THE BRAZILIAN FOREST CODE AND SCIENCE:

Contributions to the dialogue

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Special participation:
Aziz Nacib Ab'Sáber (in memoriam)

Sociedade Brasileira para o Progresso da Ciência

The Brazilian Society for the Advancement of Science

Academia Brasileira de Ciências

The Brazilian Academy of Sciences

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FOREWORD

The Brazilian Forest Code and Science: Contributions to the Dialogue, second edition, includes the English version and:

- A letter from the SBPC and the ABC sent to Honorable Dilma Rousseff, President of the Federative Republic of Brazil, regarding the approval of the Forest Code (PL 1,876-E/1999) by the House of Representatives.

- An open letter from the SBPC and the ABC issued to the Federal Senate including a table with the most serious changes suggested by the Bill (PLC 30/2011) on the proposed Forest Code sent by the Senate to the House of Representatives.

- "From Forest Code to Biodiversity Code" – The opinion of Aziz Ab'Sáber, Ph.D. *(in memoriam)* on the change of the Forest Code in Brazil, criticizing the absence of all the physical and ecological zoning of the country in the Bill: the semiarid region of the northeastern backlands, the Brazilian cerrado, the araucaria plateaus, the mixedwood plains from Rio Grande do Sul and the Pantanal of Mato Grosso, proposing the creation of the Biodiversity Code to consider the preservation of animal and plant species and sent by Dr. Ab'Sáber and the SBPC and the ABC, respectively, to the rapporteur of the bill and to the House of Representatives.

The scientific reflections contained herein contribute to the dialogue held by society on possible changes of the Brazilian Forest Code. It should be noted, however, that this is not a detailed analysis on the provisions of the present Forest Code, or of the proposed modification to Bill No. 1,876/99 and its respective appendices.

The perspective of new concepts and new technological tools for territorial planning and ordaining have inspired and guided this work, intended to stimulate the increase of agricultural production and productivity in synergy with environmental sustainability.

This document explains the scientific reference used for the analysis of various topics of rural and urban environments which cannot be disregarded, quoting examples for provisions of the present Forest Code and the proposed modification under discussion. The Brazilian Society for the Advancement of Science (SBPC) and the Brazilian Academy of Sciences (ABC) remain available for mobilizing expertise within society to scientifically support the dialogue, by participating in multi-sectoral agendas.

This document is the result of extensive review and prospective research work developed by the Forest Code Working Group - SBPC / ABC, who sought, in the light of science and the available technology, contribute to a vigorous dialogue on the Forest Code. However, in view of the complexity of the subject, it shall be clear that the findings reported here may and should be expanded, welcoming other scientifically based contributions to refine the present legislation, which will result in improvements for both the preservation and conservation of the environment, as for the country's agricultural sector.

PRESENTATION

The Brazilian Society for the Advancement of Science (SBPC) and The Brazilian Academy of Sciences (ABC), were founded in 1948 and 1916, respectively, being representative bodies of the countries' scientific community, they are non-profit organizations and free from political bias.

Among their objectives, there are:

- To represent the Brazilian scientific community nationally and internationally, seeking to implement a Science, Technology and Innovation (CT&I) policy which promotes the development of science for the benefit of society;
- To provide incentives to the scientific community for acting together with the concerned government branches in the pursuit of a national scientific and technological advance and the encouragement of innovation;
- To ensure that a high ethical standard is kept among scientists and in their relation with society;
- To strive for the removal of obstacles and misunderstandings which hinder the advancement of science;
- To assume position in matters of scientific, educational and cultural policies, as well as in scientific and technological development programs which meet the real interests of the country.

Answering to a demand from society – in particular from the scientific community – for a more effective participation of science in the reformulation of the Forest Code (FC), SBPC and ABC formed a working group (WG) to offer data as well as technical and scientific arguments that could subsidize the discussion around modifications in the Forest Code which have been suggested in the proposed modification for Bill 1,876/99.

The first Brazilian Forest Code was established through Decree No. 23,793 of January 23th, 1934, later revoked through Law 4,771, of September 15th, 1965, which established the present Forest Code. Both the original legislation and all subsequent amendments took into account the scientific knowledge available so far. Now that the dialogue on the subject is reopened, the scientific community hereby supported by the legitimacy of its most comprehensive and representative associations, requests that the National Congress continues to consider the scientific advancement and the technological development so far in the dialogue on the Brazilian forest legislation.

In addition to the SBPC and ABC members, several research institutions, universities, professional representations and civil organizations were invited to participate on the Working Group, among which are:

The Brazilian Corporation for Agricultural Research (EMBRAPA); Butantan Institute; The National Institute of Space Research (INPE); The National Institute of Amazon Research (INPA); The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA); The Emilio Goeldi Museum (MPEG); The Ministry of Environment (MMA); The Federal Council of Engineering, Architecture and Agronomy (CONFEA); The National Confederation of Agricultural Workers (CONTAG); The Brazilian Society of Forest Engineers (SBEF); The Brazilian Society of Silviculture (SBS); The Brazilian Forest Association (ABRAFLOR); The Brazilian Agroforestry Network (REBRAF) and the following universities: *Universidade Estadual de Campinas* (UNICAMP), *Universidade Federal do Rio de Janeiro* (UFRJ), *Universidade Federal Rural de Pernambuco* (UFRPE), *Universidade Federal de Viçosa* (UFV) and *Escola Superior de Agricultura Luiz de Queiroz - Universidade de São Paulo* (ESALQ-USP).

Many of these institutions appointed representatives. Later, other names were added to the group, by appointment of the WG members. The methodology adopted for the works consisted in splitting up the document topics by areas, whereas the WG members would write their contributions, which were then shared with the other members for analyses, corrections and suggestions. A coordinator was appointed to organize the actions of the WG.

All meetings took place at the SBPC headquarters in São Paulo. The first occurred on July 7th, 2010. Goals were outlined to be met and a diagnosis was made on the state of art of the Forest Code and the above-mentioned modifications proposed.

The second meeting was held on August 26th and 27th, 2010. Congressman Aldo Rebelo (PCdoB/SP), rapporteur of the proposed modification to Bill 1,876/99, explained his Project to the WG members and guests. The former Secretary of Biodiversity and Forest of the Ministry of Environment (MMA), Maria Cecília Wey, presented the perceptions of the MMA on the subject. After the presentations, the WG produced the first letter which was sent to Congressmen and Senators. The letter was signed by Marco Antônio Raupp and Jacob Palis Junior, respectively presidents of SBPC and ABC.

In the third meeting, on October 7th and 8th, 2010, continuation was given in building the document. Another letter was drafted and sent to presidential candidates. In December, on the 2nd and 3rd, another WG meeting took place, which was attended by Congressman Ivan Valente (PSOL/SP), a member of the environmental committee in Congress. A new meeting was held on January 28th and 29th, 2011, at which the executive summary was drafted and sent to Congressmen and Senators, and released at a national level.

During these meetings, several people contributed with their points of view on the subject, participating in one or more occasions, among which were: Aziz Ab'Sáber (USP); Aldo Malavasi (Board of Directors of SBPC/Moscamed); Alysson Paulinelli (Former Minister of Agriculture); Antoninho Rovaris (CONTAG); Claudio Azevedo Dupas (IBAMA); Gustavo Curcio (EMBRAPA Forests); Helena Bonciani Nader (UNIFESP/Vice-president of SBPC); Helton Damin da Silva – (Head of EMBRAPA Forests); Jacob Palis Júnior (President of ABC/IMPA); João de Deus Medeiros (MMA); José Raimundo Braga Coelho (Board of Directors of SBPC); Luiz Antônio Martinelli (CENA/USP); Marco Antônio Raupp (MCT/President of SBPC at that time); Maria Cecília Wey (MMA); Otávio Velho (Vice-president of SBPC/UFRJ); Rinaldo Augusto Orlandi (Advisor of Congressman Aldo Rebelo); Rute Maria Gonçalves de Andrade (Board of Directors of SBPC/Butantan Institute); Sourak Aranha Borralho (IBAMA).

The working group which organized this document consisted of:

Antonio Donato Nobre (INPA/INPE) – Agricultural Engineer (ESALQ USP), M.Sc. in Tropical Ecology (INPA UA), Ph.D. in Earth Sciences (UNH – USA);

Carlos Alfredo Joly (UNICAMP – BIOTA) – B.Sc. Degree in Biological Sciences (USP), M.Sc. in Plant Biology (UNICAMP), Ph.D. in Plant Ecophysiology at the Botany Department, University of Saint Andrews, Scotland, GB, Post Ph.D. at *Universität Bern*, Switzerland;

Carlos Afonso Nobre (INPE – MCT) – Electrical Engineer (ITA), Ph.D. in Meteorology (MIT-USA), Post Ph.D. from University of Maryland, USA;

Celso Vainer Manzatto (EMBRAPA Environment) – Agronomist (UFRJ), M.Sc. in Soil Science (UFRJ), Ph.D. in Plant Production from *Universidade Estadual do Norte Fluminense*;

Elibio Leopoldo Rech Filho (EMBRAPA Genetic Resources & Biotechnology) – Agricultural Engineer (UnB), M.Sc. in Plant Pathology (UnB), Ph.D. in Life Sciences from University of Nottingham, England, Post Ph.D. in Manipulation of Yeast Artificial Chromosomes (YACs) from University of Nottingham, Oxford, England;

José Antônio Aleixo da Silva (UFRPE – SBPC) – Agricultural Engineer (UFRPE), M.Sc. in Forest Sciences (UFV-MG), Ph.D. and Post Ph.D. in Biometry and Forest Management from University of Georgia, USA – Working Group Coordinator;

Ladislau Araújo Skorupa (EMBRAPA Environment) – Forest Engineer (UnB), Ph.D. in Biological Sciences (Botany) (USP);

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Tatiana Deane de Abreu Sá (EMBRAPA Board of Directors) – B.Sc. Degree in Agronomy from *Escola de Agronomia da Amazônia*, M.Sc. in Soil Science and Biometeorology from Utah State University, USA, Ph.D. in Plant Biology (Plant Ecophysiology) (UNICAMP).

Special Participation:
Aziz Nacib Ab'Sáber *in memoriam* (USP - SBPC - ABC) - Born "amid a sea of hills," as he always declared, this geographer who was awarded with the highest scientific honors - in Physical Geography, Archeology, Geology and Ecology - conducted scientific research in all Brazilian ecosystems and was a leading expert on environmental issues, acknowledge and prized nationally and internationally. Professor Emeritus at USP, honorary Professor at the Institute for Advanced Studies (IEA) and many other institutions, Honorary President of the SBPC, Member of the ABC. Worked and collaborated with various institutions of education and research. Only a few have crossed the country as he did, observing the landscapes, its people and their way of life. He participated actively in public debates, contributing with his opinion on biodiversity and environmental conservation dilemmas.

The SBPC and the ABC also wish to thank the following Professors: **Oswaldo Ferreira Valente**, from the Universidade Federal de Viçosa, **Eleazar Volpato**, from the Universidade de Brasília, and **Luiz Antônio Martinelli**, from the Escola Superior de Agricultura Luiz de Queiroz, for their excellent review of the document and valuable critical contributions.

Our thanks to **Beatriz de Bulhões Mossri**, spokesperson for the SBPC in the House of Representatives.

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- **Ana Luiza Coelho Netto** – Geographer and Geomorphologist; Ph.D. from Katholieke Universiteit Leuven, Belgium; Post Ph.D. from University of California-Berkeley, USA; Professor – IGEO/UFRJ; Researcher 1A-CNPq and State Scientist-FAPERJ.

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- **José Felipe Ribeiro** (Researcher and Advisor to the Executive Board of EMBRAPA); Biologist (UNICAMP); M.Sc. in Ecology (UnB) and Ph.D. in Ecology from University of California-Davis, USA.

- **Eduardo Delgado Assad** – EMBRAPA Agriculture Informatics; Agricultural Engineer (Universidade de Viçosa); M.Sc. and Ph.D. in Hydrology and Mathematics from Université de Montpellier, France.

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- **Luciano Mansor Mattos** – EMBRAPA Technology Transfer; Agronomist (ESALQ), M.Sc. in Environmental Engineering from *Escola de Engenharia de São Carlos*, USP; Ph.D. in Economic Development (Unicamp) and Social Anthropology and Global Climate Change from Indianna University.
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- **Ricardo de Oliveira Figueiredo** – EMBRAPA Environment; Agronomist (*Universidade Federal Rural do Rio de Janeir*o); M.Sc. in Geosciences from *Universidade Federal Fluminense*; Ph.D. in Biosciences and Biotechnology from *Universidade Estadual do Norte Fluminense* Darcy Ribeiro; and Post Ph.D. in Biological Sciences from Woods Hole Research Center and University of Georgia.

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SUMMARY

LETTER FROM THE SBPC AND THE ABC SENT TO THE PRESIDENT OF THE FEDERATIVE REPUBLIC OF BRAZIL, REGARDING THE APPROVAL OF THE FOREST CODE (PL 1,876-E/1999) BY THE HOUSE OF REPRESENTATIVES

São Paulo, May 17th, 2012.

Honorable
President DILMA ROUSSEFF
Presidency of the Federative Republic of Brazil

Honorable President,

The Brazilian Society for the Advancement of Science (SBPC) and the Brazilian Academy of Sciences (ABC) are surprised with the approval of the Bill (PL 1,876-E/1999) by the House of Representatives last April 25th. It concerns a Forest Code which, by not having incorporated the advances sent by the Federal Senate and suggestions based on scientific and technological knowledge, brings serious setbacks and risks to Brazilian society.

The approval of this Bill represents immediate economic interests of groups within the House of Representatives, which do not take into account the peculiarities of huge regions such as the Amazon and other biomes within the country. It favors those who disrespected environmental laws by offering a general pardon for infringed acts and, especially, it does not reconcile agricultural production with environmental sustainability.

The reform of the Brazilian Forest Code, as has been processed by the Congress represented the deregulation of the agribusiness sector with serious risks to the environment and the very agricultural production itself. The protection of natural areas is being considerably reduced. This way the historical opportunity is lost to put Brazil in a leading position. Agriculture in Brazil can and should be differentiated by the conciliation of efficient food production with environmental sustainability, the latter which will be the central theme of the RIO+20 Conference hosted by Brazil upcoming June.

As representatives of the Brazilian scientific community, we cannot withhold reaffirming our positions, all based on scientific and technological knowledge and made available to legislators, in order to subsidize them in their decisions when handling this issue. Therefore, we respectfully present technical and scientific subsidies to Your Excellency which justify the development of the Brazilian legal framework, with important tools to ensure sustainable agricultural production, with economic, social and environmental benefits.

Although we recognize that advances were made through the modifications proposed by the Senate regarding the Rural Environmental Registry (CAR), the promotion of incentives for preservation, conservation and environmental restoration, a greater environmental protection in urban areas, including mangroves, salt marshes and *apicuns* as permanent preservation areas (APP), the construction, within a period of three years, of bills specific to each biome of the country, regulating the use of fire, conditioning the agricultural credit to the environmental regulation and making a distinction between transitional and permanent provisions, the Working Group (WG) on the Forest Code, created by the SBPC and the ABC reported in correspondence addressed to congressmen and Your Excellency in March 8th, 2012, that serious problems still persist, which should be corrected based on scientific arguments as explained in the WG document.

However, in addition to not considering the recommendations made by the SBPC and the ABC WG, the lawmakers of the Forest Code in the House of Representatives withdrew important provisions from the text approved by the Senate and therefore in some cases without the possibility of veto over-rides. To redeem, at least, these points, a new legal proposal will be essential to restore the lost points and as not to leave a protection void in sensitive issues, such as listed below:

- **Modification of Article 1, which suppresses the principles of the Law**

The House of Representatives removed all items of Article 1 which clarified the principles by which the law should be ruled, such as the recognition that forests and other native vegetation are goods of common interest for all the country's inhabitants and reaffirms its commitment to protect them; recognition of the importance for reconciling the productive use of land with the protection of forests in order to maintain the environmental services that forests and other native vegetation provide to society; creation and mobilization of legal and economic incentives to encourage preservation and restoration of native vegetation and promotion of the sustainable production model, among others. This provision guarantees the rule of law and the intention to reconcile productive activities with the conservation of forests.

- **Differential treatment for agricultural uses by traditional and riparian communities, and the definition of fallow land**

We reaffirm that the agricultural uses practiced by traditional, riparian communities and smallholders in general should have a differentiated treatment. In particular, fallow areas should be recognized only for these classes, as have been until the present, without exceptions.

Moreover, in the text approved by the House of Representatives, the definition of a maximum period and the percentage of the productive area which can be used under a temporary disruption of agricultural activities were withdrawn from the definition of fallow (Article 3, XI). Such a definition will enable forested areas under regeneration to be considered as agricultural areas "at rest".

• Legalization of new deforestation

Besides the change in the definition of fallow, which will allow further deforestation to occur under the new law, Article 13 § 5 was maintained, enabling the reduction of legal reserves in the Amazon from 80% to 50% in some cases. We believe that this disposition is not compatible with the Brazilian environmental policy, given the commitments made by Brazil to reduce its greenhouse gas emission rates and in face of the effort made by universities and research institutions to valorize the standing forest, developing economically viable alternatives for a sustainable exploitation of timber and Non-Timber Forest Products (NTFP).

It may also be noted that the House of Representatives withdrew from the text the phrase "provided it does not involve further suppression of areas with native vegetation" from many articles of the law, whereas several of these flexibilization mechanisms in the legislation may lead to further deforestation, which will then be considered as legal.

• Permanent Preservation Areas (APPs) on the banks of watercourses, springs and wetlands in general

All Permanent Preservation Areas on the banks of watercourses and sources should be preserved and, when degraded, should have its vegetation fully restored. In the current text, the areas that must be legally restored in the APPs were reduced to 50% for rivers less than 10 meters wide, while this was not defined for wider rivers.

The APPs along the margins of watercourse should remain delimited, as has been hitherto, by the highest water level of the river. The substitution of the higher bedding of the river by the regular bedding in the definition of APPs, makes extensive wetland areas vulnerable throughout the country, particularly in the Amazon and the Pantanal. These areas are important providers of ecosystem services, especially in the protection of water resources, the prevention of erosion in riparian areas and the consequent clogging of rivers, which is why they are object of international treaties of which Brazil has been signatory, such as RAMSAR (the International Wetlands Convention).

Additionally, with the view of natural disasters, the maintenance of APPs also protects public and private property and, especially, human lives.

The Forest Code bill approved by the Senate and the House of Representatives dramatically reduces the protection of wetlands in general and flooded forests in particular. About 20% of the Brazilian territory is covered by wetlands; only in the Amazon they occupy 1.8 million km^2 (of which 400,000 km^2 are floodable) and in the Pantanal 160,000 km^2.

The text directly conflicts with Law No. 7,803 from July 18th, 1989 and CONAMA Resolution 004/85, which define the "highest level" as a parameter for the width measurement of a watercourse, considering, for the purpose of calculating the average of ordinary floods, the maximum annual quotas, related to floods with a recurrence period equal to three years, thereby excluding floods with a recurrence period equal or above 20 years (ON – GEADE – 003 06/04/01).

To make matters worse, the House of Representatives suppressed the definition of wetlands (Article 3, XXIV), leaving even more vulnerable such important areas, prone to misuse by intensive agricultural activities.

The House of Representatives also removed the need to protect a strip with a minimum width of 50 meters along creek lanes, counted from the marshy and wet areas (Article 4, XI), allowing for the consolidation of irregular occupations and leaving them vulnerable to new occupations and deforestation, besides submitting the creek lanes to edge effects of adjacent occupations. It is essential that in the new legal proposal this mandatory protection strip along creek lanes is restored.

With the removal of the Article 4, § 7 and § 8, concerning the obligation of municipal Master Plans and Soil Use Laws to keep marginal vegetation strips along watercourses (Article 4, I) in urban areas, populations are more susceptible to problems related to floods, flows and landslides.

Still regarding wetlands, Article 6, Item I removes the possibility for the Executive Power to consider the protection of wetlands as a social interest in order to declare new Permanent Preservation Areas.

The potential uses of APPs in humid areas deserve specific and relevant legislation in the Forest Code, due to its relevance, specificity, socio-environmental and typological multiplicity, its environmental services and its biodiversity.

- **Protection of mangroves**

In the text approved by the House of Representatives, despite considering the mangroves along its entire length as APPs, a safeguard is inserted as to *apicuns* and salt marshes, thereby not considering them as APPs (Article 4, § 3). As a result of the ecological importance of mangroves, *apicuns* and salt marshes, and of all the transitions between them and, considering that the conservation/preservation of just one of them will not ensure the conservation/preservation of the other(s), nor the maintenance of the integrity and functionality of mangroves, a veto of that paragraph is requested.

The House of Representatives kept the provision which threatens the protection of mangroves by allowing the intervention or removal of native vegetation from APPs in places where the "ecological function of the mangrove" is hampered. In this case (Article 8, § 2), housing and urbanization works inserted in projects of land regularization of social interest are authorized in urban areas consolidated and occupied by low-income populations. If the ecological function of the mangrove is hampered, it must be restored, since most of the contaminated mangroves show high levels of heavy metals and oil. To keep low-income population in these locations would therefore be immoral.

• Permanent Preservation Areas (APPs) should not be included in the calculation of Legal Reserves (RLs)

Biological communities, ecosystem structures and functions of APPs and Legal Reserves (RLs) are distinct. It makes therefore no sense to include APPs in the computation of RLs as was kept in the text approved by the House of Representatives (Article15).

The House of Representatives also added that in this calculation all the enforcement modalities of Legal Reserves may be considered, i.e., regeneration, restoration and compensation.

The SBPC and the ABC always argued that an eventual deficit compensation of RLs should be made in the areas nearest to the estates, within the same ecosystem and preferably in the same microbasin or hydrographic basin. However, the proceeding project makes the possibility of RL compensation wider within the extent of the same biome, which does not ensure the ecological equivalence of composition, structure and function. By maintaining this disposition, its regulation should require such equivalence and set a maximum distance from the area to be compensated, in order to maintain the regional ecosystem services.

The main motivation which justifies the RL is the sustainable use of the natural resources within areas with a lesser land use potential, allowing the conservation of native biodiversity under economic exploitation, besides production diversification. This way, an eventual initial temporary use of exotic species for the recovery of degraded RLs cannot be transformed in a permanent practice.

• Consolidated Rural Areas

The scenario of rural areas consolidated in APPs up to the baseline date of July 22th, 2008, and the possibility given by the approved law for them to be maintained and regulated is not justified. Since at least 2001, deforestation in these areas for an alternative use of soil was already explicitly prohibited and these should be fully restored with native vegetation as to provide their environmental services.

One of the prerequisites for a successful restoration of riparian vegetation is to isolate the degradation factor. Therefore, letting marginal strips recover simultaneously with cattle grazing, as allowed under Article 61, hinders the recruitment of seedlings and therefore the regeneration of native vegetation.

The House of Representatives also aggravated the situation by exonerating rural estates with consolidated activities from restoring APPs along natural watercourses with marginal strips exceeding a width of 10 meters.

Also removed was the disposition which prohibited the consolidation of any activity at APPs in estates situated at the limits of Strict Conservation Units (Article 62, § 13). In addition, § 14 was suppressed from the same article, which formerly enabled a greater protection of native vegetation for those hydrographic basins considered critical.

• **Restoration of APPs**

Other exceptions relate to the obligation to restore. The differential treatment of being able to restore a lesser extent of APPs should be restricted to smallholders, whether traditional or riparian populations. In view of this, § 4 and § 8 of Article 62 should be suppressed.

• **Granting Agricultural Credit to all rural landowners**

The House of Representatives suppressed Article 78 of the Senate's text, which linked, after five years of publication of the Law, the concession of agricultural credit with the inclusion of rural estates within the Rural Environmental Registry (CAR) system. This way, there will be no restriction anymore for credit lines to not registered farmers, discouraging the environmental regularization of their property. It is unacceptable that credit will be provided to the landowners with disregard to the environmental care of their agricultural activity.

• **Withdrawal of demands for the authorization to suppress native vegetation**

In Chapter V, which handles the suppression of vegetation for an alternative use of the soil, the House of Representatives has removed the need for the federal environmental agency to approve the removal of vegetation in areas where endangered species prevail, as listed by the federal government (suppression of Item IV, § 1, from Article 26). Under this article, in § 4, the House of Representatives suppressed Items V and VI, which required informing, in the clearing request, the inventory of all trees with a diameter greater than 30 (thirty) centimeters, as well as its destination, respectively, rendering the control system of the exploitation of native forest species and timber transport vulnerable.

More in-depth reviews made by the SBPC and the ABC throughout the proceeding period of the bill in Congress are available at the SBPC website (www.codigoflorestal.sbpcnet.org.br).

Confident in Your Excellency's attention to the considerations hereby reported, we send you our most respectful greetings.

HELENA B. NADER
President of the SBPC

JACOB PALIS
President of the ABC

JOSÉ ANTÔNIO ALEIXO DA SILVA
Forest Code WG Coordinator

OPEN LETTER FROM THE SBPC AND THE ABC, ISSUED TO THE FEDERAL SENATE, INCLUDING A TABLE WITH THE MOST SERIOUS CHANGES SUGGESTED BY THE BILL (PLC 30/2011), ON THE PROPOSED FOREST CODE SENT BY THE FEDERAL SENATE TO THE HOUSE OF REPRESENTATIVES

The Brazilian Society for the Advancement of Science (SBPC) and the Brazilian Academy of Sciences (ABC) come to alert for some of the consequences which might result from the Bill which changes the Forest Code (FC), in its version which soon will be voted in the National Congress' House of Representatives.

The SBPC and the ABC recognize the advances in the text of the FC in the version presented by the Congress' Senate, in particular the establishment of the Rural Environmental Registry (CAR) and the support and incentive mechanisms for the conservation and restoration of the environment, environmental compliance as a condition for agricultural credit lines, increased environmental protection in urban areas, the inclusion of mangroves among areas of permanent preservation, the mandatory biome-specific bills within a period of three years, the new specifications and legal instruments that regulate the use of fire and fire control, and the distinction made between the FC's permanent and transitional provisions.

Serious problems, however, remain. As not to allow that the endorsement of science be claimed for the text which is now in its final stages of legislative deliberation, the SBPC and the ABC, being the most representative scientific community associations of the country, hereby again manifest and reiterate their positions, whose scientific justifications have been presented throughout 2011 in a book and two documents which are accessible on the SBPC website (www.codigoflorestal.sbpcnet.org.br).

All **permanent preservation areas (APP) along the banks of watercourses and water sources** should be preserved and, whenever degraded, should have its vegetation **fully restored**. The concerned APP area, that legally should be recovered, was reduced by 50% in the current text.

APPs along the banks of watercourses should continue to be marked, as has been hitherto, **counting from the river's highest annual water level**. The substitution of the river´s larger bedding by the regular bedding in the definition of APPs makes extensive wetlands vulnerable throughout the country, mostly in the Amazon and the Pantanal. These areas are important providers of ecosystem services, especially concerning the protection of our water resources and, therefore, also subjected to international wetland treaties of which Brazil is a signatory, such as the RAMSAR Convention.

We reaffirm that the agricultural models practiced by traditional communities and by riparian settlers should receive a differentiated treatment. In particular, **fallow areas** should continue to be **recognized only for small estates smallholders or traditional communities, as is currently the case**.

Biological communities, structures and ecosystem functions of APPs and legal reserves are distinct. **It makes no sense to include APPs in the calculation of Legal Reserves (RLs)** as proposed in article 16^{th} of the Bill.

The SBPC and the ABC always argued that any RL deficit compensation was to be made in the areas nearest to the property, within the same ecosystem, preferably in the same microbasin or hydrographic basin. However, the proceeding project widens the possibility of compensating RLs within the same biome jurisdiction, which does not ensure its ecological equivalence of composition, structure and function. Upon maintaining this disposition, its **regulation should require such equivalence and set a maximum distance for the area to be compensated, in order to maintain the regional ecosystem services**.

The main reason which justifies the RL is the sustainable use of natural resources in areas with a lesser land use potential, allowing the conservation of the native biodiversity with economic profitability, in addition to production diversification. Therefore, **in the recovery of degraded RLs, the possible initial temporary use of exotic species should not be allowed a permanent character**, as provided in the current text.

The figure of **rural areas consolidated in APPs until the date of July 22^{nd}, 2008, and the possibility given in the project for these to be maintained and regularized are not justified**. Since at least 2001, the deforestation of these areas for an alternative use of the soil was already explicitly prohibited. These areas should be fully restored with native vegetation so they can provide their environmental services.

One of the prerequisites for the **successful restoration of ciliary forest is the isolation of the degradation factor. Therefore, recovering the marginal strip simultaneously with its utilization by cattle, as permitted by Article 62, paragraphs 4, 5, 7 and 8, prevents the recruitment of seedlings and regeneration of the vegetation**.

Finally, as in several other laws, multiple exceptions can detract from the rule. Some examples are particularly noteworthy. **Although mangroves are protected in the Senate's text, the permission to exploit 35% of the mangroves outside of the Amazon (in addition to those already in so-called "consolidated" areas) and 10% within the Amazon** is worrying since these mangroves, among other very important services, are essential for the reproduction of several commercial fish species.

