SUSTAINABLE DEVELOPMENT GOAL 15

LIFE ON LAND

CONTRIBUTIONS OF EMBRAPA

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Technical Editors

Embrapa

Brazilian Agricultural Research Corporation
Ministry of Agriculture, Livestock and Food Supply

Sustainable Development Goal 15

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Foreword

Launched by the United Nations (UN) in 2015, 2030 Agenda for Sustainable Development is powerful and mobilizing. Its 17 goals and 169 targets seek to identify problems and overcome challenges that affect every country in the world. By being independent and indivisible, the Sustainable Development Goals (SDG) clearly demonstrate to those who are looking at them what the search for sustainability is.

Reflecting and acting on this Agenda is an obligation and an opportunity for the Brazilian Agricultural Research Corporation (Embrapa). The incessant search for sustainable agriculture is at the core of this institution dedicated to agricultural research and innovation. Moreover, sustainable agriculture is one of the most transversal themes for the 17 goals. This collection of ebooks, one for each SDG, helps society to realize the importance of agriculture and food in five priority dimensions — people, planet, prosperity, peace, and partnerships —, the so-called 5 Ps of 2030 Agenda.

This collection is part of the effort to disseminate 2030 Agenda at Embrapa while presenting to the global society some contributions by Embrapa and partners with potential to affect the realities expressed in SDG. Knowledge, practices, technologies, models, processes, and services that are already available can be used and replicated in other contexts to support the achievement of targets and the advancement of Agenda indicators.

The content presented is a sample of the solutions generated by agricultural research at Embrapa, although nothing that has been compiled in these ebooks results from the work of a single institution. Many other partners joined in – universities, research institutes, state agricultural research organizations, rural technical and extension agencies, the Legislative Power, the agricultural and industrial and agricultural productive sector, research promotion agencies, and federal, state and municipal agencies.

This collection of ebooks is the result of collaborative work within the SDG Embrapa Network, which comprised, for 6 months, around 400 people, among editors, authors, reviewers and support group. The objective of this initial work was to demonstrate, in Embrapa's view, how agricultural research could contribute to achieve SDGs.

It is an example of collective production and a manner of acting that should become increasingly present in the life of organizations, in the relations between public, private and civil society. As such, this collection brings diverse views on the potential contributions to different goals and their interfaces. This vision is not homogeneous; sometimes it can be conflicting, just like society's vision about its problems and respective solutions, a wealth which is captured and reflected in the construction of 2030 Agenda.

These are only the first steps in the resolute trajectory that Embrapa and partner institutions take towards the future we want.

Maurício Antônio Lopes
President of Embrapa

Preface

This publication presents contributions from the Brazilian Agricultural Research Corporation (Embrapa) to the Sustainable Development Goal (SDG) 15, whose theme is Life on Land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Under the assessment of Embrapa Intelligence and Strategic Relations Division (Sire), out of twelve strategic goals of the Company in the Master Plan 2016-2019, six are in synergy with SDG 15's targets, and this is the goal that most closely relates to what Embrapa develops. SDG 15 includes nine targets in total. This book presents seven targets from SDG 15 that are related to works and research studies that Embrapa has developed during its 45 years. They are: 15.1) By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements; 15.2) By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally; 15.3) By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and flood, and strive to achieve a land degradation-neutral world; 15.4) By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development; 15.5) Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species; [...] 15.8) By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species; and 15.9) By 2020, integrate ecosystems and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

At first, this ebook presents SDG 15 background and its relationship with the world, Brazil, and Embrapa; besides, it reports on the advance of global actions on the theme following the emergence of comprehensive global environmental issues, including the importance of Brazil as the main global source of biodiversity and Embrapa efforts to conciliate agricultural production and preservation of natural resources. In Chapter 2, the need for planning and joining efforts, based on demands posed by SDG 15 on national researchers, is discussed.

Contributions of Embrapa aligned with SDG 15 are described in Chapters 3 to 9. Report of contributions begins with the Company's engagement with commitments made in international conferences about environmental and climate themes, and also includes (native and planted) forestry themes, their sustainable management and deforestation control. In this context, it is worth emphasizing the establishment of partnerships for the development of great national or regional projects. The strategy adopted for developing protocols and models to restore degraded environments also stands out. Furthermore, contributions to equip agriculture to address delicate, complex, and difficult themes, such as the maintenance and management of threatened species and focus on species considered invasive, their dangers and strategies for coexistence with environmental safety are also approached. The last target comprises the engagement of Embrapa with promoting public policies on the following themes: food production, food safety, and the preservation of biological diversity.

Finally, Chapter 10 is about the perspectives and future challenges of Embrapa to comply with the targets presented.

Technical Editors

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Chapter 1

SDG 15 in global and Brazilian scenarios, and in Embrapa scenario

Paulo Augusto Vianna Barroso
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Global scenario

At the dawn of civilization, people's survival depended on mineral wealth and biodiversity. Up until nowadays, they are the basis of human existence on Earth. For too long, natural reserves were understood as endless, regardless of the way and the amount used. Over time, with the increase of the human population followed by the development of different sciences, evidence showing that resources are finite heightened.

Concern with environmental conservation seemingly exists since the beginning of the industrial era, but alerts to society on the risks posed by environmental vulnerability were marked by the publication, in the end of 1968, of an article titled *The Tragedy of Commons* in *Science* magazine by Garrett Hardin (Hardin, 1968). In 1972, the *Conference on the Human Environment* took place in Stockholm, Sweden, sponsored by the United Nations (UN). Thus, the theme became part of UN's scenario under the Food and Agriculture Organization (FAO). In 1983, the World Commission on Environment and Development (WCED) was created. In 1987, WCED published a report called *Our Common Future*, also known as *Brundtland Report,* which was historically very important, because in it was coined the term "sustainable development", which is undefeated until now to appoint "[development] that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Report…, 1987, p. 16).

A cornerstone in the environmental scenario was *Eco-92* (*United Nations Conference on Environment and Development*), in 1992, when the *Earth Charter*, the *Forest Principles*, and *Agenda 21* were disclosed, and the three great global summits on climate, desertification, and biodiversity were created. Each one of these summits started to organize meetings and discussions involving experts with the purpose of seeking both consensus among the countries and strategies to reduce and mitigate the negative effects of anthropization. In 2000, the UN established, with the support of 191 nations, the Millennium Development Goals (MDG). Also in 2000, the United Nations Forum on Forests (UNFF) was created based on the *Forest Principles* and on *Agenda 21*. In 2007, the forum adopted the *Non-Legally Binding Instrument on All Types of Forests*. Recently, at the *21st Conference of the United Nations Framework Convention on Climate Change*, which took place in Paris in 2015, leaders of 193 of UN's member states approved the adoption of Agenda 2030 and the 17 Sustainable Development Goals (SDG).

National scenario

Brazil is a mega-diverse country. This means it has a biological variety far above the average of other countries. FAO's estimates suggest that Brazil has 20% of the planet's biodiversity and 30% of its rainforests (Indústria Brasileira de Árvores, 2017). Although there is room for more balance, the country is implementing actions related to preservation, environmental conservation, and reduction of the impact of human activities on the environment.

As an answer to important environmental questions, Brazil currently has areas assigned to preservation in a significant part of its territory. Parks, national forests, indigenous areas, and lands that belong to the federal government cover approximately 45% of the national territory. Besides areas expressly assigned to the maintenance of biodiversity, significant percentages of agricultural areas are also assigned to preservation. By act of law, farmers are obliged to preserve between 20% and 80% of the area of their properties which are covered by native forest, and they are responsible for both conducting a rational and suitable exploitation of their main means of production (land) and its natural resources, and looking after the preservation of the environment in order to promote general well-being (Figure 1).

Recent estimates of areas destined for environmental preservation in rural properties indicate that farmers protect 25.6% of the national territory (Miranda, 2018). This means that contributions and financial efforts are made not only by the Brazilian government, but also by the Brazilian society, with a strong contribution of farmers. Furthermore, forestry companies are aligned with the proposition of keeping Permanent Preservation Areas (PPAs) and Legal Reserves according to the law. All these efforts also contribute to maintaining areas with native forest remnants. For each hectare of planted forests, an area of 0.7 hectare is destined to preservation or conservation. Almost 14% of the 50 million hectares of natural habitats preserved in Brazil in conservation units are under the responsibility of

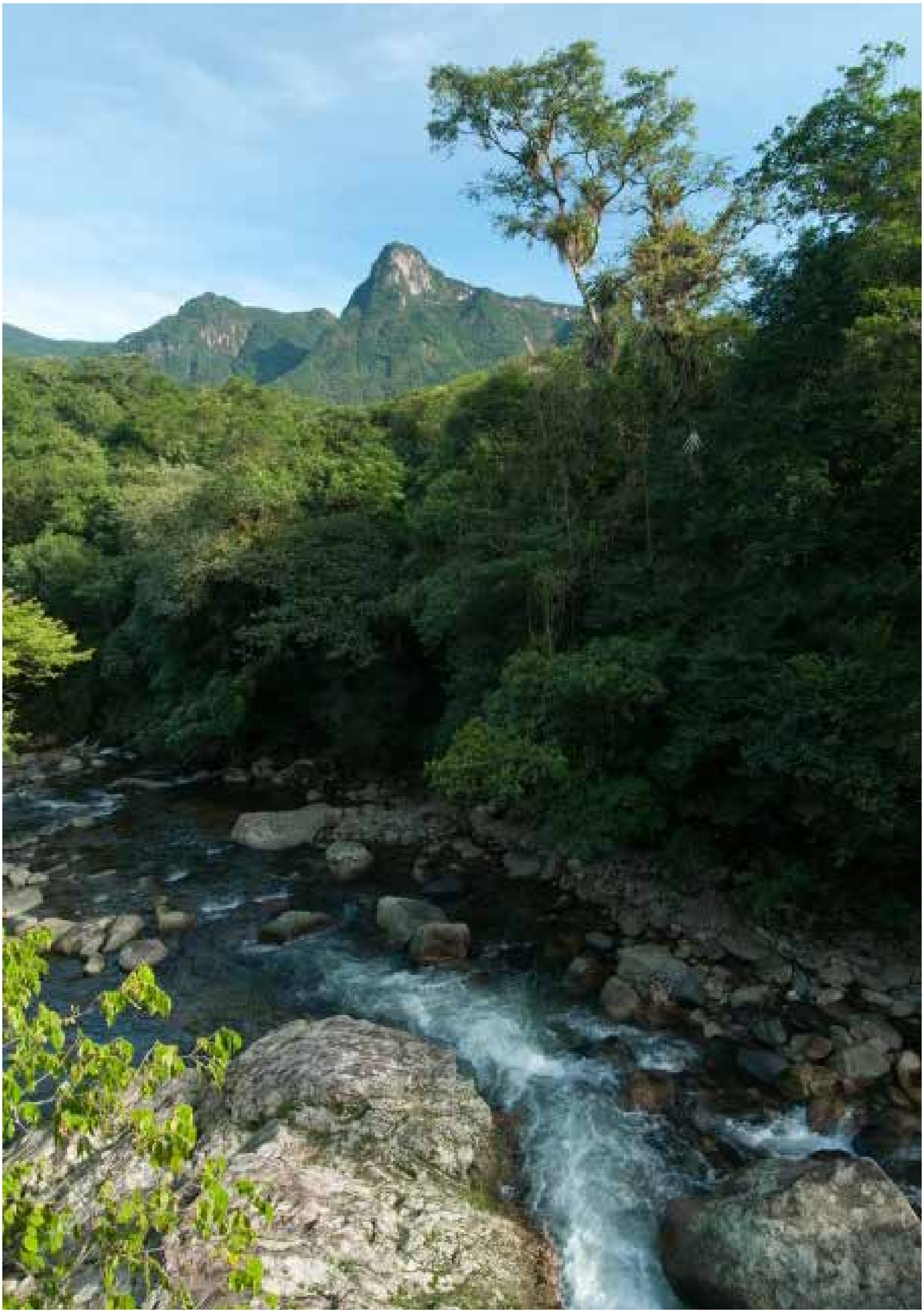

Photo: Zig Koch

Figure 1. Part of the Atlantic Forest preserved closely to River Mãe Catira, Paraná.

the forest sector, according to the 2017 annual report produced by the Brazilian Tree Industry (Ibá) (2017).

Caring for the existent biodiversity in Brazil would already be a massive job, once more than 65% of the territory is destined to preservation (Miranda, 2017). But the efforts do not stop there. Policies of access control and incentives to the sustainable use of biodiversity were also implemented and contribute decisively to make Brazil a country concerned with the preservation of native biodiversity and with its sensible use for the benefit of humanity (Figure 2). Even so, there are many knowledge gaps due to the great abundance of species, environmental diversity, and damages caused by the inappropriate, not sustainable use in the long run.

Photo: Diva da Conceição Gonçalves

Figure 2. An example of agricultural diversity: an agroforestry system constituted by banana (*Musa* sp.), beans (*Phaseolus vulgaris*), and rubber tree (*Hevea brasiliensis*) at the Chico Mendes Extractive Reserve, Brasileia, AC.

Therefore, within the Brazilian context, governmental and non-governmental agencies, companies, and the organized society recognize the importance of the forestry component to guarantee the quality of rural and urban life. Many of these entities act to ensure the continued positive role of forests.

Embrapa scenario

The purpose of increasing food productivity, allied to the concern and need to ensure environmental conservation, has motivated Embrapa researchers and partners, since the Company's creation in 1972, to enable technological solutions in different agricultural production chains.

In accordance with the increasing demands for information on the forestry component, and focusing on the generation of products and on the promotion of environmental conservation services, the Programa Nacional de Pesquisa Florestal (National Program on Forestry Research) was created in 1978 and encompassed *Caatinga*, *Cerrado*, Amazon, and the Southern-Central region. Research teams devoted themselves to regional priorities (from management of natural forests to subjects like testing species introduction), approaching genetic improvement, forest protection, silviculture and management of native and introduced species, among others.

Thus, during its 45 years, Embrapa has offered solid contributions for the protection, restoration, and use of biodiversity. There has always been a widespread concern on the conservation of the diversity of animals, plants, and native and naturalized microorganism species in germplasm databases.

Maintaining the genetic variability of Brazilian biomes is a widespread activity in Embrapa units. Hundreds of thousands of samples of plant species and samples of animal sperm and egg cells are stored under special conditions, thus enabling their viability for longer terms, in the Basis Collection maintained by Embrapa Genetic Resources & Biotechnology (Figure 3). All samples are duly catalogued and kept under conditions that ensure the safety of heritage, so important for Brazil and the world.

Surely, a mere stock of accesses is not enough. Knowing the real value of each sample is important. Therefore, there is a careful work within the Active Collections of Germplasm (Figure 4); a conscious genetic and phenotypic characterization of the accesses is made, identifying what makes every single sample unique. The Basis Collections are not only the entrance door for new samples (which is ensued by collection, donations, and exchange), but also the exit door both to restore a lost variability for traditional communities and to improve germplasm collections of other agencies. Finally, there are Work Collections or Geneticist Collections, which are the ones used by Embrapa itself to make products that impact the Brazilian people daily. The Work Collections are directly related to breeding

Photo: Ana Cristina dos Santos

Figure 3. Collection of cassava (*Manihot esculenta*) samples.

Photo: Claudio Bezerra Melo

Figure 4. Embrapa Gene Bank.

programs, which manage diversity to generate new cultivars, and consequently products with better quality, higher productivity and lesser risks.

Embrapa research endeavors to improve cultivation systems and agroforestry systems also impact directly the conservation and use of biodiversity. Embrapa develops cultivation systems that are in permanent evolution to become more efficient under economic, social, and environmental perspectives. Hence, these systems increase the sustainability of agricultural activities and reduce the need for incorporation of new areas for agriculture. The Crop-Livestock-Forestry Integration System that Embrapa and its partners have developed is an important example, as well as the Agroforestry Systems and techniques for sustainable forest management.

