

Reclaiming the Brazilian Amazon: the Restoration and Management of Pasture Lands



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Foreword

The current growth in the Brazilian cattle herd suggests that in the future the Northern Region of the Legal Amazonia is expected to be a dominant player in the nation's cattle sector. With reduced deforestation pressure as a key condition, cattle production in the Amazon must be built on the recuperation of already-cleared lands and improved pasture management.

This manuscript summarizes challenges in sown pasture development for the Brazilian Amazon, including their historical beginnings, and the learning that resulted from past research. Emphasis is placed on nearly 40 years of accumulated experience of research activities on the reclamation of degraded pasture lands in the Amazon by Embrapa. It is shown that improved pasture technology, mainly the recovery of abandoned pasture lands, has helped to increase the productivity of Amazonian cattle systems by increasing the stocking rate, ensuing that, during the past three decades, the size of the Amazonian cattle herd has grown much more rapidly than the land area in sown pastures.

Although during the past 30 years, a lot has been written about cattle ranching in the Brazilian Amazon, only a few of these reports have been authored by native Amazonian agricultural experts, with a long lasting experience in the region. So, it is our expectation that the present manuscript might bring a fresh view on this very important and usually

misunderstood area of knowledge, being a valuable asset to subsidize public policies in this strategic area for food security and environmental preservation in the region.

Adriano Venturieri

Embrapa Eastern Amazon Director-General

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Reclaiming the Brazilian Amazon: the Restoration and Management of Pasture Lands

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Introduction

Although cattle were introduced to the Brazilian Amazon in 1644 (BARATA, 1915), it was not until the 1960s that cattle ranching began its rapid expansion, especially in the northern state of Pará. Initially, this process was partly stimulated by chronic market shortfalls in the supply of fresh beef, which since the mid-19th century affected local populations, especially low-income families (DIAS-FILHO, 2013). These shortages made cattle husbandry economically attractive in the Brazilian Amazon. An aggressive policy of tax incentives established in 1966 by the military government further boosted cattle ranching. Growth of this enterprise was accelerated by the opening of the Belém-Brasília highway in the early 1960s and subsequently other trans-regional routes (e.g., PA-70 in 1969). Pasture lands established along these roadways opened the way for herd expansions that produced the needed flow of beef to population centers.

This initial growth phase in the 1960-1970s of a pasture-based cattle production system was built upon an extensive (i.e., land plentiful) system of production. This ranching sector was generously

subsidized by a liberal policy of tax breaks on cheap lands possessing scant infrastructure (DIAS-FILHO, 2014a). Like other new frontiers, this land development strategy relied on a scant portfolio of pasture management and forage germplasm options borrowed from different ecosystems. As a result, serious errors occurred in their transplantation to growing conditions inherited from Amazonian ecosystems, which caused instability and short-lived pasture lands.

Therefore, productivity shortfalls to achieve ranch and market supply targets generally led to the abandonment of pastures that had been degraded and opening of newly sown areas on lands previously covered by natural vegetation (primary forest or cerrado). This land conversion dynamic increased the size of the stock of degraded pastures by stimulating land substitutions via increased deforestation. This land use model, which prevailed into the mid-1980s, helped stigmatize cattle ranching in the Amazon as an unproductive enterprise, harmful to the environment.

Starting in the mid-1970s, this policy scenario also fostered pioneering research projects in the Amazon region aiming at the reclamation of degraded pastures. Among these, Propasto Legal Amazonia¹ (Reclamation, Improvement and Pasture Management in the Amazonia), initiated in 1976, merits highlighting. Coordinated by Embrapa Eastern Amazon (then called Agricultural Research Center of the Humid Tropics, CPATU), the objective of this government-sponsored project was to evaluate technology options for restoring the productivity potentials lost from pasture lands (DIAS-FILHO; SERRÃO, 1982; EMBRAPA, 1979a, 1979b; SERRÃO et al., 1979). Closed in the 1980s due to a lack of strategic leadership, this project produced a technology generation milestone by forming a team of scientists experienced in land reclamation (DIAS-FILHO, 2014a). Knowledge generated through this effort continues to inform the actions and current programs of Embrapa (Brazilian Agricultural Research Corporation) and other

¹ Legally defined for purposes of regional planning and policy, Legal Amazonia comprises eight states (Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima and Tocantins) and part of one other (Maranhão).

institutions seeking to improve pastureland stability (longevity) and food security by reducing deforestation pressures in Amazonia (DIAS-FILHO; ANDRADE, 2006; VALENTIM; ANDRADE, 2009).