Another exception to the protection of mangroves refers to those whose ecological function is impaired. In this case (Article 8, paragraph 2), housing and urbanization works are allowed, inserted in land regularization projects of social interest, in consolidated urban areas occupied by low-income population. **If the ecological function of the mangrove is impaired, it must be recovered, since** most of the contaminated mangroves show high levels of heavy metals and oil. To keep low income populations on these locations would be immoral.

Other exceptions refer to the obligation to restore. **The differential treatment that allows restoring lesser extensions of the APPs should be restricted to smallholders.**

In this regard, paragraphs 4, 7 and 8 of Article 62 of the text approved by the Federal Senate should be suppressed.

Given the procedural rules for Bills at the National Congress, most of the mentioned problems will no longer be corrected within the Legislative sphere. **Excepted are a few devices for which suppression is still viable. These include Article 16, paragraph 7 of Article 13, the three paragraphs 4, 7 and 8 of the above mentioned Article 62, and paragraph 3 of Article 68, regarding the use of exotic species for the recovery of legal reserves**. For further details see Table 1.

The reform of the Brazilian Forest Code, as has been processed in the Congress, under the influence of sectoral pressure groups, represents the **deregulation** of the agribusiness sector with serious risks for the environment and their own agricultural production. The protection of natural areas is being considerably reduced, thereby losing the opportunity to produce food in a more efficient and environmentally sustainable way, which should be the great differential of Brazilian agriculture.

São Paulo, February 27th, 2012.

THE BRAZILIAN SOCIETY FOR THE ADVANCEMENT OF SCIENCE (SBPC)

THE BRAZILIAN ACADEMY OF SCIENCES (ABC)

Table 1 – The most serious changes proposed by the Bill (PLC 30/2,011) intended to amend the current Forest Code, as approved on December 2011 by the Federal Senate, and its commented consequences. These changes are organized by the following items: decline in the coverage of protected areas by reduction of legal control, reduction in area and loss of legal protection for the entire protected area.

Topic	Current Forest Code	Bill	Location on the Bill	Consequences
• reduction of legal control: **compensation**	• compensation of the Legal Reserve areas will be done in the same ecosystem and the same watershed or as close as possible to where deforestation occurred.	• compensation of the Legal Reserve areas will be done within the same biome.	Article 68, § 5, IV, § 6, II	• opens the possibility for acquisition of forests in regions distant from those where the native vegetation has been illegally removed or degraded.
• reduction of legal control: **fallow areas**	• "fallow areas" are only recognized in the case of small rural estates, smallholders, or indigenous ancestral lands.	• the item "fallow area" can be attributed to all types of rural estates.	Article 3, XI	• this term, under the current legislation, is employed in areas where planting occurs in systems of crop rotation, a method related to soil use by smallholders or traditional populations.
• reduction of legal control: **National Environmental Council (CONAMA)**	• The National Environmental Council (CONAMA) has the power to regulate the removal of native vegetation of Permanent Preservation Areas and Legal Reserves for up to fifty percent owned in the Legal Amazon region.	• withdraws power from the National Environmental Council – (CONAMA).	Article 14, I gives power to the states to establish activities which may justify the regulation of deforested areas	

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Table 1 (continued).

Topic	Current Forest Code	Bill	Location on the Bill	Consequences
• decrease in area: **properties exempted from restoring their Legal Reserves (RLs)**	• the requirement to restore the areas of Legal Reserves is generalized to all types of properties. Especially in the case of small estates, or smallholder properties or indigenous lands, this can be achieved through the use of fruit trees, exotic or commercial species. However, the current law does not make such distinction according to the size of the property, but the law assigns it to family income and traditional land use.	• "small rural estates" defined as those of up to "four fiscal modules" (between 20-440 hectares) are exempted from restoring their Legal Reserves. • the remaining estates will only be required to restore their RLs if deforestation occurred on or after July 22nd, 2008.	Article 69 Article 7, § 3	• this definition will include over 90% of the Brazilian rural estates, which will be exempted from restoring their Legal Reserves. • the RL regulation will become virtually extinct, thereby losing an important legal instrument legal deemed necessary for the sustainable use of natural resources, conservation and rehabilitation of ecological processes, conservation of the biodiversity and to shelter and protect the native fauna and flora
• decrease in area: **the use of exotic species in Legal Reserves**	• the planting of exotic species in Legal Reserves is allowed temporarily.	• the proposed law allows the restoration of Legal Reserves with the use of exotic species in up to 50 percent of its area.	Article 68, § 3, II	Will allow the agricultural use of this area, which should be designated as a reserve for native species

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Table 1 (continued).

Topic	Current Forest Code	Bill	Location on the Bill	Consequences
• decrease in area: **along rivers**	• the restoration of the vegetation of the Permanent Preservation Areas will be 30 meters for rivers up to 10 meters wide.	• the restoration of the vegetation of the APPs will be only 15 meters in consolidated rural areas for rivers up to 10 meters wide.	Article 62, § 4	• increase of the edge effect which will hinder the maintenance of equilibrium of a forest in process of restoration.
	• Permanent Preservation Areas will be counted from the highest bedding (seasonal).	• calculation of Permanent Preservation Areas will be counted from the average bedding		• dramatically reduces the protection of rivers, further undermining the already critical water availability in some regions of Brazil. Moreover, there will be a increased possibility for lost of harvest in this strip by impairment of the seedlings during periods flooding periods.
• decrease in area: **hilltops**	• 50 meters is the minimum height for hills that should have their tops preserved.	• the Bill changes the minimum height for hills that should have their tops preserved to 100 m.	Article 4, IX	• generalized loss of protection from this APP type
	• the protection of hilltops occurs in cases in which they have in their steeper portion an inclination of at least 17°.	• the Bill intends to protect the hilltops if they reach an minimum average inclination of 25°.	Article 4, IX	• this Bill will significantly modify the protected areas, since reaching a minimum inclination average of 25° is extremely rare in the case of Brazilian hills, which in general are not so steep.

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Table 1 (continued).

Topic	Current Forest Code	Bill	Location on the Bill	Consequences
• decrease in area: **Legal Reserve**	• The inclusion of Permanent Preservation Areas in the calculation of the Legal Reserve percentage is allowed only on properties where the sum of APPs and RLs exceeds 80% of the rural estates located in the Amazon, 50% of the rural estates located in other regions of the country and 25% of the small rural estates.	• The inclusion of Permanent Preservation Areas in the calculation of the Legal Reserve percentage will be allowed for all rural properties.	Article 16	• generalized loss of protection on all properties, since there are differences in the roles of the APPs and RLs. Therefore, a legal instrument will be lost in the enforcement of the sustainable use of natural resources, the conservation and rehabilitation of ecological processes, the conservation of biodiversity and the sheltering and protection of the native flora and fauna.
• loss of legal protection of any protected area and reduction of legal control: general pardon for owners who illegally deforested permanent protection areas	• the term, "consolidated rural areas" is not mentioned in current law. We stress that in 2008 there was only an improvement in their control mechanisms, but the rule in fact already exists since 1998 (under the Environmental Crimes Law) and already foresees severe penalties for non compliance. Therefore, the stipulated date is contradictory.	• insertion of the term "consolidated rural areas" until July, 22th 2008, as base date for admissions of prior deforestation.	Article 3, IV; Article 60, § 5; Article 62	• this will allow deforested areas to remain in a state of degradation, as well as to perpetuate environmental problems that these areas are experiencing at the time, such as erosion and sedimentation of river channels. In addition, the owners will not be obliged to restore them and these areas may in future be used for various other purposes instead of conservation.

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Table 1 (conclusion).

Topic	Current Forest Code	Bill	Location on the Bill	Consequences
• loss of legal protection for the whole protected area: **The permission of harmful activities in Permanent Preservation Areas**	• this is not allowed, since watercourses and hilltops are regarded as Permanent Preservation Areas.	• permission of agroforestry activities in Permanent Preservation Areas in general	Article 62	• these activities cause soil compaction, erosion and siltation of rivers.
• loss of legal protection for the whole protected area: **mangroves**	• there is no exception for the case of impaired ecological function, only in case of public utility.	• the removal of mangrove vegetation will be allowed if its ecological function is impaired. • The apicuns and salt plains can be used for crustacean farming and salt extracting activities, as long as the total area occupied in each state does not exceeds 10% (ten percent) of this phytophisiognomy modality in the Amazon biome and 35% (thirty five percent) in the others, excluding consolidated occupations.	Article 8, § 2 Article 12 § 1	• loss of legal protection of mangroves
• loss of legal protection for the whole protected area: **hillsides**	• the deforestation of hillsides with inclinations between 25 and 45 degrees is not allowed.	• consolidated rural activities will be allowed between 25 and 45 degrees.	Article 11	• grazing in these areas is harmful, since it causes erosion and increases the chance of landslides.

Source: Mascia e Pailler (2011).

FROM FOREST CODE TO BIODIVERSITY CODE

The opinion of Aziz Ab'Sáber, Ph.D. ("in memoriam") on the change of the Forest Code in Brazil sent by him and the SBPC and the ABC, respectively to the rapporteur of the bill and to the House of Representatives.

In face of the enormity of the territory and the actual situation of its six macro biomes – the Brazilian Amazon, the Brazilian Atlantic Tropical Forest, the cerrados of Central Brazil, the Araucaria Plateau, and the mixedwood plains of subtropical Brazil – and its numerous mini-biomes, transitional and contact strips, and ecosystem relics, any attempt of change in the "Forest Code" must be conducted by competent and bioethically sensitive persons. Lobbying for a wide validation of the deforestation processes means ignoring the progression of biotic scenarios towards different spaces of future times, thereby favoring in a rather naive and ignorant manner the ownership cravings of social classes whom are only seeking their own personal interests, within the context of a country gifted with large social inequalities. Citizens from the privileged social classes, whom understand nothing of impact prediction, do not have any ethics towards nature nor try to find technical and scientific models suitable for the recovery of degraded areas, whether in the Amazon, the Atlantic Tropical Brazil, or elsewhere. People for whom demanding the adoption of "ecologically self-sustaining" agricultural activities is a habit of unrealistic scientists.

For many reasons, if there would be a movement to improve the current Forest Code, it would have to involve in the broadest sense a Biodiversity Code, taking into account the vegetation mosaic of our territory. We forwarded this idea to Brasília and received as a reply that this was a good idea, although complex and inconvenient (...). Meanwhile, currently other personalities engage in preposterous and sweeping changes in the so-called Forest Code. That is why we dare to criticize those who insist on generic and dangerous arguments for the country's future, being necessary, more than ever, to avoid that people from other lands, especially from hegemonic countries, would say that it is proved that Brazil does not have competence to manage the Amazon (...). In other words, the reviewers of the current Forest Code would not have competence to rule the whole territory of Brazil. How sad, folks.

The first major mistake of those who currently lead the revision of the Brazilian Forest Code – in favor of the privileged social classes – concerns to the so-called decentralization of the ecological facts from their specific territory. Not to mention that such delicate issues concerning the progressivity of deforestation require joint actions from the specific federal agencies, together with similar state agencies, a rural Federal Police, and the Brazilian Army. Everything also connected with the municipal authorities, which have much to learn from a new Code that involves all the country's macro-biomes, and the mini-biomes which dot them, with especial attention to the coastlines, strips of contact between the core areas within the morphoclimatic and phytogeographic domain of each territory. For intelligent people, able to predict impacts at different points in the future, it is clear that instead of "decentralization" it is absolutely necessary to focus on the physical and ecological zoning of all natural domains in the country. Namely, the two main belts of Brazilian Tropical Forests: the zonal Amazon and azonal Atlantic Forests, including imperative studies on the domain of *cerrados*, *cerradões* and savannas: the complex semi-arid region of the northeastern wilderness: the araucaria plateaus and the mixedwood plains from Rio Grande do Sul, beyond our coast and the Pantanal in Mato Grosso.

It would be necessary to remind the honorable lawmakers – which in my understanding are quite neophyte in the field of ecological, spatial and futurology issues – that in the Brazilian Amazon currently prevails a true parallel army of farmers which locally hold more power than governors and mayors. What was seen in Marabá, with the passage of the farmers' troops through local Transamazônica Avenue, should be known by Congressmen in Brasília, and various members of the executive power. From each of the regional farms passed a group of fifty to sixty comrades led by the farmer himself and his wife on noble horses, as well as their children, also on beautiful horses. These groups were parading at intervals of only a few minutes, while as if commanding the parade, someone on foot was controlling the orderly passage of the horsemen, not allowing us to cross a bridge to attend a cultural event on the other side. Meanwhile, no one from the righteous and important city of Marabá was watching the farmers' frightening display, except, maybe, for two boys on their bicycles, which they left behind at a street corner, looking on silently as the troops passed by. Not one single newspaper from the state of Pará, nor elsewhere, reported this menacing occurrence.

Undoubtedly, it's based on such deeds, that we interpret the message of the Southern Amazonian landowners in terms of "it is my property and I'll do with it what I want to, the way I want it and whenever I wish so". But none of them hereby explains how they conquered their huge originally forested estates. Meanwhile, others, living elsewhere in the southern-central areas of Brazil, when asked how they have gained their fortune, explain that they owe it to "their businesses in Amazonia" (...), that is, through illegal land claims, by selling of estates in places of difficult access to the unwary, which after a certain time are allotted to predatory timber companies. And the most unfortunate fact is that no one is really searching caring for new knowledge on how to re-use degraded lands or demanding appropriate technologies from the government to revitalize the ravaged soils, which over time become saturated with fine sand (siltation).

Among the many chaotic aspects derived from some arguments of the Code reviewers, the phrase stating that the vegetation should be protected up to seven and a half meters from the riverside is emphasized. A curtailment of a fact which, by itself, was very wrong, but is now generally reduced to almost nothing with regard to the great rivers of this country. Just imagine that in the case of the Amazon River the protection requirement would only be of seven meters, while for the vast majority of the streams and brooks also the same requirement would be applied. It is a saddening ignorance about the order of magnitude of the hydrographic networks within the Brazilian inter-tropical territory. Within the traditional Amazonian language, the people themselves have already acknowledged facts concerning the typology of regional rivers. For them, there are, in ascending order: *igarapés* (creeks), small rivers, rivers and *parás* (large rivers), an ultimately logic pragmatic division, accepted by all who know the reality of the Amazonian riverine network.

By ignoring these facts, the reviewing lawmakers apply the length of seven meters from the riverside to all inland watercourses, without ever having been there to see the fantastic mosaic of rivers of the regional territory.

But the worst thing is that the new requirements from the proposed Forest Code are characterized by an excessive and abusive validation. One speaks of an edge of seven meters and a half for ciliary forests (riparian-biomes) and afterwards of the preservation of the occasional and distant hilltop vegetation, hereby not being able to imagine how much space becomes available for any kind of occupation. This is regrettable in terms of regional planning of the rural and wilderness areas. Also regrettable in terms of forced generalizations by interest groups (some of them large landowners).

One could foresee that one day those interested in Amazonian lands would push again to change the percentage to be preserved within each Amazonian estate. The simplistic argument deserves a decisive and radical counter reply. For them, if in the southern-central regions of Brazil the rate of internal protection of the forest vegetation is 20%, why does the law requires 80% in Amazonia? But nobody has the courage to analyze what happened in the ecological areas of São Paulo, Paraná, Santa Catarina, and Minas Gerais with the percentage of 20%. At the inland plateaus of São Paulo the sum of deforestations reached scenarios of widespread dilapidation.

In these important areas dominated by forests and pockets of cerrados and savannas, only the integrated conservation of the Serra do Mar, involving the Atlantic forests, soils and water sources of the remarkable ridge, was able to safeguard the orographic ecosystems of this rugged region. The remaining, at the *"mares de morros"* (sea of hills), mounds and floodplains of the Middle Paraíba and Paulistano Plateau, as well as the majority of the Serra da Mantiqueira, suffered a miserable dilapidation. This is what someone in Brazil – now talking about smart and bioethical people – do not want repeated in the Brazilian Amazon, in an area of 4,200,000 km^2.

The lawmakers of the Forest Code say that the very deforested and degraded areas could be subjected to a "(re)forestation" by homogeneous species, hereby thinking of eucalyptus and pine. This is a proof of their great ignorance, for they do not know the difference between reforestation and forestation. The latter, intended by them, is a fact of exclusively entrepreneurial economic interest, which unfortunately is not intended to preserve biodiversities, being that, they seek to ignore that for very badly degraded areas, a plan was made for the (re)organization of the remaining areas, with the focus on reinvigorating the economy of small and medium landowners: the FLORAM project. The "eucaliptologists" lose ethics and foresight of ethical impacts when they lease areas for thirty years, of unwary landowners, hereby preferring areas still endowed by fertile tropical soils, of the oxisoil type, and avoiding degraded areas of bare hills reduced to trampled hypsometric soils, similar to the existing prototype of the High Paraíba Plateau, in São Paulo. By leasing lands of unwitting landowners, for use over 30 years, and knowing that the landowners could already be deceased when completing the term, this creates a major legal problem for the heirs, whereas at the end of the negotiation the companies cut all the eucalyptus or pine trees, leaving myriads of stumps stuck in the ground, a scenario that prevents the re-use of that parcel for agricultural activities. All this should be known by those who fiercely defend a validating Forest Code.

For all reasons, we are obliged to criticize the persistent and repetitive arguments of Congressman Aldo Rebelo, whom we know for a long time and from whom we always expected the best. At the moment we have to remind him that each of us has to think on our own biographies, and, being a politician, he has to honor the history of our political parties. Above all, this concerns especially political parties which claim to be leftist and which could therefore never concoct projects fully directed towards the personal interests of large landowners.

We insist that in any revision of the current Forest Code, one should focus on the guidelines based on the large natural regions of Brazil, especially in natural domains very different from each other, such as the Amazon and its very extensive tropical forests, and the dry Northeast, with its different types of Caatingas. These are two opposite regions concerning their physiognomy and ecology, as well as in view of their social and environmental conditions. By taking sides for the great domains which are technically and scientifically managed by federal executive agencies we would have to connect specific institutions of the Brazilian government with similar state institutions. There are regions like the Amazon where this involves connecting to nine Northern states of Brazil. Regarding the Brazilian Atlantic Tropical forest, the Federal Government agencies – IBAMA, IPHAN, FUNAI e INCRA – would have to maintain connections with various similar sectors of the state governments from the North to the South of Brazil. And so on.

While the whole world advocates a radical reduction of CO_2 emissions, the proposed reform project for revision of the Forest Code at the Federal Chamber defends a process implying a wave of deforestation and uncontrolled carbon dioxide emissions, a fact observed by many critics in various studies and interviews.

It seems to be very difficult for those not initiated in cartographic scenarios to realize the effects of a deforestation in Amazonia of up to 80% of pristine rural estates. In any area of the Amazonian territory, where plots can be established allowing a deforestation rate of up to 80%, there will be a chaotic patchwork of deforested areas, with narrow and poorly preserved inter-property strips. Reminding that, in the review propositions, properties starting from a few dozen hectares up to 400 hectares would be entitled to the total deforestation of their land, I feel obliged to say that at the medium and long run there would be an infernal kaleidoscope on the total surface of any area in the Amazon. In this case, the edges of forest remnants, in between the plots would be at the mercy of the slashing of trees endowed with hardwood. In addition, the animal biodiversity would certainly be the first to be affected, in a radical way.

A symbolic cartography of deforestation in properties of different sizes, allows a virtual foresight of what would be the virtual dynamics of regional deforestation scenario, envisioned at medium term, based on real events already occurred in the valley of the Tocantins River (Pará) and the inland plateaus of São Paulo and Minas Gerais.

Unfortunately, it has been impossible to understand the framework in process that will take place in Amazonia, due to basic changes that were directed onto the Forest Code.

The panel of dilapidation brought about by the lawmakers tends to be scary. Only people who understand geographical areas can assess the level of progressivity that deforestation will carry many times over. In a worthy article, Marta Solomon, from Brasilia, managed to publish in the newspaper *O Estado de São Paulo* (dated April 22th, 2011), under the title "Forest Code", assessed that by 200 thousand km^2 of forest would be devastated, when taking into account the excessive validation of the so-called "Legal Reserves" within large properties in the Amazon. The worse, furthermore, is that the vision of the future, at various depths of time, is progressive and uncontrollable, especially by the audacity of people who engage in "business in Amazonia." Some time ago, a senior government official said that "the Amazon could not remain intact, because 20 million people live there." As if his arguments by any chance would favor the poor and unappreciated.

In the critical and progressive vision of the future, the consequences of deforestation for estates of different sizes could be seen, i.e. huge properties being deforested without any control or surveillance, comprising 80% of a terrain in any property of the immense Amazonian territory, while next to these large properties, so-called "family farms" or smallholder units of up to 400 hectares, (...) would be extricated for total devastation. Hereby, the greatest absurdity is the fact that the total deforestation of a property of 400 times 10,000 square meters, would eliminate even the possibility of planting Amazonian species at the forest edges for food or commercialization. It is incredible that those who intend to review a Code, do not know the importance of using moisture and light from the forest edge to plant *açaí* and *pupunha* (palms), *cupuaçu*, bananas and papayas by taking advantage of this effect. Considering that family properties of up to 400 hectares may be allowed to dilapidate all the forest from their land is one of the biggest and most dangerous mistakes of the Code proposal under review, even more so because any area of up to 400 hectares, in any part of Brazil, could be considered as a farm.

Losing land without any vision of regional planning, 400 times 10,000 square meters here and there, and moreover 80% of all large estates, involving 500, 1,000 or 10,000 times 10,000 square meters, (or 100 times 10,000 square meters or 10,000 or more hectares), is the great crime for which they push in support for a Code, made on ignorant foundations. Assuming in principle that from afar they do "business in the Brazilian Amazon," with the sale or resale of allotted estates and sales of timber from regional trees transported through rivers or trucks to different regions of Amazonia (Breves, Santarém), or with some added value to the Southeast of Brazil or even distant areas of the world (China, USA).

In the case of Amazonia, which concerns us most, ax or chainsaw loggers – followed by syncopated burns – devastate the region along its roads, its secondary branches and sub-branches, reaching radically the fish-bone patterns of the allotments made in speculative blocks within the biodiverse forests. Parcels of up to fifty to one hundred hectares, considered small in Amazonia, were sold to unwary residents of distant regions. In this latter case, the many buyers, who could not even arrive to the site of land purchased from a distance, gave up their estates for smart and persistent timber companies, which can be seen and analyzed through satellite images of northern Mato Grosso, the Middle Tocantins river, the Bragantina zone, South-eastern Acre, Rondônia, West-Northwestern Maranhão, and several other sectors of Amazonia.

We insist to foresee that if there is a Code which limits the legal reserve for the protection of forests to only 20% of the total space of each property, whatever its size, from 400 to one million hectares, the razing on the medium term will be unimaginably large and progressive.

One of the most frequent justifications used by those who are favorable for the expansion of deforestation on each property of land in Amazonia, is that this would mean more employment for Amazonian workers. However, few remember that in many farms and small farms in the Brazilian Amazon the semi-slave labor predominates. Since the beginning of the expansion of the so-called frontiers, said agricultural, irregular or temporary, manual labor predominated for ax and chainsaw loggers, ranchers and eucalyptus planters, being that, in the rare areas of better soils, the traditional back-and-forth kind of work for land preparation and planting was established for limited periods, as well as several activities afterwards at harvest time. Truckers made bizarre penetrations to reach hardwood trees sites or carrying trunks of trees to sawmills or to remove products of rare commodities. Now, in areas of soybeans, sugar-cane, and very eventually rice plantations, only overbearing foremen earn fairly.

Those looking for any job on a farm, even temporarily, suffer of a tragic and very tiring drama. To reach the farm chosen some of them have to walk for miles on the narrow trails of the forest, with their withered pack of unassuming clothes, until reaching the properties at which they can perform manual labor. Whether it is for soil preparation or planting; expansion of pastures for cattle; the cutting of trees for detention of so-called productive spaces; whether at fast and exhausting work on harvest times. When they are fired, they are forced to return to roadside areas where there are rustic villages or pseudo-commercial "streets".

Since 1972 we have followed the problems created by authoritarian foremen on Amazonian properties belonging to individuals or groups of alien people. Conflicts of many different types occur between the poor forestry-rural workers and landowners of all kinds. There is a permanent resistance in face of the remuneration of those who come from the outside compared to those who were born in the Amazonia itself. Conversely, the behavior of the landowners in relation to the few tracts of fertile land belonging to Indian reservations is catastrophic and almost insoluble. One day I met at an airport a farm owner, who would travel to the Amazon in Northeastern Roraima, where he owned lands. I asked him how was the relationship between his comrades and the Yanomami Indians of the region, and the answer quickly and unethically: "Towards them, it is my foreman who answers, by raising his dangerous machete."

At one occasion, at the end of a visit to a farm dedicated to cattle, we were asked to take with us a sick fellow on our return, who was very ill, for a visit to a pharmacy. In fact, he was someone who contracted a severe type of malaria, referred to as "malignant tertian fever." One cannot talk about the sad state of the poor worker. At the distant pharmacy, we learned that in similar cases the only action was an aggressive cocktail of drugs, through which the poor patient either "improved or died".

On the roadway between Rio Branco and Brasiléia (Acre), we could feel the hatred that some young people had for what they called *"paulistas"*, whom had bought local land during the roadway construction works. The interfluvial deforestation caused the headwaters of the *igarapés* to dry up; and much of the deforested properties remained without any productive activity. The explanation of local people for this was: it was the fault of the alien owners because they never wanted any partnership with us, who have much more experience in local agricultural activities. Note that by using the term *"paulista"*[1] they refer to any person coming from the southern-central part of Brazil. As in this vast area, all migrants are called *"baianos"*[2], regardless of where they come from.

Having come this far in our considerations, it is essential to also mention activities of smallholders, endowed with the most fertile lands, of limited dimensions, such as floodplains of rich fluvial-alluvial soils along the Amazon River, or small areas of land endowed with oxisoils from the decomposition of basalts or diabases [unfortunately, however, these latter areas are quite rare, involving in its total space less than eight thousand square kilometers] of the Amazonian territory. Or in a model located at seasonal dry margins of the Acre River; or, where watermelons, melons and some edible plants thrive in a linear manner, or at the remaining forest edges on the terrains of failed projects, where the important and famous RECA project was established. There was a time when much had been said on extractive reserves, from the Chico Mendes' Acre, to all of the Amazon territory. Evidently, there was much exaggeration throughout this campaign, both sympathetic and impracticable. But, fortunately, it so happens that a much more complex and diverse proposition, which may have a wide application in the short and medium term in many regions of the Amazon which introduced more logical and productive activities, without eliminating completely the complementary sense of extractive activities. It concerns a pioneering model, invented by a French ex-priest, of rural origin, whom after working in Paraná went to Acre with the idea of invigorating and reusing degraded areas. After talking with the clever Bishop Don Grec, in Rio Branco, the idealistic former priest decided to make an extremely valid and almost scientific experience, because it used the so-called edge effect to start plantations with local Amazonian fruit species, such as *açaí* and *pupunha* and *cupuaçu*.

His project was carried out in cooperation with Amazonians living on the border between Rondônia and Acre, with its initial focus on the small town of Nova California.

No government realized how much that project, which was installed and developed locally, could be useful for other areas of remaining forest edges. Not to mention that within the heart of the forest the extractive project so dear to the companions of the extraordinary *acreano*[3] Chico Mendes continued. Besides, the so-called Joint Consortium for Economic "Reforestation" (RECA), had a didactic character for the members that had joined the work, producing Amazonian fruit species and edible products important for their diet (such as *açaí*, pineapples, nuts and, especially, cassava). At the edge of the forest, due to strong light and moisture of fallen leaves and branches, the production is much higher, in favor of the Amazonians, such as banana

1 Translator's note: *Paulista* is someone born in the state of São Paulo.

2 T.N.: Someone born in Bahia.

3 T.N.: acreano: born in the Brazilian state of Acre.

and papaya trees, and various other fruit trees. Much remains to be analyzed from this famous agroforestry project, which unfortunately was very little understood by technicians and rulers.

Among the changes intended do the current Forest Code there are some extremely questionable topics. When discussing the size of smallholder properties these were defined as having between a few dozen hectares to up to four hundred hectares. This fact means that all small and medium productive or partially utilized properties, of up to 400 hectares could be completely cleared. The fact that hereby the properties of said smallholders up to a size of 400 hectares can be completely cleared of forest is a total nonsense. This is an excessive flexibilization which will produce a destructive mosaic of forests along the roadways, roads, small rivers and *igarapés*. It's a tragic scenario for the future in process within the Brazilian Amazon. However, properties of between 100 to 400 hectares, which retain a reasonable percentage of forests in the surrounding areas could receive similar schemes as with the RECA project, on the edge of the forest remnants. This was not considered, not even superficially, by the creators and lawmakers of the new Forest Code. That is why we leave here, beyond a critical, which we judge absolutely necessary, a proposition of additional activities for small and medium family properties. Reminding that those who criticize have to prepare well-planned propositions to resolve the situations considered negative.