The continuous work of collecting, profiling, breeding, and managing also enabled that some species with agricultural potential, but not adapted to a given agricultural environment, were better exploited. Some species (such as Brazilian nuts, *Bertholletia excelsa*) were bred to become more suitable to extractive management processes. Others (such as bacuri, *Platonia insignis*) were subjected to an association of extractive management, which exploits materials that exist naturally, and domestication, by planting crops under intercropping or under single Agroforestry Systems.

Special emphasis should be given to the Company's strategy of developing protocols and models for the restoration of degraded environments and its huge 45-year effort to develop and offer technologies for higher productivity of planted forests. Recently, addressing a request of forestry companies and the society, Embrapa produced a document evaluating the environmental impacts of planted forests. Management and forest management have been themes in Embrapa research studies since 1978.

Embrapa researchers are active players in national and international discussions, and contribute with their technical expertise to Brazilian public policies as well as to solutions for themes discussed in different international forums, thus increasing international recognition of the importance of Embrapa production. Recently, Embrapa Territorial publication (Miranda, 2018), which NASA (USA) confirmed, provided important information showing that Brazil protects and preserves the native vegetation in more than 66% of its territory and cultivates only 7.6% of the lands. In other words, Brazilian farmers should improve production systems, continuing to contribute to the conservation, recovery, and sustainable use of ecosystems.

References

HARDIN, G. The tragedy of the commons. **Science**, v. 162, n. 3859, p. 1243-1248, Dec. 1968. DOI: 10.1126/science.162.3859.1243.

INDÚSTRIA BRASILEIRA DE ÁRVORES. **Relatório 2017**. Available at: <http://iba.org/images/shared/Biblioteca/IBA_RelatorioAnual2017.pdf>. Accessed on: Dec. 10, 2017.

MIRANDA, E. **Tons de verde**: a sustentabilidade da agricultura no Brasil. 2. ed. São Paulo: Metalivros, 2018. 218 p.

REPORT of the World Commission on Environment and Development: our common future. Oslo: World Commission on Environment and Development, 1987. Available at: <http://www.un-documents.net/our-common-future.pdf>. Accessed on: Dec. 14, 2017.

Chapter 2

Demands and opportunities for sustainable development

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Introduction

Recognizing the non-sustainability of using natural resources over the centuries became imperative when the term "development" still did not include the environmental consequences of all types of uses, among which were those related to food production in the so-called "rural environment." In another type of use of the physical space, small human groups attracted people in search of a sense of community and work, gave rise to villages, which were converted into cities, and also used natural resources after frequent misplanning, which led to river and atmosphere pollution, besides deforestation.

In the 20th century, due to some environmental disasters and the scholars' attention, the theme expanded beyond academic and philosophical realms. The concern of organized society with the effects of human activities on the environment has arisen due to the inattentive and uncontrolled use of natural resources. Several global initiatives were implemented, which resulted in *Rio-92* (also called *Earth Summit*), which embraced the term "sustainable development" in full.

Challenges for agricultural research

In agricultural research, the main challenges are clearly identifying problems and demands primarily of the rural society, which are increasingly influenced by and overlap with those of urban society. These demands must be responded to by well-structured teams technically prepared to approach each raised problem. Available resources may and shall be disputed by different projects, so as to reveal those that are more likely to deliver good results.

Currently, due to changes in communication and information access, demands increased exponentially, such as those included in Sustainable Development Goal 15 (SDG 15). Themes such as deforestation and restoration of degraded forests, management of invasive alien species and strategies to protect species threatened with extinction are the targets.

This reduced scope of themes already reveals the risk of pulverized efforts. Additionally, one can observe that each technology targets a specific environment, out of which it must be tested.

Thus, careful planning regarding the approach to each problem, its scope and range is needed. Following changes in society and in its needs and adapting to new scenarios are also vital. It could be said that relating agricultural and forest products with water and soil shall be a continuous concern of research teams, as well as the consequent monitoring and search for mitigating solutions.

In search of indicators for the sustainable use of natural resources, some themes appear, such as the suitable use of water, soils, fauna, flora, and renewable energies on the planet. It is worth stressing that, in forest, all such themes are integrated (Oliveira; Oliveira, 2017).

For example, society is becoming increasingly aware of the importance of preservation and environmental restoration of river banks, steep slopes, and other permanent preservation areas provided in the environmental law (Figure 1) to regularly supply water to crops, livestock, and urban areas, to generate hydropower, among other uses.

However, the importance of soil conservation in sustainable agricultural production is still not well-recognized; thus, improving the joint action of programs on degraded land restoration and soil and water conservation in agricultural production is needed.

Biodiversity use

There are information gaps that restrain conservation actions of several species, mainly native species with economic potential, for which still there are not tools allowing its wide use. Additionally, the lack of research and development on promising native species has contributed to increased imports of potentially invasive species (for example, alien fishes and forages) for which technological packages are already available. The purpose is to simplify management and increase productivity, which results in problems for the conservation of native species.

Photo: Fabiano Bastos

Figure 1. Example of springs conservation: *vereda* ecosystem with *buriti* (*Mauritia flexuosa*) trees.

Degradation and soil conservation

Degraded lands can be considered those that, after having gone through some type of environmental impact, had considerable losses or even the complete loss of their mechanisms of natural recovery (that is, they have lower resilience) and may return or not to its original condition. So, to recover those areas, it is necessary to apply technologies allowing the restoration of their ecological functions, thus contributing to expedite natural regeneration processes and/or the soil capacity of vegetative production; depending on the degradation condition, this can take hundreds of years (Figure 2).

Among factors responsible for the sustainability of agricultural production systems, soil is considered one of the most important. This thin layer covering the land surface and that takes millions of years to be formed can be lost in a few years because of erosion or become unproductive depending on the use and management practices adopted. After the loss of the natural vegetation coverage, degradation can be worse due to erosion. Despite being a natural process, erosion

Photo: Luiz Henrique Magnante

Figure 2. Agricultural landscape with winter crops promoting coverage and soil conservation.

can become more intense due to the use of areas highly susceptible to erosion and/or improper agricultural practices. Therefore, sped-up erosion (provoked by anthropogenic action) can be considered one of the worse enemies of tropical agriculture, for it can lead to more than 100 ton/ha/year of soil loss, depending on the climate, soil class, use, and management system (Andrade, 2015).

Availability and use of water

Water availability and organized use are currently among the greatest concerns. Approaching those themes is expected not only in documents that organize the rationale and conclusions on the environmental impact of its use in agriculture, but also in expert meetings, such as the *8th Water Global Forum*, held in Brasilia in March, 2018. The other themes approached here shall be a priority for discussion in the *XXV World Congress of the International Union of Forest Research Organizations — IUFRO*, which will happen in Curitiba in 2019. Knowledge gaps and challenges regarding the reversion or mitigation of the improper use of natural resources must be a priority for experts and widely disclosed to demanding parties and potential beneficiaries.

References

ANDRADE, A. G. de. Preservar é única solução. **Agro DBO**, n. 415, p. 44-46, maio 2015.

OLIVEIRA, Y. M. M. de; OLIVEIRA, E. B. Considerações finais. In: OLIVEIRA, Y. M. M. de; OLIVEIRA, E. B. de. (Ed.). **Plantações florestais**: geração de benefícios com baixo impacto ambiental. Brasília, DF: Embrapa, 2017. p. 91-95.

Chapter 3

Conservation, recovery, and sustainable use of ecosystems

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Introduction

This chapter presents contributions of the Brazilian Agricultural Research Corporation (Embrapa) to achieve target 15.1 of the Sustainable Development Goal 15 (SDG 15) (United Nations, 2018): "By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements".

This target relates to deliberations of the *United Nations Conference on Environment and Development*, held in Rio de Janeiro in 1992, which definitely established the theme "sustainable development" as a global public agenda. After this conference and the Intergovernmental Panel on Climate Change – IPCC (created in 1988 and which set the global goals for reducing greenhouse gas emissions), the Convention on Biological Diversity (CBD) and the Convention on Climate Changes were established. These, combined with the Ramsar Convention, adopted in 1971 to protect wetlands, and the Convention to Combat Desertification, adopted in 1994 to fight desertification, form the basis to achieve target 15.1. Rules established in these agreements resulted in a series of governmental actions that motivated projects in Embrapa. Embrapa main actions to comply with these agreements are described below.

Convention on Biological Diversity and biodiversity promotion

Biological diversity is the variety of genes, species, and ecosystems on Earth. Ensuring its conservation, its sustainable use, and the fair distribution of benefits from the use of their genetic resources are the objectives of CBD, which came into force in December 1993, and was ratified by 186 countries, including Brazil.

The core of Embrapa work is within the scope of CBD. In addition to establishing rules for in situ and ex situ conservation and the sustainable use of biological diversity, CBD addresses research, training, education and technological and scientific cooperation and recognizes that investing in knowledge of the biodiversity for the benefit of different sectors such as agriculture, energy, health, and the environment is essential. Actions on research, innovation, education, and training developed at Embrapa revolve around these themes and aim to learn about, conserve, and promote the sustainable use of biodiversity to promote health and social and environmental well-being (Figure 1).

Photo: Fernanda Muniz Bez Birolo

Figure 1. Biotechnology laboratory of Embrapa Semiarid, in Petrolina, PE.

In situ and ex situ conservation of genetic resources

Research for increasing knowledge on and developing technologies using genetic resources from animals, plants, and microorganisms is conducted in most of Embrapa Research Units including not only thematic units (devoted to the advance of knowledge) and regional units (devoted to researching different

Brazilian biomes), but also product units (which seek to develop technical solutions for specific crops or for animal husbandry). All these research studies are focused on the main demands of society.

Embrapa maintains, in its germplasm banks, herbaria, museums and data banks on plants, animals and microorganisms, a large pool of genetic resources for real or potential use, mainly for agriculture and livestock. This collection is available for consultation, exchange, and technological business prospection in Alelo Database. New accesses are added daily after new collections in agricultural areas and natural ecosystems are conducted; subsequently, the characterization and/or bio-prospecting of genes and bioactive molecules are performed. Internally and externally financed projects are focused on the valuation of these resources by developing technologies for human nutrition and for food, phytosanitary, biofertilizer, biofuel, medicine and cosmetic industries, among others (Figure 2).

Thus, new varieties of cultivated plants and improved animal races for increased productivity and resistance to pests, diseases, and abiotic factors such as drought and high temperature are developed. Such technologies support Brazilian agriculture in producing more in smaller areas, thus ensuring the maintenance of native vegetation in most of the national territory. Research on biofuels, biological

Photo: Vivian Chies

Figure 2. Laboratorial research of microorganisms for agro-energy.

control of pests, diseases, and invasive plants sustainably using biodiversity resources contributes to reducing the use of environmentally harmful or polluting agricultural inputs and practices.

Embrapa also conducts research on traditional knowledge in partnership with indigenous peoples, traditional communities, and family farmers aiming at preserving and valuing this knowledge for future generations, as agreed on in CBD (Figure 3).

Photo: Priscila Viudes

Figure 3. Researcher and indigenous person in ethno-knowledge and bio-prospecting identification activities.

Conservation and use of pollinators in agriculture

The fast disappearance of bees around the world before researchers have an extensive knowledge about the environmental services provided by native bees in Brazil has caused concern and discomfort. Great efforts are underway worldwide to conserve the important ecosystemic service of pollination. Joining CBD initiatives, Embrapa supported the creation of the Iniciativa Brasileira de Polinizadores (Brazilian Initiative of Pollinators – BIP), together with the Ministry of Environment (MMA), and the University of São Paulo (USP) in 2000, under the facilitation of the Food and Agriculture Organization of the United Nations (FAO). The purpose was to conduct research on the service provided by pollinators for their conservation and sustainable use (Figure 4).

Photo: Viviane Pires

Figure 4. Bee (*Apis* sp.) pollinating a cotton flower (*Gossypium hirsutum*).

Research networks, co-sponsored by Brazilian funding agencies, were formed to research on diversity, management, and conservation of stingless bees in different biomes and agroecosystems, and to evaluate the impact of pollination service in productivity of native species, such as Brazilian nuts (*Bertholletia excelsa*), and crops as cotton (*Gossypium hirsutum*), tomato (*Solanum lycopersicum*), melon (*Cucumis melo*), and apple (*Malus domestica*).

Subsequently, Embrapa set the theme as a priority by approving the project Conservação de Recursos Genéticos de Insetos Polinizadores (Conservation of Genetic Resources of Pollinating Insects), aiming to preserve, maintain, and enrich the genetic resources of pollinating insects in the Northern, Northeastern, and Southeastern regions of Brazil. Six Embrapa Units work together to maintain conservation cores of 41 species of stingless bees and 4 species of solitary bees. In situ and ex situ conservation actions by means of an insect tissue bank are planned (Motta Maués, 2002; Freitas; Pereira, 2004; Imperatriz-Fonseca et al., 2006; Polinização…, 2013).

Conservation and use of microorganism culture collections

Embrapa coordinates and maintains microorganism collections, including viruses, bacteria, fungi, and protozoans, collected in wetlands, *Caatinga*, *Cerrado*, and Atlantic Forest. In general, collections are organized according to functionalities of microorganisms (such as soil nutrient fixation, bioindication, growth promotion, biological control, antibiotic action, and dye production) or according to their use (such as in rice cultivation and biofuel industry). In addition, there are multifunctional microorganisms of agricultural and environmental importance. These collections are constantly enriched, researched, and prospected so as to promote innovation for agricultural sustainability (Melo; Azevedo, 2008; Mattos et al., 2011; Mattos, 2015).

One of the most emblematic cases is that of co-inoculation of soybean, bean, and sugarcane crops with nitrogen fixing bacteria of the genera *Rhizobium* and *Azospirillum* (Reis Júnior; Mendes, 2007; Schultz et al., 2012; Hungria et al., 2014). These technologies have resulted in reduction of nitrogen fertilizer use, significant increments in productivity and increased resistance to water stress (Figure 5).

Photo: Ana Lucia Ferreira

Figure 5. Nodules of bacteria *Rhizobium* sp. on root of beans (*Phaseolus* sp.)

Biological control

Biological control is an ecosystemic service performed by natural enemies to maintain the balance of populations in natural and managed ecosystems, such as agroecosystems and urban environments, where it is adopted for suppressing animals, plants, and microorganisms regarded as pests, which are harmful to human activities. Natural enemies such as predators, parasitoids, parasites, competitors, and pathogenic microorganisms maintain under control insects and mites that cause damages to crops, as well as plant pathogens and weeds (Figure 6). Biological control allows production of healthier food in a more sustainable way, and the conservation of natural habitats.

Photo: Erika Sevilha

Figure 6. Predatory wasp (*Vespa* sp.) capturing a beetle pest.

Research on biological control is carried out in several Embrapa Units, from North to South of Brazil. Two project portfolios group these research studies: Controle Biológico: Ciência a Serviço da Sustentabilidade (Biological Control: Science in the Service of Sustainability) and Sistemas de Produção de Base Ecológica (Eco-based Production Systems). Examples of technologies developed by Embrapa in this area are products based on entomopathogenic bacteria *Bacillus thuringiensis* for the control of dengue- and malaria-transmitting mosquitoes, and several caterpillar pests of crops such as maize (*Zea* sp.), soybeans (*Glycine* sp.), and cotton (*Gossypium* sp.) (Monnerat et al., 2017).

Cartagena Protocol on Biosafety

The 2003 Cartagena Protocol establishes procedures for the transboundary movement of organisms resulting from modern biotechnology aiming to ensure that the transport, transfer, handling, and use of these organisms have no adverse effect on the conservation and sustainable use of biological diversity, also considering human health. The Brazilian Biosafety Law (11,105 of 2005) and normative rules of the Comissão Técnica Nacional de Biossegurança (National Biosafety Technical Commission – CTNBio) guide the Cartagena Protocol implementation in Brazil.

Before the implementation of the Protocol, in the 1990s, Embrapa already aimed at reaching a suitable level of safety in its projects with genetically modified organisms (GMOs) and contributed with technical inputs for discussions on the development and approval of Brazil's first law on biosafety at the Brazilian House of Representatives, in 1995. The current law replaced this Law in 2005. Since then, Embrapa experts act at CTNBio and take part in international negotiations of the Cartagena Protocol providing a specialized technical contribution to the Ministry of Foreign Affairs.

