Seré, Sistemas de producción pecuaria extensiva: Brazil, Colombia, Venezuela, CIAT, Cali-Colombia 1985.

Table 1. Basic economic indicators

Country	GNP per capita 1989	Annual rate of growth of GNP per capita (1981/89)	Distribution of GNP agriculture industry services		
			Agri-culture	Mining	Manufacture
Brazil	2280	-0.1	7.9	1.8	28.2
Colombia	1432	1.3	17.1	6.6	20.8
Venezuela	3035	-2.6	6.4	12.1	19.9
Guyana	568	-3.2	22.8	7.7	10.3
Bolivia	763	-3.5	24.7	12.2	14.6

Source: BID (1990)

Table 2. Sectorial GNP growth rates (percentage)

Country	GNP total		Agriculture		Industry		Manufacture		Services	
	1965/80	1980/90	1965/80	1980/90	1965/80	1980/90	1965/80	1980/90	1965/80	1980/90
Brazil	9.0	3.0	3.8	3.0	10.1	2.7	9.8	2.2	9.5	3.2
Colombia	5.7	3.5	4.5	2.6	5.7	5.0	6.4	3.1	6.4	2.8
Venezuela	3.7	1.0	3.9	3.4	1.5	1.4	5.8	4.9	6.3	0.4
Guyana	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Bolivia	4.4	-0.9	3.8	1.9	3.7	-3.8	5.4	-3.3	5.6	-0.5

Source: Banco Mundial (1991).

Table 3. Trade balance and international reserves (US$ millions)

Country	Net balance of goods and services (1990)	International gross reserves (1989)
Brazil	10500	10505
Colombia	1725	3862
Venezuela	9770	8702
Guyana	n.a	n.a
Bolivia	-25	563

Sources: CEPAL (1990), Banco Mundial (1991)

Table 4. External debt indicators (US$ millions)

Country	Total (1990)	Per capita (US$)	Debt interest as a percentage of exports
Brazil	121000	804	33.3
Colombia	17200	521	19.5
Venezuela	31000	1571	18.0
Guyana	2570	3228	n.a
Bolivia	3700	506	26.3

Sources: CEPAL (1990)

Table 5. Land area and use (million hectares)

Country	TOTAL (million has)	CROPLAND (million hectares)	PASTURES (million hectares)	FOREST (million hectares)	OTHERS ('000 ha)	Annual deforestation 1980/90 (%) a/
Brazil	845.6	76.7 (22.7)	167.0 (6.4)	560.4 (-4.2)	9050	1.8
Colombia	103.9	5.3 (3.2)	39.8 (7.3)	51.5 (-5.5)	890	1.7
Venezuela	88.2	3.8 (6.0)	17.5 (3.4)	31.3 (-8.5)	245	0.7
Guyana	19.7	0.5 (21.3)	1.2 (17.0)	16.4 (-7.7)	3	0.0
Bolivia	108.4	3.4 (3.0)	26.8 (-1.2)	55.8 (-1.3)	117	0.2

( ) The figures enclosed in parenthesis are annual rates of change for 1975-1987

a/ Rate of forest lost annually

Source: WRI (1990-91)

Table 6. Livestock in savannas regions in Latin America ('000 heads)

	Brazil (1987)		Colombia (1988)		Venezuela (1986)	
	Total	(%)	Total	(%)	Total	(%)
Beef cattle	79620.4	58.7	3750.0	16.0	4841.3	39.2
Pigs	6679.9	20.6	26.4	1.0 a/	884.6	29.4
Chicken	50002.0	15.2	200.0	0.5 a/	10479.3	18.6
Sheeps	465.3	2.3	n.a	n.a	n.a	n.a
Goats	297.4	2.8	n.a	n.a	n.a	n.a

a/ Estimated

Source: Brazil (IBGE, 1989)
Colombia (Arias et al., 1990)
Venezuela (MAC, 1990)

Table 7. Agricultural production in savanna regions of Latin America ('000 mt)