We further note that the idea of reducing to 15 meters the protection borders of ciliary forests (riparian mini-biomes) has an extremely generic character, of dubious applicability. In our view one cannot limit the protection of river edges in the Amazon valley by and large in terms of a few meters wide. Rather, it is necessary to consider the facts related to *igarapés*, small rivers, rivers and "parás" (large rivers). The impression that one gets is that by determining an overall width for protection, deforestation would be possible at the level of all the spaces between the edge of watercourses and far beyond, up to the interfluves of hills or slopes of small Amazonian hills. There is a whole lecture to be given about this problem which tends to create extremely chaotic scenarios relative to the future at different depths of time.

A near-final comment: one cannot create any project of national interest by only thinking of favoring just one present generation immediately in terms of speculation with ecological areas, even more so because it's our opinion that we should think about the success of all human groups throughout a longer period: in this case, a bioethical question about the future. Without thinking of the great capacity that the whole of the vast preserved zonal forests of Amazonia holds in relation to the climate on planet Earth; an issue which worries all sensitive researchers around the world, as well as others who hope that Brazil will effect an integrated protection of the largest area of forest vegetation remaining in the equatorial and sub-equatorial regions of the world. It will be very sad, culturally and politically speaking, that people from different parts of the world, once reading about the absurd changes intended for the Brazilian Forest Code, would say that it is proved that "Brazil does not have capacity to rule and manage Amazonia," even if in other countries there is a permanent interest in acquiring timber from the Amazonian regional territory at ridiculous prices. Sad phrases, which have always been said when tragic events occur in our main area of forest vegetation with an extension of several million square kilometers.

The utopia of a development with as much as possible standing forests cannot be eliminated on principle due to radical changes of the Forest Code, being necessary to think in terms of the total territory of our country, under an enlarged and correct Biodiversity Code. That is, a thought which involves our great forests (Amazonia and Atlantic Tropical Forests); the domain of Caatingas and Rugged wilderness; central plateaus with Cerrados, Cerradões and savannas; southern-Brazilian plateaus of araucarias, mixedwood plains of Rio Grande do Sul, and strongholds and mini-biomes of the Brazilian coast, the Pantanal of Mato Grosso and the transition and contact borders (core-areas) of all Brazilian morphoclimatic and phytogeographic domains.

It would be necessary that the alleged reformers of the Forest Code would draw on paper the limits of the plots of 500 to thousands hectares, thereby pointing out within each plot parcel indications of the 20% corresponding to said forests intended for preservation. And, observing the simulated result of this mapping, could realize that the path of slow and progressive destruction would create some scenarios of devastation similar to what happened in the confines of the long roads and its branches, within the areas of the blocks designed for selling lots of 25 to 100 hectares, where the devastation of forests within each block was complete and inconsequential.

In a timely fashion, as an addition to this work, we will make important warnings to rulers and politicians. We have no doubt that the three groups of problems that most affect the future of Brazilian nature depend on the pressure from a few large landowners (not all) with a fanatical drive for their interests, and the neo-capitalist real estate brokers who choose the more chaotic nodal points to rise buildings of all kinds, without thinking about the mobility of the local and sub-regional population. And finally, the special case of forest dilapidation in between roads, avenues and highways, increasing the pressure for an unusual kind of "global village", as in the fateful example sketched between Granja Viana and Alphaville, all of this under the incentive of mayors eager to raise taxes, without thinking of the consequences of a total lack of balanced planning.

São Paulo, May 9th, 2011.

AZIZ NACIB AB'SÁBER

1 SCIENTIFIC KNOWLEDGE RELATED TO THE CONSTRUCTION OF ENVIRONMENTAL LEGISLATION

Brazil witnesses an intense debate on its Forest Code. In essence, what is discussed is the future of Brazilian flora, with its implications for human activities and consequences of political decisions on environmental, social and economic dimensions across the national territory and to all society.

The conservation of floristic heritage and the establishment of rules for its use constitute premises for the existence of a Forest Code. The rationale of various legal representations of the Forest Code keep a causal relationship between its institution and the protection of elements of the natural environment (soil, air, water, flora, fauna, as well as their functional relationships) and incorporate an anthropocentric perception of life protection and of the productive activities, in perpetuity.

The formulation of a public policy on a public good, such as the floristic heritage of Brazil, shall result from a consensus agreement among all levels of government and all stakeholders, including the scientific community. In this process, it is also necessary to consider public policies already formulated for other issues such as the environment, agriculture and energy, as well as the international commitments already made by society through the government.

As a result and in response to a demand of the Brazilian scientific community, the Brazilian Society for the Advancement of Science (SBPC) and the Brazilian Academy of Sciences (ABC) established a Working Group (WG) to support the dialogue with perceptions of a strictly technical-scientific character. This document summarizes the work carried out by the WG which focused, in an illustrative form, the following topics:

1. Agricultural use of the national territory: potentials and challenges of the Brazilian legislative framework;

2. Soil and water losses resulting from land use: erosion and its impact;

3. The impacts of the Forest Code on biodiversity;

4. The importance of Permanent Preservation Areas (APPs) and Legal Reserve (RL) in rural estate, including environmental and economic benefits of APP and RL;

5. Natural hazards associated with land use in urban areas.

The matter is broad and prolific. There is a growing production of scientific knowledge which has its own dynamics. Therefore, this document points to the need for a broader, deeper and more detailed further work on the already discussed topics, as well as others which should also be properly appreciated.

1.1 AGRICULTURAL USAGE OF THE NATIONAL TERRITORY: POTENTIALS AND CHALLENGES FOR THE BRAZILIAN LEGISLATIVE FRAMEWORK

1.1.1 Land Use Potential

The appropriate use of land is the first step towards the preservation of natural resources and attaining agriculture sustainability (MANZATTO et al., 2002a). Therefore, each parcel of land should be allocated according to its potential, carrying capacity and expected economic productivity, with minimal environmental degradation, ensuring that the natural resources are under the best potential usage and at the same time being preserved for future generations (LEPSCH et al., 1991).

Table 2 provides an overview of the potential for crops, husbandry and forest use of lands in Brazil by region, without considering legal constraints, but showing the different levels of management, potential land use categories and types of land use. From the analysis of this table, based on Ramalho Filho and Pereira (1999), one realizes that there is a great predominance of lands suitable for crops in relation to the other activities. Throughout the different technological levels, the country disposes of approximately 65% of its territory (5,552,673 km^2) consisting of lands with a potential for crop and husbandry.

Table 2 – Potential of the lands of Brazil, by region and management level for different types of uses listed.

Use Type	Region*	Potential land use categories by management level (km²)								
		Management level A			Management level B			Management level C		
		Good	Regular	Restricted	Good	Regular	Restricted	Good	Regular	Restricted
Crops [1]	N	25.850	204.982	2.046.873	106.878	1.751.585	427.377	30.032	1.731.001	326.120
	NE	13.394	145.079	435.307	15.555	421.060	321.150	7.482	436.452	267.025
	SE	22.715	118.648	147.506	102.929	130.785	330.767	78.230	266.287	45.966
	CO	2.508	68.048	358.065	10.708	385.902	579.222	107.426	636.919	231.460
	S	46.191	96.824	142.717	64.975	171.474	162.399	38.388	233.857	48.078
	Total	110.658	633.581	3.130.468	301.045	2.860.806	1.820.915	261.558	3.304.516	918.649
Planted pasture [2]	N	-	-	-	-	234.113	4.935	-	-	-
	NE	-	-	-	4.908	91.636	27.967	-	-	-
	SE	-	-	-	2.957	40.215	96.807	-	-	-
	CO	-	-	-	-	339.309	22.119	-	-	-
	S	-	-	-	34.125	16.836	10.210	-	-	-
	Total	-	-	-	41.990	722.109	162.038	-	-	-
Silviculture [3]	N	-	-	-	-	-	3.816	-	-	-
	NE	-	-	-	1.939	33.908	71.854	-	-	-
	SE	-	-	-	-	58.619	9.415	-	-	-
	CO	-	-	-	-	139.418	71.006	-	-	-
	S	-	-	-	3.127	7.322	11.238	-	-	-
	Total	-	-	-	5.066	239.267	167.329	-	-	-
Natural grassland [4]	N	-	-	9.469	-	-	-	-	-	-
	NE	287	141.564	290.781	-	-	-	-	-	-
	SE	-	945	77.084	-	-	-	-	-	-
	CO	-	-	209.181	-	-	-	-	-	-
	S	19.789	10.359	3.102	-	-	-	-	-	-
	Total	**20.076**	**152.868**	**589.617**	-	-	-	-	-	-

[1] Lands suitable for crops as well as for other types of less intensive uses, such as pastures and silviculture.

[2] Lands with a sole potential for pastures; not suitable for crops.

[3] Lands with a sole potential for silviculture; not suitable for crops and pastures.

[4] Lands with exclusive occurrence of natural grasslands.

Source: Ramalho Filho (1985), Ramalho Filho and Pereira (1999), Manzatto (2002b).

* Regions of Brazil: North N, Northeast NE, Southeast SE, Midwest CO, South S

However, when analyzing the crop activity in all regions of Brazil, it is observed that the management levels interfere with the definition of potential lands which are suitable for this purpose. At management level A (primitive), there is a predominance of land with severe limitations (Restricted class) in all regions of the country, which means that a low use of technology limits the cultivation of certain crops by farmers (Table 2).

At management level B (underdeveloped), there is some balance between the lands with moderate and strong limitations (Regular and Restricted potential class) in most regions of Brazil, while at management level C (developed; highly industrialized) occurs a strong predominance of lands with moderate restrictions, considering the current technological adoption level in the country.

It is noteworthy that even areas considered suitable for the cultivation of crops with regular or restricted potential have limitations, indicating the fragility of these lands to agricultural use and the need for a judicious planning when adopting conservation management practices.

The large territory, the variation of the land's productive potential and environmental and socioeconomic diversity determine patterns of land use, characterized regionally by different forms of use pressure and actual intensity of degradation. However, when considered globally, the changes in land use and soil cover are so important that even affect fundamental aspects in the functioning of the global land system.

The impact of these changes, as quoted by Lambin et al. (2001), reflects upon the biotic diversity (SALA et al., 2000), contributes to local and regional climate changes (CHASE et al., 1999), as well as to global climate change (HOUGHTON et al., 1999), besides having a direct influence on soil- (TOLBA; EL-KHOLY, 1992) and water degradation.

1.1.2 Changes in land use

Land use can be understood as the changing way in which the geographic space is used by mankind. Changes in land use occur largely because of market demands for fibers, energy and food, new agricultural technologies and environmental regulation. They represent an important factor, conditioning global climate change (MEYER and TURNER 1996) and may bring serious implications for sustainability in its three dimensions (social, economic and environmental) and the production of food, fibers, biofuels and raw materials.

Therefore, the need of understanding the causes of changes in agriculture land use has long been emphasized by the Committee on Global Change Research (1999). Lambin et al. (2001) point out that such changes in land use and cover are related to environmental and developmental policies. These authors concluded that the changes are not due solely to population growth or poverty, but also as a reaction from the population to economic opportunities mediated by institutional factors.

Hereby, opportunities and constrains for new land uses are created by local and national markets and policies. However, global forces are the main determinants for land use changes, enhanced or attenuated by local factors, such as gains in productivity, infrastructure and public policies (Forest Code and Economic Ecological Zoning – ZEE).

Additionally, according to the IPCC (the Intergovernmental Panel on Climate Change) emissions of Greenhouse Gases (GHG) from the LULUCF (Land Use, Land-Use Change and Forest) sector represent 17% of total global emissions. In Brazil, this sector accounts for approximately 55% of total emissions, mainly from deforestation. The burning of vegetation, a common practice after slashing, is another factor of impact on natural resources, water resources and biodiversity.

Meanwhile, reforestation, averted deforestation (Reduced Emissions from Deforestation and Forest Degradation – REDD) and forest conservation are relevant forms of land use for the mitigation of climate change and are closely associated with the occupation of land by agriculture.

Such changes are still a spatial and transversal phenomenon, intrinsically correlated to most of the processes of environmental deterioration and consequent impairment of the ecosystem services associated to the energy balance, essential for the sustainability of agricultural production activities.

The hydrological cycle regulation, the maintenance of climatic seasonality, the mitigation of greenhouse gases (GHG) emissions and the sequestration of carbon dioxide (CO_2) from the atmosphere and its accumulation in biomass and soil, as well as minimizing the energy consumption of agricultural activities are environmental benefits which require spatial resources and the monitoring of land use and soil cover for its quantification (ANDRADE et al., 2010; DUMANSKI et al., 2010a, 2010b; FREITAS et al., 2007), aiming at eventual financial compensations arising from environmental services in rural areas.

Current lands use

Table 3 presents a summary of the main forms of land use as given by the 2006 Agricultural Census. The total land occupied by rural estates is 329.9 million hectares, representing 38.7% of the national territory. In these lands, the main agricultural activities account for about 27.1% of the territory. The lands are hereby being occupied by various crop and husbandry practices, as is also demonstrated through data collected by the Ministry of Agriculture (MMA/Probio), for the base year of 2002 (Figure 1).

Analysis of the country's productive structure reveals that the main land use form is cattle husbandry, occupying 18.6% of the Brazilian territory (158.8 million hectares). This implies that 48.1% of the agricultural area covered by the census is occupied by natural and planted pastures, which corresponds to 2.7 times the land used for the production of permanent and temporary crops (59.8 million hectares).

The pasture areas of the Brazilian Midwest stand out above the others with about 58.5 million hectares, followed by the Northeast, with around 30.5 million hectares; Southeast, North and South (Table 4).

It should be noted, however, that the use of natural pastures is still quite widespread, despite differences in climate, land value, cultural patterns and territorial dimensions. In general, it can be inferred that this kind of activity is a result of land use under low use of technology and/or marginal lands, with climate and/or soil limitations or either degraded, abandoned or underutilized areas.

Considering only those aspects of the soil, the area currently occupied by crops is relatively small compared with the potential area of the country especially in the Midwestern region (MT, MS and GO). This increase in production occurred during the past two decades and resulted in an area with 59.8 million hectares under crops. Of these, in the 2010 harvest, the estimated area planted with grains, leguminous plants and oilseeds was 46.7 million hectares, being due, largely, to the conversion of areas previously occupied by pastures, especially in the states of Maranhão, Mato Grosso, Mato Grosso do Sul, Tocantins, the west of Bahia, the south of Pará and the cerrados of Piauí.

The association of this expansion with the gain in productivity has also resulted in an increase of over 100% in grain production when compared to the 1996 harvest, reaching about 148 million tons in 2010. Among the grains, soybean showed the highest growth in terms of area and production thanks to agricultural research which developed and introduced new varieties adapted to the soil conditions of the Cerrado biome, mainly in Goiás (GO), Mato Grosso do Sul (MS) and Mato Grosso (MT).

Table 3 – Current land use in Brazil.

Forms of land use	Area (hectares)	% of land in use
Permanent crops	11.612.227	3,52
Temporary crops	44.019.726	13,34
Crops with area planted with forage for cutting	4.114.557	1,25
Crops with cultivation of flowers (including hydroponics and plasticulture), nurseries, greenhouses and polytunnels	100.109	0,03
Natural grasslands	57.316.457	17,37
Degraded planted grasslands	9.842.925	2,98
Planted grasslands	91.594.484	27,76
Woodlands and/or natural forests for permanent preservation or legal reserve	50.163.102	15,2
Woodlands and/or natural forests (not including permanent preservation areas and those under agroforestry systems)	35.621.638	10,8
Woodlands and/or forests planted with essence oil trees	4.497.324	1,36
Agroforestry systems	8.197564	2,48
Ponds, lakes, reservoirs and/or areas of open water bodies under aquaculture	1.319.492	0,4
Buildings, infrastructure or roads	4.689.700	1,42
Degraded land (eroded, desertified, salinized etc.)	789.238	0,24
Land not suited for agriculture (swamps/ marshes/ sand mines, quarries etc.)	6.093.185	1,85
Total Land in use	**329.971.728**	**100**

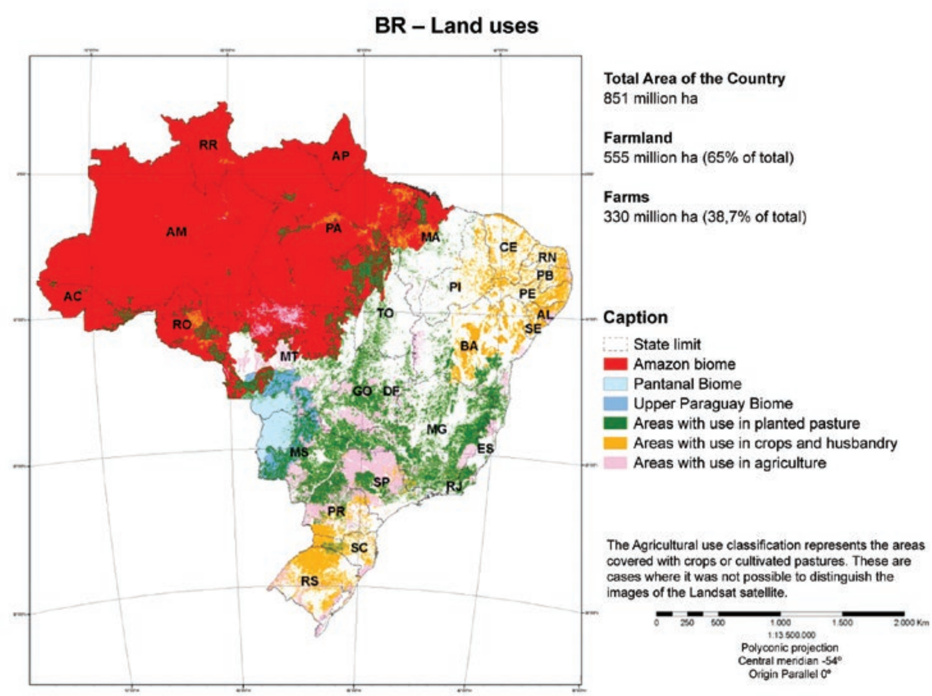
Source: 2006 Agricultural Census (IBGE, 2006) Brazilian Institute for Geography and Statistics (IBGE).

Table 4 – Current use of land under pasture per Brazilian region.

Region	Type of use			Total
	Natural grasslands	Degraded planted grasslands	Planted grasslands in good conditions	
Midwest	13731189	3338809	41448215	58518213
Northeast	16010990	2233350	12295265	30539605
Southeast	10853455	1653121	15054568	27561144
North	5905157	2168266	18450751	26524174
South	10815667	449378	4345683	15610728
Total	**57316458**	**9842924**	**91594482**	**158753864**

Source: 2006 Agricultural Census (IBGE, 2006).

Figure 1 – Current land use in Brazil.



Source: MANZATTO et al. (2009).

Based on the data from Table 5, it is possible to draw conclusions about the streamlining of land use in the country compared with data on land potential. It appears that crops and husbandry activities are more intensive in the South, Southeast and Midwest. The Northeastern region, although quite degraded by human activities, presents an intermediate intensity of use, due to climatic limitations on part of its territory, recording, however, a strong expansion in grain production recently. Meanwhile, the Southern region has the highest percentage of area with high intensity of land usage (41%), differentiated from the other regions of the country by the predominance of small rural estates and agriculture increasingly industrialized, usually organized into cooperatives.

In the Northern region, there is low intensity in land use on 95% of its territory, with the states of Amazonas and Amapá showing low levels of human activity. In this region, the areas of greatest intensity in land use include eastern Pará, Tocantins, the north of Mato Grosso and Rondônia, which form the boundaries of the agricultural frontier. The forms of land use in this strip include timber extraction and the establishment of pastures. Currently, there is a trend for grain production, eucalyptus and palm oil in the region.

This data confirmed the estimates on the land use potential of the lands in the country, its fragility and the great potential for agricultural intensification, through the adoption of appropriate technologies, increasing production through the increase of productivity. Considering the environmental value of the Amazon Forest – the largest remaining rainforest in the world – and the great availability of degraded land suitable for intensification of its current use in other regions, one concludes that its usage with large intensive crop or husbandry systems may pose unnecessary risks to the sustainable use of its natural resources (LUNZ and FRANKE, 1997, 1998).

Table 5 – Intensity of agrosilvopasture use of municipal lands by regions in Brazil.

Intensity	**Region**									
	N		**NE**		**CO**		**SE**		**S**	
	Surface									
Class of Pressure	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Low	3682612	95	1214470	78	761442	47	291792	32	136168	24
Medium	148679	4	233031	15	500558	31	360400	39	200116	35
High	35722	1	104275	7	359367	22	271244	29	240472	41

Source: Manzatto et al. (2002b).

The country has a significant area with soils suitable for irrigation, estimated at 29.5 million hectares (Table 6). However, the use of irrigated agriculture in Brazil is still low when compared to rainfed agriculture, although the share of production from irrigated crops is already significant.

In this sense, a study produced by the Brazilian National Water Agency (ANA, 2004) states that:

> *[...] although there is a small percentage of irrigated area in our lands, compared to the cultivated area, in 1998, irrigated agriculture produced 16% from our food crop harvest and 35% of the production value. In Brazil, each irrigated hectare is equal to three hectares rainfed agriculture concerning physical productivity and to seven in economic productivity.*

A more precise notion of the percentage of irrigated land in relation to the total planted area in Brazil can be obtained from the work of Cristofidis (2008), who considered the data on the 62 main crops in the base of SIDRA/IBGE from 2005 was considered, concerning the harvest of 2003/04, especially for showing a greater number of permanent crops in which the practice of irrigation was adopted.

The author points out that fruit culture and, more recently, sugar-cane use irrigation technologies. The total planted area was 58.461 million hectares, of which 11% with permanent crops and 89% with annual crops. The area under irrigation in the country over 2003/2004, estimated at 3.44 million hectares, was equivalent to 5.89% of the total planted area for the production of the 62 major crops (Table 6).

This is far below the world standards and the opportunities offered by the country, becoming an alternative for the intensification of lands currently in use by agriculture by the adoption of sustainable systems and the rational use of the water.

The practice of irrigation in the country experienced a great expansion until the mid 1990s. Afterwards, there was a growth stagnation, which continues up to date. The exponential growth of irrigation, especially in the 80s, was a result of the National Program of Rational Utilization of Irrigable Floodplains (PROVÁRZEAS), established by Decree No. 86,146 on 06/23/81, and the Irrigation Equipment Finance Program (PROFIR), in the same year. The programs allowed the use of more than one million hectares of drained and/or systematized floodplains, benefiting about 40,000 producers and creating more than 150,000 direct jobs during its existence (1981-1988). However, this activity took place within Permanent Preservation Areas (APP), defined as such by the Forest Code, which generated a large environmental liability. More recently other programs are being implemented on this topic, which will be conducted in a way as to avoid generating new environmental liabilities (Table 6).

Table 6 – Irrigation indicators in Brazil.

Region	Planted area (Temporary and Permanent) *	Soils suitable for irrigation	Irrigated area	Irrigated area/ Planted area
	1.000 ha			%
North	2.560	11.900	100	3,89
Northeast	11.975	1.104	733	6,12
Southeast	11.751	4.429	988	8,41
South	19.222	4.407	1.302	6,77
Midwest	12.953	7.724	318	2,46
Total	**58.461**	**29.564**	**3.441**	**27,65**

Source: Adapted from Cristofidis (1999, 2008). (*) Area of 62 cultures, 2003/2004 harvest.

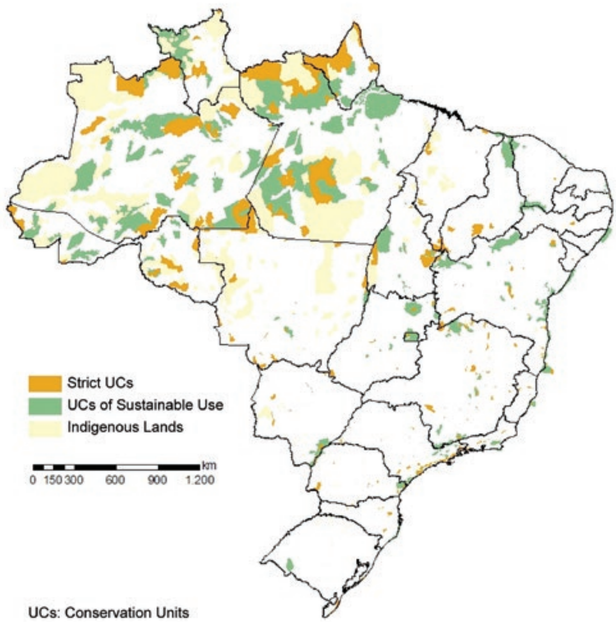
Areas of Conservation Units (UCs) already demarcated represent today about 120 million hectares or 14% of the territory (Table 7 and Figure 2), divided into strictly protected areas (approximately 5.5% of the territory) and sustainable use (about 8.9%).

With regard to indigenous lands, the areas already approved accounted for about 98.47 million ha in 2010 (estimates of EMBRAPA Satellite Monitoring) or 11.6% of the national territory.

The areas of farms with forests/natural woodlands/agroforestry systems covered by the Agricultural Census (about 85.8 million hectares) added to the Conservation Units and Sustainable Use may represent a regional alternative to the adoption of regional policies in any environmental compensations of agricultural activities, such as for example, the Legal MT Program.

Considering the lands covered by the Agricultural Census, the Indigenous Lands and the lands with use restrictions (Strict Conservation Units), the country has already allocated around 475 million hectares or 56% of its territory to several forms of occupation.

Figure 2 – Nature Conservation Units and indigenous lands in Brazil.



Source: EMBRAPA Satellite Monitoring.

Table 7 – Estimates of areas with native vegetation cover and Conservation Units.

BIOME	Mapped Area PROBIO	Vegetal Cover/ Water Areas		Strictly Conservation Unit (2)		UC of Sustainable Use(2)	
	(M ha)	(M ha)	%(1)	(M ha)	% biome	(M ha)	% biome
Amazon	423,50	382,86	90,51	38,13	9,12%	60,04	14,35%
Caatinga	82,58	52,61	63,72	0,81	0,99%	4,29	5,19%
Cerrado	204,72	124,92	61,02	5,15	2,53%	7,32	3,59%
Atlantic Forest	105,90	30,77	29,05	1,91	1,73%	3,69	3,34%
Pampa	17,82	9,15	51,3	0,09	0,49%	0,32	1,80%
Pantanal	15,12	13,38	88,46	0,44	2,91%	0,00	0,00%
Total	**849,64 ***	**613,69**	**72,27**	**46,54**	**5,49%**	**75,66**	**8,92%**

Source: Adapted from MMA/PROBIO - www.mma.gov.br/probio. (*) Area considered in the study. (1) Relative to the area of the country. (2) Estimate of EMBRAPA Satellite Monitoring.

General dynamics of agricultural use of the lands

Analyzing the Agricultural Censi of 1970, 1975, 1980, 1985, 1995-1996 and 2006, Gasques et al. (2010) observed that the number of rural establishments rose sharply until 1980, expressing the broad process of expansion and occupation of new areas that have occurred until then. From that year, there is some stability in the number of establishments of around 5.1 million in 2006. The mean area reduction observed since the beginning of the period reflects, among other things, the increased productivity of land and of the production factors generally obtained through investments in resource, workforce qualification and the results of agricultural policies.

The authors report yet that the use of land shows a significant increase in the percentage of areas intended for crops, which has been growing consistently over time. In 2006, its participation in relation to the total area was 18.14%. But the most relevant characteristic of land use in Brazil is the proportion of grazing areas, which has been maintained over time between 44.0% and 50.0% of the total area of establishments.

Concerning the ratio between pasture areas and herd size, the authors emphasize the sharp decline in the analyzed years. The ratio grows from 2.56 ha per animal in 1940 to 1.96 ha in 1970, and 0.93 ha in 2006. This ratio expresses the carrying capacity of pasture and indicates that the increase in this capacity can release land for other purposes.

In recent years, however, the trend in Brazilian agriculture has been that of a systematic production growth, mainly due to gains in productivity. Contini et al. (2010) evaluated the historical behavior of production, area and productivity for grains in the period 1975 to 2010 (Figure 3). While the area has increased 45.6% in this period, production has increased by 268%. The trend has been of a marked growth in productivity during the whole period considered. The verified downfalls are due more to the occurrence of droughts, such as between 2004 and 2006. The productivity indicator for grains increased from an average of 1,258 kg/ha in 1977 to 3,000 kg/ha in 2010.

Concerning the production of meat, Contini et al., (2010) found that its production also grew dramatically over the last three decades. From 1979 to 2009, beef production increased 5.42% per year, pork 4.66%, and poultry 8.45%. From 2002 to 2009, beef, fowl and pork increased 3.1%, 7.25% and 1.97% per year, respectively. This dynamic is related to the development of exports. It could have had a better performance if it weren't for the international economic crisis that started in September 2008.