Growth in the national cattle herd suggests that in the future the Northern Region² of the Legal Amazonia is expected to be a dominant player in the nation's cattle sector (DIAS-FILHO, 2011a). Correspondingly, Amazonian cattle systems are expected to become yet more important enterprises, which portends needs for greater productive efficiency and a pasture-based cattle production model that is sustainable by conserving natural resources and ecosystem services (BLAKE; NICHOLSON, 2004; NICHOLSON et al., 2001). This signifies need for developing an Amazonian production system for an increasingly global marketplace with effective price competition and quality assurances regarding environmental and social principles as well as animal welfare.

With reduced deforestation pressure as a key condition, cattle production in the Amazon must be built on the recuperation of already-cleared lands and improved pasture management. Thus, the reclamation of degraded lands plays decisively in a modernized livestock strategy, where production goals are obtained without further substitutions of natural vegetation for new pasturelands but rather through skilled applications of efficacious technologies. Food security, livestock (land) productivity and environmental conservation must be the central foci, especially recognizing the growing regional and global demands for animal products (BLAKE; NICHOLSON, 2004; DIAS-FILHO, 2011a, 2014a; NICHOLSON et al., 2001). Correspondingly, public and private investments in research and development are essential to helping farmers build the required skills to test and implement new practices.

The purpose of this paper is to summarize challenges in sown pasture development for the Brazilian Amazon, including their historical

² Brazil's twenty-six states and the Federal District (Distrito Federal) are divided conventionally into five regions - North (Norte), Northeast (Nordeste), Southeast (Sudeste), South (Sul), and Center-West (Centro-Oeste).

beginnings, and the learning that resulted from past research. Emphasis is placed on research by Embrapa to reclaim lost productivity of degraded pasture lands in the state of Pará, a principal consequence of past land conversion policies.

Ranching incentives and knowledge shortfalls

Multiple predisposing conditions converge to account for the rapid expansion of beef production in the Amazon region during the 1960s and 1970s. Necessary infrastructural conditions were created by new transportation routes (e.g., Belém-Brasília (BR-10), Pará-Maranhão (BR-316) and PA-70 (now, BR-222) highways). These highways opened new lands for pastures (in addition to other agricultural activities) and associated cattle flows. The large unmet demand for fresh beef in the Amazon region itself, as well as other regions of the country, was a dominant market supply factor and chief government policy concern. The Amazon was then considered the “new frontier” which the government’s ambitious development programs hoped to convert into a breadbasket for Brazil’s exploding population. The policy of tax incentives established by the military government (Law 5.174 of October 27th, 1966) (RIBEIRO, 2005) was another key driver favoring the expansion of ranching.

Ensuing land speculation, aided by high inflation, further stimulated Amazon cattle ranching (HECHT, 1982). Initial ranching successes in the Paragominas region of Pará (VALVERDE; DIAS, 1967) further spurred cattle production with additional projects throughout the 1970s.

Also important was the high regional demand for fresh beef driven by growing population centers experiencing chronic supply deficits in city markets throughout Amazonia (DIAS-FILHO, 2013). Moreover, in the early 1970s other regions experienced a recurrent beef crisis, which was more acute during herd productivity off-seasons (July-November). These domestic market deficits helped solidify ranching as a fundamental use of land throughout Amazonia.

The beef crisis of the early 1970s was featured by the Brazilian press. The news magazine *Veja* reported 1972-73 average retail beef prices in nine major cities: Brasília, São Paulo, Rio de Janeiro, Belo Horizonte, Recife, Porto Alegre, Salvador, Fortaleza and Belém (A CARNE..., 1973). Belém was depicted as “an isolated oasis of (beef price) tranquility” owing to “the first results of the SUDAM’s project (beef) being delivered to the city” coupled with the inability of Paragominas ranchers to find “an efficient mechanism to place their steers into southern markets or abroad.” Consequently, while beef was plentiful in Belém consumers in São Paulo and Rio de Janeiro stood in long lines at supermarkets with purchase permits to buy, at most, 1 kg of beef. Further illustrating this market volatility, five years earlier, beef in Belém was “prohibitively expensive for most of the population” because of a “precarious and costly” market supply that depended on animals reared on natural pastures in the Marajó archipelago (PENTEADO, 1968). This shortage was attributed to insufficient “concern for improving pastures and concomitant increases in stocking rates.” An acknowledged cause of this beef supply shortfall was the low productivity potential of the region’s natural pasturelands.