Crop	Brazil (1987)		Colombia[a] (1988)		Venezuela (1986)	
Cereals						
Rice	3806.4	(36.5)	441.5	(24.7)	123.6	(99.6)
Maize	7747.6	(28.9)	12.6	(1.4)	483.5	(74.3)
Sorghum	67.8	(15.4)	25.4	(3.7)	340.1	(89.3)
Others	517.9[b]	(8.6)				
Oil seeds						
Soybean	6605.5	(38.9)	22.5	(27.1)		
Sesame					110.9	(99.7)
Cotton					46.7	(95.7)
Peanut					2.8	(100.0)
Beans	418.8	(8.2)				
Fruit trees						
Sugar Cane	37760.3	(14.6)			n.a	
Cassava			9.7	(0.7)	20.4	(51.6)
Planted forest	2134.3	(9.1)				
Others						

( ) The figures in parenthesis correspond to the percentage of national production

a/ Only Meta Department

b/ Wheat

Source: IBGE (1989), MAC (1987), URPA (1990)

Table 8. Area of principal crops in savanna regions of Latin America ('000 hectares)

Crop land	Brazil (1987)	Colombia[a] (1988)	Venezuela (1986)	Bolivia (19)
Cereals				
Rice	2805.1 (46.9)	103.0 (27.6)	123.7 (99.7)	
Maize	3318.6 (24.6)	7.0 (1.1)	483.3 (74.3)	
Sorghum	40.7 (17.6)	10.6 (3.9)	340.1 (89.3)	
Others	434.2[b] (12.5)			
Oil seeds				
Soybean	3252.9 (35.6)	15.0 (27.1)		
Sesame			110.9 (99.7)	
Cotton		4.3 (1.7)	46.6 (95.4)	
Peanut			4.6 (100.0)	
Beans	875.0 (16.8)	0.7 (0.6)	16.8[c] (27.4)	
Fruit trees				
Sugar Cane	531.1 (12.3)			
Cassava	165.4 (8.4)	1.3 (0.8)		17.0 (42.2)
Planted forest				
Others				

( ) The figures in parenthesis correspond to the percentage of national crop area

a/ Only Meta Department

b/ Wheat

c/ Cowpea= caraota

Source: IBGE (1989), MAC (1987), URPA (1990)

Table 9. Agricultural input use [a/]

Country	Cropland hectares/ inhabitant (1989)	Fertilizer use kg/ha of cropland	Number of tractors (1985/87)	Number of combine harvesters (1985/87)
Brazil	0.53	49	775000	42000
Colombia	0.17	81	33813	2417
Venezuela	0.20	143	44667	4733
Guyana	0.48	32	3560	419
Bolivia	0.48	2	790	278

a/ Data refer to the national aggregate, not specifically the savanna area.

Source: WRI (1990)

Table 10. Selected input and output prices in savannna regions of Latin America (producer level), US$ 1991

	Brazil [a/]	Colombia [b/]	Venezuela [a/]
Beef (line weight) (kg)	0.81	0.89	1.05
Milk (lt)	0.23	0.14	0.33
Rice paddy or milled rice (kg)	0.15	0.22	0.25
Maize (kg)	0.16	0.17	0.18
Sorghum (kg)	0.14	0.17	0.15
Triple Superphosphate (kg)	0.25	0.29	0.16
Urea (kg)	0.27	0.25	0.10
Gasoline (lt)	0.51	0.16	0.07

a/ Brasilia, D.F., September
b/ Villavicencio, August
c/ San Fernando, Apure, October

Source: RIEPT Survey (1990) and (1991)

Table 11. Selected relative prices in savanna regions [a/]

Relative prices	Brazil	Colombia	Venezuela
Beef/milk	3.52	6.30	3.18
Beef/urea	3.00	3.07	10.50
Beef/TSP	3.20	3.10	6.60
Beef/gasoline	1.60	5.56	15.00
Beef/rice	5.40	4.04	4.20
Beef/maize	5.01	5.20	5.80

a/ 1990/91 averages

Source: RIEPT Survey (1990) and (1991)

Table 12. Government expenditures on agriculture: research and extension, irrigation, land reform and education and health, 1980 (in 1960 US$, million)