While productivity gains in cattle husbandry have also been reported recently, in the extensive cattle ranching, stocking rates are still low, around 1 head/ha, according to the 2006 Agricultural Census. A small investment in technology, especially in areas with low stocking rates (< 0.5 head/ha), can extend this capability, freeing lands for other productive activities, or even avoiding new deforestation.

As examples of support for modernization and productivity gain in the cattle husbandry, it may be quoted the official and private programs for genetic improvement of the national breeding stock, which includes programs of genetic improvement, artificial insemination and embryo transplants, the integration of crops, husbandry and forests, confinement and semi confinement, good practices in husbandry and, recently, the ABC Program (Low Carbon Agriculture - TRECENTI, 2010). This program stands out as a policy for the intensification of land use in compliance with the Law (12,187 – 12/29/2009), which instituted the National Policy in Climate Change (PNMC), stating in its Article 11 that: "Sectoral plans for mitigating and adapting to global change will be established by specific decrees, aiming at the consolidation of a low carbon consumption economy".

PNMC defines important tools from a financial point of view for organizations which are developing actions to reduce GHG emissions, such as: a) fiscal stimulus packages; b) credit lines and specific financing of public and private agents; c) the establishment of a market for reduced emissions, with carbon credits considered as tradable securities on the stock market.

The actions developed in the group's action program, of which this work plan is a part, aims to support the achievement of the ABC program goals, including: a) the recovery of an area of 15 million hectares of degraded pastures (reduction of 101 Mt C_{equiv} – millions of tons in GHG in carbon equivalent); b) adoption of integrated systems of crop-livestock-forest (ILPF) on 4 million hectares (reduction of 20 Mt C_{equiv}); c) expansion in the use of zero-tillage (ZT) systems on 8 million hectares (possible reduction of 16 to 20 Mt C_{equiv}) (TRECENTI, 2010).

Even considering the productivity gains over the past decades (Figure 3), Brazil was one of the few countries worldwide to increase its agricultural areas, estimated at 278 million hectares or 27.1% of its territory. According to Sparovek et al. (2010), from this amount, about 61 million hectares with low and average agricultural productivity could be used for intensive food production. From the grand total, at least 83 million hectares are non-compliant with the Forest Code and should therefore be improved.

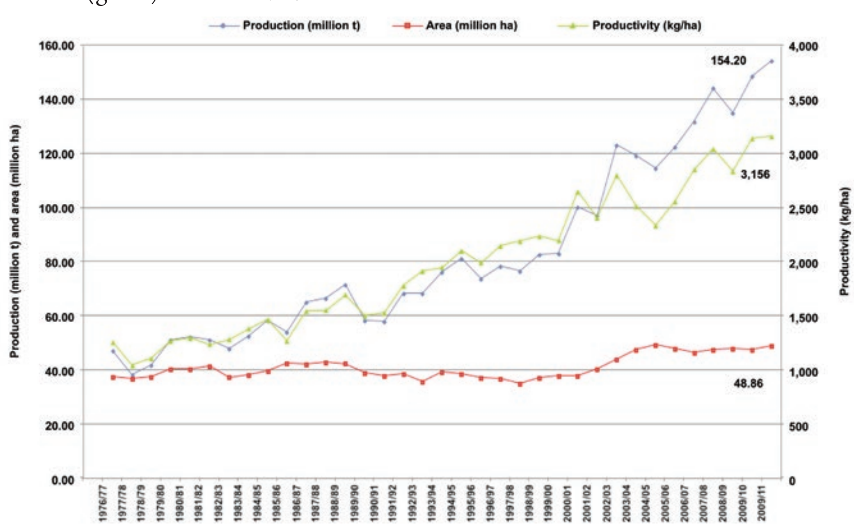
Nevertheless, the payment of any environmental liabilities by the agricultural sector must take into account its payment ability, as well as the benefits that the activity provides to society through productivity gains and food security, regardless of surpluses in the trade balance.

In this sense, França (2001) reports that the gross income from crops (rice, potatoes, onions, beans, cassava, corn, wheat, cotton seed, peanuts and soybeans), i.e., the monetary value of the production obtained by the producer decreased in approximately 40% during the 80s and 90s, revealing that every effort in productivity gain has, ultimately, been used to compensate the fall of relative prices paid to the grower, benefiting other segments of society.

Other authors, such as Souza and Viana (2007) and Geraldine (2005) also observed this downward trend of the amount paid to grower and the transfer of resources from the agricultural sector, understood as the loss or gain of income in relation to changes in relative prices. Silva (2010) reports that in the 1995-2008 period the evolution of the product was always greater than the evolution of the Gross Domestic Product (PIB) at current real prices. Therefore, the product grew to decreasing real prices. This, coupled with the increase of livestock production accounted for a loss of agribusiness income, absorbed by society.

Silva (2010) estimated that the transfer of accumulated income was approximately R$ 837 billion, being more pronounced in livestock than in the crops sector. Of this total, 47% were from the primary sector (46% of crops and 54% of cattle husbandry), 38% of the distribution segment, 20% of the agricultural related industry (62% of plant-based industry and 38% of animal), the input sector being the net receiver of R$ 41 billion. The study also indicated that the largest transfer done directly to society was of the basic sector, in the order of R$ 641 billion, 67% being from crops, and the rest from livestock.

Figure 3 – Evolution of cultivated areas (red), production (blue), and grains productivity (green) between 1975 and 2010.



Source: CONTINI et al., 2010.

Scenarios on land use and changes in land use

Estimates of the Ministry of Agriculture (BRASIL, 2010), indicate that the growth of agricultural production in Brazil will continue to occur based on productivity gains, with major increases in production rather than in occupied area.

Projections made by the Ministry indicate a sharp increase in food consumption on the planet, especially corn, soybean and wheat, for the period of 2009/2019. According to projections, the production of grains in the country (soybean, corn, wheat, rice and bean) shall increase from 129.8 million tons in 2008/2009 to 177.5 million in 2019/2020, i.e., an increase of 36.7%. Meat production would also suffer an increase of 37.8% over this period.

The studies also indicate that the average annual rate in growth of crop production will be 2.67%, while the expansion of the occupied area will be, annually, of 0.45%, shifting from 60 million hectares in 2010 to 69.7 million in 2020. The expansion will be concentrated on soybeans – with over 4.7 million hectares – and sugar-cane – with over 4.3 million hectares. Corn has a predicted expansion of around one million hectares, while other crops will remain with stable cultivated areas or even suffering a decrease.

In a recent study sponsored by the World Bank intended to support Brazil's efforts to identify opportunities for reducing its GHG emissions while promoting economic development, Gouvello et al. (2010) modeled future demands for agriculture land and the emissions generated by land use changes according to various scenarios, considering criteria such as agricultural land use potential, distance to roads, urban concentration, cost of transport to ports, declivity and the distance to converted areas.

According to the Reference Scenario designed for this study, approximately 17 million additional hectares of land will be required to accommodate the expansion of all activities during the period 2006 to 2030. In all of Brazil, the total area allocated to productive uses, which is estimated at 257 million hectares in 2008, shall pass through an expansion of 7 percent – reaching around 276 million hectares in 2030; 24 percent of that growth should occur in the Amazon region.

In 2030, in the same way as in 2008, the expectation is that pasture grasslands will occupy most of this area (205 million hectares in 2008 and 207 million in 2030). The growth seen over time to this total amount makes it necessary to convert the native vegetation in use for production, which occurs mainly in areas bordering the Amazon region and to a lesser extent in the states of Maranhão, Piauí, Tocantins and Bahia.

In the Low Carbon Scenario in Agriculture designed by the study, the amount of additional lands required for mitigation of emissions and carbon sequestration reaches over 53 million hectares. Of that amount, more than 44 million ha – more than double the projected land expansion in the Reference Scenario – would be dedicated to the recovery of forests.

Along with the additional land in the Reference Scenario, the total amount of additional land required amounts to more than 70 million ha, more than twice the total extent of lands planted with soybeans (21.3 million ha) and cane sugar-cane (8.2 million ha) in 2008, or more than twice the area under soybeans projected for 2030 in the Reference Scenario (30.6 million ha). To obtain the amount of additional lands required in the projected scenario, the option was to increase cattle husbandry productivity by considering three options: (a) promote the recovery of degraded pasture areas; (b) stimulate the adoption of production systems which involve fattening confinement; (c) encourage the adoption of integrated crop-cattle systems.

The increase in stocking rate resulting from the improvement of degraded areas combined with more intensive integrated crop-cattle systems and fattening confinement is reflected by a marked reduction in the demand for land, projected to be around 138 million ha in the Low Carbon Scenario, as compared to 207 million hectares in the Reference Scenario for 2030. The difference would be sufficient to absorb the demand for additional land associated both with the expansion of agriculture and cattle husbandry activities in the Reference Scenario, as with the expansion of the mitigation and sequestration of carbon, in the Low Carbon Scenario.

It is considered that, technically, this option is possible, since the productivity of Brazilian cattle husbandry is generally low and the existing confinement and crop-cattle systems could be expanded. Furthermore, the use of more intensive production systems could trigger higher economic returns and net gains for the sector's economy. The potential represented by the release and recovery of degraded pasture areas would be sufficient to accommodate the most ambitious growth scenarios for cattle husbandry.

The study also explored two important options for carbon removal: restoration of native woodlands and production forests for the steel and iron industry. In the case of restoration of forests, the Low Carbon Scenario considered the compliance of legal actions concerning a mandatory reconstitution, in accordance with legislation relating to the ciliary forests and Legal Reserves. In this sense, the Low Carbon Scenario gave rise to a "scenario of legality". Using these areas for reforestation, the study modeled the potential for CO_2 reduction. According to what was demonstrated by the scenario of legality, the carbon sequestration potential is high: a cumulative total of 2,9 Gt CO_{2equiv} over 20 years, or approximately 140 Mt CO_{2equiv} per year in average (GOUVELLO et al., 2010).

Such projections indicate that the country can improve any environmental liabilities without impairing production and the future supply of food, fibers and energy, maintaining the trend of recent decades, as long as income policies and territorial ordainment are implemented. As an example, the high cost for adopting new technologies in the field against the cost of incorporating new land on the agricultural frontier, especially in the Cerrado, where the costs of deforestation are still very low due to the use of practices such as burning, which in fact hampers any environmental planning.

Therefore, it appears that thanks to the Brazilian agricultural research and entrepreneurial activity of farmers, Brazil ranks first in the exportation of soybeans; has the largest commercial cattle herd in the world; is the largest exporter of coffee, sugar, orange juice and beef, besides occupying a prominent position in several others production chains. It is also one of the world's largest biofuel producers.

However, even considering the advances in conservationist agriculture and the success of tropical agriculture, the historical occupation process of the Brazilian territory resulted, in some cases, in the increase of pressure and negative impacts on the environment. Therefore, the waste of natural resources resulting from inappropriate use of land is a reality to be faced, leading to rethink this occupation in order to avoid the mistakes of the past and to promote a gradual environmental adequacy of rural activities.

Brazilian agriculture now has a new socioeconomic and environmental dimension and is largely responsible for the current Brazilian trade surplus. This activity demands science, innovation, modern technology and a careful attention as to their impacts on natural resources towards a green economy.

1.2 ENVIRONMENTAL IMPACT DUE TO LAND USE: SOIL AND WATER LOSSES BY WATER EROSION

The use of land for plantation, husbandry and forest purposes can promote the removal of its natural vegetation cover and the exposure of the soil to the effects of heavy tropical rains, which occur virtually in all of the national territory. The environment impact of the agricultural use of lands has the effect of losses of soil and water. It is understood that this impact is not exclusive to the presence or not of RLs and APPs in greater or smaller extent in the agricultural estate.

It is understood, rather, that these areas to be protected are part of a productive strategy that maximizes the conservation of water, soil and the agrobiodiversity in any rural estate. Such a statement is based on the fact that in lands under forest cover, the root system, litter and dense vegetation of woodlands succeed, together, to hold on average 70% of the rainfall volume, regulating the flow of rivers and contributing to the improvement of the water quality.

Therefore, the negative environmental impact of the agricultural use of land causes severe losses of soil and water, being the main factor of land degradation in tropical and subtropical humid environments (HERNANI et al., 2002). Water erosion, a natural process which happens on a geological time scale, tends to be accelerated by human activity, to a point where its effects become visible through the formation of ravines and gullies and by the siltation and eutrophication of creeks, rivers and lakes.

Being a continuous process, the degradation is ignored when it occurs in smaller magnitudes, until catastrophic events happen, such as floodings and landslides under high intensity rainfalls or by long periods of drought – which happens frequently – which in 2001 resulted in one of the biggest energy crises recorded in the country, causing heavy losses to the Brazilian society.

Several studies show that changes in vegetation, as well as its replacement by crops or pasture, cause changes in the water flow. Analyzing 94 experiments carried out in microbasins throughout the world, Bosch and Hewlett (1982) showed that the removal of forest cover increases the annual discharges of rivers. The same effect was reported for the tropical region (BRUIJNZEEL, 2004).

In a study conducted in the state of Pará, Prado et al. (2006) showed that the runoff in forested areas is less than 3% of the precipitation, while in pasture areas the percentage can reach 17%. The greater runoff results in more faster hydrologic responses and lower water infiltration into the soil, increasing the peak rates of flow with a potential to generate great discharges and even flooding in the rainy season and reduction of discharges during droughts. Moreover, the increase in runoff has a greater erosive potential, carrying soil particles, organic matter, fertilizers, pesticides and seeds to the watercourses and reservoirs. This process is further enhanced in steep slopes.

The importance of maintaining riparian APPs to minimize soil loss by surface erosion and the consequent siltation of creeks, streams and rivers has been demonstrated experimentally by Joly and colleagues (2000), working in the river basin of Jacaré-Pepira, in the municipality of Brotas (SP). Through the use of erosion plots in the fields, the group of researchers determined that the annual loss of soil in pasture is around 0.24 t ha^{-1}, while on the same type of soil, with the same declivity and distance from the river, the annual loss of soil within the ciliary forest was about 0.0009 t ha^{-1} (JOLY et al., 2000).

Therefore, the maintenance of forested areas in the midst of rural estates has positive effects on water infiltration and soil protection, helping to stabilize the hydrological regime, its water quality and reducing runoff and the amount of soil particles being carried into water bodies.

For this reason, it is necessary to adopt a conservationist agricultural production strategy, in which soil management practices such as Zero-tillage systems and integrated crop-livestock-silviculture provide increased productivity and profitability to rural producers. When coupled with the availability of native forest cover in the landscape, these practices favor the reduction of soil losses in fragile areas and the mitigation of these impacts on the surface water resources, thereby even generating environmental and ecosystem services to society.

In the context of agricultural production, the degradation of land is related to actions that contribute to a decrease of agricultural production sustainability, by the decline of soil quality and its physical, chemical and biological attributes (FREITAS et al., 2007).

This concept is applicable to any area in which the basic principles for the conservation of soil and natural resources were not obeyed during the establishment of agricultural activity after deforestation or other uses (CASTRO FILHO et al., 2001). Land degradation also involves the loss of quality and water availability, especially for human consumption, in addition to the permanent loss of biodiversity due to the processes used for its initial management or anthropic modification of the soil, as well as the lack of planning, the use of fragile and permanent preservation areas (HERNANI et al., 2002).

1.2.1 *Impacts related to water erosion in Brazil*

The economic valuation of damage caused by erosion is complex, especially in Brazil, because of difficulties in defining and quantifying the types and the extent of the effects and impacts of erosive processes. Therefore, the assessment of the impacts of water erosion resulting from agricultural use of the lands results from partial and incomplete estimates which shall be considered only to illustrate the magnitude of the problem in the country, and the alternatives to mitigate them, within the perspective of agricultural socio-environmental sustainability.

Using data of soil losses determined for different cultures and in experimental conditions of soil and climate from the state of São Paulo, and extrapolating these values to their respective cultivated areas in Brazil, Vergara Filho (1994) estimated the average annual losses of soil at 1.1 billion tons.

The environmental damages caused by the process of soil erosion, according to Marques (1998) can be focused in two forms: the internal ones (within the rural estate) and those external to the agricultural production area or place of origin.

The author estimated the economic value of environmental damages based on the concept of use value and methods of measurement of the replacement cost and lost production or reduced productivity. However, he points to the possibility of having underestimated the total impacts, since he did not consider components like the values of option, existence and others.

Although estimates for the costs of erosion have almost always been based on the value of nutrients removed from the topsoil or the replacement cost of these nutrients in the form of fertilizers and lime, other costs should be considered, such as degradation of the own superficial layer, where root growth and the main gas and water exchanges occur, thereby limiting the achievement of high economic and sustainable productivity. The internal cost (within the rural estate) of erosion increases when considering the long term productive capacity loss and the costs of inputs as water (irrigation), fuel, fertilizers, pesticides and labor (CASTRO FILHO et al., 2001; LANDERS et al., 2001).

On the other hand, on top of these costs the external costs (off property) should be added, such as the need for maintenance of country and rural roads and irrigation channels, the increase in the cost for treating drinking water, the loss of the ability to store water in reservoirs for the production of electricity and irrigation, the lower replenishment of aquifers as natural water reservoirs for different purposes and by additional emissions of carbon into the atmosphere from soil management now considered inappropriate (LANDERS et al., 2001).

In a preliminary estimate, Hernani et al. (2002) illustrated the magnitude of potential soil loss by water erosion in areas with agricultural activity in Brazil. They considered the total area used for crops (annual and perennial) and pasture (natural and planted) according to the 1996 Agricultural Census (IBGE, 1997) and admitting a value of 15.0 t ha^{-1} for the average annual loss of soil for crops, based on Bragagnolo and Pan (2000) and De Maria (1999) – under conventional management with an intensive soil tillage and 0.4 t ha^{-1} for pasture, based on Bertoni and Lombardi Neto (1990) – in artificial pastures with some level of degradation.

This way, they estimated the potential for annual soil losses in Brazil at 822.6 million tons, whereas 751.6 million tons owed to areas occupied by crops and 71.1 million tons of land covered with pastures. Likewise, the potential for water loss was estimated at 171 million m^3. Considering the internal costs and those external to the agricultural estate due to erosive processes, the authors estimated that erosion can generate an annual loss of R$ 9.3 billion to the country.

The values estimated by Hernani et al. (2002) to illustrate the potential loss of soil and water in areas under agrosilvopastoral systems are high and alarming. However, the action of farmers and technicians based on knowledge of tropical soils and the adoption of zero-tillage systems represents today a response to water erosion of soil in more than 50% of the Brazilian agricultural area (FEBRAPDP, 2011), which can be quickly expanded through public policies.

In recent years, the environmental legislation has been expanded and improved and in the last decades integrated soil management programs in hydrographic basins have been successful in some states (BERTOLINI et al., 1993; BRAGAGNOLO and PAN, 2000), always counting with the participation and commitment of most sectors of society, resulting in substantial improvements in environmental quality.

In this sense, assessing the dynamics of sediment production in Rio Grande do Sul as a result from the evolution of Zero-Tillage (ZT) systems based on a large-scale modeling of secondary data (1985, 1996 and 2006 Brazilian Agricultural Censi and the state monitoring of ZT adoption), Lino (2010) noted that the sediment production did not vary in water basins where pastures were predominant, while decreasing in basins used for crops during the years of 1996 and 2006, when it equaled the production of basins with pastures. The adoption of ZT showed a mean reduction in sediment load of 82%, a value close to the reduction of erosion rates in trials with zero-tillage systems.

Additionally, the sequestration of carbon from the atmosphere to the soils under zero-tillage systems is a very significant additional contribution, being yet another indicator for the possibility of building a highly sustainable agriculture in the tropics (FREITAS et al., 2007). In a study drawn from data by the same authors and the review of further data published in the country, Bayer et al. (2006) show that, in average, for grain crops grown under zero-tillage systems in the Cerrado there was an accumulation of carbon in the soil, sequestered from the atmosphere, of about 350 kg ha^{-1} $year^{-1}$, which could reach 480 kg ha^{-1} $year^{-1}$ in the Southern region of Brazil, at a depth of 20 cm.

In areas under conventional management, on the contrary, an emission of carbon into the atmosphere is observed. Converting these values into amounts of carbon dioxide (CO_2) approximate totals of 1.28 tons ha^{-1} $year^{-1}$ and 1.76 tons ha^{-1} $year^{-1}$ of CO_2 have been removed from the atmosphere in the Cerrado and the Southern region, respectively.

Therefore, the adoption of practices and techniques that cause less environmental impact and that necessarily involve the re-ordainment of land use and the activities conducted on the estates – including the maintenance of APPs and RLs – has as its main product the minimization of natural resources degradation.

This is clearly a matter of choice, which is in the hands of society: to chose for agricultural practices in the traditional ways, hereby incorporating the related environmental costs or to generalize the examples that ensure profitability and agricultural sustainability by making full use of technological knowledge, through the planning of land usage, of soil and water management, and through minimal degeneration of the plant – soil – climate system. Hereby, it is possible to promote agricultural activity in harmony with nature, through the use of biological and agronomic precepts adapted to our edaphic- and environmental reality.

The international community, and certainly also the Brazilian, recognizes that the preservation and conservation of natural resources is a joint responsibility for all sectors of society. This way, assumptions such as the increase of production per area and input unit, maximizing production factors, optimizing the use of inputs and labor and living together peacefully with nature, requires society to accept the need for compensating farmers, environmental managers and those responsible for the sustainable use and management of natural resources through environmental services they provide, as proposed by Landers and Freitas (2001) and Landers et al. (2002), particularly for the production of clean and abundant waters.

1.3 THE IMPORTANCE OF PERMANENT PRESERVATION AREAS (APPS) AND LEGAL RESERVES (RLS) FOR BIODIVERSITY CONSERVATION IN BRAZIL[1]

Brazil is one of the most biologically diverse countries in the world, since it houses at least 20% of the species on the planet, with high rates of endemism for different taxonomic groups. This implies ample opportunities, in particular economic (development of new drugs, biotherapics, biomimetic technologies, food, ecological tourism etc.), but also a greater responsibility. The Brazilian environmental legislation has advanced more and more, reflecting the importance of the unique natural heritage of the country. Setbacks will have serious and irreversible environmental, social and economic consequences.

To recognize the importance of the conservation and sustainable use of this priceless natural heritage, Brazil became a signatory of major international commitments such as The Convention on Biological Diversity (CDB) and The Convention on Wetlands (RAMSAR). Moreover, Brazil also committed under the UN Convention on Climate Change to reduce 38% of its emissions of greenhouse gases by 2020. These commitments require not only the implementation of its current environmental legislation, but also the rescue of the great environmental liability from the Brazilian agricultural sector.

There is a consensus among researchers that the guarantee for maintenance of Permanent Preservation Areas (APP) along the river banks and water bodies, the hilltops and hillsides steeper than 30 degrees, as well as the conservation of areas of Legal Reserve (RL) in the different biomes are of fundamental importance for the Brazilian biodiversity conservation.

Among the negative impacts of the reduction of APPs and RL are the extinction of species of many of plants and animals (vertebrates and invertebrates); the increase of CO_2 emissions; a reduction of ecosystem services, such as pest control, pollination of cultivated or wild plants and protection of water resources; the spread of diseases (hantavirus and others transmitted by wild animals, such as the tick associated with the capybara); intensification of other disturbances (fires, hunting, predatory exploitation, impact of domestic and feral dogs and cats, effects of agrochemicals);

1 This text was adapted and/or partially reproduced from the following documents already published: Impactos potenciais das alterações propostas para o Código Florestal Brasileiro na biodiversidade e nos serviços ecossistêmicos, elaborado por pesquisadores do Programa BIOTA/FAPESP e ABECO (Potential impacts of the proposed amendments to the Brazilian Forest Code on biodiversity and ecosystem services, developed by researchers of the BIOTA/FAPESP and ABECO programs) (http://www.abecol.org.br/wordpress/?p=185); Metzger (2010); Martinelli et al. (2010); Joly et al. (2010); Metzger et al. (2010).

the siltation of rivers, reservoirs and ports, with clear implications for water supply, energy and transportation of the agricultural production across the country.

Below, some aspects of changes in the environmental legislation that would have a direct impact on biodiversity are highlighted.

1.3.1 The widths of the riparian Permanent Preservation Areas (APP)

The current legislation stipulates a series of minimum widths for riparian Permanent Protection Areas and around reservoirs and water sources. These limits were established based on the available scientific knowledge when the 1965 Forest Code was amended in 1989.

The smaller rivers, besides having a great expression in the Brazilian river system, shelter a unique fauna. Studies of amphibians anurans (frogs and toads) in the Atlantic Forest indicate that 50% of the species are concentrated in creeks with less than 5 m wide (TOLEDO et al., 2010). Only in the last list of endangered species from the state of São Paulo, out of 66 fish species classified as being under some degree of threat, 45 show high fidelity to streams and are, therefore, dependent on the quality of the surrounding and internal habitat.

There is a large number of species of semi-aquatic mammals, such as otters and giant otters which depend on ciliary forests (GALETTI et al., 2010), and several species of endangered birds (DEVELEY and PONGILUPPI, 2010), reptiles (MARQUES et al., 2010), butterflies (FREITAS, 2010) and fishes (CASSATI, 2010), which live exclusively in these areas.

The effectiveness of these remnant vegetation strips depends on several factors, including the type of ecosystem service considered and the width of preserved vegetation. For example, some data indicate that widths of 30 m would be sufficient for riparian forests to retain much of the nitrates coming from agricultural fields (PINAY and DÉCAMPS, 1988). However, given their multiple functions, including the retention of soil, the protection of water resources and the conservation of fauna and flora, a sufficient minimum width for this strip should be thought of in order for it to perform these functions in a satisfactory manner.

Consequently, from the scientific point of view, defining this width should respect the most demanding ecosystem service, including in this assessment the conservation of biodiversity. In addition to a local conservation, in biological terms the corridors formed by the ciliary vegetation are recognized as a factor which facilitates the movement of individuals.

The importance of maintaining riparian APPs to minimize the soil loss by surface erosion and the consequent siltation of creeks, streams and rivers has been demonstrated experimentally by Joly and collaborators (JOLY et al., 2000), who worked in the Jacaré-Pepira river basin, in the municipality of Brotas (SP). This group of researchers estimated that under field conditions, with the use erosion plots, the annual loss of soil in pastures is about 0.24 tons ha^{-1}, while in the same soil type, with the same declivity and distance from the river, the annual loss of soil within the ciliary forest amounted to 0.0009 t ha^{-1} (JOLY et al., 2000). However, it was not possible to determine the ability of this native vegetation strip to retain solid particles of erosion generated on its outside.

The survival of many vertebrates from the native fauna depends on the ability they have to move, maintaining genetically viable populations, especially in areas where the native vegetation is fragmented. In areas which are heavily modified by human activities, the native vegetation is reduced to small isolated islands in a plantation or pastoral matrix. In this situation, invariably, the wildlife populations are small and the genetic variability tends to decrease, making them highly vulnerable to local extinction. In this situation, the corridors of native vegetation are essential to connect fragments, establishing a positive energy between the increase of populations, of the genetic variability and hence of the species survival (DEVELEY and STOUFFER, 2001).

As proposed by researchers of the BIOTA/FAPESP Program (RODRIGUES et al., 2008) for the state of São Paulo, the registration of RL areas should be done as to promote connectivity between native vegetation remnants. This way, it would be possible to create a network of native vegetation corridors connecting RLs and APPs. Locally, the positive synergy of the connection between fragments causes this network to provide a conservation capacity for the native fauna which is significantly higher than the simple sum of the capacity of each isolated fragment (AWADE; METZGER, 2008; BOSCOLO et al., 2008; MARTENSEN et al., 2008; PARDINI et al., 2010). On a wider spatial and temporal scale, this network has also a greater potential to mitigate the impacts of climate change (MARINI et al., 2009).

1.3.2 The importance of floodplain areas as APPs

Floodplains are highly relevant areas in terms of ecology and hence the importance of their inclusion in the concept of APPs. Unlike the investment necessary for maintaining these areas, the cost for the recovery of its functionality – usually paid by society as a whole – is extremely high (GUTRICH and HITZHUSEN, 2004). These authors calculated that the cost for restoration of ecological functionality of floodplains which are degraded by human activity amounts to US$ 5,000 per hectare, in processes that can take more than 20 years. A much higher cost than the restoration of ciliary forests.

Besides sheltering a particular fauna and flora, including endemic species – which live exclusively in these environments – floodplains provide many ecosystem services of great relevance to humans (JUNK et al., 2010; TUNDISI and TUNDISI, 2010).

They are the ones that dissipate the erosive forces of runoff waters, functioning as important drivers of floods (veritable pools, like those built in large cities to mimic the function of floodplain areas). Floodplains also facilitate the precipitation and deposition of sediments suspended in the water, substantially reducing the costs for treatment of the water supply. They also have high biological importance because they provide food, shelter and tropic and breeding sites for many species, and may still hold unique aesthetic and cultural values.

For riparian populations throughout the Amazon region, the floodplains are essential, both from an economic standpoint – since they assist in maintaining the fish stocks, ensuring feeding sites and shelter for young stages of several important species in the diet and economy of the families – as from the social and cultural point of view. For these reasons, there are programs worldwide for the protection of wetlands and their ecosystem services.