Through the national policy of tax incentives, a process for integrating the heartland into the domestic economy, private investors were given incentives to colonize the Amazon. Under the military government (President Castelo Branco), the economic integration of the Amazon region was legally facilitated in 1966 by dissolving the SPVEA (Superintendency for the Valorization of the Amazon) and creating the Amazonian Development Superintendency (SUDAM), as part of “Operation Amazonia” (RIBEIRO, 2005). Under SUDAM, income taxes were halved for those investing in livestock, agriculture and industrial and basic services projects. Consequently, investors flocked to the Amazon. By 1978, the Legal Amazonia states of Pará and Mato Grosso disproportionately received about 70% of total incentives according to the Association of Entrepreneurs of the Amazon (HECHT, 1982). Many early investors came from the ranching sectors of Goiás and Minas Gerais. Therefore, for reasons of heritage and economic rationale,

investors acquiring these new lands used low-risk, extensive production methods, which required little labor, little infrastructure and low-cost pastures. In addition, beef production was the only economic activity receiving public financing (transfers) to rapidly colonize the Amazon and with high earnings potential. Thus, the cattle industry historically constituted the prime use of land on the agricultural frontier (DIAS-FILHO, 2011a).

The initial expansion of ranching was also influenced by high inflation rates throughout the 1960s and 1970s, which yielded rapid capital gains from land valuation. For example, in the lapse of one decade lands along the Belém-Brasília highway increased about 1,000 times in value (HECHT, 1982). Also, because cattle prices tended to keep up with the inflation rate, the cattle enterprise was able to maintain its liquidity and was often used as a hedge against inflation, thus attracting investors with little cattle husbandry experience who were principally interested in short-term financial gains. Consequently, the stability of cattle ranching was jeopardized by the use of stocking rates above pastures' carrying capacity, or overgrazing.

Furthermore, many ranching projects in this "by hoof" land accrual scenario were merely speculative. Credit was acquired through preferential (i.e., negative) interest rates with beneficiaries accruing wealth through further tax exemptions; a lucrative outcome for the privileged. Thus, financial resources were often appropriated (diverted) to accumulate capital reserves of land. Even if cattle enterprises were well established, animal and land productivities typically were low, even for those with prior ranching experience in another ecosystem due to barriers of knowledge and technology. Until the late 1970s, the technology portfolio for the effective establishment and management of sown pastures was essentially ineffective, especially regarding fertilization (soil nutrient management) and viable forage grass options (DIAS-FILHO, 2011a, 2013). So, until the late 1970s, the cattle sector in the Brazilian Amazon operated mostly in a technological vacuum. This knowledge favored land use for extensive systems of cattle ranching.

The challenges arising from this scarce soil and land management information scenario were clarified by a 1976 survey of ranchers conducted by the forerunner of Embrapa Eastern Amazon (EMBRAPA, 1979a). Findings revealed that pasture fertilization was nearly entirely unknown to producers. Only 1% of them fertilized their pastures. Furthermore, about 80% of pasturelands were sown to guinea grass (*Panicum maximum*), a bunch-grass species that has since been replaced by better adapted grasses, released by Embrapa in the 1980s. Heretofore, the management of sown pastures in the Amazon was prone to serious errors, which fostered crash-and-burn outcomes from soil nutrient depletion, forage species losses resulting in less ground cover and weed invasions (i.e., degradations), and low pasture longevity.

Overall market supply targets were obtained by the abandonment of lowly productive lands and replacing them with new pastures established on recent clearings; hence accelerating both deforestation and the stocks of degraded pasturelands (DIAS-FILHO, 2011a). This unsustainable land conversion model, aided by land tenure policies that promoted deforestation to quickly establish property rights, helped to stigmatize ranching in the Amazon as an unsustainable and environmentally destructive food production system (DIAS-FILHO, 2013). Such stigma may, in part, explain the incorrect perception, pointed out by Faminow (FAMINOW, 1998, p. 180), that “abnormally low productivity” is often used to characterize cattle ranching in the Amazon.