Country	Research and extension	Irriga-tion	Land reform	Education and health
Brazil	174.3	569.1	n.a	84.3
Colombia	8.1	36.1	13.1	71.3
Venezuela	45.2	40.2	n.a	n.a

Source: Elias (1985)

Table 13. Government expenditures on agriculture in Brazil, Colombia, Venezuela and United States, 1980 (US$ 1960)

Country	Government expenditure per: Hectare of cropland	Person employed in agriculture
Brazil	169	485
Colombia	185	377
Venezuela	538	1004
United States	244	9412

Source: Elias (1985)

Table 14. Size and growth rate of population and labor force [a/]

Country	Total population 1990 (millions)	Rate of growth of population 1985/90 (%)	Urban population as percentage of total 1990	Percentage of labor force in agriculture 1990
Brazil	150.4	2.07	76.9	31.0
Colombia	31.8	2.05	70.3	34.0
Venezuela	19.7	2.61	90.5	16.0
Guyana	1.0	1.74	34.6	27.0
Bolivia	7.3	2.76	51.4	46.0

a/ Estimated
Source: WRI (1990)

Table 15. Road infrastructure in savanna regions

Country	Paved Roads (km/'000 km_)
Venezuelan Llanos	50.9
Brazilian Cerrados	11.6
Colombian Llanos	0.1

Source: Vera and Seré (1985), IBGE (1990)

Table 16. Brazil: road infrastructure in the Cerrados region, 1988

State	Paved Road (km)			Area ('000 km²)	Road paved density (km/ '000 km²)	Unpaved roads (km)	Total roads (km)	Total road density (km/ '000 km²)
	Federal	Statal	Total					
Minas Gerais	8969	5498	14467	582	24.9	9945	24412	41.9
Mato Grosso do Sul	2502	1128	3630	351	10.3	9142	12772	36.4
Mato Grosso	2612	971	3583	881	4.1	15450	19033	21.6
Goiás	2695	3594	6289	642	9.8	9916	16205	25.2
D.F.	165	382	547	6	91.2	859	1406	234.3
Cerrados	16943	11573	28516	2462	11.6	45312	73828	30.0
Brazil	49479	60865	42565	8512	5.0	105123	147688	17.4

Source: IBGE (1990)

Table 17. Brazil: gross production of electric power (GWH), 1988

State	GWH
Minas Gerais	53720
Mato Grosso do Sul	201
Mato Grosso	276
Goiás	3330
Federal District (Brasilia)	117
Total Cerrados	57644
Total Brazil	231951
Percentage of total	24.8

Source: IBGE (1989)

Table 18. Brazil: grain storage capacity

State	Number of plants	Capacity[1/] ('000 m^3)
Minas Gerais	1126	7145.5
Mato Grosso	466	3733.5
Mato Grosso do Sul	532	2851.2
Goiás	717	6626.3
Federal District.	35	279.1
Total Cerrados	2866	20635.6
Brazil	12484	96802.9
Percentage	22.9	21.3

1/ In terms of number of plants and user capacity.

Source: IBGE (1989)-First Semester 1987

Table 19. Brazil: production of charcoal, firewood and logs of planted forests, 1987

State	Charcoal ('000 tm)	Firewood ('000 m^3)	Logs[1/] ('000 m^3)
Minas Gerais	5270.7	3925.7	5338.5
Mato Grosso do Sul	11.1	797.9	326.7
Goiás	92.7	204.6	2.2
Federal District	2.6	52.4	3.4
Total Cerrados	5377.1	4980.6	5670.8
Brazil	5619.5	45908.1	47935.6
Percentage	95.7	10.8	11.8

1/ For celulose production and other purposes

Source: IBGE (1989)

Table 20. Some generalized climatic, soil and topographic parameters of the savannas