Embrapa trained specialists on biosafety to do research and work with public policies as part of two (a national and an international) major projects. By technically training professionals and students from several Brazilian institutions, methodologies to assess environmental and food risks of GMOs were developed and improved; currently, they are widely used in Brazil and abroad by research, inspection, customs control, monitoring and public policy planning authorities.

Embrapa was the first public company in the world to develop and certify the safety of genetically modified transgenic crop varieties: beans resistant to the golden mosaic virus and soybeans tolerant to herbicides from imidazoline group.

Nagoya Protocol on Access to Genetic Resources

Approved in 2014, the Nagoya Protocol establishes rules for sharing benefits arising from the use of genetic resources and associated traditional knowledge of indigenous peoples, traditional and local (*quilombola*, *caiçara*, and rubber tapper) communities, and family farmers.

Brazil is home to the largest biodiversity on the planet, with more than 20% of all species on Earth, which corresponds to about 1.8 million varieties of plants, animals, and microorganisms. This biodiversity, known as genetic heritage

(GH), generates countless benefits to humanity as a source of food, fuel, fibers, medicines, and raw material for industrial products. It is the raw material for bio-economy that is of enormous importance in this century. Biological richness is within these organisms or on their barks, leaves, roots, hairs, feathers, skins, etc. It is also in substances produced by them such as resins, latex, poison, and chemical substances. This valuable Brazilian heritage is protected by Law 13,123/2015 (Brasil, 2015a) and ruled by the Conselho de Gestão do Patrimônio Genético (Genetic Heritage Management Council – CEGEN).

To comply with the objectives of CBD, Brazil adopted a provisional measure in 2001 to regulate the access to genetic resources. Since then, Embrapa experts have been playing a main role in debates on the theme within decision-making bodies, such as technical committees, and acting as counselors in CEGEN, by offering technical input. Law 13,123/2015, developed with Embrapa researchers active involvement, substituted the provisional measure. Furthermore, these researchers contributed in international negotiations within the Nagoya Protocol.

Nagoya Protocol covers all genetic resources but acknowledges the autonomy of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA), developed within the framework of FAO. Most research studies developed at Embrapa are within the scope of IT PGRFA, but many projects must also meet the requirements of the Nagoya Protocol and the Brazilian Law on Access to the Genetic Heritage (Brasil, 2015). Such research studies involve accessing the genetic heritage, such as using genetic information contained in samples of plants, animals, microorganisms or substances extracted from them to study what they are made of, to test what they are useful for or to develop marketable product or process, such as medicines, perfumes, and cosmetics (Figure 7). The result of these studies contributes to developing new products, many of which are patented. The marketing of these products results in benefits that should be shared with genetic resource providers, that is, the Brazilian State representing the people in general or traditional and local peoples and communities who are holders of traditional knowledge.

Between 2010 and 2016, Embrapa maintained a major project to implement regulations of access to genetic heritage. Workshops were organized in different Embrapa Research Units to train technicians and researchers in order to raise their awareness and enable them to duly and correctly follow the law.

At the same time, genetic resource collections belonging to other institutions and kept by Embrapa in its germplasm banks, conservation nuclei, and biological

Photo: Zineb Benchekchou

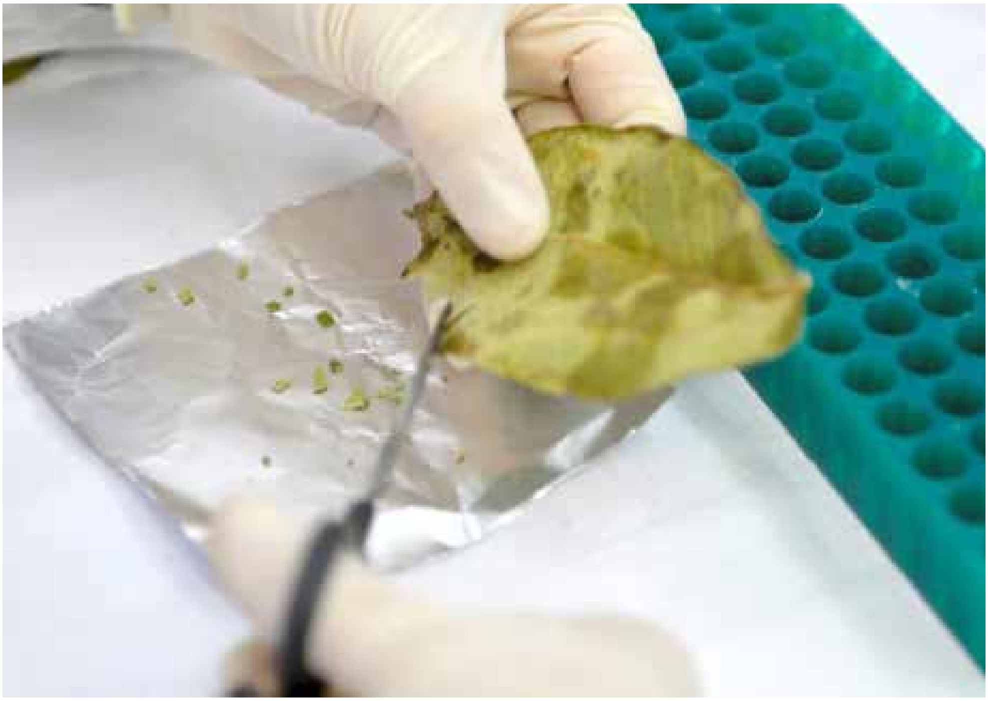

Figure 7. DNA extraction in Plant Genetic Laboratory at Embrapa Genetic Resources & Biotechnology.

collections were regularized (Figure 8). By offering training for its employees, Embrapa becomes a strong player in the regulatory environment and is able to provide expert inputs to its public-and-private-sector partners, as well as to governmental, legislative, and educational authorities, thus effectively contributing to the development, consolidation, and application of the Law on Access to the Genetic Heritage and, consequently, of the Nagoya Protocol.

Conventions on climate change and their protocols

Global mobilization to face climate changes started in 1992 when 197 countries acceded to an international treaty to combat climate changes, the United Nations Framework Convention on Climate Change (UNFCCC). Its purposes were to limit global temperature average increases and the resulting climate change and to deal with the impacts arising from them. In 1995, the countries (called Parties) adopted the Kyoto Protocol so as to strengthen the global response to climate changes.

Figure 8. Plant tissue propagation in a laboratory at Embrapa Eastern Amazon.

Kyoto Protocol and Paris Agreement

Kyoto Protocol legally binds the parties of developed countries to gas emission reduction targets. The first commitment period started in 2008 and ended in 2012. The second period started in 2012 and will end in 2020. Out of 197 countries that are currently taking part in the convention, 192 ratified the protocol.

The Paris Agreement, approved in December 2015 at the *21st Conference of the Parties (COP 21)*, marks the latest steps in the development of UN's climate change regime, creating a historical momentum to make climate change one of the main focuses in the development agenda. The Paris Agreement seeks to intensify actions and investments necessary for a sustainable future, with low carbon emission. Its main purpose is to strengthen the global answer to the threat of climate change, keeping the increase in global temperature well below 2.0 °C in this century as compared to pre-industrial levels, and pursuing efforts to limit temperature rise to 1.5 °C.

Paris Agreement requires that all parties present their best efforts through nationally determined contributions (NDCs). This requires that all parties report regularly on their emissions and their implementation efforts. Most developing countries have opted to include an adaptation component in NDC, alligning their national long-term development priorities and zero-emission pathways with SDG targets.

The practices and agricultural, technological, and knowledge systems described below are examples of how Embrapa has acted to fulfill these commitments.

Good agricultural practices

Good agricultural practices (GAP) are a set of rules and standards that farmers shall comply with; in addition to making production systems more profitable and competitive, GAP ensure safe food production (Figure 9). By adopting good practices in husbandry based on recommendations of the book *Boas Práticas Agropecuárias – Bovinos de Corte* [*Good Agricultural Practices – Beef Cattle*] in Mato Grosso farms, a 25% decrease in greenhouse gas emissions from pastures and 60% from beef production were possible (SF Agro, 2016).

Embrapa and partners have being developing awareness-raising actions for farmers and training multipliers in quality control protocols for GAP. This not only

Photo: Paulo Kurtz

Figure 9. Good agricultural practice: no-till farming on straw.

results in more competitive production systems due to a consolidated domestic market and expanded possibilities to gain new markets that value high quality beef and leather, but also contributes to fulfilling Brazil's commitments within the Paris Agreement.

Integrated Crop-Livestock-Forest Systems

Embrapa developed integrated crop-livestock-forest systems (ICLF) based on the proper management of crops and pastures so as to provide a substantial increase in production, specially in cases of recovering degraded or low-production areas (Balbino et al., 2011). By adopting these systems, it is possible to avoid opening of new areas, which promotes environmental benefits (such as protection of native vegetation, and soil and water resources conservation), and regional socioeconomic development (Figures 10 and 11). Growing grains, pasture, and forests contributes to the sequestration of atmospheric carbon dioxide (CO_2) via photosynthesis and subsequent incorporation in the form of organic matter to the soil. It is also possible to reduce the age at which animals are slaughtered by improving production processes; feeding them with appropriated diet reduces methane emission per product unit, thus contributing to mitigate agricultural greenhouse gas emissions.

The systemic conception of this strategy also incorporates other desirable attributes to the agroecosystem concerning its environmental suitability, such as the maintenance of Permanent Preservation Areas (PPAs) and Legal Reserve Areas (LRA). Thus, the environmental services provided by PPAs and LRAs benefit production systems.

Agricultural zoning of climatic risk

The agricultural zoning of climatic risk (AZCR) is an instrument for agricultural policy and risk management in agriculture. It is a technology developed to minimize risks related to adverse climatic phenomena. It allows each municipality to identify the best time for planting crops for each soil type and cultivar cycle.

Farmers, financing agents, and other users can easily understand and adopt this technology. In designing AZCRs, parameters of climate, soil, and cultivar cycles are analyzed using a methodology validated by Embrapa and adopted by the Ministry of Agriculture, Livestock and Food Supply (Mapa). Thus, climatic risks involved in crop production that can cause severe losses in production can be quantified, thus strengthening the capacity of farmers to deal with the impacts of climate change.

Photo: Gabriel Rezende Faria

Figure 10. Cattle under integrated crop-livestock-forest system.

Photo: Síglia Regina Souza

Figure 11. Sheep under integrated crop-livestock-forest system.

Monitoring of the dynamics of land use and land cover

TerraClass is a project whose purpose is to deliver, every 2 years, in figures and explicit spatial schemes, systematic maps referring to land use and coverage in all deforested areas of the Brazilian Legal Amazon, identified by the Projeto de Monitoramento do Desmatamento na Amazônia Legal por Satélite (Project for Monitoring Deforestation in the Legal Amazon via Satellite – Prodes) (also see Chapter 4 on this topic).

Promotion of renewable energy sources

The Brazilian energy matrix is notable for its large share of renewable sources. In 2016, renewable sources represented 43.5% of the energy matrix in Brazil, while the world average was 14.2% (Resenha..., 2017). Solely considering renewable biomass sources, biomass derivatives of sugarcane (*Saccharum* sp.) are predominant (40.1% – ethanol and sugarcane bagasse), followed by firewood and charcoal (18.4%), and biodiesel (2.4%). Biomasses contribute as much for generating electric power, which is the case of sugarcane bagasse, as for supplying vehicle fuels. The use of biofuels for vehicles effectively started by means of public policies with the Programa Nacional do Álcool (National Alcohol Program – Proálcool) in 1975 (Resenha..., 2017) and the Programa Nacional de Produção e Uso do Biodiesel (National Program for the Production and Use of Biodiesel – PNPB) in 2005 (Programa..., 2005). Embrapa has played a fundamental role in supporting these programs by offering technologies for producing saccharine and oilseed plants, which are required for the generation of these biofuels.

Among these contributions, stood out actions led by Embrapa Agrobiology and Embrapa Soybean in the understanding of biological nitrogen fixation in sugarcane and soybeans (*Glycine* sp.), resulting in production systems with less use of nitrogenous fertilizers and reduced greenhouse gas emissions.

Another crucial point to promote the continuity and improvement of production systems are biological collections kept by Embrapa to support breeding programs. For crops arising from traditional oilseed plants, Embrapa Soybean Active Germplasm Bank, which maintains over 35 thousand different accesses, can be mentioned. In addition, there are collections of species that are under the process of domestication, such as Embrapa Cerrados Active Germplasm Bank of Macaúba Palm Tree (*Acrocomia* spp.) (Figure 12), with around 450 accesses.

Photo: Simone Favaro

Figure 12. *Macaúba* palm tree (*Acrocomia* spp.), perennial oilseed species under domestication by Embrapa Cerrados.

More recently, Embrapa has also been active in industrial processing. Embrapa Agroenergy is leading projects to optimize fermentation processes of saccharine biomasses for first and second generation ethanol production; processing technologies for oilseed species with higher energy density than soybeans; technological routes for biodiesel production; and use of coproducts (Geração..., 2013). In addition, Embrapa has contributed to the sustainable production of dynamic forests, such as the development of ICLF systems to supply woody biomass.

Another relevant segment is the use of residues of animal production for generating biogas and microgenerating electric power. Embrapa Swine & Poultry leads this work in partnership with Usina Binacional de Itaipu.

Ramsar Convention and wetland protection

The Ramsar Convention was negociated in the 1960s and signed in 1971 to pursue “the conservation and wise use of wetlands through national actions and international cooperation as a contribution towards achieving sustainable development throughout the world." It was originally created to preserve transboundary wetlands, which shelter waterbird species, and its current concept is based on three principles. Contracting parties shall commit to:

- Work towards the wise use of all wetlands.
- Place suitable wetlands onto the List of Wetlands of International Importance (the list of Ramsar Sites).
- Cooperate internationally on transboundary wetlands.

In Brazil, the convention was ratified in 1993 and formalized by Federal Decree in 1996. The Comitê Nacional de Áreas Úmidas (Wetlands National Committee – CNZU), representing the Ramsar Convention in Brazil, defines these areas as "ecosystems at the interface between terrestrial and aquatic, continental or coastal, natural or artificial environments, permanently or periodically flooded or with soaked soils" (Brasil, 2015b), and defines the extent of a wetland area by the limit of a shallow flooding or permanent or regular waterlogging, or in the case of areas susceptible to flood pulses, by the limit of reach of maximum average floods, including, if any, permanently dried areas within them, habitats which are vital for the maintenance of their functional integrity and biodiversity." Their outer limits are indicated by hydromorphic soil and/or permanent or regular presence of hydrophytes and/or woody species adapted to permanently soaked soils" (Junk et al., 2014). Brazil lists 22 Ramsar sites, with a total area of 8,783,614 ha.

Embrapa works on several themes contribute to the SDGs. Among them are research studies directly involving one of Brazil's biomes: *Pantanal* (Figure 13). Embrapa Pantanal has being conducting research on the characterization, mapping, use, and sustainable production of natural resources in *Pantanal*, management of native fauna and flora, traditional management of livestock, recommendations and direct actions to control invasive species and others threats to the biome, its wetlands and the Ramsar sites located there (Jongman, 2005; Crispim et al., 2017; Oliveira et al., 2017; Santos; Cardoso, 2017). In Brazilian wetlands, Embrapa researches, develops and proposes innovations on products, technologies, and methods of use, production, and sustainable management. Themes such as adapted and improved cultivars [açaí (*Euterpe* sp.), and rice (*Oryza* sp., etc.)], sustainable production, greenhouse gas emissions from ecosystems and/or agroecosystems, and provision of ecosystem services are other topics addressed (Queiroz; Mochiutti, 2012; Silva et al., 2017; Winckler et al., 2017).

Photo: Sérgio Galdino

Figure 13. *Pantanal*: one of the largest wetlands on the planet.

References

BALBINO, L. C.; BARCELLOS, A. de O.; STONE, L. F. (Ed.). **Marco referencial Integração Lavoura-Pecuária-Floresta**. Brasília, DF: Embrapa, 2011. 130 p. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/103901/1/balbino-01.pdf>. Accessed on: Nov. 22, 2017.