Research to reclaim degraded pasture lands

Under this generally inefficient cattle production scenario initial research projects targeted increasing longevity of pasture lands. Studies conducted on private ranches under a five-year agreement signed in 1975 between SUDAM and the Ibec Research Institute (IRI) (Agreement 061/75 IRI-SUDAM) focused on land reclamation

and the performance of forage grasses in Paragominas (Amazon Biome) and grass establishment in northeastern Mato Grosso (Cerrado Biome) (KOSTER et al., 1977; ROLIM et al., 1979). Following this restoration strategy, the Center of Agricultural Research in the Humid Tropics (CPATU, now Embrapa Eastern Amazon), launched Propasto Legal Amazonia in 1976. Financial support for this project was from BASA (Bank of Amazonia) and Polamazônia (Program of Agricultural, Livestock and Mineral Poles in Amazonia) mediated by SUDAM. Objectives were to determine the fundamental causes of low pastureland longevity by alleviating them to increase animal product offtake and the sustainability of beef production systems in the Amazon (DIAS-FILHO; SERRÃO, 1982; EMBRAPA, 1979a; SERRÃO et al., 1979).

Propasto research experiments were carried out on private ranches (called “experimental fields”) selected to represent cattle ranches across the Amazon and for their strategic location and collaboration by owners. Each research unit comprised about 200 ha in sown pastures (undergoing degradation), natural pastures and degraded pasturelands. In 1978, the Propasto research network comprised 14 experimental fields in 7 states (5 in Pará, 3 in Roraima, 2 in Amapá and 1 in Amazonas, Rondônia, Acre and Tocantins, then Goiás). It was “one of the first serious attempts to internalize agricultural research in the region, which united researchers, farmers, entrepreneurs and regional development agencies” (EMBRAPA, 1979b, p. 280). The primary research issues were: 1) the introduction and evaluation of forage grasses and legumes; 2) performance of grass-legume mixtures; 3) pasture fertilization; 4) methods of land reclamation, improvement and management of degraded pastures; 5) grazing trials.

Propasto activities were undertaken by a multidisciplinary team (e.g., agronomists, animal scientists, agricultural experts) primarily from Embrapa centers in the Amazon region. At Embrapa Eastern Amazon in the early 1980s there were ten pasture scientists (mostly agronomists) and seven technicians conducting research in five “experimental fields”

in Pará, and two in Amapá. This intensive research agenda facilitated major breakthroughs in better managing grassland productivity and recovering degraded pastures (e.g., DIAS-FILHO, 2014a; DIAS-FILHO; SERRÃO, 1982; SERRÃO et al., 1979; VALENTIM; ANDRADE, 2009).

Funding was discontinued in the early 1980s and Propasto Legal Amazonia was formally closed. This decision was inconsistent with the associated research findings on the productivity restoration of degraded pasture lands and associated potential relief in deforestation pressures and food insecurity, prejudiced misguided view still prevalent today in some government agencies and sectors of Brazilian society.

Major research findings

Improved germplasm and land reclamation techniques have been developed by Embrapa and other institutions (DIAS-FILHO; ANDRADE, 2006). Correspondingly, Amazon ranch managers have learned through experience and by testing alternative management strategies.

Improved pasture technology, mainly the recovery of abandoned pasture lands, has helped to increase the productivity of Amazonian cattle systems by increasing the stocking rate. So, during the past three decades (the last Brazilian agricultural census was conducted in 2006) the size of the Amazonian cattle herd has grown more rapidly than the land area in sown pastures (Table 1).

Table 1. Relative percent change over time in the cattle herd and pasture areas in Brazil and major Brazilian regions between 1975 and 2006.

Change (%)	North	Northeast	Southeast	South	Center-West	Brazil
Herd	1.845.9	52.0	10.2	25.5	183.4	100.8
Pasture	517.9	6.6	-32.2	-14.3	-7.3	4.0

Source: IBGE (2007).

Table 2. Stocking rate (number of head per hectare) in 1975 and 2006, in Brazil and major Brazilians regions, and percentage change over time of this stocking rate between 1975 and 2006.

Parameter	North		Northeast		Southeast		South		Center-West		Brazil	
Carrying capacity (heads/ha)	1975	2006	1975	2006	1975	2006	1975	2006	1975	2006	1975	2006
	0.4	1.26	0.6	0.85	0.75	1.22	1.0	1.5	0.4	1.24	0.62	1.19
Change (%)	215		41.7		62.7		50		210		92	

Source: Dias-Filho (2014b).