As a signatory of the RAMSAR Convention (ratified by the federal government through Decree 1,905/1996), Brazil is committed to the development of a special policy to protect its wetlands. The removal of the APP condition of floodplains directly contradicts this commitment undertaken nationally and internationally, as reaffirmed in the Cuiabá Declaration from 2008 (INTECOL WETLAND WORKING GROUP, 2008). Environmental legislation should encourage the recovery of these areas rather than reduce their protection and make them more fragile and vulnerable.

On the long run, reducing the size of APPs in width and length or the exclusion of fragile areas now protected, generates irreversible environmental impacts, often putting the very human life at risk. Even with the evolution of scientific and technological knowledge, the costs to restore these areas are extremely high and not all of the ecosystem services will be fully recovered.

1.3.3 The biological significance of hilltops and areas with more than 1,800 m in altitude

Areas with over 1,800 m altitude represent a tiny portion of the national territory (less than 1%), but have a very high ecological importance for being areas with high rates of endemism, as the result of a long process of speciation through geographic isolation (RIBEIRO and FREITAS, 2010). These areas of higher elevation shelter many species particularly sensitive to disturbances of their habitat since they occur in very limited areas.

1.3.4 Extension of Legal Reserves (RLs) in different biomes of Brazil

There are several reasons to maintain the current RLs. First they are relevant areas for biodiversity conservation and, along with APPs, should maintain a cover of native vegetation above 30%. According to recent scientific studies (PARDINI et al., 2010), this percentage represents an important threshold, below which the risk of extinction of species increases very rapidly.

In the Legal Amazon region, according to the Ecological-Economic Zoning (ZEE) of each state, the possibility of reducing the RL of forested areas from 80% to 50% is taken into account, and non-forested areas, such as Cerrados and Fields, from 35% to 20% of each property. Although many states have not yet approved zonings, one can predict that under pressure from interest groups, all will tend to sanction such a percentage reduction, becoming important inducers or facilitators of deforestation in large areas of the Amazon.

This change will have an especially striking effect, for it may favor the reduction of forest cover in the Amazon to levels below 60%, a figure now regarded as a critical threshold for the maintenance of physical connectivity (or continuity) of the forest (STAUFFER, 1985; WITH and CRIST, 1995; WITH and KING, 1999). Below this threshold, the environments tend to be more fragmented, with smaller fragments, more isolated and at greater risk of extinction of species and deterioration of the fragments themselves, besides the loss of their effectiveness as functional ecosystems.

In addition to the biological issue and ecosystem services, small fragments of native vegetation retained as RL have an important role to decrease the isolation of the few larger fragments, functioning as ecological springboards in the displacement of species across the landscape. Without these fragments, the biological flows would be greatly harmed, further accelerating the process of extinction.

In regions with high human occupation, the small fragments (< 100 ha) represent a considerable portion of what remained. In the case of the Atlantic Forest, the small fragments represent 90% of the total number of fragments mapped. Taken together, they account for 30% of the total area of remaining forest (RIBEIRO et al., 2009). Although small, these fragments represent relevant areas and provide important services to humans and species that live there.

1.3.5 The need to separate RL and APP, and to maintain the RLs predominantly occupied by native species

One of the current proposed changes of the Forest Code expands the possibilities of incorporating the APP in the computation of RL of all properties. The major purpose of this amendment is to reduce environmental liabilities, since this mechanism should not be authorized in case it involves the suppression of new areas of native vegetation. With this change, an estate (with more than four fiscal modules[1]) which includes 10% of APP will need only to maintain additional 10% more as RL; one that has more than 20% of APP will not have to maintain any RL. This would imply a substitution of RL by APP.

This combined calculation makes no sense in biological terms. APP and RL areas have different functions and characteristics, keeping different species and ecosystem services. Areas of riparian APP differ from areas between rivers kept as RL; similarly, APPs in steep hillsides do not equate to nearby areas on flat soils which still maintain native vegetation, preserved as RL.

The APPs protect more fragile or strategic areas, such as those at higher risk of soil erosion or which serve as replenishment surfaces for aquifers, whatever the vegetation that covers them, in addition to having an important role in biodiversity conservation. Since they are located outside the fragile areas that characterize APPs, the RLs are an additional tool which extends the range of ecosystems and conserved native species. These are complementary areas that must coexist in the landscape to ensure its biological and ecological sustainability in the long term.

It should be noted that, unlike APPs, the RLs can be managed by the owners who can extract timber, essences, flowers, fruits and honey from them. Therefore, the RLs are a source of employment and income for the owner, provided that the activities carried out do not jeopardize the survival of the native species that they shelter.

Among others causes, noncompliance with the present Forest Code concerning APPs and RLs is one of the main factors responsible for the continuous increase in number of Brazilian vulnerable and endangered species on the lists periodically updated by scientific societies and adopted by the organs and institutions from the environmental area[2].

In the Amazon region, the reduction of RLs would decrease the level of forest cover

1 Translator's Note: A fiscal module (módulo fiscal) implies in a land unit with a legally defined size in hectares, which varies for each Brazilian municipality.

2 See IBDF Ordinance, No. 303, of May 29th, 1968; IBAMA Ordinance, No. 1,522, of December 19th, 1989; MMA Regulatory Instruction, No. 03, of May 27th, 2003; MMA Regulatory Instruction, No. May 5th, 2004 and MMA Regulatory Instruction, No. 52, of November 08, 2005.

to levels that would affect the physical continuity of the forest, significantly increasing the risk of species extinction, thereby also undermining its effectiveness as a functional ecosystem and its ecosystem services.

The restoration of RL areas, which is feasible owing to the advancement of scientific and technological knowledge, should be done preferably with native species, because the use of exotic species undermines its role in biodiversity conservation and does not ensure the restoration of its ecological functions and ecosystem services. In this component (RL) one finds the greatest environmental liabilities of the Brazilian agricultural sector. New techniques for restoration and sustainable management of native species should be used for a legal and environmental streamlining of rural estates.

The survival of species depends on their ability to move across the landscape. Native vegetation corridors can have a vital role where the original vegetation is reduced and dispersed in innumerable fragments, isolating and reducing the size of the native populations who live there, since many wild species cannot use or cross open areas created by man, not even when it concerns very narrow interferences such as roads (DEVELEY and STOUFFER, 2001).

1.3.6 The possibility of grouping the RLs of different owners in larger fragments and/or compensate the RL on another property or region

One possibility being considered is the stipulation of a percentage of total vegetation to be maintained by estate or hydrographic basin, favoring those with highest biotic functional value. This percentage is expected to ensure, simultaneously, spaces for economic activity and the conservation of ecosystems and their services, also benefiting agricultural production areas in the vicinity. Within the extent ensured for native vegetation should be included, necessarily, all APPs, completing the total percentage stipulated with RL.

Compensation of RLs outside of the estates should be limited to areas located within the same biogeographic regions and equivalence in physiognomic formations. This way, it is impossible to think of all compensation within a whole biome. Such compensations should only be possible in more restricted geographical areas, possibly as those managed by the Basin Committees. In this case, the arrangement of RLs would allow not only to think in the best areas for biodiversity conservation, but also in those which would bring more benefit to the protection of water and soil resources or the restoration with native forests from areas inadequately available for agriculture in the past, now marginalized because of their low potential.

It is also necessary to set a maximum quota of compensation within a region as not to create large contrasts with much depleted landscapes of vegetation in certain basins and others with a high concentration of RLs. These contrasts are not desirable, not only for creating poor landscapes in the biological sense, but also since the ecosystem benefits of RLs are more intense if they are close to productive areas.

It is also necessary to rethink the use of exotic species within the RL. They can be useful to accelerate or facilitate the restoration of these areas in the early stages of restoration of the RL, but they should not be considered as permanent elements of RLs. The sustainable use of natural resources should be the priority, and may even become a more profitable economic alternative than the agricultural use of soil, such as in the case of the Amazon.

1.4 THE IMPORTANCE OF PERMANENT PRESERVATION AREAS (APPS) AND LEGAL RESERVES (RLS) IN RURAL ESTATES

1.4.1 Environmental Benefits Associated with the Presence of Permanent Preservation Areas and Legal Reserves in Rural Estates

The scientific and technological advances achieved by animal husbandry research in the recent decades enabled significant increases in production rates and agricultural productivity. The dynamics of the sector over time also demanded varied answers to the socioeconomic and environmental diversity of the country.

There are areas where agriculture has a long history, such as in the Atlantic Forest and the Caatinga biomes, with environmental problems associated to the long historical process of occupation and development of their farming systems. These contrast with the Amazon and Cerrado biomes, in which agricultural occupation on a large scale is relatively recent, with trajectories of a few decades and production systems in different stages of development.

On technical grounds, this production depends on the diversity of technologies, cultures and geographic areas, particularly from South-Central Brazil, where agricultural practices with intensive industrial inputs and machinery predominate. In many cases, it is consolidated in agro-industrial chains, such as sugar-cane, soybean, corn, coffee, rice, cotton, planted forests, vegetables, citrus and other temperate/ tropical fruits, cattle, pigs, poultry etc.

In contrast, there are areas with a mostly traditional agriculture, mainly in the Northeast and North – the latter with a strong presence of natural systems, dominated by extensive production systems, despite the emergence of organized activities in terms of agricultural intensification.

Given the diversity of scenarios and technological options for production, there is consensus in the husbandry research that continuous adjustments are necessary in conventional production systems to overcome problems which are difficult to solve because of its diffuse and multifaceted character, for example: pollution and environmental contamination; soil erosion and its physical, chemical and biological degradation, with consequently loss of resilience, reduction of its production capacity, besides risks of desertification and loss of biodiversity and environmental services.

While many of the problems faced by research can be treated as a matter of technological development, others require different approaches due to its yet intangible character, not priced in terms of economic returns, as is the case with ecosystem services offered by natural areas and biodiversity. Some of these services generate benefits of global reach, but others are essential to their own production systems and profitability.

One of the priorities of sciences which deal with the interface between productive systems and environmental management is to assess the impact that changes in land use and landscape composition promote on human welfare, and to establish the scientific basis for the conservation and sustainable use of ecosystems. Among the components of this interface are ecosystem services.

They can be divided into four categories: a) provision: is essentially the production of food, fibers, fuels and water; b) regulation of: climate, hydrology and environmental health, c) cultural: concerns spiritual, aesthetic, recreational and educational dimensions; d) support: primary production, soil formation, maintenance of biotic flow.

Methods for economic valuation of these services are already available and widely used in Brazil (MAY et al., 2000) and their remuneration to growers is already becoming a reality (cases of carbon market, charging for water use, Ecological ICMS – Tax on Circulation of Goods and Services etc.) (VEIGA and MAY, 2010).

Worth mentioning here are two matters approved by the Environmental Committee of the House of Representatives on December 1st, 2010 to regulate the mechanism of Certified Reduction of Emissions from Deforestation and Degradation (PL 5,586/09) and which establishes the National Policy on Payment for Environmental Services (PL 792/07 and appendices). They allow the Payment for Environmental Services (PSA) associated with protection of natural resources by private property Conservation Units, as well as the marketing of carbon credits linked to the maintenance of standing Forest and under sustainable management (REDD+) and its contribution to national targets to reduce emissions of greenhouse gases.

Table 8 shows the categories of ecosystem services outlined above and the factors that contribute to the welfare of citizens. Both maintain intrinsic relations and should therefore not be considered separately.

At least four ecosystem services provided by natural areas are important for today's society and future generations, as well as the sustainability of production systems: a) hydrological regulation (increased storage, transfer and replenishment of aquifers); b) atmospheric regulation (greater carbon sequestration and reduction of greenhouse gases); c) erosion control; d) services provided by biodiversity (pollination and agricultural pest control).

In addition to these services, also those provided by native vegetation bordering rivers and protecting hillsides may be mentioned, while acting as corridors of gene flows and important filters in the retention of particulates that would eventually enter the water bodies.

Just like any other agricultural input, the ecosystems and their services constitute a capital good for a nation, state or property. These are already being defined in the international literature by the name of Natural Capital (ARONSON et al., 2007; NEßHöVER et al., 2009; ARONSON et al. 2010). The costs associated with an improper management of these goods are implicit in the official economic indicators (nutrient and pollinators, resulting in low productivity, for example). The benefits can be explained by specific methods of valuation assessment, indicating the potential gains obtained from the same protection.

The scarcity of available ecosystem services has been increasingly perceived by economic actors, resulting in the formation of specific markets for such services (carbon, water). However, due to a lack of explicit prices for most of these services it is necessary for society to define the importance of its maintenance for human survival, placing limits on the expansion of economic activities.

Understanding the importance of maintaining natural areas as APPs and RLs on a rural property is essential, since there is a misconception that areas with native vegetation represent non-productive areas, with additional costing, without any return to the farmer. These areas, strictly speaking, are critical for maintaining the productivity in agricultural systems in view of their direct influence on production and the conservation of water, biodiversity, soil, on the maintenance of shelter for pollinators, for dispersers and natural enemies of pests of the own cultures on the property.

Therefore, the maintenance of remnant native vegetation on the properties and the landscape transcends a purely environmental and ecological discussion, also regarding, besides its economic potential, the sustainability of the agricultural activity.

Table 8 – Relationships between biodiversity, ecosystem services and human welfare.

<table>
<tr><th colspan="2">ECOSYSTEM SERVICES</th><th colspan="2">FACTORES CONTRIBUITING TO HUMAN WELFARE</th></tr>
<tr><td rowspan="4">Support
• Nutrient cycling
• Soil formation
• Primary Production</td><td>Provisioning
• Food
• Drinking water
• Timber and fibers
• Fuels</td><td>Security
• Individual safety
• Secure access to natural resources
• Insurance against disaster</td><td rowspan="4">Freedom of choices and action
Opportunity to achieve what individuals value doing and being</td></tr>
<tr><td>Regulation
• Climate regulation
• Regulation of flooding
• Regulation of diseases
• Purification of water</td><td>Raw material for a good life
• Adequate income
• Sufficient and nutritious food
• Shelter
• Access to goods</td></tr>
<tr><td rowspan="2">Cultural
• Aesthetic
• Spiritual
• Educational
• Recreational</td><td>Health
• Force
• Feel good
• Access to clean air and water</td></tr>
<tr><td>Good social relations
• Social cohesion
• Mutual respect
• The ability to help others</td></tr>
<tr><td colspan="4">LIFE ON EARTH – BIODIVERSITY</td></tr>
</table>

Source: Adapted from Millennium Ecosystem Assessment (2005).

1.4.1.1 *Ecosystem Services Associated with Riparian Permanent Preservation Areas (APPs)*

The ecosystem services provided by riparian APPs are well known. Among them may be mentioned (a) its role as a barrier or filter, preventing sediment, organic matter, soil nutrients, fertilizers and pesticides used in agricultural areas to reach the aquatic environment; (b) favoring the infiltration of water into the soil and aquifer replenishment; (c) protecting soil on the banks of watercourses, thereby avoiding erosion and siltation; (d) creating conditions for the gene flow of flora and fauna (BATALHA et al., 2005); (e) provision of food for the maintenance of fish and other aquatic organisms; (f) refuge for pollinators and natural enemies of crop pests.

The organic matter present in litter deposited on the soil of riparian areas can be leached by the infiltration of rain water and reach the river through surface or subsurface hydrologic flows or still through the drag of litter by torrents or through direct fall of leaves in the river channel. Thus, forests can be seen as sources of organic matter and energy in aquatic systems, fulfilling an essential role in the functioning of these ecosystems (McCLAIN and ELSENBEER, 2001).

Among the potential impacts of reducing the width of APPs are changes in water storage capacity along the riparian strip with a consequent reduction of water flow in the dry season (LIMA and ZAKIA, 2000).

It is noteworthy that hydrological interactions occur between surface and subsurface of watercourses, whereas water does not flow solely through the river channel, but also through the interstices of the sediments along the banks and under the channel. This compartment is known as riparian or hyporheic zone (JONES and HOLMES, 1996; TRISKA et al., 1989). Important biogeochemical processes occur in this compartment, which determines the importance of marginal areas to watercourses in the attenuation of the contribution of nutrients from the fertilized agricultural soils and the transformations of molecules and metabolites from the application of pesticides on crops.

Consequently, the presence of vegetation in the riparian area acts as a biogeochemical barrier to the entry of organic and inorganic chemical species in the rivers, a fact which gives the arboreal riparian vegetation great importance in the maintenance of water quality and the health of the aquatic ecosystem (CORREL et al., 1992; FORTESCUE 1980; TRISKA et al., 1993). Gilliam (1994) reports the reduction of more than 90% of the sediment concentrations and of dissolved nitrogen sorts as a result of the filtering action of riparian forests. Also, Emmett et al. (1994) verified that the riparian forest reduced the concentrations of nitrogen, phosphate and total dissolved phosphorus in respectively 38%, 94% and 42%.

The recent expansion of the agricultural frontier in the Amazon to plant grains associated with the deforestation of riparian vegetation has promoted impacts on the functioning of aquatic ecosystems and the water quality of small *igarapés* (Amazonian creeks) used by riparian communities, as reported by Figueiredo (2009) on various studies conducted by EMBRAPA and its partners.

In these studies, one comes to the conclusion that even the secondary vegetation in riparian areas should be playing an important role in the conservation of water quality and the maintenance of aquatic ecosystem functions in basins with the predominance of smallholder farming.

However, in headwater areas where the forest was severely altered, significant changes were observed in the concentrations of potassium, calcium, magnesium, ammonium, chloride, sulfate, nitrate and dissolved organic carbon, as well as significant changes in water quality parameters such as turbidity, conductivity, pH, temperature, dissolved oxygen and temperature, when compared to headwater areas where the forest is relatively preserved.

Furthermore, studies have indicated that under decreasing forest areas and increasing pasture coverage, temperatures and conductivity increase and the concentration of sulfate and nitrate in the river waters decreases. Also, the increase of areas planted with grain associated with the absence of ciliary forests has reduced dissolved oxygen and increased turbidity and the concentrations of sodium and chloride in waters of *igarapés* in the studied basins.

With the aim to base public policies on the management of hydrographic basin, Figueiredo et al. (2010) concluded that turbidity, temperature, pH and dissolved oxygen parameters are simpler and more suitable for detecting the effects of changes in land use on river water quality.

Other studies report the great importance of maintaining riparian vegetation in any situation of adopted agricultural practices, since ciliary forests can determine the magnitude of the flow of creeks, streams or *igarapés* in small basins, feeding the water flow of larger basins (WICKEL, 2004). Regarding the role of riparian forests as nutrient filters which enter creeks or *igarapés*, the existence of a 'buffer' function of ciliary forests was established by assessing the chemical composition of underground water of the riparian area with pastures and forests.

Studies conducted in Rondônia also point out how the replacement of riparian forests by pastures affect the functioning of igarapés, altering the concentrations of nitrogen (N), phosphorus (P) and oxygen (O) dissolved in their waters and, also due to the change in N:P ratio, the aquatic biota is impacted (NEILL et al., 2001). Ballester et al. (2003) identified increases in the concentration of sodium, potassium, chloride and phosphate in river waters, besides an increase in electrical conductivity due to deforestation and the establishment of pastures.

Research conducted by Zocolo (2010) sought to investigate concentrations of isoflavones in surface and subsurface waters at a large soybean plantation in Mato Grosso do Sul. Also known as phytoestrogens, isoflavones are natural estrogenic compounds found in plants and particularly soybeans. These compounds have structures similar to estrogen hormones produced by mammals, being classified as endocrine disruptors (AE).

Studies of these substances indicate altering effects such as intersex physicalities in fishes. There is, therefore, a growing interest related mainly to the highest potential estrogenic isoflavones present in high levels in soybeans: genistein, daidzein, daidzin, genistin, formonoetin and biochanin A, in addition to the degradation product, the equol, obtained from these metabolites.

The environmental impact of these substances in the aquatic environment has been significantly less investigated, while there are few studies in rural areas. Soybean post-harvest produces large quantities of straw, a source of isoflavones for the soil. Leaching processes can cause runoff of isoflavones to the rivers, due to the water solubility of these compounds.

The survey revealed that phytoestrogens were present in the river and in upwelling groundwater, in concentrations ranging from 12 to 1957 ng L-1, values considered high for a rural region, whereas the highest concentrations were obtained for equol and genistein for samples collected in the rainy months at the study region.

The concentrations found were similar to those already found in big cities like Osaka, Japan, for the river water, where the source are domestic effluents. An information of great importance lies in the fact that the highest concentrations of isoflavones were detected in areas with a low density of ciliary forests, which certainly contributed to the discharge of these substances into the river.

Studies led by EMBRAPA Pantanal in the Taquari river basin, located in the states of Mato Grosso and Mato Grosso do Sul, found that due to the removal of ciliary forests, associated with poorly managed cattle husbandry, without the adoption of soil conservation practices, there were higher rates in soil erosion processes and siltation of rivers. The Taquari River is one of the main tributaries of the Pantanal.

In the basin of the Upper Taquari, the greatest impact on the use of land comes from pressures of cattle husbandry, followed by crops, since with the expansion of these activities in Cerrado, forest and transition areas, sources of erosion are enhanced, leading to degradation of water resources and soil. This process results in significant loss of water and an increased siltation rate of the Taquari River, causing further meandering and increased floodings on its lower course.

Additionally, due to the erosion caused by deforestation, an increase of up to 70% was registered for the entrance of suspended solids and nutrients in the upper Taquari River in the rainy season, causing impacts on periphyton communities and the trophic chain in aquatic systems with direct consequences for small fishes and microcrustaceans. This fact was reflected in biology and ecology studies of fish in the same basin. The research found changes in reproduction and feeding patterns of these animals with damage for the fisheries, a formerly important activity in the region's economy.

The increase of flooding due to land use is also impacting ciliary forest in the lower parts of the basin, affecting the regional socio-economy through migration to the cities, the isolation of human communities and harming the marketing of local products. Among the recommendations of EMBRAPA Pantanal and its partners to mitigate the environmental and socioeconomic impacts on the Taquari River basin is the restoration of ciliary forests (GALDINO and VIEIRA, 2005).

In the Cerrado, the hydrographic basins are formed by a few large rivers and dozens of narrow brooks, along which, due to the topography and high groundwater, the ciliary forests – there called gallery forests – may occur in different soil types, present variations in floristic communities and, consequently, different patterns of nutrient cycling.

Studies conducted in these landscapes indicated that nutrient concentrations in river waters are very low because the gallery forest acts as a barrier against the outflow of nutrients from the system, contributing to the maintenance of water quality in the watercourses. The removal of these woodlands would jeopardize the protection of biodiversity, volume and quality of water needed for social welfare in the region.

An example of protection of ciliary forests in rivers from the Atlantic Forest can be demonstrated by the work of Moraes et al. (2002). In this study, the authors found that in the Jundiaí-Mirim River basin, the concentration of ammonium nitrogen and total phosphorus was above the limit set by environmental legislation of the state of São Paulo. These high levels of phosphates are directly related to contamination from fertilizers, carried during the erosion process of crop areas nearby river banks devoid of ciliary forests.

One of the challenges of current research is to identify the conditions that may support the decision making process concerning the appropriate size of marginal widths to ensure that these areas fulfill the expected ecosystem services. For this, some key features to be considered in this process are recognized, among which are groundwater depth, the texture and thickness of the soil and the declivities of hillsides adjacent to watercourses, in addition to sufficiency of vegetation in order to guarantee the gene flow of species and conservation of biodiversity.

Due to the diversity in climate, geology, soils and biology of the Brazilian territory, a consistent effort is required to raise the necessary information for possible differential and substantiated treatment with respect to the widths of APP marginal strips.

1.4.1.2 Other ecosystem services associated with Permanent Preservation Areas (APPs) and Legal Reserves (RLs)

1.4.1.2.1 Carbon Storage in vegetation

Concerning sustainable agriculture, one of the major opportunities ahead for Brazil is the possibility of converting part of the natural resources existing on the property into income for the farmer. The main one would be the maintenance of carbon storage in native areas which, once maintained as Legal Reserves, may provide additional compensations to the farmer.

The values in Table 9 refer to the stocks of carbon in various Brazilian biomes. In general, they are considered to be 120 t C/ha in the Amazon Region and 38 t C/ha in the Cerrado. This carbon has value on the global market. For the countries in Appendix 1[1], the models used indicate that it is possible to attain a cost of US$ 10 to 60 per ton of CO_2 emission reduced. In the case of Latin America, according to CEPAL – which has a more conservative stance – the value per ton would be around US$ 10 to US$ 20 for projects associated with carbon sinks from activities in the forest sector. The expansion of deforestation both in the Amazon as in the Cerrado would reduce the ability for income diversification for agribusiness through environmental services.

The lack of mandatory recovery of Legal Reserves in areas within four fiscal modules – which are of different sizes by municipality – can also reduce the opportunity for other sources of income for farmers. For example: supposing that part of the Legal Reserve (RL) areas in the Amazon region would not be recomposed by secondary forests, the loss would be, on average, 57 t C/ha; in case of floodplain forests, this value would increase to 94 t C/ha; with agroforestry systems, 87 t C/ha.

These facts are opposed by the recent government policy to encourage farming of low carbon emission, since the non-recovery of reserves would only maintain emissions (GOUVELLO et al., 2010).

1 Carbon Market: http://www.cebds.org.br/cebds/pub-docs/pub-mc-carbono.pdf consulted on 03/13/2011.

Data from the 2006 Agricultural Census (IBGE, 2006) estimate that Brazil now has at least 60 million hectares of pastures with low stocking rates of cattle (less than 0.4 animal units/ ha). These areas can have their efficiency increased or, if used in association with grains, could generate a surplus of over 2.4 million heads of cattle in addition to around 120 million tons of grain.

Reducing APPs or RLs to increase planted areas would not be the priority for increasing agricultural production. Rather, it is necessary to strengthen public policies aimed at intensifying the use of land already in usage through the adoption of appropriate technology, such as the integration of crop and livestock, the recovery of pastures and the adoption of quality zero-tillage systems, all of them with a high capacity to reduce CO_2 emissions and increase carbon storage.

Table 9 – Dry epigeous biomass and carbon storage in different in vegetation types in North and South regions.

Type	EBE ($Mg.ha^{-1}$)	EC* ($Mg.ha^{-1}$)	Sampling (cm)	Source	Site
FS	56	25	DAP ≥ 5	Lima et al. (2007)	Manaus, AM
FS	125	56	DAP ≥ 2,5	Batistella (2001)	Machadinho d'Oeste, RO
FS	199	90	DAP ≥ 5	Pereira (2001)	Paragominas, PA
MD	**127**	**57**			
FV	213	96	DAP ≥ 10	Stadtler (2007)	Barcelos, AM
FV	108	49	DAP ≥ 10	Keller et al. (2004)	Paragominas, PA
FV	307	138	DAP ≥ 5	Tsuchiya e Hiraoka (1999)	Abaetetuba, PA
MD	**209**	**94**			
FTF	466	210	DAP ≥ 1	Silva (2007)	Manaus, AM
FTF	269	121	DAP ≥ 2,5	Batistella (2001)	Machadinho d'Oeste, RO
FTF	289	130	DAP ≥ 5	Tsuchiya e Hiraoka (1999)	Abaetetuba, PA
MD	**341**	**154**			
SAF	153	69	DAP ≥ 2,5	Bolfe et al. (2009)	Tomé-Açu, PA
SAF	298	134	DAP ≥ 5	Santos et al. (2004)	Cametá, PA
SAF	126	57	DAP ≥ 5	Montagnini e Nair (2004)	Amazônia
MD	**192**	**87**			
FOM	195	88	DAP ≥ 10	Socher et al. (2008)	Araucária, PR
FOM	210	95	DAP ≥ 10	Vogel (2006)	Itaara, RS
FOM	210	95	DAP ≥ 10	Caldeira (2003)	General Carneiro, PR
MD	**205**	**92**			
CAM	1	---	---	Fonseca et al. (2007)	Bagé, RS
CAM	3	---	---	Heringer e Jacques (2002)	André da Rocha, RS
CAM	1	---	---	Santos et al. (2008)	Eldorado do Sul, RS

Obs.: (EBE) epigeous biomass; (EC*) carbon storage values estimated in 45% of epigeous biomass; (SAF) Agroforestry systems; (FS) Secondary forests; (FV) Floodplain forests; (FTF) Mainland forests; (FOM) Araucaria forest and (CAM) Southern Fields.