BRASIL. Lei nº 13.123, de 20 de maio de 2015. Regulamenta o inciso II do § 1º e o § 4º do art. 225 da Constituição Federal, o Artigo 1, a alínea j do Artigo 8, a alínea c do Artigo 10, o Artigo 15 e os §§ 3º e 4º do Artigo 16 da Convenção sobre Diversidade Biológica, promulgada pelo Decreto nº 2.519, de 16 de março de 1998; dispõe sobre o acesso ao patrimônio genético, sobre a proteção e o acesso ao conhecimento tradicional associado e sobre a repartição de benefícios para conservação e uso sustentável da biodiversidade; revoga a Medida Provisória nº 2.186-16, de 23 de agosto de 2001; e dá outras providências. **Diário Oficial da União**, 14 maio 2015a. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2015/lei/l13123.htm>. Accessed on: Dec. 15, 2017.

BRASIL. Ministério do Meio Ambiente. Recomendação CNZU nº 7, de 11 de junho de 2015. Dispõe sobre a definição de Áreas Unidas Brasileiras e sobre o Sistema de Classificação destas áreas. **Diário Oficial da União**, 2015b.

CRISPIM, S. M. A.; SOARES, M. T. S.; SORIANO, B. M. A.; SANTOS, S. A. **Avaliação de pastagem nativa em áreas sujeitas a inundação com predominância de *Hymenachne amplexicaulis* no Pantanal, MS, Brasil**. Corumbá: Embrapa Pantanal, 2017. 16 p. (Embrapa Pantanal. Documentos, 148).

FREITAS, B. M.; PEREIRA, J. O. (Ed.). **Solitary bees**: conservation, rearing and management for pollination. Fortaleza: Imprensa Universitária, 2004. Available at: <http://www.webbee.org.br/bpi/solitary_bees.htm>. Accessed on: Dec. 21, 2017.

GERAÇÃO sustentável de bioenergia, biomateriais e químicos renováveis. Brasília, DF: Embrapa Agroenergy, 2013. 1 folder. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/146023/1/folder-embrapii-issuu.pdf>. Accessed on: Dec. 15, 2017.

HUNGRIA, M.; CAMPO, R. J.; NOGUEIRA, M. A. A pesquisa em fixação biológica do nitrogênio na Embrapa Soja: passado, presente e perspectivas futuras. In: REUNIÃO DA REDE DE LABORATÓRIOS PARA RECOMENDAÇÃO, PADRONIZAÇÃO E DIFUSÃO DE TECNOLOGIA DE INOCULANTES MICROBIANOS DE INTERESSE AGRÍCOLA, 16., 2012, Londrina. **Anais**… Londrina: Embrapa Soja, 2014. p. 54-59. Available at: <https://www. embrapa.br/soja/busca-de-publicacoes/-/publicacao/990886/a-pesquisa-em-fixacao-biologica-do-nitrogenio-na- embrapa -soja-passado-presente-e-perspectivas-futuras>. Accessed on: Dec. 15, 2017.

IMPERATRIZ-FONSECA, V. L.; SARAIVA, A. M.; DE JONG, D. (Ed.). **Bees as pollinators in Brazil**: assessing the status and suggesting best practices. Ribeirão Preto: Holos, 2006. Available at: <http://www.webbee.org.br/bpi/pdfs/bees_pollinators.pdf>. Accessed on: Dec. 4, 2017.

JONGMAN, R. H. G. (Ed.). **Pantanal-Taquari**: ferramentas para tomada de decisão em gestão integrada dos recursos hídricos. Wageningen: Partners for Water, 2005. 40 p.

JUNK, W. J.; PIEDADE, M. T. F.; LOURIVAL, R.; WITTMANN, F.; KANDUS, P.; LACERDA, L. D.; BOZELLI, R. L.; ESTEVES, F. A.; CUNHA, C. N. da; MALTCHIK, L.; SCHÖNGART, J.; SCHAEFFER-NOVELLI, Y.; AGOSTINHO, A. A. Brazilian wetlands: their definition, delineation, and classification, for research, sustainable management, and protection. **Aquattic conservation**: marine and freshwater ecosystems, v. 24, n. 1, p. 5-22, Feb. 2014. DOI: 10.1002/aqc.2386.

MATTOS, M. L. T. Microbiologia do solo. In: NUNES, R. R.; REZENDE, M. O. O. (Org.). **Recurso solo**: propriedades e usos. São Carlos: Cubo, 2015. p. 250-272.

MATTOS, M. L. T.; NUNES, C. D. M.; STEINMETZ, S.; MARTINS, J. F. da S.; VIEIRA JUNIOR, R. J.; FACIO, M. L. P.; SILVA, M. F. da. **Atividade de microrganismos do solo em diferentes períodos de cultivo do arroz irrigado**. Pelotas: Embrapa Clima Temperado, 2011. 8 p. (Embrapa Clima Temperado. Circular técnica, 126).

MELO, I. S. de; AZEVEDO, J. L. de (Ed.). **Microbiologia ambiental**. 2. ed. rev. ampl. Jaguariúna: Embrapa Meio Ambiente, 2008. 647 p.

MONNERAT, R. G.; NACHITGAL, G. de F.; CRUZ, I.; BETTIOL, W.; HOFFMANN-CAMPO, C. B. The role of Embrapa in the development of tools to control biological pests: a case of success. In: FIUZA, L. M.; POLANCZYK, R. A.; CRICKMORE, N. ***Bacillus thuringiensis*** **and** ***Lysinibacillus sphaericus***: characterization and use in the field of biocontrol. Cham: Springer, 2017. p. 213-222.

MOTTA MAUÉS, M. Reproductive phenology and pollination of the Brazil nut tree (*Bertholletia excelsa* Humb. & Bonpl. Lecythidaceae) in Eastern Amazonia. In: WORKSHOP ON THE CONSERVATION AND SUSTAINABLE USE OF POLLINATORS IN AGRICULTURE, WITH AN EMPHASIS ON BEES, 1998, São Paulo. **Pollinating bees**: the conservation link between agriculture and nature: proceedings. Brasília, DF: Ministry of Environment, 2002. p. 245-254.

OLIVEIRA, M. D. de; MANSUR, M. C. D.; BARBOSA, D. S. **Ocorrência de moluscos exóticos invasores no rio Miranda, bacia do rio Paraguai, MS**. Corumbá: Embrapa Pantanal, 2017. 14 p. (Embrapa Pantanal. Documentos, 151).

POLINIZAÇÃO do algodoeiro no Brasil: rede de pesquisa sobre os polinizadores dos algodoeiros no Brasil. Brasília, DF: Embrapa Recursos Genéticos e Biotecnologia, 2013. Available at: <http://ainfo. cnptia. embrapa.br/digital/bitstream/item/109026/1/1113-08-clp-folhetoPolinizadoresdoAlgodoeironoBrasil.pdf>. Accessed on: Feb. 27, 2018.

PROGRAMA Nacional de Produção e Uso de Biodiesel: inclusão social e desenvolvimento territorial. Brasília, DF: Ministério das Minas e Energia, 2005. Available at: <http://www.mda.gov.br/sitemda/sites/sitemda/files/user_arquivos_64/Biodiesel_Book_final_Low_Completo.pdf>. Accessed on: Nov. 26, 2017.

QUEIROZ, J. A. L. de; MOCHIUTTI, S. **Guia prático de manejo de açaizais para produção de frutos**. 2. ed. rev. e ampl. Macapá: Embrapa Amapá, 2012. 35 p.

REIS JÚNIOR, F. B. dos; MENDES, I. de C. **Biomassa microbiana do solo**. Planaltina, DF: Embrapa Cerrados, 2007. 40 p. (Embrapa Cerrados. Documentos, 205). Available at: <https://www. embrapa.br/soja/busca-de-publicacoes/-/publicacao/990886/a-pesquisa-em-fixacao-biologica-do-nitrogenio-na-embrapa -soja-passado-presente-e-perspectivas-futuras>. Accessed on: Dec. 15, 2017.

RESENHA energética brasileira: exercício de 2016. Brasília, DF: Ministério das Minas e Energia, 2017. Available at: <http://www.mme.gov.br/documents/10584/3580498/02+-+Resenha+Energ%C3%A9tica+Brasileira+2017+-+ano+ref.+2016+%28PDF%29/13d8d958-de50-4691-96e3-3ccf53f8e1e4?version=1.0>. Accessed on: Dec. 4, 2017.

SANTOS, S. A.; CARDOSO, E. L. **Boas práticas de manejo de pastagens nativas de áreas úmidas no Pantanal**. Corumbá: Embrapa Pantanal, 2017. 9 p. (Embrapa Pantanal. Comunicado técnico, 104).

SCHULTZ, N.; MORAIS, R. F. de; SILVA, J. A. da; BAPTISTA, R. B.; OLIVEIRA, R. P.; LEITE, J. M.; PEREIRA, W.; CARNEIRO JÚNIOR, J. de B.; ALVES, B. J. R.; BALDANI, J. I.; BODDEY, R. M.; URQUIAGA, S.; REIS, V. M. Avaliação agronômica de variedades de cana-de-açúcar inoculadas com bactérias diazotróficas e adubadas com nitrogênio. **Pesquisa Agropecuária Brasileira**, v. 47, n. 2, p. 261-268, fev. 2012. DOI: 10.1590/S0100-204X2012000200015.

SF AGRO. **Boas práticas na pecuária reduzem em 25% as emissões de gases estufa**. 2016. Available at: <http://sfagro.uol.com.br/boas-praticas-na-pecuaria-reduzem-em-25-as-emissoes-de-gases-estufa/>. Accessed on: Dec. 10, 2017.

SILVA, M. A. S. da; SANTOS, A. B. dos; MADARI, B. E.; MASCARENHAS, Y.; GONÇALVES, G. de M. O. Perdas de N-N2O e produtividade econômica em arroz tropical irrigado. In: CONGRESSO BRASILEIRO DE ARROZ IRRIGADO, 10., 2017, Gramado. **Intensificação sustentável**: anais. Gramado: Sosbai, 2017. Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/item/163354/1/CNPAF-2017-cbai-mass.pdf>. Accessed on: Dec. 10, 2017.

UNITED NATIONS. **Life on Land**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

WINCKLER, L. T.; GÜTHS, A. K.; GAYER, P. R. Benthic macroinvertebrates and degradation of phytomass as indicators of ecosystem functions in flooded rice cropping. **Pesquisa Agropecuária Brasileira**, v. 52, n. 4, p. 261-270, abr. 2017. DOI: 10.1590/s0100-204x2017000300006.

Chapter 4

Sustainable forest management

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Introduction

Target 15.2 of Sustainable Development Goal 15 (SDG 15) — by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally (United Nations, 2018) — describes great global problems, challenges, and strategies for mitigating and reducing the impacts of unsuitable use of natural resources. Since the end of the 1970s, Embrapa has been seeking for solutions for these demands and contributing to create systems to monitor the conversion of forest lands into other uses.

Sustainable forest management

In Brazil, the word "management" usually refers to activities related to the planning and administration of activities and spaces. The United Nations describes sustainable forest management (SFM) as: "[a] dynamic and evolving concept [that] aims at maintain and enhance the economic, social, and environmental values of all types of forests, for the benefit of current and future generations." The concept emphasizes adaptations of SFM in the long run, keeping its primary function of, at least, maintaining all forest values perpetually and their multidimensions, incorporating the economic, social, cultural, and environmental principles of sustainability. Thus, people are also at the center of SFM.

Embrapa research studies on forest management have focused on natural forests and planted forests. In the case of natural environments, approaches vary depending on each biome, type of owner and property size.

Embrapa experience on sustainable forest management of small properties or community management in the Amazon biome, disclosed in reports such as Araújo and Guarino (2015), and Araújo et al. (2017), ranges from search for information on the presence of species and their composition in the forest to discussions on the productive and sustainable maintenance of the environmental wealth in terms of timber and non-timber products, including those with medicinal and cosmetic properties. As an example, the 1995 experience called Pedro Peixoto Agricultural Colonization Project (d'Oliveira et al., 2007) can be mentioned.

Research on SFM for timber production and forest byproducts has been ongoing mainly in the Amazon and *Caatinga* biomes since the end of the 1970s (Figure 1). Embrapa teams have always had an important role in SFM research and have developed systems focusing on good practices and low impact exploitation. Recommendations range from minimum stock (for species) and cutting cycles to average intensity of exploitation (in volume). The understanding of some businessmen involved in exploitation processes has changed, and currently, some companies are following the system that Embrapa developed. Besides allowing it to be an economically viable activity, planned management adds value to timber. One of the partner companies of the project has already been awarded the certification seal for the third consecutive time, which facilitates its exports to countries in Europe and North America (Silva et al., 1996; Ruschel, 2008; Souza et al., 2017).

Areas located within the Atlantic Forest biome, as defined in Law 11,428/2006 (Brasil, 2006) and other related legal decisions, cannot be managed. Even so, Embrapa research efforts are ongoing for the development of models for the sustainable use of Brazilian pine forests (Mixed Ombrophilous Forest) with species such as yerba mate (*Ilex paraguariensis*), *bracatinga* tree (*Mimosa scabrella*), and Brazilian pine (*Araucaria angustifolia*) (Lacerda et al., 2012; Radomski et al., 2014). Experiments for conservation and sustainable use leading to financial return to land owners occupy approximately 40 ha. Other Embrapa studies are contributing to landscape management and land-use planning and to sustainable integration of agricultural areas with areas for preservation, use and forest conservation. Table 1 shows a quantitative overview of the published bibliography.

As an example of multi-institutional work, Rede Kamukaia started researching in the Amazon region (more precisely in the state of Acre) in 2005, focusing on the creation of basic knowledge on ecology and management of non-timber forest species and the information exchange among (governmental and non-governmental) research institutions acting in the Amazon (Wadt et al., 2017). A fundamental support for monitoring SFM activities are permanent plots, which are periodically observed by researchers organized in a network, mainly in Amazon and *Caatinga* (Coelho et al, 2017).


Photo: Rejane Stumpf Sberze

Figure 1. Sustainable forest management in the Amazon.

Table 1. Contribution of Embrapa for the technological evolution of landscape and timber and non-timber product management in different biomes and scales from 2008 to 2017.

Scope	Management				
	Landscape	Timber	Non-Timber	Timber and non-timber	Total
Amazon Biome	73	24	78	15	190
Cerrado Biome	54	1	10	2	67
Atlantic Forest Biome	53	3	18	5	79
Caatinga Biome	70	1	19	5	95
Pampa Biome	12	0	1	0	13
Pantanal Biome	10	0	1	0	11
Regional Scope	99	0	11	2	112
National Scope	215	6	11	8	240
Total	**586**	**35**	**149**	**37**	**807**

In *Caatinga*, firewood and charcoal represent between 30% and 50% of available energy. After having recognized these natural resources intensive and uncontrolled use, public authorities created laws to regulate timber exploitation in the biome area. Even though some technical questions are still pending, Embrapa and several other partner research institutions established the Rede de Manejo Florestal da *Caatinga* (RMFC), embracing a set of permanent plots, which are coordinated and managed by researchers in charge. Embrapa is also involved in identifying priority actions for conservation, sustainable use, and sharing of benefits from *Caatinga* (Drumond et al., 2000; 2004; Kiill et al., 2007; Alvarez; Kiill, 2014).

Halting illegal deforestation

The concept of deforestation shall be considered based on legal versus illegal deforestation. Thus, for example, in the Amazon biome, each property (individual or limited company ownership) can convert 20% of its area into other uses, and should maintain 80% of its native vegetation coverage. In other regions, removal of native vegetation is authorized at different rates. Therefore, not all natural vegetation removal is illegal deforestation; such removal shall be provided by law and depends on approval of the local environmental authority.

When it comes to deforestation, the global focus is on tropical countries, especially Brazil, for it holds a great part of the Amazon Rainforest. According to the National

Institute for Space Research (Inpe), from 2004 to 2014, when the Plano de Ação para Prevenção e Controle do Desmatamento na Amazônia Legal (Action Plan for Deforestation Prevention and Control on Legal Amazon – PPCDAm) was launched, there was an 80% reduction in the annual deforestation rate in the Amazon and, consequently, a reduction in greenhouse gas emissions due to deforestation. Even though the reduction trend had not been sustained in 2015, the decreasing deforestation rate resumed in 2016. Thus, as compared to 2004 rates, illegal deforestation decreased by 76%.