Parameters	Units	Brazil	Bolivia	Guyana	Colombia	Venezuela
CLIMATIC						
Mean rainfall	mm per year	1000-1800	1300-1800	800-1500	1500-3800	900-2200
Length of wet season	months	6-8	6-8	6-10	5-10	6-10
Mean annual temperature	celsius	21.3-25.6	25-26	24-26	26.5-27.5	24-28
Altitute	m.a.s.l	200-1000	200-600	200-600	100-400	100-800
Solar radiation	hrs per day	7-10	5-8	7-8	8-10	8-10
Relative humidity	percentage	50-85	55-80	65-90	51-76	55-89
SOILS						
Order: Oxisols	% area	45	30	65	75	15
Ultisols	% area	35	40	25	10	25
Others	% area	20	30	10	15	60
Chemical constraints						
- pH level <5.3	% area	75	18	43	100	30
- Al saturation >70%	% area	22	12	15	82	8
- High P fixation	% area	17	9	5	57	3
Physical constraints:						
- Low moisture-holding capacity	% area	39	71	35	48	31
- Sandy topsoils	% area			47	39	28
TOPOGRAPHIC CLASS						
< 8%	% area	47	7	26	21	23
8-30%	% area	26	10	20	28	24
>30%	% area	15	5	10	21	17
Flat poorly drained	% area	32	78	45	30	36

Source: Cochrane et al. (1985), CIAT (1982), World Resources Institute (1990), Vera and Seré, eds. (1985)

LIST OF ACRONYMS USED IN THIS REPORT
REGIONAL INSTITUTIONS

Institution or Program	Name	Country	Principal Working Areas				
			Research	Natural Resources	Development	Extension Technical Assistance and Credit	Education and Training
CIAT	Centro Internacional de Agricultura Tropical	Colombia	x				x
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias	Venezuela	x				
EGF PROGRAM	Programa de Emprestimo do Governo Federal				x	x	
AGF PROGRAM	Programa de Adquisicoes do Governo Federal				x		
CONDEPE	Conselho Nacional de Desenvolvimento da Pecuaria	Brazil			x		
PCI	Programa de Credito Integrado	Brazil				x	
SUDECO	Superintendencia do Desenvolvimento do Centro-Oeste	Brazil			x		
POLOCENTRO	Programa de desenvolvimento dos Cerrados	Brazil	x				
EMBRATER	Empresa brasileira de Assistencia Tecnica e Extensao Rural	Brazil			x	x	
CPAC	Centro de Pesquisa Agropecuaria dos Cerrados	Brazil	x				x
CNPAF	Centro Nacional de Pesquisa do Arroz e Feijao	Brazil	x				
CNPMS	Centro Nacional de Pesquisa de Milho e Sorgo	Brazil	x				
NNA	Nucleo de Monitoramento Ambiental	Brazil		x			
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria	Brazil	x				
USP	Universidad de Sao Paulo	Brazil	x		x		x
UFV	Universidad Federal de Vicosa	Brazil	x		x		x
UNELLEZ	Universidad de Los Llanos Ezequiel Zamora	Venezuela	x	x	x		x
CVG	Corporacion Venezolana de Guyana	Venezuela		x			
UCV	Universidad Central de Venezuela	Venezuela					
UDO	Universidad de Oriente	Venezuela	x				
USB	Universidad Simon Bolivar	Venezuela	x				x
IVIC	Instituto Venezolano de Investigaciones Cientificas	Venezuela	x	x			
ICA	Instituto Colombiano Agropecuario	Colombia					
FEDEARROZ	Federacion Nacional de Arroceros	Colombia				x	
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo	Mexico	x				
INTSORMIL	International Sorghum and Millet Program		x				
NGO'S	Non-Government Organizations		x	x	x		
IICA	Instituto Interamericano de Cooperacion para la Agricultura	Costa Rica			x	x	
PROCITROPICOS	Programa Cooperativo de Investigacion y Transferencia de Tecnologia para los Tropicos Suramericanos	Costa Rica Costa Rica	x			x	
TPP	Tropical Pasture Program (Ciat)	Colombia	x				x
IARC's	International Agricultural Research Centers						
CRECED	Centro Regional de Capacitacion Extension y Difusion Tecnologica	Colombia	x		x	x	x