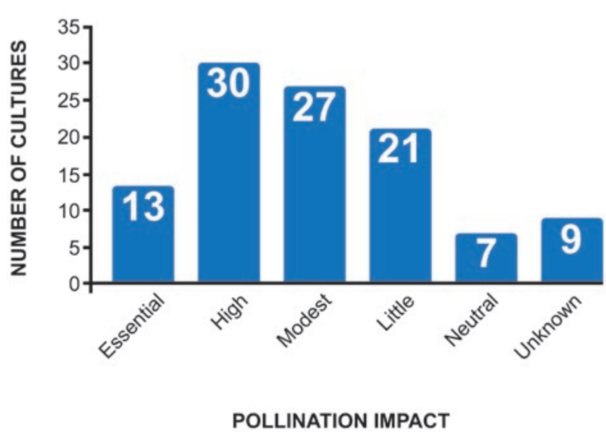
1.4.1.2.2 Pollination

Beside the APPs, RLs also offer important ecosystem services which ensure the sustainability of agricultural production. Among the more important ones are those which provide the maintenance of fauna responsible for the pollination of cultures and natural control of pests, especially insects. These are certainly the most tangible and most important among all the environmental services provided by APPs and RLs related to the success of crop production and productivity of various cultures. **The services provided by pollinators are highly dependent on the conservation of the native vegetation, where they find shelter and food.**

On the other hand, the native vegetation depends on the same pollination services to be feasible over time through the maintenance of its floristic diversity, since the majority of these species require specific pollinators in order to perpetuate itself within this native vegetation.

In a relevant review on the importance of pollinators for cultures, Klein et al. (2007) concluded that, based on the evaluation of 107 expressive cultures in terms of production volume and intended for human consumption (fruits, vegetables and grains), 91 of them depend on some degree of biotic pollination (Figure 4). When the cultures that contribute with higher production volumes are considered, 35% of them depend directly on the action of these pollinators.

Figura 4 – Levels of biotic pollination dependence based on potential production drops in the absence of pollination in 107 cultures of global agricultural importance. **Essential:** up to 90% reduction; **High:** 40 to 90%; **Modest:** 10 to 40%; **Little:** up to 10%; **Neutral:** no interference of biotic pollination in production; **Unknown:** no information available.



Adapted from Klein et al. (2007).

In the Brazilian case, the impacts of pollination on cultures are still poorly studied. Much of the data available focuses on a small number of cultures, but of great importance for the national agriculture, including: melon, coffee, passion fruit, peach, orange, soybean, cotton and cashew. According to IBGE data (IBGE, 2008), these eight cultures yield R$ 59.8 billion annually, covering an area of 26,242,361 hectares and, including processed products, yield U$ 25.9 billion in exports to Brazil (Table 10).

Table 10 – Planted area, production, value of production and export of some cultures in Brazil, in 2008

Culture	Planted area (ha)*	Production (t)*	Production Values * (R$ x 1000)	Export Values** (U$ FOB)
Soybean (grain)	21.252.721	59.833.105	39.077.161	18.021.957.851 (b)
Coffee (grain)	2.250.491	2.796.927	10.468.475	4.763.068.651 (d)
Orange	837.031	18.538.084	5.100.062	2.087.191.169 (a)
Cotton seed (woody and herbaceous)	1.067.444	3.983.361	3.927.671	696.058.104 (c)
Passion fruit	49.112	684.376	483.588	–
Peach	21.326	239.149	263.742	–
Melon	15.788	340.464	257.515	152.132.031
Cashew (nut)	748.448	243.253	213.299	196.074.102

* Agricultural Production – (a): Fresh and dried fruits, juices, Municipal 2008/IBGE System for Automatic Recovery (IBGE, 2008). ** Ministry of Development, Industry and Foreign Trade/ Foreign Trade Secretariat/AliceWeb, (BRASIL, 2008) – (a): Essential oils; (b) Grains, oils, flours and pellets, pulp and other solid wastes and soybean proteins; (c) whether or not threshed, not carded nor combed; other types of cotton, not carded nor combed; (d) In grain, soluble, extracts, essences and concentrates, peel skins and coffee substitutes.

Examples of the importance of these pollinators for the agricultural cultures in Brazil are available for soybeans (CHIARI et al., 2005); melon (SOUSA et al., 2009); coffee (AMARAL, 1972; MALERBO-SOUZA et al., 2003c), orange (MALERBO-SOUZA et al., 2003c), passion fruit (FREITAS and OLIVEIRA FILHO, 2003), cotton (SANCHEZ JÚNIOR and MALERBO-SOUZA, 2004) and peach (MOTA and NOGUEIRA-COUTO, 2002).

These studies demonstrate that even in self-pollinating cultures considered autogamous, cross-pollination with pollen of other plants and mediated by pollinators can bring substantial increases in production. Moreover, the action of pollinators can increase the effectiveness of the pollination process (transportation of pollen from antera - the male structure of the flower - to the stigma - the female structure of the flower), even in cultures with flowers that have mechanisms which encourage self-fertilization. The examples below illustrate these contributions.

Soybean

Chiari et al. (2005) evaluated the influence of pollination in production and quality of soybean seed (Glycine max (L.) Merr.) (BRS133) in the region of Maringá (PR). **The research concluded that grain production was 50.64% higher than in controlled experimental areas where the plants were exposed to pollination, when compared to areas isolated from contact by any insect.** The results found were similar to those obtained by Moreti et al. (1998), who obtained increases of 58.58% in the number of pods and 82.31% in the number of seeds.

Melon

Melon plants *(Cucumis melo L.)* present male and female flowers arranged separately. Each one of them remains open only for a day and pollination is performed by insects, especially bees *(Apis mellifera L.)*. Due to the limited period of time for flower opening, the success of pollination is critical for the production and productivity of the culture (DUARTE, 2001). Research conducted by Sousa et al. (2009) in the region of Acaraú (CE) demonstrated the importance of pollination performed by insects (entomophile) in the quantity and quality of fruits in melon culture.

The results indicated that manual pollination was the most effective in terms of fertilized flowers, or initial fruit set (98,3%), followed by open pollination with bees (75.7%) and open pollination (39.3%). Treatment with restricted pollination (with the isolation of flowers from biotic pollinating agents) did not present any fertilized flower.

Coffee

Malerbo-Souza et al. (2003a) analyzed the effect of the presence of pollinators in a coffee culture (*Coffea arabica L., Mundo Nov*o variety) at Jaboticabal (SP). Among the variables studied, the fruit production was monitored in treatments with artificially covered plants to prevent access of any insect and also in uncovered treatments. The research concluded that the uncovered treatments, in which the flowers were visited by insects, produced more fruits. This increase amounted **38.79%** over the first year of experiment and **168.38%** in the second, when plants were more developed. The results obtained by Malerbo-Souza et al. (2003c) confirmed the trend already registered by Amaral (1972), who had seen an increase in the yield of cherry coffee in 72% for plants pollinated by insects.

Orange

Malerbo-Souza et al. (2003b) conducted studies in an orange cultivation area *(Citrus sinensis L.* Osbeck, Pera-Rio variety) in Jaboticabal (SP) to investigate, among other aspects of its reproductive biology, the visiting insects, as well as their effects on the quantity and quality of fruit production. The results showed that the percentage of fertilization of orange flowers was 57.4% higher in those exposed to insect pollination. **In this case, the production of fruits was 35.3% higher when compared to treatments in which the pollination is prevented.** The study also concluded that the pollination by insects provided fruits which were heavier, sweeter and with a higher number of seeds per segment.

Passion fruit

Brazil is the largest global producer of yellow passion fruit *(Passiflora edulis)*. However, the culture productivity of 13.9 t/ha, as observed in 2008 (Table 10), is considered low. According to Ruggiero (2000), the potential productivity of this culture in the country is 40 to 45 t/ha. The low productivity is hereby attributed to the lack of natural pollinators of culture, the main one being the carpenter bee *(Xylocopa spp)*. One of the factors recognized as responsible for the reduction in natural occurrence of the carpenter bee is the reduction of native vegetation in the vicinity of plantations and the excessive use of pesticides on crops. To circumvent the low occurrence of pollinators in the natural environment, the growers have resorted to manual pollination techniques, increasing production costs.

An assessment of the requirements for passion fruit pollination carried out by Freitas and Oliveira Filho (2003) in São Luís do Curú (CE) showed that the culture of passion fruit is entirely dependent of biotic pollination, i.e. there is no fruit set in flowers which are isolated from pollinators. **In flowers with open pollination (without barriers for access of insects in general), a fruit setting in the order of 25% was observed. In a controlled treatment, where flowers were visited by a carpenter bee only once, the fruit setting amounted 68.3%.**

Cashew

The cashew tree *(Anacardium occidentale)* is widely spread in Brazil. The contribution of biotic pollination on cashew production was investigated by Freitas and Paxton (1998) in the region of Beberibe (CE). **The study concluded that treatments where**

the cashew flowers were exposed to open pollination, production was 88% higher, when compared with treatments with flowers isolated from pollinators.

Cotton

Beside soybeans, the culture of cotton *(Gossypium hirsutum L.)* is one of the most important for Brazil. The economic importance of the culture goes beyond the provision of fibers used in the textile industry, since its seeds are also used in the production of edible oil and meal for the manufacture of animal feed. The cotton plant is generally considered a self-fertilizing culture, although there is a variable percentage of cross-pollination, depending on the populations of pollinator insects in the cultivation area (CARVALHO, 1999; PEDROSA, 2005). Sanchez Júnior and Malerbo-Souza (2004) performed a research in Ribeirão Preto (SP) to evaluate the presence and effects of pollinators in the cotton culture.

The flowers from treatments open to pollination had 92% fructification versus 88% in the covered treatments (free from insects). **Moreover, the average number of seeds per apple (the fruit of green cotton) in the treatments open to pollination was 42.6% higher than the treatments isolated from pollinators.**

Peach

Mota and Nogueira-Couto (2002) conducted experiments in Jaboticabal (SP) to determine, among other factors, the role of insects in the production and quality of peach fruits *(Prunus persica L.)*. The experiment evaluated treatments on branches protected to prevent access of insects, and also treatment with exposed branches. The survey results showed that **there was an increase of 14% in the number of fruits produced under treatments in which the peach flowers were exposed to pollination.**

Summary

In all of the above cases, although it is assumed that the percentage of production gain may change according to culture varieties and also the region considered for production, the benefits of pollination are expressive, particularly when confronted with the production and export values obtained in Brazil during 2008 (Table 10).

Although restricted and still limited to a few cultures, the examples provide good indications on the importance of the ecosystem service of pollination to Brazilian agriculture. The results also warn for the risk of decline of these pollinator populations in response to changes in area and distribution of the vegetation which compounds the various biomes. The information clearly indicates that any damage to pollinator populations may represent high losses to the national agricultural production.

Recognizing the close relationship between the composition of flora and fauna, as well as the fact that biological diversity has a very heterogeneous spatial distribution brings with it a warning about the potential risks of the reduction in the whole of native vegetation present in APPs and RLs.

Globally, the moment is one of great valuation of the natural capital. There is an increasing growth in the importance of taking responsibility for the appropriate use of biotic and abiotic natural resources (ARONSON et al. 2007, 2010; LAMB et al. 2005; TEEB, 2010).

The different national biomes are still responsible for the megadiversity which exists in the country (MITTERMEIER et al., 2005). Brazil, as a signatory of the Convention on Biological Diversity (CDB), has pledged before the international community to implement the Global Strategy for Plant Conservation (GSPC). Among the 16 targets set by GSPC, the first one is the development of a "widely accessible working list of known plant species in each country, as a step towards the elaboration of a complete list of the global flora". Thus, in the Amazon, Cerrado, Pantanal, Atlantic Forest and Pampa biomes almost 41,000 plants species occur (http://floradobrasil.jbrj.gov.br/2010/), which are registered in the official lists.

In the Cerrado, for example, more than 12,000 species are described (MENDONÇA et al. 1998) distributed in forest, savanna and grassland environments. Several species have been used with significant economic return, showing good prospects of success in extractive use or agroforestry systems. Among the fruit trees identified are *baru (Dipteryx alata* Vog.), *araticum (Annona crassiflora* Mart.), *mangaba (Hancornia speciosa* Gomes), *pequi (Caryocar brasiliense* Camb) and *cagaita (Eugenia dysenterica Mart.* ex. D.C.), which have been marketed regionally with reasonable success.

Other species with economic potential from the Cerrado physiognomy (restricted sense) are widely distributed in the biome (RATTER et al. 2003) with an enormous potential for their sustainable use, through restoration activities. Outstanding examples are *sucupira preta (Bowdichia virgilioides), faveira (Dimorphandra mollis), pacari (Lafoensia pacari), pequi (Caryocar brasiliense), mama-cadela (Brosimum gaudichaudii), pimenta de macaco* – monkey Chilli *(Xylopia aromática), gonçalo-alves (Astronium flaxinifolium), mangaba (Hancornia speciosa)* and *murici (Byrsonima verbascifolia).*

Furthermore, the breeding of wild animals, the domestication of some native species, sustainable extraction and management of the standing Cerrado are ways to diversify the activities of rural estates and to achieve sustainable forms of usage of the natural resources (RIBEIRO et al., 2003).

The same economic potential has also been exploited at other Brazilian physiognomies, such as the Atlantic Forest, in restoration actions (RODRIGUES et al., 2009). However, **to achieve the sustainable use of different species and landscapes of national biomes it is necessary to improve the territorial ordainment and management, to valorize and properly manage these resources and to recover altered and degraded areas, i.e., organize, integrate and implement these actions within the concept of sustainable productive landscapes.**

1.4.1.3 Services to the Climate

There is increasing evidence that the global climate is finely regulated by the biosphere, i.e., by the integrated and homeostatic functioning of the natural ecosystems (FOLEY et al., 2003; GORSHKOV et al., 2000; KLEIDON, 2004). In the Amazon basin, several studies reveal regulatory mechanisms of climate mediated by the forest, as for example the promotion of rain through cloud biogenic nuclei (PöSCHL et al., 2010) or the active pumping of atmospheric humidity into South America from the equatorial Atlantic (MAKARIEVA and GORSHKOV, 2007).

Marengo et al. (2004) described atmospheric vapor rivers (low level jets) which link the hydrological capacity of the Amazon rainforest to the rains that irrigate productive regions in South America. In counterbalance of these benign effects, continued deforestation has been linked to worrisome changes in rainfall patterns (MALHI et al., 2008; SAMPAIO et al., 2007).

Several studies with climate simulations found thresholds in the reduction of rainfalls which, if surpassed, may jeopardize the continuity of the Amazon forest as such (NOBRE et al., 2009; NOBRE and BORMA, 2009). Probably, already as a testimony of these projected effects, a recent study (LEWIS et al., 2011) shows that droughts in the Amazon are hitting record intensity and seem to be increasing in frequency.

Through interaction with the climate, activities of the agricultural sector have more liabilities than demonstrated regulatory capacities (De FRIES et al., 2004; FOLEY et al., 2005). In most cases, the agrosystems do not replace natural ecosystems in their supporting functions to the climate, due to, among other reasons, genetic manipulation (which removes natural evolutionary abilities and adjustments); the small number of plant species used (which reduces the complexity and the functional complementarity); ephemeral and shallow rooting in short cycle cultures and pastures (which hinders an effective hydrological regulation); the mechanical intervention in the soils with the application of fertilizers and agrochemicals (which alters the biogeochemical cycles) and the removal of products and use of fire (which disrupts the buffer stocks of organic compounds).

Plantations and livestock husbandry tend to be biologically and ecologically fragile systems, whose limited success is often achieved through technological manipulation and cultural interventions. Nevertheless, they are systems which, to exist, produce and make profits depending first and foremost on natural inputs provided by the regulated and benign functioning of the climatic system.

In spite of not replacing natural systems, agricultural systems can be considerably enhanced to contribute for the mitigation of climate change through good practices which take into account gas emission and other effects from the interaction with climate (FOLEY et al., 2005).

The extent and integrity of nearby and further natural ecosystems have a relevant role in the productive functioning of agriculture and are in the immediate interest of all the economic activities at the benefited regions. In face of this, it is important that farmers, regardless of the size of their property, understand the importance of their role in the maintenance of climate support system and environmental integrity.

With the demonstrated range of environmental services for the climate, the economic valuation of natural ecosystems becomes increasingly justifiable within private properties and its recognition as a productive element of the landscape.

In Georgia (USA), which is the same size of the Brazilian state of Acre, collaboration between forest companies, agribusiness and environmental organizations recently completed a study that estimated at US$ 37 billion the annual value of environmental services to climate and environment exported by APPs of forests on private land (MOORE et al., 2011). How much wouldn't the environmental services of natural areas on private land in Brazil be worth?

A paleontological study (HECKENBERGER et al., 2008) revealed that pre-Columbian societies that inhabited the region of the Xingu River, in the Amazon, reached a high degree of urbanization, with an accentuated manipulation of the environment that included agriculture, roads and dams, however without generating a broad deforestation. The same region in Mato Grosso demonstrates today that the destruction of APPs and RLs in rural properties had terrible consequences. On the other hand, in that state there are also projects linking farmers and environmentalists, which are recovering part of the environmental liability of APPs and RLs at the headwaters of the Xingu River, with the use of cutting-edge agricultural technology, modest and affordable investments and with good prospects of financial return for the aggregation of environmental services to the mix of products from those properties (*Globo Rural* video, *Técnica da muvuca acelera reflorestamento nas nascentes do rio Xingu* – The Muvuca technique accelerates reforestation on the headwaters of the Xingu River). These examples show concrete actions to contain and mitigate environmental changes, through viable and profitable ways.

1.4.1.4 Potential physical impacts of the removal of APPs from hilltops and hillsides

As well as for other APPs and RLs, hilltop and hillside APPs compose protection areas for the natural vegetation within the properties with all the environmental services and benefits listed above. Add two unique characteristics as to the partitioning of the water flows: the presence of protective vegetation in these circumstances increases the soil structure and thereby the permeability, resulting in a greater buffering of the water input and infiltration. This leads to a slow replenishment of aquifers.

Under a greater vertical infiltration at the top of the hill, a lower amount of water will drain across the surface along downstream hillsides, increasing its stability. Either one effect or the other is important for the geological integrity of the hillsides. The landslides in the Itajaí River valley during 2008 and on the mountainous regions of Rio de Janeiro in 2011 have an important link, although not exclusive, to the state of conservation of natural vegetation on hilltops, hillsides and even at the base of hills. The specificity of the fragility of these areas to excessive water is a combination of various heterogeneous factors, such as those related to geology, geomorphology and soils, not all of them foreseen or logically encompassed by the forest legislation.

The implementation of the Forest Code involves the incorporation of some definitions liable to questioning by the lack of clarity of their meanings and/or by the difficulty in its implementation in the field. The term 'top', for example, refers to a portion of the relief which would be located 2/3 of its minimum distance in relation to the foot of the hillside. It is noteworthy that, besides the difficulty in defining the position of the foot of a hillside (which is variable according to the scale of topographic representation of the area of interest or even in the field), it should be considered that the upper limit of 2/3 upstream of the hillside foot can be at a variable distance from the ridge zone as in the case of the slopes of asymmetric interfluves, for example. Although there are elaborated topological analyses to support mathematical descriptions of hilltops (for example CORTIZO, 2007), there remains the semantic difficulty of the law and its regulations.

The lack of clarity, as well as the ambiguity in the interpretations of terms guiding the legislation, tend to make it vulnerable in its interpretation and implementation, neglecting its crucial importance as a guide for territorial planning and management. However, despite its conceptual weaknesses, one cannot deny the importance of considering the potentials and limitations of land use at any position in the topography of the Earth's surface.

Although the definition of hilltop is a matter of some controversy, the weaknesses and potential of soils can be accurately mapped with new technical means. This would allow us to evolve from the general field of little accurate geomorphological definitions and move to new accurate quantitative parameters to describe potential usage versus weaknesses and risks. As an example, a new model of terrain which employs the normalization of the landscape in relation to drainage (NOBRE et al., 2011a) has shown excellent ability in the indication of groundwater depth, an important parameter for the definition of relative weaknesses of the soil (Appendix A).

Extensive tests performed at different terrains in Brazil showed great strength of this terrain model (HAND), impressing through its indication of terrains and groundwater and by its independence of geology, geomorphology and soils. In other words, **with such terrain model it is possible to map fragile areas within the landscape which would need to be protected, using only remote images of the topography as an input.** It is therefore a clear example of an innovative approach already available from the standpoint of science and technology, and which can be used at a low cost, relatively fast, for the improvement of the environmental legislation, in particular for the protection of fragile terrains under difficult topographical conditions.

1.4.2 Economic benefits associated with Permanent Preservation Areas and Legal Reserves in rural properties

The economic use of Permanent Preservation Areas and Legal Reserves in rural properties present some particularities closely related to their end-use, as defined in the environmental legislation, especially in Law 4,771/65 and Provisional Measure 2,166-67/2001 and in the CONAMA Resolutions (2002, 2006). The allocations of both areas are complementary.

The Legal Reserve is intended for the sustainable use of natural resources, the conservation and rehabilitation of ecological processes, to biodiversity conservation and to shelter and protect the native fauna and flora; the Permanent Preservation Areas, in turn, have a function for preserving water resources, the landscape, geological stability, biodiversity, the gene flow of fauna and flora, and protecting the soil while ensuring the welfare of human populations.

Whereas in areas of Legal Reserves the sustainable use of natural resources is permitted (except for clear cutting) – independently of the dimensions and characteristics of the rural property – in Permanent Preservation Areas, the economic and sustainable use of its natural resources is conditioned and permitted only in agroforestry systems in smaller properties or under smallholder ownership, in which such use is considered of social interest (CONAMA, 2006).

In addition, to the concessions given to small properties or smallholders in the use of Permanent Preservation Areas, there is yet another, concerning the fulfillment of the maintenance or compensation of the Legal Reserve area on the property, where the areas planted with fruit, ornamental or industrial exotic tree species, cultivated in an intercropping system or consortium with native species can be computed in the calculations (Law 4,771/65, Art. 16. § 3).

The use of Legal Reserves, albeit very little exploited in terms of research, has an enormous economic potential. The examples with the largest volume of data available on the economic use of Legal Reserves relate to the sustainable use of Amazon rainforest remnants called Sustainable Forest Management of multiple uses.

The economical use of remnant forests in landscapes which are heavily degraded by human activities is still very controversial, given the impact of this management on biodiversity and the importance of these fragments in the conservation of remnant biodiversity (METZGER et al., 2010). However, areas of low land use potential, but historically occupied by agricultural activity in an improper mode, can be restored with native forests for the purpose of timber production, medicinal plants, honey varieties, native fruit or ornamental tree production, etc. Surely these plantations allow higher economic returns than nowadays, due to its occupation with low-tech agricultural activities, especially cattle husbandry with a low occupation capacity (RODRIGUES et al., 2009; SPAROVEK et al., 2010).

1.5 RISK SITUATIONS IN URBAN AREAS

With respect to APPs along and around water bodies and in areas with steep slopes, empirical observations, supported by scientific studies (ACKERMAN, 2010; AUGUSTO FILHO, 2001; FARAH, 2003; RODRIGUES and LEITÃO FILHO, 2000; ZUCCO et al., 2011), indicated that parameters for urban areas and human occupation should be established in a specific way to prevent natural disasters and preserve life. As a general principle, all headwater drainage valleys should be the target of sharp restrictions in its use and prioritized as areas for biodiversity reserves, water storage and hillside stabilization.

Recent disasters driven by extreme rainfalls in the hilly region of the state of Rio de Janeiro corroborate this statement inasmuch as, among the hundreds of landslides mapped by GEOHECO-IGEO/UFRJ in the municipality of Friburgo (COELHO NETTO et al., 2011), more than 50% occurred in the upper portion of the slopes, including in what would be classified as hilltop or ridge areas.

These studies also indicate that the scars of landslides were largely associated with areas covered by grassy vegetation, and degraded shrub formations. In face of the extreme character of landslide trigger rains, also areas with more preserved forests were affected, which is a natural process of landscape metabolism in rugged reliefs. However, in this case the scale of occurrence demonstrates the amplifying effect of the degradation of natural vegetation on the frequency of such events.

Previous studies in the Tijuca Massive (COELHO NETTO et al., 2007; OLIVEIRA et al., 1996) already indicated that, among more than 100 landslides in the mountainous slope of Jacarepaguá, only 14% occurred in areas under preserved forests, while 43% occurred in areas under grasses and 42% in areas under degraded forests.

Also compared with those studies, it is noteworthy that the rainfalls of 1996 were as intense as the recent rains in the mountainous region of Rio de Janeiro, although, in the first case, they have been very localized only at summit and ridge zones, while the more recent disasters spread over an area of greater extent.

The events mentioned herein indicate that, while on one hand the hillsides exceeded their respective thresholds of resistance to high-intensity of trigger rainfalls, on the other, it became evident that the presence and conservation of Hillside Atlantic Forest, under mountainous landscape conditions, widely favored the mitigation of disastrous effects from extreme rainfall events. The studies demonstrated, therefore, that the conservation and functional rehabilitation of forests in these hilltops areas and ridge zones should be considered as a priority.

1.5.1 *Protection against floodings and floods*

In urban areas, the occupation of floodplains and natural overflow areas of watercourses and in areas around natural or artificial lakes and lagoons has been one of the major causes for natural disasters, leading to mortality, morbidity and hundreds of thousands of victims every year, major economic losses in infrastructure, homes, buildings etc. floodings are greatly amplified due to the impermeabilization of urban areas.

Usually, in case of natural disasters, poor populations are the most vulnerable and affected. This justifies the maintenance of natural vegetation in most part of the floodplains in the form of APPs in urban areas or, more generally, in areas intended for human occupation, to serve as a natural defense against floodings and floods from watercourses and natural or artificial lakes and lagoons. This way, these would function as buffer- and cushioning zones once the waters exceed their natural beddings.

Due to huge variations in the extent of the flooding plains for different landscapes and hydrological regimes, a fixed range depending on the width of watercourses would be less effective. For urban areas, riparian APPs must cover a reasonable limit of the flooding plains – hydrologically defined by the flooding with a 100 years recurrence period. Therefore, a smaller area, called flooding passage, should be defined as one which should not be occupied.

This zone has a technical criterion definition which depends on the local hydrological and hydraulic conditions. The passage strip can, for example, represent the limit reached by floodings with a recurrence period between 10 and 20 years, which may be small or large, depending on the topography. Setting this parameter requires knowledge of the hydraulic and hydrologic regime of the watercourse, the natural or artificial lake or lagoon, and the topography of the flooding plain.

However, it is likely that this knowledge exists for watercourses crossing urban areas. For rivers with flood prevention dams, where these do not occur, the parameters of APPs would be the same as for non-urban areas, as well as in cases where the topography causes the flood passage strip to be smaller than the limits of APPs for non-urban areas.

1.5.2 *Protection against landslides and debris flows on hillsides*

In urban areas intended for human occupation, the maximum limit acceptable for using hillsides for homes, buildings or similar human settlement usage should be such that the risk for landslides or debris flows is minimized. Generally, the risk becomes too large for declivities above 25 degrees in hillside areas within Brazilian cities, although there are other geological parameters which control the susceptibility of these types of natural disasters.

In areas which will necessarily lose its natural vegetation due to occupation, declivities above this threshold hold a greater risk for suffering repeated processes of debris flows on hillsides, as has been the case in the country, resulting every year in hundreds to thousands of deaths and causalities.

Therefore, the declivity limit inserted for rural areas where hillsides shelter crop and animal husbandry activities are not valid for human occupations in urban areas. Following the same logic, hilltop areas very close to steep slopes must remain covered with natural vegetation due to the risk of landslides or debris flows.

2 CONTRIBUTIONS TO THE IMPROVEMENT OF LEGISLATION: CASE STUDIES

Based on the scientific knowledge considered in this study, some provisions of the present Forest Code and the current proposed modification were analyzed as a preliminary methodological exercise and an example, at this moment without propositions for new provisions. The following topics were chosen due to their relevance in terms of its spatial, environmental and social extent:

a) **environmental legislation in urban areas;**

b) **the proposed change in the width of APPs for rivers up to 10 meters wide;**

c) **the proposal to incorporate APPs in the computation of RLs;**

d) **the compensation of RLs outside the rural property (in the microbasin or biome).**

Summary

The analysis revealed that the present Forest Code needs improvements. Major advances can be introduced in the legal framework by adopting a process of communitarian construction of the productive activities of the occupation and use of spaces, for their adequacy to environmental legislation, including stimulus and incentive measures.

This improvement will allow overcoming outdated perceptions – such as the unfounded conflict between agricultural production and the conservation of natural resources – in the construction of new collaborative concepts among all human activities that create productive and sustainable landscapes in their synergy. Review of the legislation should also incorporate socioeconomic evolution, always based on dialogue, science and equity.

2.1 ENVIRONMENTAL LEGISLATION IN URBAN AREAS

With regard to Permanent Preservation Areas (APPs) in urban areas, we mention § 3 of Art. 4 of the proposed modification below, followed by a similar text of the present Forest Code.

Proposed modification

§ 3º In the case of urban areas consolidated under the terms of Law No. 11,977, from

July 7th, 2009, changes in the limits of Permanent Preservation Areas shall be foreseen in the master plans or in the municipal laws on land use, respecting the principles and limits referred to in this article. (our emphasis).

Present Forest Code

Sole Paragraph. In the case of urban areas, as understood by those included within the urban perimeter as defined by municipal law, and in metropolitan areas and urban agglomerations, throughout the embraced territory, the disposed shall be observed within the respective master plans and land use legislation, respecting the principles and limits referred to in this article (Included by Law No. 7,803 from 7.18.1989). (our emphasis).