Over the last 10 years (2008 to 2017), Embrapa research teams have been dealing with the "deforestation" topic of SDG 15 under different aspects. As assessed by the authors of this chapter, some results are directly related to measuring deforestation, while others address ways to halt deforestation. Besides, it can be observed that, over that period, regional or even local approaches prevailed mainly focusing on the mapping and use of geotechnologies. Studies addressing forest fires were also included in the assessment.

As regards to the six Brazilian biomes, the assessment revealed that Amazon and *Cerrado* biomes were frequently studied during the period. By joining efforts with partners involving geotechnologies, Embrapa has contributed to monitoring the vegetation in large areas. However, there are concerns regarding the follow up of the substitution of land coverage for agricultural and forest uses in both *Caatinga* and *Pantanal*. The Atlantic Forest has been addressed in reports with a strong trend for regional results, in view of the characteristics of its geographic and latitudinal distribution. In 2006, a governmental initiative took place for the mapping of the remaining native forests all over the country, with the launching of *Mapas de Cobertura Vegetal dos Biomas Brasileiros* (*Maps of Vegetation Cover of Brazilian Biomes – Probio*) by the Ministry of Environment (MMA) (Brasil, 2018). Embrapa took part by joining efforts of consortiums between institutions for each biome.

Figure 2 shows that reports of Embrapa researchers constantly address the "deforestation" theme, particularly focusing on the Amazon biome. There are fewer reports on the biome as a whole than reports on local or regional contexts since several studies are concentrated in regions, such as specific river basins or biomes.

Regarding the theme "monitoring changes in land use/land cover", different strategies have been used to develop technologies mainly in the Amazon (for which there are regional studies and solutions) and *Pantanal* biomes. In monitoring

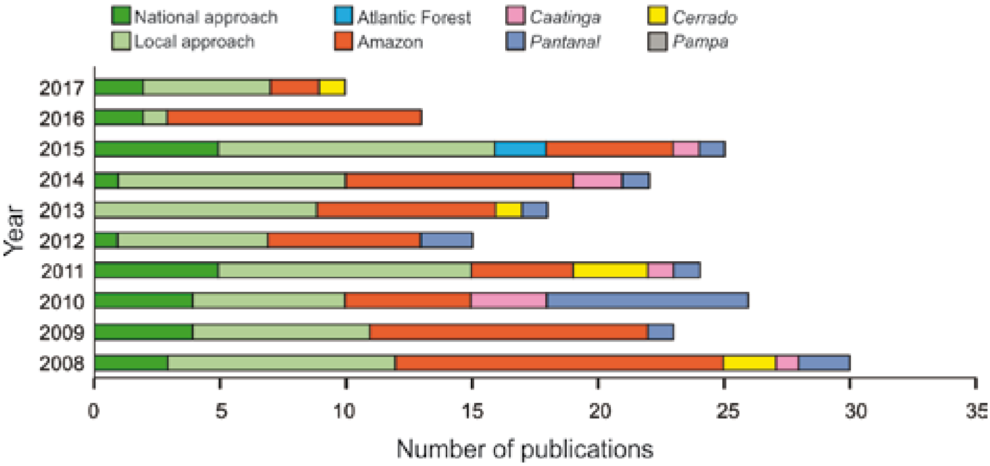

Figure 2. Number of technical-scientific reports by Embrapa researchers, from 2008 to 2017, approaching "deforestation" as a theme.

studies, identifying changes in land use or cover serves as a basis for other works that evaluate consequences of these changes over time by following up climatic and environmental parameters, which include soil and water characteristics, as well as pressures on the natural vegetation in each place under study. TerraClass project, which, since 2008, monitors land use and cover in deforested areas in Legal Amazon (and has been extended to the *Cerrado* biome), is an example of that. In 2014, Embrapa selected it as an outstanding outcome, which strengthened its partnership with Inpe in searching for solutions for this national challenge (Figure 3). Developing the Sistema Interativo de Análise Geoespacial da Amazônia Legal (Geospace Analysis Interactive System for Legal Amazon – SIAGEO Amazônia), which systematically collects information on the regional ecologic-economic zones (EEZ), with partner institutions was also an important decision.

A nationwide joint initiative between the Serviço Florestal Brasileiro (Brazilian Forestry Service – SFB) and Embrapa has been the methodology development for the Landscape Sample Units (LSU), a component of the Inventário Florestal Nacional (National Forestry Inventory – IFN-BR), also under SFB's coordination. LSUs (each one covering an area of 10 km^2) are distributed every 40 km in the same grid of field data. As the methodology predicts a time analysis of the involved areas, these changes may be monitored and followed-up in regions where deforestation is more intense and where vegetation fragmentation is greater all over the country (Archard et al., 2017).

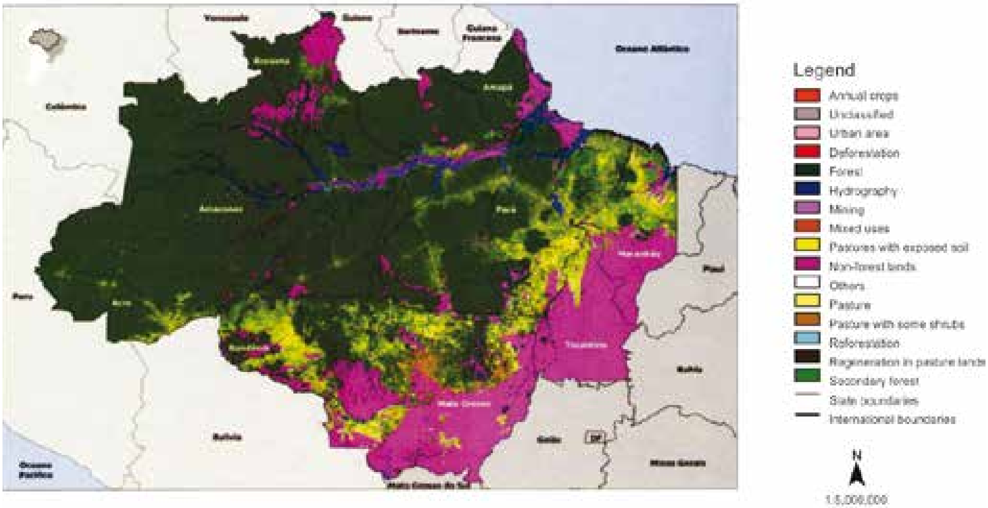

Figure 3. Mosaic of images of TerraClass project, developed in partnership between the National Institute for Space Research (Inpe) and the Brazilian Agricultural Research Corporation (Embrapa).

Source: TerraClass... (2016).

Regarding research and development projects, it is important to stress the partnership with national institutions, such as the Operação Arco Verde, which involves the Office of the President's Chief of Staff and Brazilian ministries. Partnerships with international institutions include, for example, the Programa de Grande Escala da Biosfera-Atmosfera na Amazônia (Program of Large Scale of Biosphere-Atmosphere in Amazon – LBA) and the Great Green Wall, an African initiative. Most actions take place in the Amazon biome, although local and regional initiatives are also being implemented in other biomes based on particular case studies.

Degraded forest restoration

Degraded forest restoration has been addressed in Embrapa using different words, but the use of the word "restoration" and its related concepts has recently increased. In one of the ongoing projects, an analysis is being performed to promote an internal debate to design a conceptual framework for forestry restoration in Embrapa.

Embrapa Board of Directors included the New Forest Code (Brasil, 2012) among its priorities. Embrapa special project called Soluções Tecnológicas para a

Adequação da Paisagem Rural ao Código Florestal Brasileiro (Technological Solutions for the Adequacy of Rural Landscape to the Brazilian Forest Code) organized the technologies created by the Company to protect and restore Brazil's native vegetation. Several national partner institutions, among them universities, research institutes and MMA, joined this initiative. The guidelines for Permanent Preservation Areas (PPAs), Legal Reserve Areas (LRAs), and Restrict Use Areas (RUAs) for different biomes and vegetation in Brazil are available and with free access at Código Florestal: Contribuições para Adequação Ambiental da Paisagem Rural (Forest Code: Contributions for Environmental Adequacy of Rural Landscape).

With the purpose of contributing to discussions on the improvement of the Brazilian environmental law, the Projeto Biomas (Biome Project) was performed in partnership between the Brazilian Confederation of Agriculture and Livestock (CNA) and Embrapa over the six Brazilian biomes. The mission of this institutional initiative is to present farmers with models for tree use leading to economic and environmental gains. It was based on research on sustainable use of forest species in PPAs, LRAs, and in production system areas. The constitution of a national research network for standardizing the entire process and offering interdisciplinary and multi-institutional training was one of the project's distinguishing features. Also joining the project are the National Rural Learning Service (Senar), Brazilian Micro and Small Business Support Service (Sebrae), Brazilian Development Bank (BNDES), and private partners and sponsors.

Afforestation and reforestation

The target 15.2 of SDG 15 confirms that expanding afforested and reforested areas is one of the recommended solutions to consolidate sustainable management.

The word "afforestation" refers to the establishment of a forest by planting or deliberately seeding land that, until that moment, was not classified as a forest; this implies a change in land use (Global..., 2015). In turn, the word "reforestation" refers to forest restoration by planting or deliberately seeding land classified as forest, and it does not imply changing in land use. Afforestation or reforestation may have both commercial and conservation purposes, but afforestation does not always represent the most suitable option for conservation, such as in the case of restoration of springs in ecosystems in which the predominant native vegetation is herbaceous.

Brazil's suitability for forests is revealed by factors such as great areas not used for agricultural purposes, suitable climate, and successful research programs, which allowed a minimum 7-times expansion in the area with forest plantations for commercial purpose over approximately 40 years. In 2017, the Brazilian Tree Industry (Ibá) reported a 7.8-million-hectare area planted by associated companies. If these figures were added to forested areas ran by small and medium farmers (either into the forestry business or not), it could achieve up to 10 million hectares. After negotiations during the *21st Conference of the Parties (COP 21)* of the *United Nations Climate Change Conference* in Paris, a new agreement was reached to strengthen the global response to the threat of climate change. Among other commitments, Brazil is to recover and reforest 12 million hectares of multiple purpose forests by 2030 by means of so-called nationally determined contributions (NDC).

One must recognize that, since the creation of the Programa Nacional de Pesquisa Florestal (National Program on Forestry Research) in 1978, Embrapa not only has sought for solutions to increase forest production and productivity in commercial areas with non-native species, but also has encouraged the use of native species from different biomes as an alternative. This is the case of the Brazilian pine (*Araucaria angustifolia*), yerba mate (*Ilex paraguariensis*), and *bracatinga* tree (*Mimosa scabrella*) in Southern Brazil, and *parica* tree (*Schizolobium parahyba* var *amazonicum*) in Northern Brazil.

Embrapa research efforts for afforestation and reforestation since that time were focused on the reality of each region of Brazil. In the Amazon, research teams conducted projects for sustainable forest management, as reported in the Sustainable Forest Management section. In turn, in Southern Brazil, initially, contributions were more focused on more productive species and progeny selection (aiming at commercial use) and on silviculture of regional native species (d'Oliveira; Braz, 2006). In *Caatinga*, efforts were towards both the management of natural environments and the crops, particularly agroforestry systems. Over time, concerns about adaptation of genetic material to be used in the states of Mato Grosso, Mato Grosso do Sul, and Goiás grew, in addition to the traditional crops in Minas Gerais.

Embrapa publications on the theme, emphasizing the Amazon and the Atlantic Forest, stand out. More recently, *Cerrado* became a theme of more interest. Substantial efforts were made in the beginning of the analyzed period (between 2008 and 2009), and resumed in 2014, but an emphasis on nationwide themes as of 2014 is noted (Figure 4).

It is worth highlighting the book *Plantações florestais: geração de benefícios com baixo impacto ambiental* (*Forestry plantations: reaping environmental low-impact*

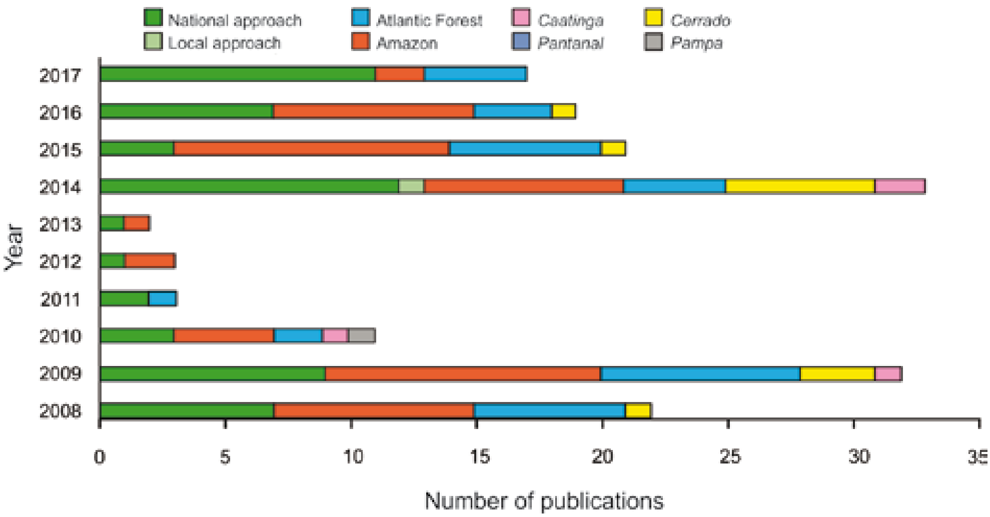

Figure 4. Number of technical-scientific reports by Embrapa researchers, from 2008 to 2017, approaching "afforestation" and "deforestation" as themes.

benefits) published in 2017 (Oliveira; Oliveira, 2017), which presents research results on the relations between planted forests and soil, water, and biodiversity, and demonstrates the importance and challenges of the coexistence among production forests, conservation and other production environments, even in landscape scale (Figure 5).

In terms of afforestation and reforestation, Embrapa regarded the following as its annual outstanding initiatives: in 2008, the first commercial crop of açaí in the world, named 'BRS Pará', to ensure the increase of açaí agribusiness (*Euterpe* sp.) on a solid basis. In 2009, BRS Manicoré cultivar, which ensures a sustainable dendê (*Elaeis* sp.) production in the Amazon and in the American continent. In 2010, Sistema Agroflorestal Cambona 4 (Cambona Agroforestry System 4), which suggests yerba mate intercropped with native trees for natural habitat restoration. Some years later, in 2015, Sistema de Produção de Pupunha para Palmito (Pupunha Palm Tree System for Heart-of-Palm Production), which leads to a 5-time increase on farmers' income per palm tree. Also in 2015, the chip for genotyping *Eucalyptus* sp. named EucHIP60k was launched globally. Its main advantage is reducing the time for genetic breeding of such plant (which is around 9 to 18 years) to 6 to 9 years. Finally, in 2016, Projeto Estradas com Araucária (Roads with Brazilian Pine Project), which

Photos: Luciane Jacques

Figure 5. *Pinus* sp. (A) and *Eucalyptus* sp. (B) plantations.

aims at stimulating family farmers in the states of Paraná and Santa Catarina, with the support of public and private institutions of the region, to plant Brazilian pine seedlings in the borders of their properties with roads.

Final considerations

There are several governmental programs focused on biodiversity. However, there is a lack of consolidated information on all Brazilian biomes related to productivity, occurrence, and management recommendation for the main commercially-used species. In addition, there is a lack of information on the use of several other flora and fauna species and environmental services (such as pollination, which is fundamental to the sustainability of agricultural crops) based on multiple uses of forests. Research results on forest products are fundamental to governmental policies, such as the definition of technical guidelines for management, processing, and commercialization aiming at promoting viable products from the socio-biodiversity, thus strengthening the market and promoting forest management as part of primary production in Brazil.

It is important to emphasize that many themes take medium-to-long-term research, which take more time between its conclusion and its validation before they are made available in the future as technologies and processes to farmers and technicians. These technologies are important contributions to the Brazilian rural sector to evolve and implement a sustainable management in each farm.