The rapid decline in the expansion of sown pasture lands in northern Brazil (Figure 1) is another indicator of the growing use of technology (appropriate pasture management practices and reclamation of degraded pasture lands) in the Amazon region, suggesting a substantial improvement in productivity in the small, medium and large ranch categories. This improved productivity is a direct result from the increasing knowledge of how to best conduct ranching in Amazonia. In fact, while during 1975-1985 cattle herd growth (150%, according to the Brazilian Institute for Geography and Statistics – IBGE) in the Amazon was about three times lower than the expansion of sown pasture lands (480%), from 1996 to 2006, this trend was reversed in the same proportion (128% growth for cattle herd, against a 40% growth for sown pasture lands). Therefore, if pasture productivity (in terms of stocking rate) had been kept at the level of the 1970s, present pasturelands in the Brazilian Amazon would have to be at least three times larger to accommodate the current cattle herd.

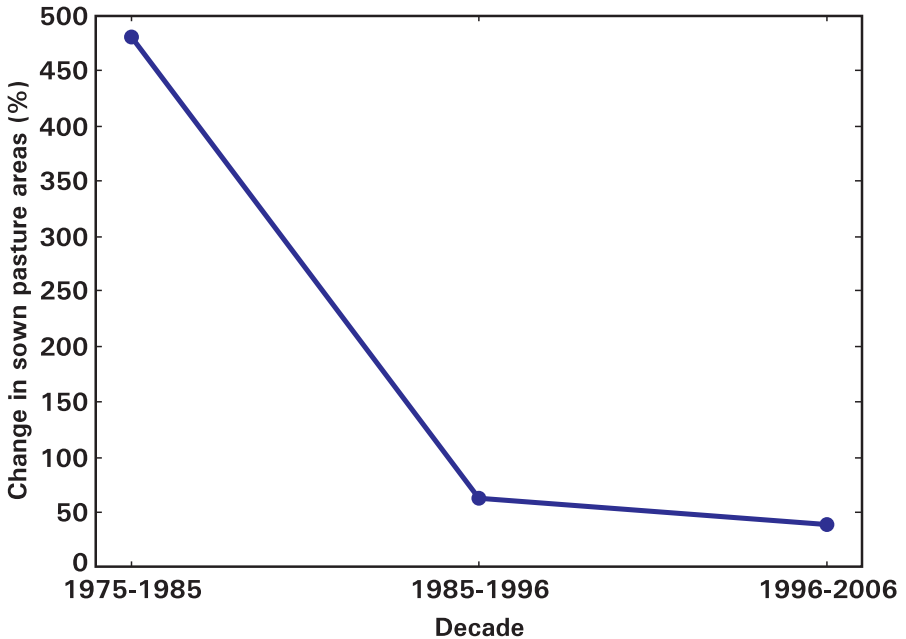


Figure 1. Relative percent change over time (10-year intervals) in new sown pasture areas in northern Brazil between 1975 and 2006.

Source: Dias-Filho (2014b).

According to Valentim and Andrade (2009), such productivity gains have precluded the incorporation of 147.5 million hectares of the Amazon and Cerrado biomes to sown pasture lands in Legal Amazonia between 1975 and 2006. This trend is confirmed by the sharp decrease in the rate of deforestation in the Amazon region in recent years (INPE, 2013).

The economic, environmental and social gains of this “avoided deforestation,” during the past decades, are considerable, and certainly outweigh the total resources spent (by the public and private sectors) to support pasture reclamation activities in Brazilian Amazonia. Recent productivity gains in the Amazonian cattle systems, besides improving Brazilian supply of animal products, has also allowed improving food

security of the Amazonian population affected by chronic market shortfalls in the supply of fresh beef from the early 1800s to the mid-1960s (DIAS-FILHO, 2013).

There are currently around 30 million hectares of degraded pasture lands in Legal Amazonia (DIAS-FILHO, 2011b). Given the productivity indices of reclaimed pasture lands (Table 3), it could be inferred that reclaiming only a relatively small proportion of these degraded pasture lands would already cause a strong positive impact on improving cattle ranching productivity and reducing deforestation pressures in the Amazon region.