Both in the present Forest Code and in the proposed modification, unless master plans and municipal legislation establish more stringent parameters for urban areas, the same principles and limits established for rural areas are valid. The underlying logic is that for urban areas the same principles of the other areas concerning the protection of soil, water resources and biodiversity must be valid.

One cannot ignore the relevance of current restrictions on human use and occupation provided under the present Forest Code, especially in the hillsides of mountainous regions, where the movement of soil debris and rock fragments tend to start in the upper portion of hillsides, as well as on what can be considered as a summit or ridge zone.

However, for urban areas and human occupations in general, the principle of life protection should figure with emphasis and as a hierarchical equal against other guiding principles enshrined of the Forest Code. The best way to protect life is avoiding the occupation of areas at risk from natural disasters, especially those resulting from floodings, floods in floodplain areas, and of landslides and debris flows on hillsides.

Thus, the Forest Code should establish principles and minimum limits, although differentiated for urban areas without consolidated occupation, while the municipal master plans for soil use would deal with areas at risk with consolidated occupation or determine more stringent limits on parameters of riparian APPs, on hillsides or hilltops.

Conclusion

Through the creation of APPs in urban areas, new corridors and green areas would be established along rivers, lakes and lagoons, and green steep hillsides, thereby increasing the usually extremely low rate of green areas in most Brazilian cities. This would bring additional benefits, such as the decrease of impermeabilization, erosion and siltation, mitigation of maximum temperatures and minimum air humidity, increasing the thermal comfort of the population and reducing air pollution.

2.2 ALTERATION OF THE REFERENCE EDGE AND THE WIDTH OF RIPARIAN APPS

The proposed modification changes the width of the APP for rivers up to 5 m wide, reducing it from 30 m to 15 m, maintaining the width of 30 m of APPs for rivers between 5 and 10 m wide and further lengths for larger rivers as established in the present code.

Present Code

Art. 2. *Are considered as being under permanent preservation, for the sole purpose of this Law, forests and other forms of natural vegetation located:*

a) – along rivers or any watercourse, at its highest level in bordering strips, whose minimum width will be (Wording of Law No. 7,803 from 7.18.1989):

1 - 30 (thirty) meters for watercourses of less than 10 (ten) meters wide (Wording given by Law No. 7,803 from 7.18.1989);

Proposed modification

Art. 4. *Are considered as Permanent Preservation Areas, in rural or urban zones, for the sole purpose of this Law:*

I *– bordering strips of any natural watercourse, from the lower bedding edge, with a minimum width of:*

a) 15 (fifteen) meters for watercourses of less than 5 (five) meters wide;

b) 30 (thirty) meters, for watercourses that have 5 (five) to 10 (ten) meters wide;

Considerations

Soils and vegetation in areas under the influence of rivers and lakes are systems of recognized importance in conditioning flows, regulating mineral nutrients and conditioning water quality, sheltering biodiversity, with its provision of environmental services and maintaining channels. There is consensus among scientists that these strips need to be kept as close as possible to their natural state.

They also are areas susceptible to coverage by the water blade with deposition of sediments during floods and sediment removal by erosion with the receding waters. The continuous presence of water saturating the soil has many physical, chemical and biological implications. Such soils, when covered by dense vegetation, favor the deposition of layers of organic material or the export of dissolved carbon which will end on the seabed, both important sinks for atmospheric carbon sequestered by vegetation. When cleared, they no longer sequester carbon. With its progressive drainage, they are susceptible to a rapid release of large volumes of carbon dioxide in the atmosphere.

The soils on the riparian strip are particularly susceptible to erosion due to their physical characteristics and the high energy contained in that strip, which becomes even more critical by the extensive catchment area in the upstream hillsides.

Both the physical erosion of particulates as the chemical erosion of dissolved compounds generate contaminants which undermine the water quality and promote siltation of canals and lakes. The key factor for its stability and functionality lies in the natural vegetation acting in the protection of these fragile environments.

When mature natural ecosystems flank the water bodies and cover the associated saturated terrains with humidity, carbon and sediments are laid down, excess water is contained, erosive energy of currents is dissipated, flows of nutrients in the percolating waters undergo chemical filtering and microbiological processing, which reduces its turbidity and increases it purity.

The importance of riparian forests was scientifically demonstrated in different Brazilian biomes and for different groups of organisms. Most studies were done in the Atlantic Forest, but there is also data for Amazon, Caatinga, Pantanal and Cerrado. In relation to taxonomic groups, there is data for trees, amphibians, birds, large mammals, small mammals and bees. There is no doubt that regardless of biome or the considered taxonomic group, the entire landscape should maintain riparian corridors, on account of their benefits for the conservations of the species.

The benefits of riparian corridors may be related to the width, length, continuity and quality of corridors, the topography and width of the areas under riparian influence, among other factors. However, the most important factor, undoubtedly, is the width of these corridors.

Studies which considered the biological functionality of the corridors with regard to their width indicate minimum values greater than 100m. In the Amazon, widths from 140 to 400m were needed to enable some degree of similarity between fauna communities (small mammals, amphibians, birds and mammals). There are a great number of semi-aquatic mammal species, such as otters and giant otters, which rely on ciliary forests, as well as various endangered species of birds, butterflies and fishes which live exclusively in these areas.

In Amazonian rivers, leachate from leaves of the adjacent vegetation inhibits microbial growth that, on the other side, restricts the occurrence of mosquitoes whose larvae feed on these bacteria, with direct implications on public health. Many other species use these strips as dispersal corridors across the landscape, making them important connecting elements between fragments of woodland remnants in areas altered by human activity or occupation.

Change of the reference edge in the proposed modification

The allocation of riparian protection strips, counting from the highest water margin (as in the current Forest Code) or lower bedding (as in the proposed modification), uses variable levels of water as a basis for allocating geographically defined strips (and temporally fixed), which is a problem common to both approaches. The zone between the higher water and the lower bed contains floodplains, flooded forests, mangroves and other wetland ecosystems, constituting the oscillating part of the water body.

Scientifically, ciliary forests beyond the highest water level cannot be detached from perennial water bodies, as defined by the lower bedding, since, among other reasons, from a functional point of view the flooding area in between present edaphic conditions typical of surface groundwater, even in periods of receding waters.

Vast regions are subjected to periodic floodings (in the Amazon, a study estimated the flooded area at 11.9% of the total area), being these areas protected in the present Forest Code, according to the prevailing interpretation, by their implicit inclusion in the definition of water bodies. By transpositioning ciliary strips through the proposed modification from the highest water level to the lower bedding, the flooded areas would lose up to 60% of its protection in the Amazon.

This change of edge in the proposed modification hides a seriously aggravating factor: the ciliary strips of the present Forest Code do not overlap with existing bordering flooding strips as in the proposed modification, which implies in the elimination of a large part of the former as protection area. The loss of protection in 60% of flood areas and the disappearance of ciliary APPs indicate the significant impact of the proposed modification.

Reduction of the ciliary strip in the proposed modification

Rivers of the first order, which reach up to 5m wide, comprise an extension of more than 50% of the drainage network. The proposed modification for reducing riparian strips from 30 to 15 m in these rivers results in a gross reduction of 31% of the protected area in relation to the existing code.

According to a study conducted at INPE which covered more than 300,000 km^2

across four regions of Brazil (NOBRE et al., 2011b), on average 17% of terrains in private areas consist of hydromorphic soils with superficial groundwater. The ciliary strips in the riparian areas defined as APPs by the current Forest Code protect less than 7% of these areas. Sixty percent of fragile hydromorphic soils remain with no protection.

The scientific knowledge accumulated so far indicates that the maintenance of ecological corridors (ciliary forests) of 60m wide (30m on each side of the river), as in the current legislation, already defines a very limited ability to maintain biodiversity, which can reach values close to 50% of the remnant diversity. is way, it is expected that this diversity will be reduced if the width of riparian corridors becomes half of that value (15m) in rivers up to 5m, as suggested by the proposed modification. Therefore, this reduction in the protective strip can have a huge impact over biodiversity, since these rivers cover a great part of the Brazilian hydrographic network, containing an unique fauna.

Studies on anuran amphibians (frogs and toads) in the Atlantic Forest indicate that 50% of their species are concentrated in creeks with less than 5m wide. In the last endangered species list for the state of São Paulo alone, from the 66 fish species classified as being under some degree of threat, 45 show high fidelity to narrow creeks and, therefore, are dependent on the quality of the surrounding and internal habitat. Moreover, most of these creeks are already highly degraded, with their margins being often occupied by pastures without any remnant ciliary forest.

Under these conditions, the rivers tend to be biologically impoverished, dominated by a few species, with high abundance of exotic species and lower biomass of fish and other organisms.

Conclusion

The Forest Code contains minimum levels of protection, still insufficient to protect the riparian zones in a scientifically substantiated way. The scientific knowledge obtained over the last years allows not only to sustain some of the figures in the present Forest Code in relation to the extension of APPs, but also indicate the need for many ciliary situations of expanding minimum thresholds of at least a 100m (50m on each side of the river), regardless of biome, of taxonomic group, of soil or type of topography.

2.3 INCORPORATING APPS IN THE CALCULATION OF RLS

Present Code

Art. 16. *Forests and other native vegetation, except those located in areas of permanent preservation, as well as those not subjected to a regime of limited use or being an object of specific legislation, are susceptible to suppression, provided that they are kept, at least, as a Legal Reserve:*

§ 6º *The concerned environmental agency will allow the inclusion of native vegetation areas within permanent preservation areas in the percentage calculation of Legal Reserves, provided that this does not imply in the conversion of new areas for the alternative use of soil, and when the sum of native vegetation in permanent preservation areas and Legal Reserve exceeds:*

I *– eighty percent of the rural estate located in the Legal Amazon region;*

II *– fifty percent of the rural estate located in the other regions of the country; and*

III *– twenty-five percent of the small estate defined in art. 1, § 2, I (b) and (c).*

b) fifty hectares, if located in the polygon of droughts or east of the Meridian of the 44th W, of the state of Maranhão; and

c) thirty hectares, if located elsewhere in the country.

Proposed modification

Art.15. *The inclusion of Permanent Preservation Areas will be admitted in the percentage calculation of the Legal Reserve on the property inasmuch as:*

I *– the benefit provided in this article does not result in the conversion of new areas for the alternative use of the soil;*

II *– the area to be included is preserved or under a recovery process, as declared by the owner to the state or municipal agency member of Sisnama; and*

III *– the owner or holder has requested inclusion of the property in the environmental register, under the terms of art. 24.*

§ 1 *The protection regime of Permanent Preservation Areas does not change under the hypothesis foreseen in this article.*

§ 2 *The owner or holder of a property with a preserved and registered Legal Reserve,* *whose area exceeds the minimum required by this Law, may impose environmental easement on the exceeding area, under the terms of art. 9-A of Law 6,938, from August 31st, 1981.*

Considerations

The scientific basis for the RL is the fact that before the existence of a property, there was a natural landscape. Thus, by recognizing the importance of a source of raw material, mainly timber, within the estate, the State proposed the maintenance of a certain portion of the total area of the property to fulfill local needs.

Currently, however, the widely established perception is that the vegetation which makes up the RL also fulfills several other relevant functions besides the utilitarian one. The historical origins and basis for the institution of reserved forest grounds can be examined in Ahrens (2007). The proposed modification, as a suggestion for discussion, maintains the obligation for the maintenance of a RL on each rural estate, but exempts, however, properties with up to four fiscal modules from such obligation.

In its article 16, paragraph 6, the present Forest Code admits to be possible to unite APPs with the RL area in the calculation of the latter, subsequently adding up the percentage in relation to the total area of a rural estate. This possibility, however, is an exception to the general rule. On the other hand, the proposed changes under art. 15, contemplates that possibility as a new general rule, although very much subjected to the observation of some prerequisites, hereby maintaining the fixed percentages established in art. 13, even under this hypothesis. It is observed that the statement present in the proposed modification is not substantiated.

It is noteworthy that APPs and RLs were legally established to fulfill different, although complementary, social and environmental functions. In this regard, Ahrens (2010) examines the organic structure of the current Forest Code and suggests that its foundations be further evaluated. The APPs result from the occurrence of certain geographical features within the rural estate, such as the presence of headwaters, watercourses, lakes, terrains with declivity greater than 45°, hills and mountains, as well as of soils, water and biodiversity.

On the other hand, preserving the vegetation which makes up the RL results from a legal imposition. Besides enabling a sustainable use of the vegetation, the RL is an important complement to APPs, as for the replenishment of water sources and biodiversity conservation (essential to enable the pollination of many species used in agriculture). In both cases, the main beneficiary of the conservation of the vegetation is the owner or farmer himself.

Additionally, the proposed modification does not mention the smallholder property as such, in accordance with the Brazilian legal system, but only defines small rural estates as those having a total area of up to four fiscal modules.

Hereby, requirements which characterize the intrinsic nature of a smallholder property are omitted from the proposed definition, such as the need for the stallholder to live on the property, to work the land with the predominant use of family labor, whereas being also his only property. The clear presence of these characteristics – and not only the area of the turf – is what constitutes the basis to substantiate a differentiated treatment within the legislation.

From the above, it appears that the hypothesis suggested in the proposed modification must be analyzed more in depth and better debated to actually constitute an advance or improvement.

2.4 RL COMPENSATION OUTSIDE OF THE RURAL ESTATE IN THE MICROBASIN OR BIOME

The suggested proposed modification creates new possibilities for the compensation of RLs, in the form of buying shares of environmental reserves, of lease under easement, or through the donation of areas within the Conservation Units to the government. The biggest problem is that such compensations may be made at any location within the same biome.

Current Code

Art. 44. *The owner or holder of any rural estate with an area of native, natural, primitive or regenerated forest, or other form of native vegetation in a lesser extent than prescribed in items I, II, III and IV of art. 16, except as provided in their §§ 5 and 6, should adopt the following alternatives, alone or in combination:*

III *– to compensate for the Legal Reserve with another area equivalent in ecological importance and extent, as long as it belongs to the same ecosystem and is located in the same microbasin, according to criteria established by regulation.*

§ 1 *In the restoration treated with under item I, the concerned state environmental agency shall provide technical support to small estates or smallholder ownerships.*

§ 2 *The restoration treated under item I can be accomplished by the temporary planting of exotic species as pioneers, aiming to restore the original ecosystem, according to general technical criteria established by CONAMA.*

§ 3 *The regeneration treated under item II shall be authorized by the concerned state environmental agency, once its viability is established through a technical evaluation,* *whereby the seclusion of the area may be required.*

***§ 4** Whenever the compensation of a Legal Reserve within the same hydrographic basin is precluded, the concerned state environmental agency should apply the as close as possible proximity criteria between the property devoid of Legal Reserve and the area chosen for compensation, provided that within the same hydrographic basin and the same state, considering, whenever present, the respective Hydrographic Basin Plan and in compliance with further conditions set out under item III.*

***§ 5** The compensation treated under item III of this article, shall be submitted to approval by the concerned state environmental agency and can be implemented through the lease of areas under a forest easement regime or Legal Reserve, or the acquisition of shares mentioned under article 44B.*

***§ 6** The rural landowner may be relieved from the obligations under this article, for a period of 30 years, by donating to the concerned environmental agency areas with a pending land registration located within National or State Parks, National Forests, Extractive Reserves, Biological Reserves or Ecological Stations, if met by the criteria under item III of this article.*

Proposed modification

***Art. 26.** The owner or holder of a rural estate who has a Legal Reserve area with an extension smaller than established under art. 13, can regularize his or her situation, regardless of having joined the Program for Environmental Regularization, by adopting the following alternatives, alone or in combination:*

***I** – recomposing the Legal Reserve;*

***II** – allowing natural regeneration of the vegetation in the Legal Reserve area;*

***III** – compensating the Legal Reserve.*

***§ 5** The compensation mentioned in the head can be made by:*

***I** – acquisition of Quotas from the Environmental Reserve – CRA;*

***II** – lease of area under Environmental Easement or Legal Reserve, equivalent in ecological importance and extension, within the same biome, according to criteria established by regulation; or*

***III** – donation to the government of an area with a pending land registration located within the Conservation Unit of the strict protection group, or contribution to a public fund which has this purpose, in compliance with the criteria established by regulation.*

Considerations

As suggested in the proposed modification, an owner in the countryside of São Paulo who should preserve a RL of Semideciduous Seasonal Forest may compensate the irregular destruction of this RL by buying an area of Dense Ombrophilous Rainforest at the Serra do Mar, or even an forested area in Pernambuco.

In both examples, the forests are not equivalent, as they are situated under very different environmental and climatic conditions, with rather different vegetations and ecosystems that do not match. This new legal provision ignores the fact that forests and other vegetation formations in Brazil are heterogeneous, resulting from complex biogeographic processes, being this precisely the reason why these areas are internationally recognized for its high biodiversity.

Most species have a limited geographic distribution within each biome, whether in centers of endemism or biogeographic zones, or either in different physiognomies. Not adjacent compensation areas or in different phytoecological regions do not lend themselves for the conservation of species from the lost region.

Moreover, the possibility for RL compensation by means of donation of an area located within a Conservation Unit to the government distorts the role of the RL and transfers to the owner a State responsibility: the maintenance of biodiversity in UCs under its responsibility. Compensations should only be made in areas ecologically equivalent, considering not only the regions of endemism, but also the differences in species composition and structure of ecosystems which occur within the subdivisions of each major Brazilian biome.

Nevertheless, it is important to note that any compensation for loss of RL in a region held in another area does not reset the ecosystem services provided by the lost RL in its original area, nor prevent the progressive environmental degradation caused by such a loss.

In Brazil, studies on ecosystem services of the RL in a rural estate are still preliminary, but there are already evidences of increases in agricultural production due to biotic pollination services. But the forested areas should be close within the landscape, in order for this ecosystem service to be more efficient.

Importance of the fragments in the regional landscape

Besides biological and ecosystem service issues, small fragments of native vegetation, maintained as RL in the same microbasin or basin play an important role in decreasing the isolation of the few larger fragments, hereby functioning as springboards in the displacement of species across the landscape. Without these fragments, the biological flows would be greatly harmed, further accelerating the extinction process.

In regions with a high human occupation, the small fragments (<100 ha) represent a considerable portion of what remains. In the case of the Atlantic Forest, these fragments represent the remaining 90% and 30% of the total area of the remnant forest. Although small, such fragments represent relevant areas and provide important services to humans and the species, especially if they are spatially planned, considering the parameters of regional landscape.

Agricultural and environmental planning in the regional landscape

Much scientific data indicate the existence of a significant percentage of agricultural areas of low land use potential and high forest potential in landscapes from many regions of Brazil. Given its low land use potential, a portion of these areas was maintained with a natural cover that can and must be used in the compensation of RLs in regions of higher land use potential within the microbasin or basin, thereby defining a legal and available instrument, very effective in protection of these natural remnants.

Besides allowing an economic gain for the owners, these areas are already compensating the deficit in RLs from properties in regions with a high land use potential. However, many of these areas were historically and inappropriately reverted to agricultural activity and nowadays are used marginally, with low tech production activities and, consequently, very low economic performances.

Such areas could be reverted into production forests, using native species, within the precepts set for RLs, not only allowing the implementation of the Forest Code, but also using already available mechanisms for compensating RLs, hereby ensuring a significant increase in economic return to its owners.

Pastures in areas of more pronounced declivity in hilly areas are examples of marginal agricultural areas. In the Atlantic Forest, pastures with declivities between 25° and 45° account for more than 6 million hectares and could be reverted into production forests, whereas the deficit of RLs within the Atlantic Forest domain is less than 3 million ha.

Conclusion

Hereby, it becomes clear that allowing the compensation of RL within the biome and not the microbasin or basin, as suggested in the proposed modification, certainly demands more scientific knowledge to support appropriate parameter definitions for the normalization of this permission, in order to safeguard that this compensation ensures, at least, the achievement of the same benefits promoted by the maintenance of a native vegetation cover within the microbasin or basin.

Based on the available knowledge, the more relevant recommendation is to advise that RL compensations are made as close as possible to the defaulted area, considering the very same microbasin or even nearby microbasins or basins, but with the same ecological equivalence and not to allow an indiscriminate compensation within the biome, without any clearly defined mechanism to ensure the ecological and even economical aspects of such compensation.

3 PROPOSAL FOR FUTURE REFERRALS

The SBPC and the ABC wish to continue contributing for the improvement of the Forest Code by providing scientific and technological inputs for the dialogue. Critical review of the various topics covered in the Forest Code should also be made in the light of the most advanced science and technology, through a careful assessment of the virtues and problems of the current law, for it is necessary to move forward with the Brazilian agricultural and environmental legislation.

Under Item 2, a first exercise in this type of analysis was developed, showing the pros and cons of the present law and of one of the proposed changes based on available scientific knowledge, in trying to go forward with predictions for an improvement of the law.

Brazil is the country which shelters the largest number of species of plants, animals and microorganisms in the world. This represents a huge differential in natural capital, strategic for the country's socioeconomic development and which needs to be preserved and used in a sustainable way. At the same time, technological innovation is at the root of the success of Brazilian tropical agriculture and is the most powerful asset to qualify countries for competition at the global market.

It would be very desirable that in the improvement of the Forest Code a new public policy could encourage the concept of intelligent and fair territorial ordainment, emerged from a careful and informed planning of the landscape. The construction of a new and improved Forest Code would depart from some basic premises considered essential for the consolidation of a sustainable environmental policy, such as:

A) It should be based on a participative construction, by consensus, with consultation of all sectors directly involved with the matter. No sector of the rural or urban environment should be unilaterally favored by these changes, although smallholder properties certainly need special attention, given their social and economic peculiarities. All sectors should have room for manifestation and be able to influence decisions on the proposed modification.

B) All propositions must be substantiated by the existing scientific knowledge on the respective subjects. If the knowledge required to support some of these propositions is still controversial or not available, these would be placed under pending scientific support, for further review, and included in a program to fill the knowledge gaps, funded by public institutions;

C) It should be grounded on a plural and propositional vision, which integrates rural and urban surroundings, respecting the environmental particularities of each biome, within the concept of territorial ordainment and landscape

planning, hereby using the most updated and advanced resources for the imaging and computational modeling of terrains;

D) It should be based on an integrated vision of the rural estate, within the perspective of their environmental adequacy, considering the agricultural production areas, the preservation and mixed use areas, thereby incorporating all possible forms of Payments for Environmental Services (PES);

E) The technological adequacy for the occupation of agricultural areas should be designed according to their potential, aimed at enhancing agricultural productivity with the least possible environmental impact, respecting all the local limitations and particularities of these production systems, including cultural ones. The objective stated under this theme, which seems to be palatable to all currents, is to introduce a new technological intelligence in the landscape and improve justice in the optimization of the uses to increase production without threatening its sustainability[1];

F) The main concept shall be that of construction of an environmental legislation which stimulates good practices able to guarantee the future and provide, as public policy, the construction of rural landscapes with a social, environmental and economic sustainability;

G) It should establish different principles and limits in urban areas without a consolidated human occupation, while the master plans for municipal land use would handle the risk areas with a consolidated occupation.

1 This adequacy of the agricultural areas should result in the provision of areas of lower land use potential on the rural estate or in the regional landscape. These areas may be re-occupied with native vegetation. This concept will consider the possibility of compensating the Legal Reserve deficit outside the rural estate, after restoring the connectivity of remaining fragments on their respective properties, thus creating an efficient mechanism for the protection of natural remnants in the regional landscape. Despite the current low land use potential, at some time in the history of the Brazilian agricultural occupation these areas were turned into production areas, although generally of small economic return due to the low technological input level, with the possibility of converting them again into natural formations. This conversion, however, must have an economic component. The proposal is to restore natural formations capable of sustainable management, as currently allowed for the Legal Reserve, providing a higher economic gain than currently obtained from these areas occupied with a poorly technified agriculture. Hereby one should sum the sustainable use of natural products, such as timber, phytochemicals, seeds, ornamental plants, native fruits etc. and other Ecosystem Services – such as the sequestration or maintenance of terrestrial carbon stocks, water production and protection, habitat for pollinators etc. – encouraged by the payment of annual compensation rates for properties in regions with a high land use potential and generally with Legal Reserve deficits.

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APPENDIX A - NEW GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN SUPPORT OF TERRITORIAL ORDAINMENT

Summary

Three dimensional images of the Earth generated with advanced technology such as radar or lasers allow the construction of virtual models of the landscape that can easily be analyzed on computers. By combining the diagnostics and quantitative functional knowledge on geology, geomorphology, soils and hydrology in mathematical models it is possible to identify and map the potential use, weaknesses and risks of each terrain in the landscape.

Crossing maps with terrain potential and weaknesses and maps with land use and cover allows the evaluation of different degrees of sustainable use, whether the use is appropriate and where it could be improved. It also allows planning the use of soil in an objective way, substantiated by the terrains functional properties.

In the same way as already happens with the weather forecast, regularly updated maps in high resolution of the whole territory could also be transparently made available to society on the internet. In the dialogue on the Forest Code, the availability of new accurate and verifiable diagnostic maps offers unprecedented potential to simplify the definition of areas for the production, conservation and environmental recovery.

With these new technologies – many of them developed in Brazil – it will be possible to build a new era in soil use, based on intelligence, justice and responsibility, with respect towards the potential and limits of nature.

Introduction

Territorial ordainment in the 21st century can now rely on powerful technological tools for the diagnosis of terrains and spatial distribution of usage potential and environmental risks. Sophisticated aerial or orbital remote sensing techniques have been extensively used to describe and quantify properties on the terrestrial surface. Most of these techniques make use of spectral signatures (colors) of the surface to classify land covers and uses, being based on images which capture two-dimensional characteristics of the landscape. However, knowing only the land cover or usage renders the diagnosis insufficient for estimating capabilities and use potentials or risk zones for natural disasters. It is natural that the horizontal proximity of a river or its riparian zone, for example – attributes extractable from a cover and use map through buffer zones (marginal strips) around the drainage network – would be related to capability or frailties and risks. But due to the physics of water in the Earth's gravitational field, the definition of potential and actual risks depends directly on the topography, i.e. the combination of horizontal and vertical dimensions.

In order to add vertical or volumetric dimensions to surface images there exist techniques for three-dimensional imaging, such as those employed to generate Digital Elevation Models (DEM). The DEMs are virtual (or numerical) models of the landscape from which many physical, descriptive and functional attributes relevant to the definition of land use potentials and risk areas can be computationally extracted.

The DEMs could be Digital Surface Models (DSM), which depict the topography of the outermost surface of the landscape, including the outlines of the vegetation canopy and building roofs; or could be Digital Terrain Models (DTM), which depict the actual or hydrologically relevant topography of the soil: directly whenever uncovered and visible; or, in the presence of vegetation and buildings, through penetrating remote imaging and/or obstacle removal processing. Some DEMs are available for continental areas across the globe, such as radar active imaging from the SRTM (Shuttle Radar Topographic Mission, 1 m vertical resolution and 90 m horizontal); or with the passive stereoscopic optical imaging of ASTER (1 m vertical resolution and 30 m horizontal). Both SRTM and ASTER are DSMs, which represent some restrictions for the mapping of areas with islands of dense forests which occupy valleys and grottos or scattered throughout deforestations or urban areas with tall buildings. DTMs of great potential for accurate mapping of risk areas are beginning to be available with active aerial remote sensing techniques, such as Light Detection and Ranging (LIDAR) lasers and P-band Synthetic Aperture Radar (SAR), both with a horizontal resolution of a few meters to less than 1 m and vertically in the scale of centimeters. Although the large scale availability of elevation models compatible with the resolutions fulfills the basic requirement of the data used in various kinds of mappings, for the definition of use potentials and risk areas those models only are not sufficient, albeit being a necessary resource.

DSMs and DTMs represent respective surfaces in a quantitative manner, allowing a mathematical manipulation of the topology in a computational environment. In these manipulations, one can employ a logic derived from fundamental physical principles and thus enhance and reveal properties of the landscape associated with specific potentials, weaknesses and risk.

HAND model of Terrains

One of the mathematical models suitable for the analysis of DSMs or DTMs is the HAND (Height Above the Nearest Drainage). It is a revolutionary terrain model developed in Brazil, which has the capacity to, among other things, foresee the depth of the groundwater based on digital topography or an elevation model alone. It is a model which solves the puzzle of soil moisture through topological maps of hydrologically relevant environments. It was developed in collaboration between the LBA project - a research group from INPA[1] active at the instrumented microbasin of Igarapé Asu, near Manaus, which discovered and structured the concept based on topographic and hydrologic data (Nobre et al., 2011a) – and the CCST – an INPE group active in terrain modeling, which wrote the computer program to represent the new concept (Rennó et al., 2008). This model consists of a topographic normalization using the drainage network as a relative reference.

In the application herein, the analysis begins with the recognition that each hillside in a hydrographic basin is subjected to gravitational forces whose effect is to accelerate the movement of percolating water or that from the runoff. Thus, topographical gradients are the basic ingredients to define the dynamics of water on the surface. The rivers are points of the relief placed on the lowest elevation relative to the hillsides, from where episodic flows come in the runoff or continuous saturated flows from the porous medium. Terrains surrounding the watercourse tend to have shallow groundwater. This watercourse becomes deeper as the relative unevenness of the surface to the closest drainage increases. This way, the HAND model indirectly describes terrains according to the depth of the groundwater.