References

ALVAREZ, I. A.; KIILL, L. H. P. Arborização, floricultura e paisagismo com plantas da Caatinga. **Informativo ABRATES**, v. 24, n. 3, p. 63-67, dez. 2014. Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/item/114240/1/4297.pdf>. Accessed on: Jan. 4, 2018.

ARAUJO, H. J. B. de; D'OLIVEIRA, M. V. N.; MIRANDA, E. M. de (Ed.). **Manejo florestal madeireiro para pequenas áreas**. Rio Branco: Embrapa Acre, 2017. 16 p. (Sistemas de produção, 8). Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/164522/1/26383.pdf>. Accessed on: Jan. 4, 2018.

ARAÚJO, H. J. B. de; GUARINO, E. de S. G. Mortalidade e mudanças na composição de área sob manejo florestal comunitário. In: SANTOS, R. C. dos; SIVIERO, A. (Org.). **Agroecologia no Acre**. Rio Branco: Ifac, 2015. p. 347-372. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/142019/1/25822.pdf>. Accessed on: Jan. 4, 2018.

ARCHARD, F.; OLIVEIRA, Y. M. M. de; MOLLICONE, D. Monitoring forest cover and deforestation. In: DELINCÉ, J. (Ed.). **Handbook on remote sensing for agricultural statistics**. Rome: Global Strategy to improve Agricultural and Rural Statistics, 2017. p. 185-215. Available at: <https://www.

embrapa.br/florestas/busca-de-publicacoes/-/publicacao/1083312/monitoring-forest-cover-and-deforestation>. Accessed on: Dec. 21, 2017.

BRASIL. Lei nº 11.428, de 22 de dezembro de 2006. Dispõe sobre a utilização e proteção da vegetação nativa do Bioma Mata Atlântica, e da outras providências. **Diário Oficial da União**, 26 dez. 2006. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/l11428.htm>. Accessed on: Nov. 23, 2017.

BRASIL. Lei nº 12.651, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa; altera as Leis nº 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nº 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória nº 2.166-67, de 24 de agosto de 2001; e dá outras providências. **Diário Oficial da União**, 28 maio 2012. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm>. Accessed on: Nov. 23, 2017.

COELHO, F. de A.; PINTO, M. V. P.; FERREIRA, F. N.; RUSCHEL, A. R. Avaliação da eficiência do monitoramento de parcelas permanentes em uma unidade de manejo. In: SEMINÁRIO DE INICIAÇÃO CIENTÍFICA DA EMBRAPA AMAZÔNIA ORIENTAL, 21., 2017, Belém, PA. **Anais**... Belém, PA: Embrapa Amazônia Oriental, 2017. Available at: <https://www. embrapa.br/busca-de-publicacoes/-/publicacao/1076214/avaliacao-da-eficiencia-do-monitoramento-de-parcelas-permanentes-em-uma-unidade-de-manejo-florestal>. Accessed on: Dec. 21, 2017.

D'OLIVEIRA, M. V. N.; ARAUJO, H. J. B. de; CORREIA, M. F.; SILVA, M. P. da. **Manejo florestal sustentável na pequena propriedade**. Rio Branco, AC: Embrapa Acre, 2007. 32 p. (Embrapa Acre. Documentos, 106). Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/117349/1/17287.pdf>. Accessed on: Jan. 4, 2018.

D'OLIVEIRA, M. V. N.; BRAZ, E. M. Estudo da dinâmica da floresta manejada no projeto de manejo florestal comunitário do PC Pedro Peixoto na Amazônia Ocidental. **Acta Amazonica**, v. 36, n. 2, p. 177-182, 2006. Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/item/112604/1/13891.pdf> Acesso em: 5 jan. 2018.

DRUMOND, M. A.; KILL, L. H. P.; LIMA, P. C. F.; OLIVEIRA, M. C. de; OLIVEIRA, V. R. de; ALBUQUERQUE, S. G. de.; NASCIMENTO, C. E. de S.; CAVALCANTI, J. Estratégias para o uso sustentável da biodiversidade da caatinga. In: SILVA, J. M. C. da; TABARELLI, M.; FONSECA, M. T. da; LINS, L. V. (Org.). **Biodiversidade da caatinga**: áreas e ações prioritárias para a conservação. Brasília, DF: Ministério do Meio Ambiente: Universidade Federal de Pernambuco, 2004. p. 329-340.

DRUMOND, M. A.; LIMA, P. C. F.; OLIVEIRA, M. C. de; OLIVEIRA, V. R. de; ALBUQUERQUE, S. G. de.; NASCIMENTO, C. E. de S.; CAVALCANTI, J. **Estratégias para o uso sustentável da biodiversidade da caatinga**. Petrolina: Embrapa Semi-Árido, 2000. 21 p. Documento para discussão em Grupo de Trabalho-GT Estratégias para o uso sustentável, apresentado no Seminário Biodiversidade da Caatinga. 2000, Petrolina. Avaliação e identificação de ações prioritárias para a conservação.

GLOBAL forest resources assessment 2015: how are the world's forests changing? 2nd ed. Rome: FAO, 2015. 46 p. Available at: <http://www.fao.org/3/a-i4793e.pdf>. Accessed on: Nov. 17, 2017.

KIILL, L. H. P.; DRUMOND, M. A.; LIMA, P. C. F.; ALBUQUERQUE, S. G. de; OLIVEIRA, V. R. de. **Preservação e uso da Caatinga**. Brasília, DF: Embrapa Informação Tecnológica; Petrolina: Embrapa Semi-Árido, 2007. 36 p. (ABC da agricultura familiar, 16).

LACERDA, A. E. B. de; ROSOT, M. A. D.; FIGUEIREDO FILHO, A.; GARRASTAZU, M. C.; NIMMO, E. R.; KELLERMANN, B.; RADOMSKI, M. I.; BEIMGRABEN, T.; MATTOS, P. P. de; OLIVEIRA, Y. M. M. de. Sustainable forest management in rural Southern Brazil: exploring participatory forest management planning. In: MARTIN-GARCIA, J.; JAVIER DIEZ, J. (Ed.). **Sustainable forest management**: case studies. Rijeka: InTech, 2012. p. 97-118. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/63352/1/AndreBiscaia.pdf>. Accessed on: Jan. 5, 2018.

OLIVEIRA, Y. M. M. de; OLIVEIRA, E. B. de (Ed.). **Plantações florestais**: geração de benefícios com baixo impacto ambiental. Brasília, DF: Embrapa, 2017. 112 p. Available at: <https://www. embrapa. br/florestas/busca-de-publicacoes/-/publicacao/1076130/plantacoes-florestais-geracao-de-beneficios-com-baixo-impacto-ambiental>. Accessed on: Jan. 5, 2018.

RADOMSKI, M. I.; LACERDA, A. E. B. de; KELLERMANN, B. **Sistemas agroflorestais**: restauração ambiental e produção no âmbito da Floresta Ombrófila Mista. Colombo: Embrapa Florestas, 2014. 47 p. (Embrapa Florestas. Documentos, 276). Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/121202/1/Doc.-276-Izabel.pdf>. Accessed on: Jan. 5, 2018.

RUSCHEL, A. R. **Dinâmica da composição florística e do crescimento de uma floresta explorada há 18 anos na Flona Tapajós, PA**. Belém, PA: Embrapa Amazônia Oriental, 2008. 57 p. (Embrapa Amazônia Oriental. Documentos, 341). Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/27916/1/Doc341.pdf>. Accessed on: Jan. 4, 2018.

SILVA, J. N. M.; CARVALHO, J. O. P. de; LOPES, J. do C. A.; OLIVEIRA, R. P. de; OLIVEIRA, L. C. de. Growth and yield studies in the Tapajós region, Central Brazilian Amazon. **The Commonwealth Forestry Review**, v. 75, n. 4, p. 325-329, 1996.

SOUZA, M. A. S. de; AZEVEDO, C. P. de; SOUZA, C. R. de; FRANÇA, M.; VASCONCELOS NETO, E. L. Dinâmica e produção de uma floresta sob regime de manejo sustentável na Amazônia Central. **Floresta**, v. 47, n. 1, p. 55-63, Jan./Mar. 2017.

TERRACLASS 2004 a 2014: avaliação da dinâmica do uso e cobertura da terra no período de 10 anos nas áreas desflorestadas da Amazônia Legal brasileira. Belém, PA: Instituto Nacional de Pesquisas Espaciais/Centro Regional da Amazônia: Embrapa Amazônia Oriental; [Campinas]: Embrapa Informática Agropecuária, 2016. 1 folder.

UNITED NATIONS. **Life on Land**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

WADT, L. H. de O.; SANTOS, L. M. H.; BENTES, M. P. de M.; OLIVEIRA, V. B. V. (Ed.). **Produtos florestais não madeireiros**: guia metodológico da Rede Kamukaia. Brasília, DF: Embrapa, 2017.

Chapter 5

Prevention of advancing degradation and recovery of degraded lands

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Introduction

This chapter presents an overview on the main technological contributions of Embrapa and partners to halt land degradation, accelerated erosive processes, desertification, sanding, salinization, and to restore degraded lands, as established in target 15.3 (United Nations, 2018): By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

Understanding the causes of land degradation, its consequences for the environment and agricultural production, and technological alternatives to halt its advance and recover already degraded lands are some of the biggest challenges to a sustainable life on Earth. In the world, around 33% of lands present some type of degradation (Status..., 2015). In Brazil, around 22% of the national territory is considered to be degraded; agricultural exploitation with the use of inappropriate practices is the main cause (Bai et al., 2008).

In general, accelerated erosion aggravates degradation of these lands, and, in an arid and/or semi-arid climate, it promotes desertification, mainly in the Northeast Semi-arid Area of Brazil, in Tocantins' *Cerrado*, and in the North of Mato Grosso and Minas Gerais. In *Pampa Gaúcho*, the sanding process is advancing in some cities.

Different kinds of erosion with varying intensities are still degrading lands in several regions of Brazil. Besides compromising the potential of agricultural production and the resilience of different ecosystems, erosion also causes the silting and contamination of water resources, thus creating rural exodus, floods, decreased capacity of hydroelectric power generation, increased costs for water treatment and loss of land and aquatic biodiversity. Thus, water erosion, which can be sufficiently sped-up by inappropriate land use and management, shall be considered as one of the most extreme environmental problems of humanity (Feng et al., 2010; Andrade; Chaves, 2012).

Currently, most lands under agricultural use in Brazil (around 173 million hectares) grow pasture. Only 10% of these areas adopt less impacting pastoral systems, such as fallow period, rotations, and integrated crop-livestock-forest (ICLF). Degraded pasture recovery is part of the voluntary commitments of Brazil in the 2009 *United Nations Climate Change Conference* in Copenhagen (*COP15*). These commitments were ratified in the National Policy on Climate Change, in which the Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura (Sector Plan of Mitigation and Adaptation to Climate Changes for the Consolidation of a Low Carbon Emission Economy in Agriculture) (ABC Plan) was established to agriculture. Among its targets is the recovery of 15 million hectares of degraded pastures by 2020.

This scenario makes the recovery of degraded pastures for sustainable agricultural production one of the greatest opportunities to increase national agricultural production with no need for converting more natural vegetation areas to the advancing agricultural frontier. In addition, besides generating income, these degraded lands, when properly recovered, will also provide ecosystem services, such as erosion control, regulation of groundwater recharge, increase of carbon stock on soil, and, consequently, mitigation of the effects of greenhouse gas emissions (GGEs).

Halting degradation and land desertification

Absence of planning for land use, indiscriminate deforestation — even in permanent preservation areas (PPAs) that are highly environmentally important and/or susceptible to degradation —, agricultural exploitation in lands with restricted suitability or no suitability and/or high environmental vulnerability, monoculture, plowing and harrowing towards the slope, use of fires, lack and/or excess of fertilizer and corrective applications, and overgrazing are the main causes of degraded lands and/or desertification.

Among the strategies to avoid advancing land degradation and desertification, Embrapa provides the understanding of agricultural production potentials and limitations. The Company offers technologies to characterize and analyze potentials and limitations of lands for agricultural production in different geographic scales, among which the following stand out: the Manual de Métodos de Análise do Solo (Handbook of Methods of Soil Analysis), the Sistema Brasileiro de Classificação dos Solos (Brazilian System of Soil Classification), the Sistema de Avaliação da Aptidão Agrícola das Terras (Evaluation System for Agricultural Land

Suitability), the Sistema Brasileiro de Classificação de Terras Para Irrigação (Brazilian System of Land Classification for Irrigation), the Zoneamento Agrícola de Risco Climático (Agricultural Zoning of Climate Risks), the Zoneamento Agroecológico (Agro-ecologic Zoning), the Planejamento Conservacionista da Propriedade Agrícola (Conservacionist Planning for Agricultural Property) presented in *Dia de Campo* TV Show and which aims at its environmental and productive adequacy, the Integração Participativa de Conhecimentos sobre Indicadores de Qualidade do Solo (Participative Integration of Knowledge on Soil Quality Indicators), among others (Ramalho Filho; Beek, 1995; Claessen, 1997; Barrios et al., 2011; Santos et al., 2013). Currently, the elaboration of a National Program of Brazil's Soils is ongoing, which intends to continue large-scale searching and interpreting of soils so as to allow more efficient planning for suitable land use.

Besides increasing the efficiency of methodologies for data analysis, storage, and interpretation for purposes of land use planning, this information should be more frequently used both for designing public policies and for providing ecosystem services and/or increasing agricultural production. Thus, mechanisms that encourage substituting degrading practices for more sustainable practices (such as the ones on agro-ecological basis), which aim at redesigning degraded landscapes to jointly create diversified production systems to improve income generation for the farmer and environmental services for all society, have been more effective not only to avoid advancing degradation, but also to produce higher quality agricultural products (Figure 1).

The *Manual para o Pagamento por Serviços Ambientais Hídricos* (*Handbook for Payment for Hydric Environmental Services*), which Embrapa recently released, approaches this theme (Fidalgo et al., 2017). Furthermore, some initiatives for training environmental education agents in themes such as soil and water management practices and conservation and recovery of degraded lands are ongoing and some new are scheduled. Studies to improve the prediction of extreme climate risks so as to contribute to increased efficiency of drought, slide, and flood prevention initiatives and to allow a better mapping of areas of higher environmental vulnerability in Brazil are ongoing.