Table 3. Productivity indices estimated for beef cattle based on average sown pasture areas of low productivity (degraded pasture) and under an improved system (reclaimed pasture).

Index	Low productivity	Improved system
Annual calving rate (%)	60.0	85.0
Calf mortality (%)	6.0	2.0
Age at first calving (years)	4.0	2.5
Slaughter age (years)	4.5	2.5
Stocking rate (animals/ha)	0.7	2.5

Source: Dias-Filho (2010).

Thus, based on Table 3, it can be estimated that for every hectare of reclaimed pasture, about 3 ha of land could be released for other purposes (agricultural, forestry, preservation, etc.), without losing the current regional production levels. Correspondingly, because on improved systems age at slaughter is substantially reduced (Table 3), Amazonian cattle systems under reclaimed pasture lands can achieve higher productivity and lower emissions of greenhouse gases (GHG) per animal (i.e., be more cost effective and environmentally friendly) (DIAS-FILHO, 2011b).

Lessons learned

The accumulated experience of nearly 40 years of Embrapa's research activities on the reclamation of degraded pasture lands in the Amazon

is considerable (DIAS-FILHO, 2014a). This experience is a valuable asset to subsidize public policies in this strategic area for food security and environmental preservation in the region.

The vastness of the Amazonian territory, the difficulties posed by infrastructural bottlenecks typical of cattle ranching areas and the biological peculiarities of the Amazonian ecosystem have pointed out important features concerning pasture research in the Amazon. Today, it is recognized that, compared to other Brazilian regions, pasture research in the Amazon requires greater volume of funds to be effective.

Coupled to this, there is the need for a relatively large staff of researchers (agronomists and animal scientists) with academic background in forage crops and pasture management and with knowledge of and, above all, commitment to the Amazon region. Experience has shown that if the professional does not establish “roots” in the region, after a short time working in the Amazon, he/she usually tends to seek transfer to other parts of the country, taking with him/her any regional experience already gained. In addition, certain agronomic and socioeconomic concepts that are true for other parts of Brazil may not be valid for the Amazon region. Even within the Amazon region, there are agronomic peculiarities that only apply to specific locations and, therefore, cannot be extrapolated to other sites within Amazonia. So, pasture research in the Amazon, besides commitment, requires regional experience. Therefore, it is necessary to form a staff of pasture scientists with experienced local professionals or, alternatively, it should be created mechanisms that encourage a long lasting stay of the out-of-the-region professional.

Another lesson learned in these four decades of research on reclamation of degraded pasture lands in the Amazon relates to difficulties in the process of technology adoption by local producers. As demographic and economic pressures influence agricultural intensification (adoption of intensification technologies), scarcity

of natural areas tends to be an important motivator of technology adoption. In the 1970s and 1980s, the scenario that prevailed in the Amazon was one in which the options of intensification (reclamation of degraded pastures) were usually more costly than more extensive traditional practices, such as land abandonment replacing degraded pastures with newly sown lands previously covered by natural vegetation. Besides, many producers who could adopt pasture reclamation technologies were in regions with still some abundance of natural areas for agricultural expansion and, therefore, low motivation for intensification. From the 1980s on, with increasing environmental restrictions against deforestation in Amazonia, growing valuation of land prices and a more extensive portfolio of technologies, adoption of technology in cattle ranching activities tended to increase.

An important lesson learned was that producers usually do not consider the benefits and the environmental and social costs inherent to a new technology, as a deciding factor for adoption of that technology. Thus, the agronomic acceptability of technological change would have the greatest influence on its adoption than its social and environmental impacts. Therefore, experience has shown that trying to encourage the adoption of a given technology, simply by emphasizing its environmental benefit, is not an efficient strategy.

Likewise, one also does not “sell” a particular technology solely for its potential to provide long-term profit. Accordingly, the possibility of having a steady income over time would have greater weight as a deciding factor for technology adoption than the probability of high future profits. This is true especially for those producers with credit restrictions, such as many small and medium farmers in the Amazon. A typical example of this situation is the low rate of adoption of silvopastoral systems in the Amazon region, in particular, and throughout Brazil, in general, as thoroughly discussed by Dias-Filho and Ferreira (2008). So, what looks good for a research scientist, who sees land as his laboratory, may not be good from the perspective of a farm manager, who sees land as his safe.