Application of the HAND model for mapping land use potentials

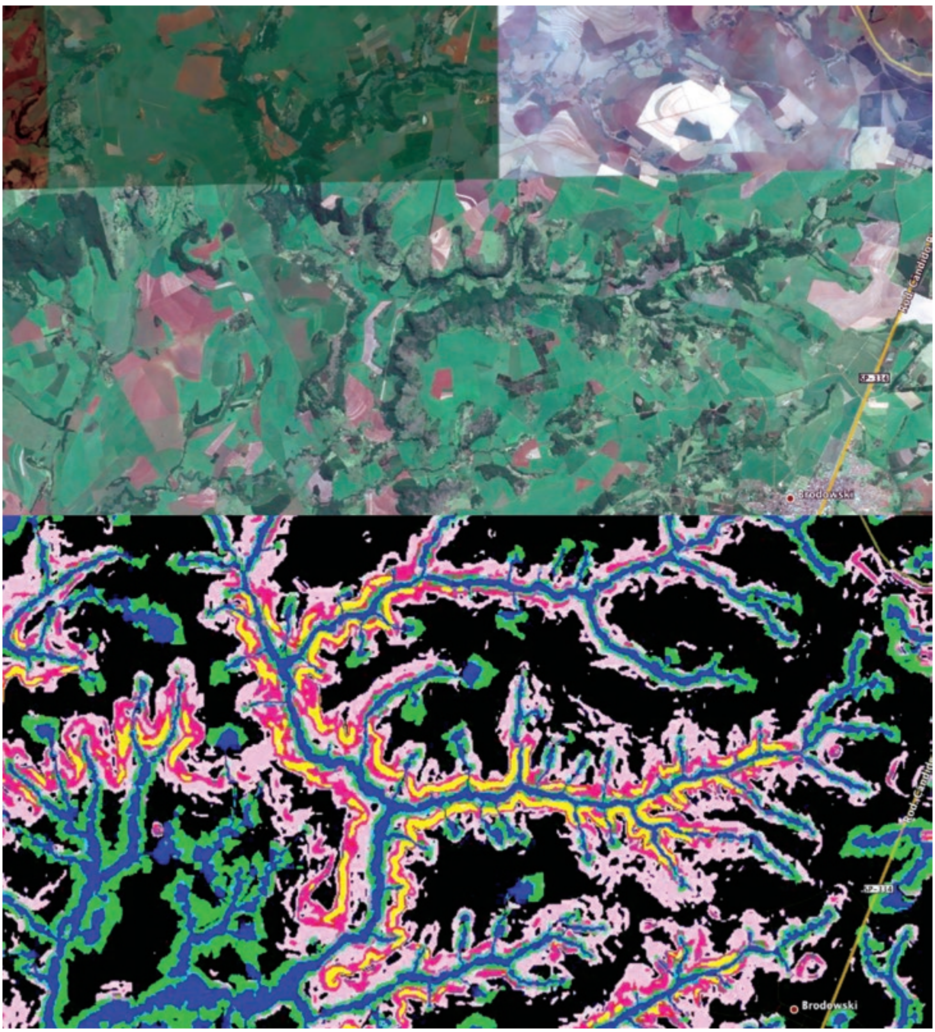
One of the most laborious tasks for a good planning of agricultural and forest activities is the mapping of topographic, physical and chemical characteristics of the soils. For most farmers such maps are inaccessible due to their cost or lack of technical assistance that would allow them to apply specialized knowledge in a beneficial way for production. This difficulty makes the use of maps for terrain diagnosis rare, which has meant big losses both for not optimized productive activities as for fragile areas used in an unsustainable manner. The HAND model offers, in a direct and quantitative way, data on the topography (declivity, position in relief etc.) and hydrology (groundwater depth, distance to watercourse etc.), which are determining factors for the potential allocation of soil use. Indirectly, the HAND model can also provide information on soil types and environmental and use susceptibilities, which are important factors for the specific allocation of agricultural activities and protected areas.

An example of application of the HAND model for mapping land use potentials can be seen in Figure 5, for the region of Brodowski near Ribeirão Preto in the state of São

1 Translator's Note: INPA stands for the National Amazonian Research Institute; LBA stands for the Large-scale Biosphere-Atmosphere research project.

Paulo. The satellite image shows a typical agricultural region with flat interfluves cut by seated drainage. The HAND map of the same area (based on TOPODATA radar data, 1 m vertical resolution and 30 m horizontal) indicates the terrains' potentials and weaknesses with relatively high resolutions. The flatter areas with well drained soils (shown in black) lend themselves to a more intensive, mechanized, high-yielding production. The areas in the bottom of the valleys along the watercourses (shown in blue) have hydromorphic soils (continuously saturated with water – or marshy), therefore fragile and which must necessarily be protected by natural vegetation. The contiguous areas with shallow groundwater (shown in green) tend to be also relatively weak terrains, but which may alternatively be used for Legal Reserves, under the increase of corridors for fauna and additional protection for riparian areas. In some well-defined situations, agriculture can be done in these areas, with special care to promote the conservation of soils and non-contamination of the nearby groundwaters and watercourses. Sites with high and critical declivities (shown in yellow and red) tend to be almost always weak terrains, highly susceptible to erosion, which mandatorily need permanent protection of the natural vegetation. Areas with moderate and steep declivities (shown in pink and magenta) also tend to be relatively weak terrains, but may alternatively be used as Legal Reserves, in complementation of corridors for fauna and protection of soils prone to erosion. In some well-defined situations, perennial crops, like fruits for example, can be done in these soils, as long as respecting evolved practices for soil conservation, such as terraces and zero-tillage under short cycle cultures.

Figure 5 – Example of a HAND model application for the mapping of land use potential in the landscape and environmental risk zones in the region of Brodowski, near Ribeirão Preto (SP). Areas in black correspond to mechanized flat soils, with a better potential for agricultural production activities. Blue and green correspond to humid areas prone to flooding; in yellow (high risk) and red (critical risk) are hilly areas with a highly limited use. In pink and magenta are the areas with a limited use potential which require precautions with erosion.



Application of the HAND model in the mapping of areas at risk

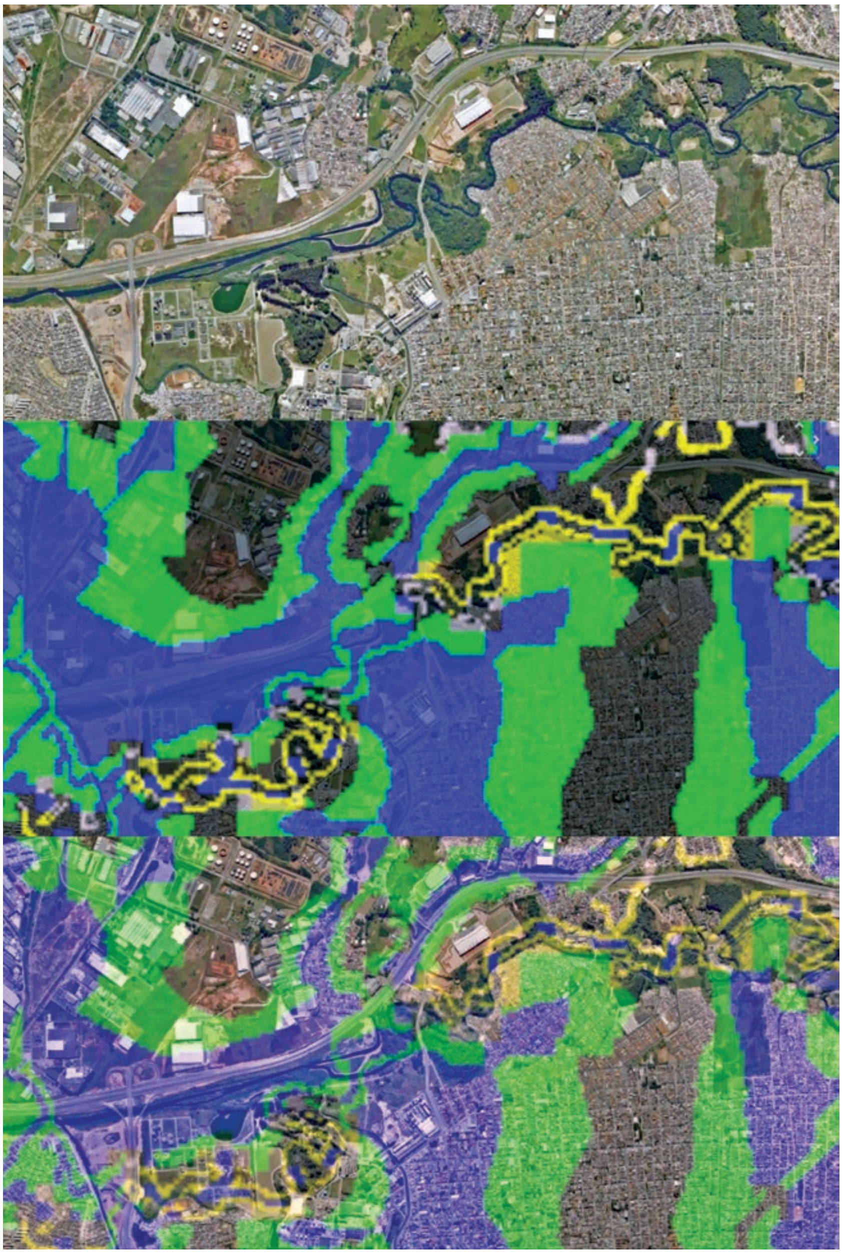
Due to the variable morphology of valleys and channels, when using elevation models above sea level only it becomes very difficult to foresee the dynamic heights of flooding levels. This difficulty is particularly intractable under accentuated topographic gradients along the drainage axis or with complex profiles of the surrounding channels and valleys. A method used to determine areas prone to floodings is the unevenness in relation to the watercourse in its cross section, which works well for relatively flat stretches of watercourses (flood pools). More sophisticated methods to represent flow leakage apply complicated hydrodynamic formulations and parameterizations fitted to the three-dimensional shape of the channel and valley. However, the parameterizations only are so difficult to obtain that their application have been restricted to isolated experiments. Therefore, prior to the HAND model there wasn't any method for a general mapping of flood risk areas, becoming ever more necessary in face of the increase in extreme weather events.

The HAND model of terrains allows for the consistent hydrological definition of the relative proximities of watercourses. Its actual capacity to map areas prone to flooding along watercourses was tested in the Megacities project, mapping the metropolitan area of São Paulo (NOBRE et al., 2010). In São Paulo, the IPT[1] and other agencies monitor the floods and, in the findings, the HAND mapping scored very well.

Figure 6 shows part of the metropolitan area with the risk areas highlighted through classification by the HAND model, in the case of Jardim Pantanal, in the vicinity of the Tietê River. In this densely populated area, it becomes possible to delineate which areas are safe and which need special attention from planning and civil defense. The delineation enables the spatial concentration of efforts both for planning and relative in susceptible areas.

1 Translator's Note: Technological Research Institute of the state of São Paulo.

Figure 6 – HAND map of areas prone to flooding for the central area of the metropolitan region of São Paulo, superimposed on a satellite image showing susceptible urban areas. a) Satellite image of Jardim Pantanal, in the metropolitan region of São Paulo; b) HAND map of areas prone to flooding in the same area; c) Superposition of the susceptibility map with a satellite image showing details of susceptible areas. Blue indicates unevenness up to 5 m and green unevenness up to 15 m from the nearest watercourse.



Source: Nobre et al. (2010).

When adding declivities with relative normalized heights to the HAND model, it becomes possible to identify and map hillsides at risk of collapse in detail. In the work done under the Megacities project, Agostinho Ogura (IPT) defined risk classes for landslides and debris flows using declivity spectrums. From the digital elevation model, the HAND algorithm located and mapped these declivity classes, hereby indicating all areas which together are prone to environmental risk (Figure 7).

Figure 7 – Application of the HAND model for mapping areas at environmental risk in the metropolitan region of São Paulo, showing in blue the areas prone to flooding and torrents, in yellow (high risk) and red (critical risk) the areas prone to landslides and mass flows. In black are the areas which are relatively safe for human occupation.

Source: Nobre et al. (2010).

Although the declivity classes are a good start for the delineation of geological hazards on hillsides, there are other factors equally or more important in determining the real risk for landslides and debris flows. Geomorphic curvatures, type and depth of the regolith, soil usage and cover are hereby the most important, all potentially liable for computational modeling. The analysis of terrains prone to landslides in the metropolitan area of São Paulo, which only employed declivity in its risk classification, provided the opportunity for great improvement of the early warning system, specifically in optimizing efforts, allowing the focus on areas with the greatest potential for accidents. Even without an accurate capability to predict landslides, for which more sophisticated models would be needed, the definition of smaller areas through the declivity maps allows for a rationalization of urban planning and provides a first approach to focus efforts on an early warning system.

Conclusions and Recommendations

As seen in extensive validations for several regions of Brazil, the HAND model demonstrates an excellent potential for its use on a large scale, quickly and inexpensively generating terrains maps which are useful for planning the territorial ordainment. Other well-established approaches, such as cover and usage maps as well as climate and water balance maps can be computationally compared to maps of terrains and environments, creating cartographic products which are even more accurate and specific for the delineation of potentials and weaknesses of terrains and environments. Topological approaches developed mathematically (Cortizo, 2007) also have the potential to add better and more sophisticated capabilities to the HAND terrain model, helping to transform the dialogue on the forest and environmental legislation in a new 'Renaissance' for the planning of soil use.

Like many other agricultural technologies, these new quantitative diagnostic tools have the potential to contribute for a considerable increase in rural production without jeopardizing the environmental services generated by protected ecosystems, also allowing to locate, with maximum efficiency, the best places for recovering the natural vegetation.

For its nature, the HAND environmental maps democratize and universalize access to accurate information about terrains, allowing farmers to know how to best use their lands. If made legal and regulated, these maps will cease the confusion in the understanding of imprecise legislation, which generates conflicting interpretations from those who apply the law and those who are ruled by it.

At a 90 meters resolution, the terrain modeling group of the CST-INPE has already completed the mapping of terrains throughout the whole of South America and therefore also of the entire national territory. At a finer resolution of 30 meters, more than 300,000 km^2 are already mapped within the Northern, Northeastern, Southern and Southeastern regions of Brazil.

Consequently, there is no need to wait for years of thorough and difficult fieldwork to add a wide knowledge of terrains to the dialogue on the Forest Code. So far, the country was able to avail in an extraordinary way the innovations brought by agricultural research to climb the podium of producing countries. Therefore, it is necessary to take this and other innovations in geographic Information systems to achieve peace in the countryside and in the cities, and respect from the markets for the clever advances made concerning territorial ordainment in Brazil.

APPENDIX B - EXECUTIVE SUMMARY

Potential land use

- The appropriate use of land is the first step for the preservation and conservation of natural resources and agricultural sustainability; it shall, therefore, be planned according to its potential, carrying capacity and economic productivity, in such way that the utilization potential of the natural resources is optimized, at the same time that its availability is guaranteed for future generations.

- Brazil disposes over a broad territorial extension for agricultural production: there are about 5.5 million km^2 with a potential use for various types of crops and different levels of agricultural technology adoption. However, 76% of the total suitable land presents some weakness due to soil limitations – a condition that requires careful planning in agricultural land use, thereby involving the adoption of conservation management practices which must also take into account the emission of greenhouse gases from these activities.

- The last 2006 Agricultural Census found that 329.9 million hectares of the Brazilian agricultural surface was occupied by rural estates, corresponding to 38.7% of the national territory. From the lands with agricultural potential (5.5 million km^2), 42.6% (231 million ha) were dedicated to major agricultural activities. The analysis of the productive structure of the country revealed that the main land use form was cattle ranching, with 18.6% of the Brazilian territory (158.8 million ha), or 48.1% of the total agricultural surface, was occupied with natural and planted grasslands, corresponding to 2.7 times the amount of the land used for the production of permanent and temporary crops (59.8 million ha).

- In recent years, the trend within Brazilian agriculture has been a systematic increase of production, mainly due to constant productivity gains. Therefore, from 1975 to 2010, the area used for grains increased by 45.6%, but the production increased 268%, that is, almost six times more than the planted area. Although recently productivity gains in cattle husbandry have also been registered, the stocking density of grasslands under extensive cattle ranching is still low, with about 1.1 head/ha, according to the 2006 Agricultural Census. A small investment in technology, especially in areas under stocking rates with less than half a head per hectare, can extend this capacity, thereby releasing land for other productive activities and avoiding further deforestation. O Ministry of Agriculture (MAPA) expects that the growth of Brazilian agricultural production will continue to occur based on productivity gains, with a higher increase of the production rather than in the occupied area. Part of the productivity gains achieved by the agribusiness has been transferred in benefit of various segments of society, by decreasing the relative price of agricultural products and increasing the production. Some studies suggest that, from 1975 to 2008, the amount transferred was approximately R$ 837 billion.

- Thanks to the Brazilian agricultural research and the entrepreneurial drive of our farmers, Brazil ranks first in soybean exports; it also has the largest commercial cattle herd in the world; it is the largest exporter of coffee, sugar, orange juice and beef; it occupies a prominent position in many other agribusiness production chains and is also one of the largest global producers of biofuels.

- However, even considering the advances in the conservationist agriculture and the success of the tropical agriculture, the historical process of occupation of Brazilian territory resulted, in some cases, in the increase of pressure on the environment, erosion processes, the loss of biodiversity, environmental contamination and social imbalances. Therefore, the waste of natural resources that results from the inappropriate use of the land is a reality to be faced, leading to rethinking this occupation to avoid the same mistakes of the past and to promote a gradual environmental adequacy of the rural activity. Brazilian agriculture, which currently has a new socioeconomic and environmental dimension and is responsible for the Brazilian trade surplus, demands science, innovation, modern technologies and increased attention regarding its impacts on natural resources.

- The diagnosis performed shows that there is a liability of about 83 million hectares in preservation areas being occupied irregularly, according to the present environmental legislation. It is estimated that the impact of erosion caused by agricultural land use in Brazil comprise around R$ 9,3 billion annually, which could be reversed by the use of conservationist technology and by planning the landscape use, thus generating environmental benefits.

- There is need of urgent measures from decision makers to reverse the current stage of environmental degradation. To stop this situation, Permanent Preservation Areas (APPs) and Legal Reserves (RLs) should be considered as a fundamental part of the conservationist agricultural planning of rural estates. The perception of RLs and APPs as an opportunity must be followed by government policies in support of agriculture which simplify and facilitate bureaucratic procedures. In order to implement this proposal, the coordination between federal, state and municipal agencies is essential for the implementation of environmental legislation, which cannot fall under the sole responsibility of the landowner or the rural estate holder. States and municipalities play hereby an important role in structuring their responsible agencies for regularization of RLs and APPs.

- It is estimated that due to misuse there are now 61 million hectares of degraded land in Brazil, which could be recovered and used for food production. There is knowledge and technology available for this recovery. In this sense, it is emphasized that the recent initiative of the federal government through the Low Carbon Agriculture Program (ABC Program), which utilizes the liability of greenhouse gases emissions and transforms it in an opportunity for agricultural production and environmental services. However, despite the great merit of this initiative, a much larger political effort is deemed necessary.

- It is recommended that the implementation of more consistent public policies to ensure that all producers – especially those who have less access to the available technology – effectively integrate into technically and environmentally correct productive systems.
- Available scientific data and projections indicate that the country can recover environmental liabilities without impairing the production and the supply of food, fibers and energy, maintaining the trend of continued increase of productivity in recent decades, provided that more consistent policies on agricultural income are established.
- For the sake of accordance and the advance of land use in Brazil, a carefully integrated planning is necessary, in order to harmonize agricultural and ecological-economic zoning with territorial ordainment and the reviewing of the Forest Code, within a new concept of sustainable productive landscapes.

Biodiversity

- Brazil is one of the countries with the largest biological diversity in the world, since it shelters at least 20% of the species on the planet, with high rates of endemism for different taxonomic groups. This implies in broad opportunities, in particular economic ones (for example, the development of new foods, drugs, biotherapics, timber and fibers, biomimetic technologies and eco-tourism), but also greater responsibility. The environmental legislation, which has already achieved important advances, requires reviews to reflect, even more, on the importance and the economic potential of the unique natural heritage of Brazil. At this point, setbacks will have serious and irreversible environmental, social and economic consequences.
- By recognizing the importance of conservation and sustainable use of this priceless natural heritage, Brazil became a signatory of international commitments, such as the Convention on Biological Diversity (CDB) and the Convention on Wetlands (RAMSAR). It also committed under the United Nations Convention on Climate Change that until 2020 it will reduce its emissions of greenhouse gases by 38%. These commitments require not only the compliance to environmental legislation, but also the retrieval of rural and urban environmental liabilities.

Permanent Preservation Areas (APPs)

- Among researchers, there is a consensus that marginal areas to water bodies – whether floodplains or riparian forests – and hilltops with highland or rocky fields are irreplaceable areas because of their biodiversity and their high degree of specialization and endemism, in addition to essential ecosystem services that they provide – such as hydrological regularization, hillside stabilization, maintenance of pollinators and ichthyofauna populations, the natural control of pests, diseases and invasive exotic species. In the riparian zone, in addition to sheltering biodiversity with the its provision of environmental services, the humid soils and its vegetation in zones under influence of rivers and lakes are ecosystems of major importance in the mitigation of receding waters and flood, reduction of surface erosion, the conditioning of water quality and maintenance of channels by protecting margins and reducing siltation. There is a broad scientific consensus that these are ecosystems that, for its stability and functionality, must be preserved and restored when historically degraded. When mature natural ecosystems flank water bodies and cover terrains with associated hydromorphic soils, the carbon and sediment are fixed, excessive water is contained, the erosive energy of currents is dissipated and the nutrient flows in the percolated water undergo chemical filtration and microbiological processing, which reduces turbidity and increases its purity.

- The efficiency of these remaining vegetation strips depends on several factors, including the width and conservation status of the preserved vegetation and the type of ecosystem service under consideration, including in its assessment the role of riparian sites in the conservation of biodiversity. A marginal gain for landowners by the reduction of vegetation in these areas can result in a huge burden for society as a whole, especially for the urban population living in that basin or region. Even with all the evolution of scientific and technological knowledge, the costs for restoring most of the degraded areas are still very high, especially in the case of floodplains. Moreover, not all ecosystem services are fully restored.

- A possible change in the definition of the riparian APP, from the highest level of the water course – as determined by the present Forest Code – to the lower bedding edge, as suggested in the proposed modification, would be a great loss of protection for sensitive areas. This proposed change on the reference edge would mean a loss of up to 60% in the protection of these areas in the Amazon, for example. Meanwhile, the reduction of the riparian strip from 30 to 15 m at rivers with up to 5 m width, which comprise more than 50% of the drainage network in length, would result in a 31% reduction of the area protected by riparian APPs. A recent study found that according to the present Code, riparian APPs represent only 6.9% of private areas.

- The presence of vegetation on hill tops and hillsides play an important role in conditioning soils for the buffering of rain and hydrological regularization, thereby reducing erosion, floods, debris flow and the debris flow in urban and rural environments.

Legal Reserve (RL)

- The Legal Reserve (RL) has distinct environmental functions and biological characteristics from the APPs regarding to composition and structure of its biota. In the Amazon, the reduction of RLs would reduce the forest cover to levels that would undermine the physical continuity of the forest, due to likely climate change. Therefore, the reduction of RLs would significantly increase the risk of extinction of species and would undermine the effectiveness of these areas as functional ecosystems and their ecosystem and environmental services.
- In biomes with higher levels of anthropic activity, such as the Cerrado, the Caatinga and some highly fragmented areas as the Atlantic Forest and parts of the Amazon, the remnants of native vegetation, even when small, play an important role in the conservation of biodiversity and reduction in the isolation of the few fragments of the landscape. Such remnants act as springboards for the movement and dispersal of species across the landscape. These characteristics require that eventual compensations should be made at the same microbasin or in the hydrographic basin. The phytoecological characteristics of the area to be compensated – and not the biome as a whole, due to a high heterogeneity of the vegetation within each biome – should be the reference for this compensation.
- The restoration of RL areas, which is feasible due to the advancement of scientific and technological knowledge, should be done preferably with native species, since the use of exotic species undermines its function in conserving biodiversity and does not ensure the restoration of its ecological functions and ecosystem services. The use of exotic species can be admitted, but only as pioneers, according to the present legislation. It is at the Legal Reserve that one notes the largest environmental liability in the Brazilian agricultural sector. New techniques for restoration of the RLs using areas of lower land use potential and incorporating the concept of a sustainable management of native species for the production of timber and fibers, medicinal plants, native fruits trees and others permitted by law are viable alternatives for production diversification with significant economic returns.

Ecosystem services and agricultural production

- Understanding the importance of maintaining natural areas as APPs and RLs on rural estates is essential, since there is a misconception implying that the native vegetation represents a non-productive area, bringing additional costs and no economic return for the grower. However, besides offering a wide range of possibilities for economic return, these areas are critical to maintain productivity in crop and husbandry systems, given its direct influence on the production and conservation of water, biodiversity and soil, in providing shelter for pollinators, seed dispersers and natural enemies of pests, among others. Therefore, maintaining remnants of native vegetation at properties and the landscape transcends its ecological benefits and provides a glimpse beyond its economic potential, at the sustainability of the agricultural activity and its social function.

- Scientific research confirms the significant benefits of pollination as an ecosystem service for the productivity of important crops. Pollinators may be responsible for 50% of the soybean production; 45-75% of the melon production; 40% of the coffee production; 35% of the orange production; 88% of the cashew production; 43% of the cotton production; and 14% of the peach production. As for passion fruit, its production depends entirely on biotic pollinators.
- Services provided by pollinators are highly dependent on the conservation of native vegetation, where they find shelter and food. Conversely, the majority of native species requires specific pollinators for its perpetuation.
- Concerning to sustainable agriculture, Brazil faces great possibilities ahead to transform part of the natural resources that exist on the property into income for the farmer. The main natural resources would be the conservation of water production and the maintenance of carbon stocks in areas with native vegetation. For areas defined as RLs and the APPs of smaller estates and smallholder ownership there is also the possibility of obtaining timber and non-timber products which can generate additional income for the farmers.

Urban environments

- In urban areas, the occupation of floodplains, natural overflow areas of watercourses and hillsides with steep slope have been one of the major causes of natural disasters, each year causing the mortality and morbidity of thousands of victims, as well as economic losses in terms of infrastructure and buildings.
- Parameters for urban areas concerning APPs along and around water bodies and in areas with steep slopes should be specifically established to prevent natural disasters and preserve human life. The Forest Code should therefore define differentiated principles and limits for urban areas with no consolidated occupation, while municipal master plans for land use should address risk areas with a consolidated occupation.
- Generally, the risk becomes very large for terrain with declivities above 25 degrees

on hillside areas of Brazilian cities. Declivities above this limit in areas that will necessarily lose its natural vegetation due to the intended occupation pose a great risk of repeated cases of landslides and debris flow on hillsides.

- In the case of the riparian APPs, *all floodable areas* must be defined as non-inhabitable. This zone has a technical definition criterion which depends on the local hydraulic and hydrological conditions. The passage strip can, for example, represent the limit reached per flooding with a recurrence period of 10 years, and may be narrow or wide, depending on the topography.

Conclusion and referrals

It is therefore necessary to ensure the continuation of scientific and technological advances in favor of improving and expanding the environmental adequacy of productive activities. The results already achieved must be translated into policies which ensure an integrated action between Science and Technology and the productive sectors. It is the highest interest of the country to implement an intelligent and fair territorial ordainment.

The scientific community recognizes the importance of agriculture in the Brazilian and global economy, as well as the importance of improving the Forest Code to meet the new reality in Brazil as well as worldwide. Any improvement must be conducted in the light of science, with the definition of parameters considering the multifunctionality of Brazilian landscapes, matching production and conservation as the buttresses of a development model that ensures sustainability. This way, it will be possible to reach decisions guided by science-based recommendations which are also consensual between farmers, legislators and the civil society.

The SBPC and the ABC wish to continue contributing for the improvement of the Forest Code by providing scientific and technological inputs for the dialogue. The critical review of the various topics covered in the Forest Code should also be made in the light of the most advanced science and technology, in a careful assessment of the virtues and problems of the current law, for it is necessary to move forward on the Brazilian agricultural and environmental legislation.

Brazil is the country that shelters the largest number of species of plants, animals and microorganisms in the world. This represents a huge differential of natural capital, which is strategic for the country's socio-economic development and which needs to be preserved and used in a sustainable manner. Simultaneously, technological innovation is at the root of the Brazilian success in tropical agriculture, while is the most powerful asset to qualify countries at the competition on the global market. The improvement of the Forest Code will serve as the basis for innovative public policies within the concept of territorial ordainment and landscape planning.