In addition to technologies offered by Embrapa for land use characterization and planning (to avoid using lands which are highly susceptible to degradation, and to predict extreme climate scenarios), several others conservationist technologies have been developed for different ecosystems. Among them, the following can be mentioned:

Photos: Aluísio Andrade

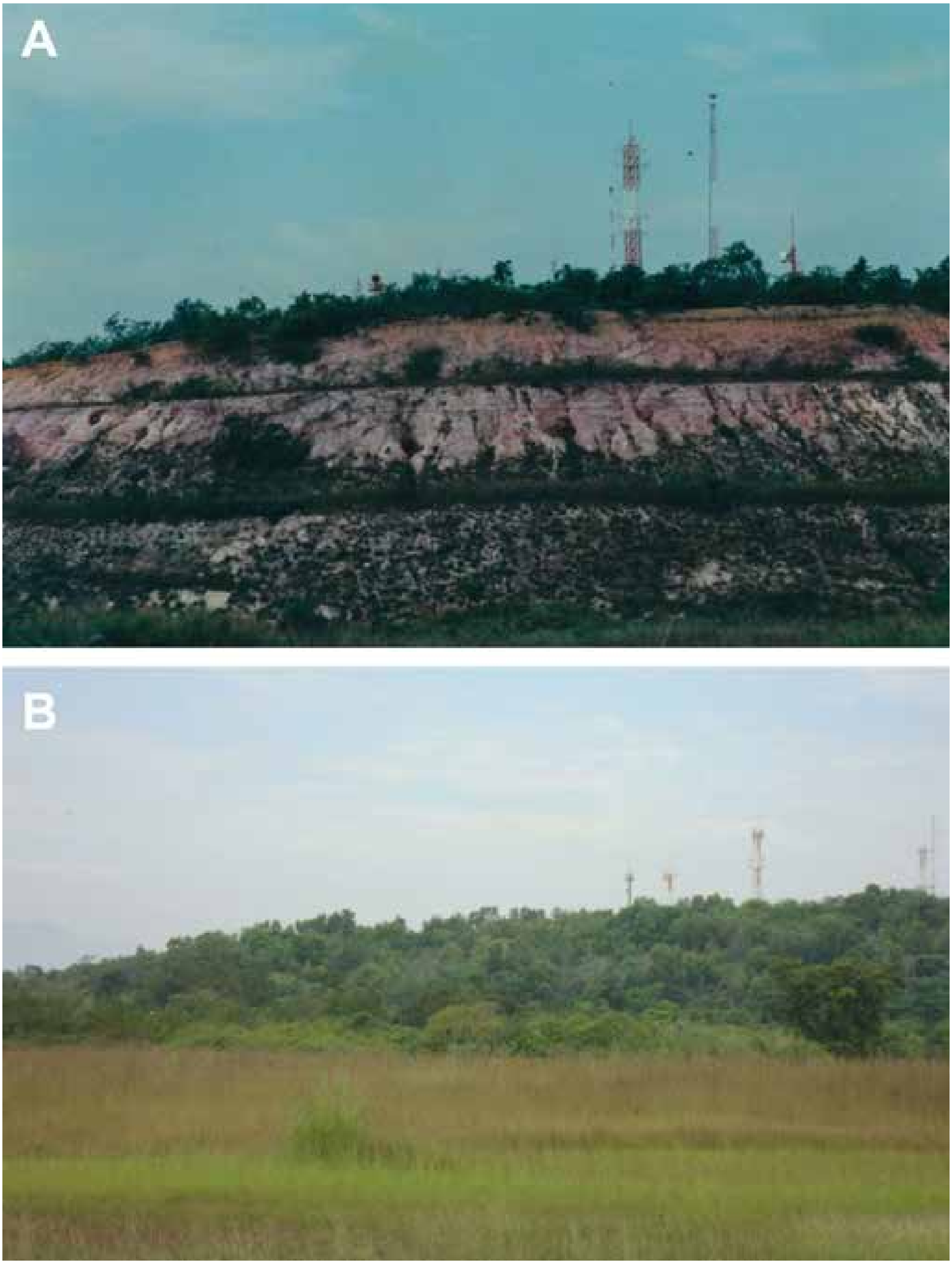

Figure 1. Degradation due to the removal of land for civil construction industry in 2003 (A) and ongoing recovery after mechanical and vegetation practices in 2005 (B).

Source: Andrade et al. (2005).

- Collection, selection, improvement, and storage of native genetic resources.
- Management and recovery of Permanent Protection Areas (PPAs).
- Diagnosis of degradation and/or conservation of management zones in areas with potential for agricultural production.
- Use of no-tillage system, with rotation, intercropping and/or succession of crops and/or livestock in agroforestry arrangements.
- Use of residues.
- Surface stormwater drainage to promote control of erosion, increase water retention (through the construction of small dams), increase water table level (through underground dams), divert upstream waters from gullies (through terraces and catchment areas) or downgrade water level through alternative drainage systems in areas under flooding.

Many activities to train environmental education agents, guide post-graduate students, and collaborate in implementing, managing, and monitoring degraded lands recovery plans and programs on soil and water management and conservation have been performed, thus allowing Embrapa to be present in the main actions to avoid advancing degradation in all regions of Brazil.

In short, good agricultural practices using lands based on their limits and potentialities and maintaining or improving soil chemical, physical, and biological properties can avoid land degradation. This enables higher soil aggregation, avoids its compression, increases water storage, and the availability of essential nutrients to plant growth, and also increases possibilities of employment and income generation. It all favors sustainability of these new agrosystems, making it possible to transform what causes degradation into an agent for sustainable rural development. In this aspect, as emphasized above, scenarios of land degradation have regularly received Embrapa contributions to revert them.

Recovery of degraded lands

To evaluate the level of land degradation, Embrapa has developed and offered methodologies for analyzing and interpreting orbital images, such as Projeto Geodegrade, which mapped areas of *Cerrado* degraded pastures and soil, water, and biodiversity quality indicators. When jointly analyzed, these data allow increasing the efficiency of recovery actions to be implemented.

According to these methodologies, technologies are adopted in two main steps. The first consists of dividing the areas in plots (management zones), as homogeneously as possible, in accordance with the characteristics of the terrain, such as topography, vegetation cover, current use, crop productivity or support capacity (if any) and exploitation history, applied conservationist practices, type and frequency of erosive processes, and soil type. If there are no soil maps in suitable scale to the farm size, the following should be observed: surface and subsurface horizon color, texture, structure and thickness, and the effective depth of roots.

The second step consists of the detailed diagnosis of the state of conservation and/or soil degradation in each management zone aiming to characterize and measure ongoing erosive processes and the presence of residues (rests of crops, correctives and/or fertilizers, animal detritus, pesticide packages, plastic bags, etc.). In this step, recommendations are to evaluate the rate of water infiltration in soil and the occurrence of compressed layers, to collect soil samples to evaluate grain size and fertility (routine analysis with inclusion of carbon) and to describe the natural vegetation cover and/or the current use and existing management practices. After diagnosis is accomplished, a set of mechanical, edaphic, and vegetation practices for recovering soil productive capacity have been developed for different environmental conditions and production systems.

Mechanical practices aim at ordering and dissipating the energy of surface runoff waters, and promoting water infiltration and sediment retention. Among them, are terracing (Figure 2), retention basins, level cultivation, drains, and subsoiling of compressed areas by overgrazing and/or excess of machine traffic. Edaphic practices refer to fertility management with a suitable application of organic and mineral fertilizers, correctives, and soil conditioners to promote increased water availability for vegetation in periods of water stress. Vegetation practices correspond to plant selection and management (rotation, intercropping or succession) for purposes of production, soil protection, biological nitrogen fixation, organic matter supply, nutrient cycling, biological decompaction, and soil structuring.

This set of practices promotes soil structure preservation and/or improvement, water and organic matter infiltration increase, nutrient cycling, and maintenance of soil coverage (live or dead) (Figure 3), which increases its resistance against erosion. No-tillage systems, agroforestry systems, integrated crop-livestock system (ICL), and ICLF are good examples of systems that contribute to soil conservation and recovery. For this same purpose, technologies for monitoring and planning

Figure 2. Terraces built to avoid surface drainage in wheat crop (*Triticum* sp.).

Figure 3. Cropping of maize (*Zea* sp.) on mulch in Technological Showcase of Embrapa Maize and Sorghum.

are been developed and provided, such as Plano ABC (through Projeto GeoABC), which incorporate analysis of orbital images, and soil and water quality indicators.

Even mined areas have been re-vegetated through herbaceous legume, shrubs, and tree species seedlings inoculated with nitrogen fixing bacteria and mycorrhizal fungi. This technology has been efficient to recover highly degraded areas (as gullies, hills, and cutting slopes, and landfill and areas contaminated with oil) and to supply nitrogen-rich organic matter for intercropping and/or agroforestry systems. Besides efficient plants, technologies for identifying characteristics and properties of degraded soils and subsequently recommending practices enabling to rebuild its fertility at large have been developed with improvements in its physical, chemical, and biological properties.

For degraded lands with recovery potential for purposes of agricultural production, there is a set of technologies that can contribute to reinsert them in the sustainable agricultural production. Among them, are technologies to identify variable soil properties through proximal sensors, drones for air inspections in order to better separate management zones, and agroecologically-based technologies, such as the use of biological pesticides, management of green manure, and selection and arrangement of crops and creations in agroforestry systems.

Final considerations

Considering the territorial extension and the variability of environmental and socioeconomic conditions and agricultural production systems of the different regions of Brazil, Embrapa has a great challenge: to contribute to increasing the generation, transfer, and innovation of technologies which enable to reach this target. There are technologies available to be applied and there is technical and operational capacity to promote the joint construction, with different players of society, of a broad and permanent national program on prevention of land degradation, soil and water management, land conservation and degraded land recovery.

In conservationist systems, the following beneficial practices are adopted, among others: reduced or even no soil preparation, leveled crop, fertilizer and corrective applications in accordance with crop needs and interpretations of soil analysis, intercropping, succession and/or rotation and permanent soil cover (with the use of vegetation cover), residue recycling, implementation of living fences, terraces, drains, and catchment basins (as appropriate), selection of vegetal species, varieties, and cultivars adapted to the different local environmental conditions, integrated management of pests, diseases and weeds, production diversification, and suitable destination of useless residues.

In order to offer more efficient technologies and develop new solutions to degraded land recovery, Embrapa efforts shall be mainly towards:

- Selecting and evaluating useful and low-cost indicators to detect different levels of land degradation through images and in field.
- Developing technologies of land recovery under varied levels of degradation.
- Evaluating the necessary investments and identifying opportunities for receiving financial incentives for recovering land under several levels of degradation aiming at sustainable agricultural production and provision of environmental services.
- Generating consistent data on the economic and environmental benefits that may come from transforming degraded lands into productive lands.
- Training technicians and farmers to increase the use of good agricultural practices, to contribute more effectively to reach target 15.3, to contribute to several other SDGs and their respective targets, specially: no poverty, zero hunger, sustainable agriculture, good health and well-being, decent work and economic growth, climate action, peace, justice and strong institutions, and partnerships for the goals.

References

ANDRADE, A. G. de; CHAVES, T. A. Manejo contra a erosão: para evitar a degradação do solo é preciso planejar as atividades de acordo com as fragilidades e potencialidades da área explorada. **Agro DBO**, p. 42-46, ago. 2012. Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/item/67984/1/manejo-contra-a-erosao.pdf>. Accessed on: Mar. 2, 2018.

ANDRADE, A. G. de; PORTOCARRERO, H.; CAPECHE, C. L. **Práticas mecânicas e vegetativas para o controle de voçorocas**. Rio de Janeiro: Embrapa Solos, 2005. 4 p. (Embrapa Solos. Comunicado técnico, 33).

BAI, Z. G.; DENT, D. L.; OLSSON, L.; SHAEPMAN, E. Proxy global assessment of land degradation. **Soil, Use and Management**, v. 24, n. 3, p. 223-234, 2008. DOI: 10.1111/j.1475-2743.2008.00169.x.

BARRIOS, E.; COUTINHO, H. L. C.; MEDEIROS, C. A. B. **InPaC-S**: integração participativa de conhecimentos sobre indicadores de qualidade do solo: guia metodológico. Nairobi: ICRAF; [Brasília, DF]: Embrapa, CIAT, 2011.

CLAESSEN, M. E. C. (Org.). **Manual de métodos de análise de solo**. 2. ed. rev. e atual. Rio de Janeiro: Embrapa-CNPS, 1997. 212 p. (Embrapa-CNPS. Documentos, 1). Available at: <https://ainfo. cnptia. embrapa.br/digital/bitstream/item/169149/1/Manual-de-metodos-de-analise-de-solo-2-ed-1997.pdf>. Accessed on: Mar. 2, 2018.

FENG, X.; WANG, Y.; CHEN, L.; FU, B.; BAI, G. Modeling soil erosion and its response to land-use change in hilly catchments Chinese Loess Plateau. **Geomorphology**, v. 118, n. 3-4, p. 239-248, June 2010. DOI: 10.1016/j.geomorph.2010.01.004.

FIDALGO, E. C. C.; PRADO, R. B.; TURETTA, A. P. D.; SCHULER, A. E. (Ed.). **Manual para pagamento por serviços ambientais hídricos**: seleção de áreas e monitoramento. Brasília, DF: Embrapa, 2017. 78 p. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/160960/1/Manual-PSA-hidricos-2017.pdf>. Accessed on: Mar. 2, 2018.

RAMALHO FILHO, A.; BEEK, K. J. **Sistema de avaliação da aptidão agrícola das terras**. 3. ed. rev. Rio de Janeiro: Embrapa-CNPS, 1995. 65 p. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/150386/1/sistema-de-avaliacao-agr-terras-3a-edicao1995.pdf>. Accessed on: Mar. 2, 2018.

SANTOS, H. G. dos; JACOMINE, P. K. T.; ANJOS, L. H. C. dos; OLIVEIRA, V. A. de; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A. de; CUNHA, T. J. F.; OLIVEIRA, J. B. de. **Sistema brasileiro de classificação de solos**. 3. ed. rev. e ampl. Brasília, DF: Embrapa, 2013. 353 p.

STATUS of the world's soil resources. Rome: Food and Agriculture Organization of the United Nations, 2015. 32 p. (Main report).

UNITED NATIONS. **Life on Land**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

Chapter 6

Mountain agriculture

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Marcos Flávio Silva Borba
Lucíola Alves Magalhães
Jorge Tonietto

Introduction

This chapter examines the contributions of the Brazilian Agricultural Research Corporation (Embrapa) to achieve target 15.4 of the Sustainable Development Goal 15 (SDG 15) (United Nations, 2018): "By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development".

Despite the fact that mountains have their own characteristics, as do the populations living there, the perception that mountainous environments demand different development strategies and public policies is new in the world. In Brazil, Embrapa is leading important initiatives seeking to articulate research and development proposals with local development strategies for mountainous environments.

Territorial development and implementation of a seal of origin

Since 2006, Embrapa, Associação Riograndense de Empreendimentos de Assistência Técnica e Extensão Rural (Riograndense Association for Technical Assistance and Rural Extension – Emater-RS), and research teams linked to federal universities in Rio Grande do Sul state (Federal University of Rio Grande do Sul – UFRGS, Federal University of Santa Maria – UFSM, and Federal University of Pelotas – UFPel) started a process of transforming the social and economic reality of a group of family cattle breeders. These breeders organized themselves in community associations in municipalities at the Alto Camaquã River Basin, which is the poorest region in the state.

Assuming that regional weaknesses were consequences of the inadequacy of economic models, technological formats, and indicators used in their analysis, local actors looked at opportunities and potentialities throughout the region. Thus, in 2013, they identified that more than 80% of the vegetation cover was composed by native plant species, and that livestock production was fundamentally based on pastures (Borba, 2016).

Also, considering that the production based on natural resources can be extremely effective and can create different products, they came up with a proposal linking the sustainable development of the region to valuation of social, historic, economic, cultural, and environmental resources, including the social construction of markets through short chains of value and network organization. This led to the creation of a collective territorial brand, owned by Associação para o Desenvolvimento Sustentável do Alto Camaquã (Association for the Sustainable Development of Alto Camaquã – Adac). This brand has a seal of origin to distinguish its products: the Alto Camaquã brand.

In 2015, the association was officially recognized as Local Productive Arrangement (LPA) for Sheep and Tourism of Alto Camaquã, the only LPA in sheep production officially recognized by Brazilian competent bodies. A project is currently being developed in order to strengthen governance: the creation of a territorial management committee in partnership with Emater-RS, Associação Brasileira de Criadores de Ovinos (Brazilian Association of Sheep Farmers – Arco), Embrapa, Federação dos Trabalhadores na Agricultura no Rio Grande do Sul (Federation of Agricultural Workers Rio Grande do Sul State – Fetag), University of the Campanha Region (Urcamp), Pampa Federal University (Unipampa), Getúlio Vargas College of the Alto Uruguay Institute for Educational Development (Ideau), National Service for Commercial Apprenticeship (Senac), and Brazilian Micro and Small Business Support Service (Sebrae), and with the support of Agência Gaúcha de Desenvolvimento e Promoção do Investimento (Gaúcha Agency for Development and Promotion of Investment – AGDI), an agency linked to the Secretariat of Economic Development, Science, and Technology (Sedect-RS).

The Alto Camaquã Network currently gathers 25 associations involving family cattle breeders, *quilombolas*, beekeepers, and artisans, with around 500 families in the municipalities of Bagé, Caçapava do Sul, Canguçu, Encruzilhada do Sul, Lavras do Sul, Pinheiro Machado, Piratini, and Santana da Boa Vista (Figure 1 and Table 1).