Prospects, recommendations and priority policies

With the greatest growth of the national cattle herd and pasture area (Table 1), northern Brazil (North Region), which covers most of the Legal Amazon, is considered a major agricultural frontier for the nation's cattle sector (DIAS-FILHO, 2010, 2011a, 2013). The state of Pará, with 42% of the regional (North Region) cattle herd (18.6 million heads) (IBGE, 2013), stands out as the prototype of this agricultural frontier in the Amazon. Thus, as for the next 10 years are projected increases in the annual rates of production (2.0%), consumption (3.6%) and exports (2.5%) of Brazilian beef (BRASIL, 2013), likewise, it can be predicted an increase in the contribution of the Amazon region to meet this demand.

Due to the growing importance of pasture-based cattle production system in the Brazilian Amazon to domestic and international agricultural economy, it is essential that this system be based on efficiency and high productivity, seeking to produce more in less pasture area. That is, to become competitive and meet the requirements of demanding markets, cattle ranching in the Amazon must be modernized. Pasture improvement should be the basis of this modernization, using already cleared areas, currently abandoned, or underutilized, reducing deforestation and making the activity more productive and sustainable (DIAS-FILHO, 2014a; VALENTIM; ANDRADE, 2009).

Thus, the reclamation of degraded pasturelands should play a central role in this modernization process, making it possible to increase production without further transforming natural vegetation into new pasturelands. That is, food security, livestock (land) productivity and environmental conservation must be central foci in a modernized livestock strategy (DIAS-FILHO, 2011a). To achieve this objective, some actions are necessary:

1. Continuous generation of technology aiming at the development of new forage plant cultivars, efficacious technologies for degraded pastureland reclamation and pasture management.
2. Constant flow of public and private investment in research and development on pasture management and strategies for helping farmers build skills and test and implement new practices and technologies.
3. Recruitment of pasture scientists and technicians by local public and private institutions.
4. Improvement or creation of technical and undergraduate courses intended for training professionals to promote more intensive and sustainable livestock-raising systems in the Amazon.
5. Strengthening of public technical assistance services.

Producers and consumers should press the public and private sectors to implement these actions. Since the 1990s, a chronic situation has been the reduced number of pasture scientists working in the Brazilian Amazon. Without changing this condition, it can be predicted that a profound crisis in the generation of improved technologies on pasture management and reclamation will be established in the Amazon. This situation will leave the local producers at the mercy of their fate, improvising management techniques without scientific basis, or transferring pasture management technologies from other regions of Brazil.

As discussed by Faminow (1998), intensification of the existing cattle systems in the Amazon is an option that deserves more financial, academic and institutional support. Accordingly, a policy of low investment in research and development to improve the efficiency of livestock-raising systems in the Amazon is entirely inconsistent with the current bold government policy goals for reclaiming degraded pasturelands and reducing deforestation (DIAS-FILHO, 2014a). To reach this goal, more productive pasture technologies and effective extension services must be developed.

As technology adoption by Amazonian farmers continues to face barriers, overcoming these barriers should focus primarily on chronic problems in this region. Among these barriers stand out the lack of financial incentive, restricted access to information, ineffective agricultural extension services, the few opportunities for the technical qualification of the producer, limited access to inputs, agricultural machinery and implements, and the increasing rural land insecurity.

Considering the environmental, social and economic benefits of using technology to reclaim abandoned (degraded) pastures in the Amazon, as an alternative to continued deforestation, it is important to have some form of financial compensation in cost reduction for this activity (DIAS-FILHO, 2011b). This may be feasible by creating public policies for specific credit lines for this activity. Also, loan criteria of existing policies should be strengthened, adapted and revised, to better match infrastructural peculiarities of the Brazilian Amazon.

Even if the economic conditions to reclaim degraded pasturelands are appropriate (i.e., easy access to credit), if there is no technology domain by the producer, or if the producer does not have access to qualified technical assistance, reclamation actions may be impaired. Therefore, it is essential that the public sector or private entities, such as farmers' associations, create or strengthen mechanisms for technical qualification of producers and extension agents in the Amazon.

Finally, if there is no legal security, farmers are reluctant to make investments, such as reclaiming unproductive pastures, because of the risk that they will lose the land. Therefore, it is up to the Brazilian government to provide the security of land tenure and services to allow for a functional property rights system. Such actions would further encourage the improvement of pasture-based cattle production systems and limit deforestation in the Brazilian Amazon.

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