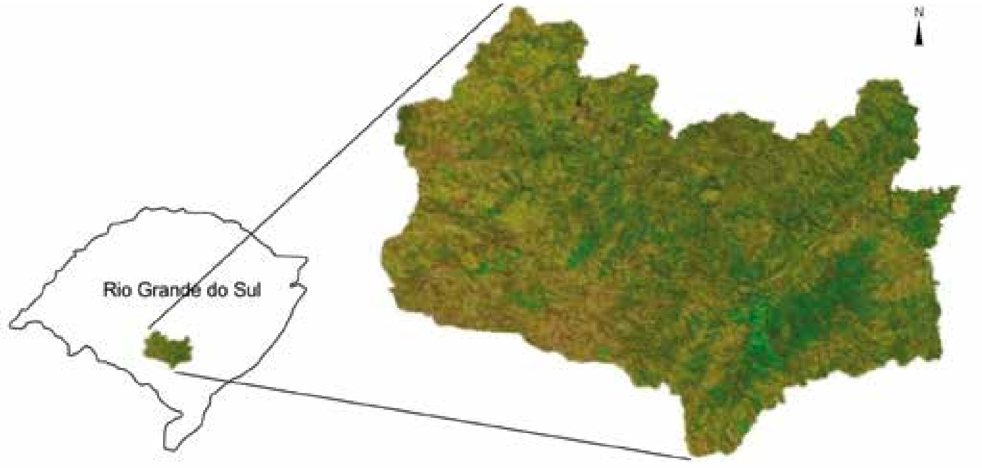


Figure 1. Location of the Alto Camaquã territory, in Rio Grande do Sul state, Brazil, which gathers 25 associations of family cattle breeders, *quilombolas*, beekeepers, and artisans.

Source: Rocha e Trindade (2015).

Table 1. Classes and areas of vegetation cover at Alto Camaquã territory, RS, Brazil.

Class	Area (km^2)	Area (%)
Water	8.0	0.06
Eucalyptus tree (*Eucalyptus* sp.)	481.9	3.61
Acacia tree (*Acacia* sp.)	250.2	1.87
Pine (*Pinus* sp.)	334.5	2.50
Natural forest	4,290.2	32.12
Field	6,750.3	50.53
Agricultural areas	1,242.4	9.30
Total	**13,357.8**	**100.00**

Geographical Indication of Serra Gaucha wine territories

Since 1995, Embrapa Grape & Wine has led an unprecedented structuring of geographical indications (GI) in Brazil for fine wines produced in Serra Gaúcha region, Rio Grande do Sul, located on the upper hills in the northeast of the state. This vitivinicultural region features rugged terrain, some areas of mountainous terrain, hills and valleys with altitudes ranging from 300 m to more than 800 m. The geographical characteristics of the region – its altitudes and slopes cultivated with vineyards – in some situations resemble and fit the concept of mountain viticulture used in Western Europe.

Several research and development (R&D) projects were carried out in this traditional production region, which has more than 15 thousand viticulture small properties. The projects were responsible for the structuring, recording, and operationalization of six geographical indications of fine wines under Geographical Indication (GI) or Appellation of Origin (AO). Farmers from these associations had requested these actions – Associação dos Produtores de Vinhos Finos do Vale dos Vinhedos (Vale dos Vinhedos Fine Wine Producers Association, Aprovale), Associação dos Produtores de Vinhos de Pinto Bandeira Wine Producers Association of Vinhos de Pinto Bandeira, Asprovinho), Associação de Vitivinicultores de Monte Belo do Sul (Monte Belo do Sul Winegrowers Association, Aprobelo), Associação de Produtores dos Vinhos dos Altos Montes (Altos Montes Wine Producers Association, Apromontes), and Associação Farroupilhense de Produtores de Vinhos, Espumantes, Sucos e Derivados (Farroupilhense Association of Wine, Sparkling, Juice, and Byproduct Producers, Afavin). Embrapa Grape & Wine, Embrapa Temperate Agriculture, UFRGS, and University of Caxias do Sul (UCS) supported these projects.

For each delimited GI (GI: Vale dos Vinhedos, Pinto Bandeira, Altos Montes, Monte Belo and Farroupilha; AO: Vale dos Vinhedos), studies on the viticulture territory were carried out and enabled to accomplish:

- Geographical delimitation of each GI area.
- Geological cartography, soil mapping, and zoning of viticultural potential.
- Viticultural climate zoning.
- Characterization of the use and cover of the soil.
- Terrain cartography, including altimetry, slope, and exposure.
- Creation of a georeferenced register of the vineyards of each GI, which includes vineyard database and cartography.
- Description of the historic evolution and renown of the vitiviniculture production in each GI territory.
- Characterization of the viticultural landscape.
- Structuring of the rules of use for each GI and its respective system and control plan.

- Sensory and physicochemical characterization of each GI wine.

Wine GIs currently belong to the vitivinicultural policy, with the support of the Committee of Geographical Indications located at the Brazilian Institute of Wine (Ibravin). Sebrae is also an important supporter of geographical indications. Geographical indications of wines are expected to increase the strength, the identity, and the quality of Brazilian wines, raising the level of the industry's competitiveness.

In addition, bearing in mind the focus on territory, GIs stimulate sustainability actions in vitiviniculture, the preservation of its tangible and intangible cultural heritage, and the enotourism impetus. The line of work related to territorial intelligence shows strong potential for use in wine geographical indications. In this sense, the geographical and viticulture production databases that already exist will enable more complex levels of territory management in GIs (Figure 2).

Training for farmers from Rio de Janeiro mountainous region

In the mountainous region of Rio de Janeiro state, the partnership between Embrapa and the local government of Nova Friburgo established in 2005 the Núcleo de Pesquisa e Treinamento para Agricultores (Farmer Center for Research and Training – NPTA). Through actions of participative knowledge construction, technologies and practices are being adapted, consolidated, multiplied, and suited to the reality of the systems used in the local agriculture production.

This region stands out as an important vegetable production area. Its production is fundamental to a suitable food supply to the metropolitan region of Rio de Janeiro city, the second biggest economic and population center in Brazil. Furthermore, this area is one of the main remnants of the Atlantic Forest in the country. In this sense, NPTA is working with technicians and farmers to create technologies suitable to the reality faced by the local production systems, to ensure environmental, economic, and social sustainability in the region mountainous environments. Rotational cropping is an example of technology that has been fostered by NPTA, since it enables the production of a diversity of species of economic interest and the introduction of cover plants, especially black oat (*Avena strigosa*) (Figure 3).

Photos: Jorge Tonietto

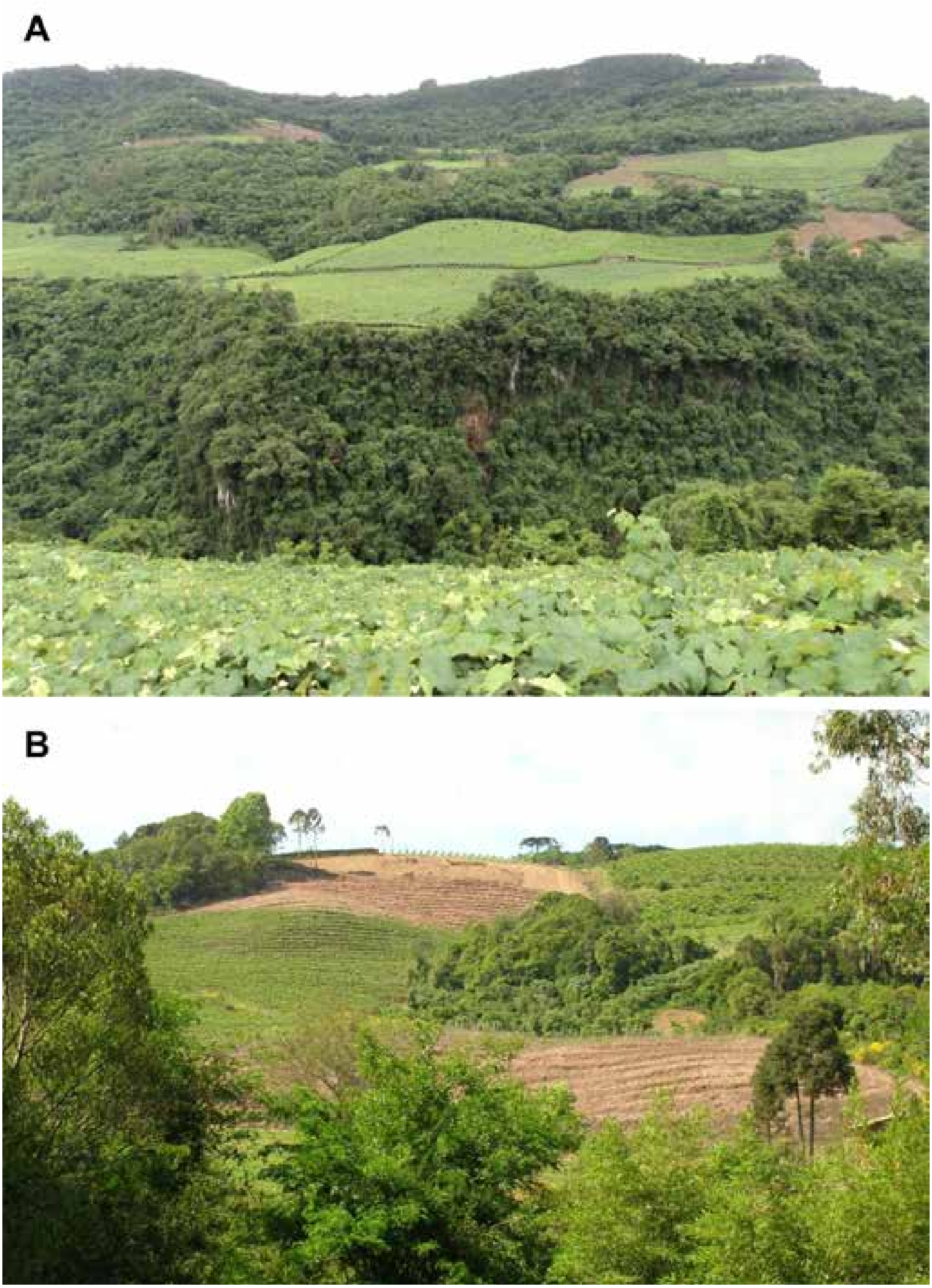
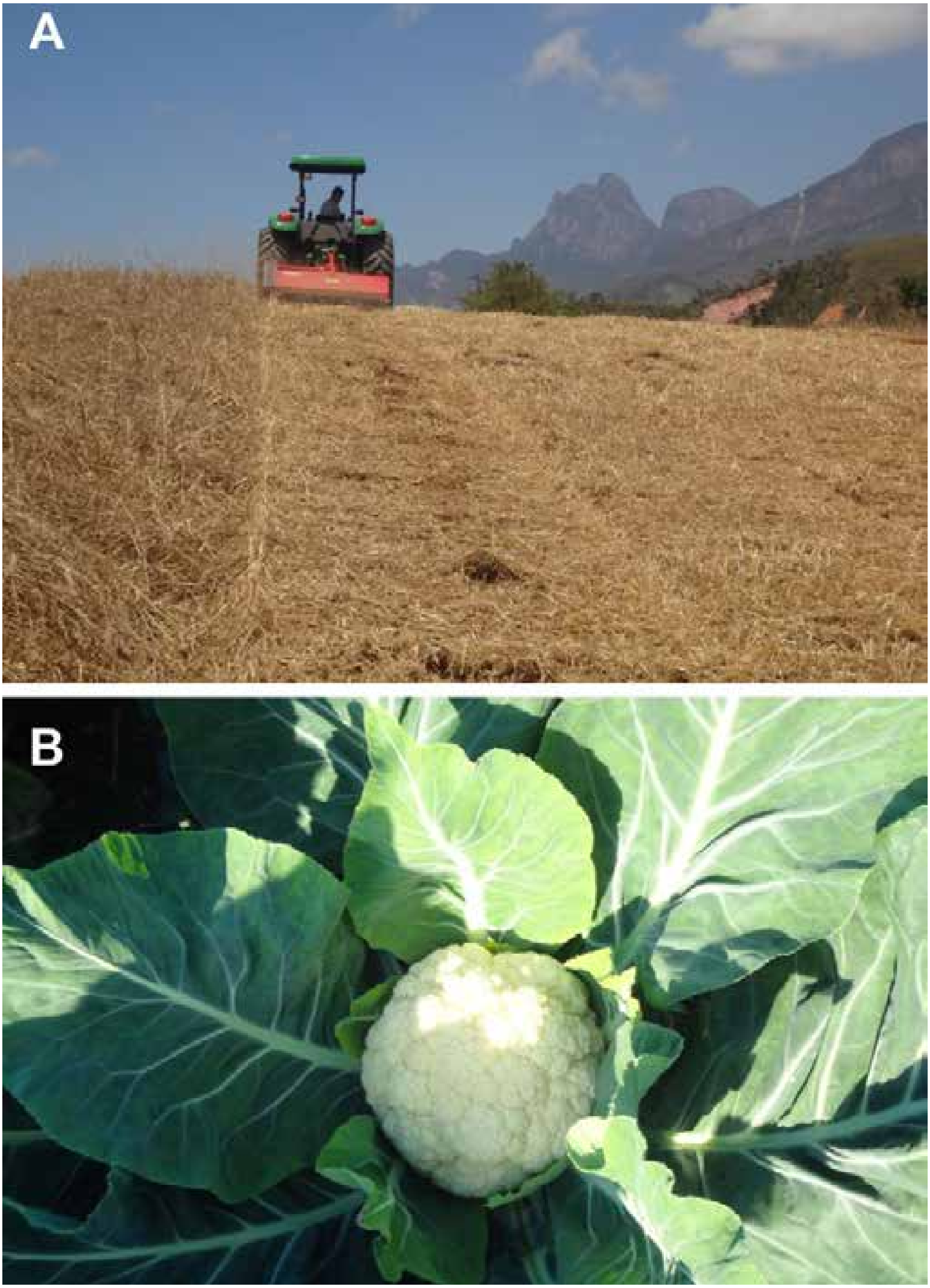


Figure 2. Viticultural landscapes in the geographical indications of fine wines Farroupilha (A) and Pinto Bandeira (B) located in Serra Gaucha region, Rio Grande do Sul state, Brazil.



Photos: Renato Linhares de Assis

Figure 3. Harvest of black oat (*Avena strigosa*) with grinder for cover (A) and no-till cauliflower (*Brassica oleracea* var. botrytis) crop after black oat (B).

Ecosystem services in mountainous environments

Ecosystem services are the contributions of ecosystems to human beings, including climate and water regulation; pollination; water, fibers, timber, and food supply; erosion control; among others. In order to their difficult access and agricultural management, areas at the bottom of mountainous terrains still feature several fragments of preserved forests. The hydrographic basin mainsprings are located there, which makes them Permanent Preservation Areas (PPAs). Thus, their environmental protection is mandatory in accordance with the law, since they harbor great biodiversity. They may be considered regions with high potential for the generation of ecosystem services. Therefore, mountainous environments have been stressed as vital areas for research that validate and develop data to improve actions that already exist and to stimulate new initiatives for agricultural production systems concearning environmental conservation.

Embrapa has an Array of Projects called Serviços Ambientais na Paisagem Rural (Environmental Services in Rural Landscape). Its main purpose is to develop knowledge and tools to support actions and policies to restore, maintain, and expand ecosystem services, and to strengthen sustainable basis production systems on rural landscapes. This array addresses matters related to the ecosystem services provided by Brazilian biomes; many of its projects approach mountainous areas or plain areas that depend on water resources arising from upstream mountainous areas.

Territorial intelligence applied to Brazilian mountainous environments

Strategic territorial intelligence (STI) applied to Brazilian mountainous environments has been discussed at Embrapa since 2016 (Galinari, 2016), in order to define and map mountainous environments in Brazil to improve the performance of public policies promoting their sustainable rural development (López et al., 2011). These researches aim not only to delimit these environments, but also to qualify them on a territorial basis according to the concepts of Strategic Territorial Intelligence System (SITE). A SITE gathers information on natural, agrarian, agricultural, socioeconomic, and infrastructural frameworks, as well as their time and space intersections, aiming to assist the agricultural development considering those multiple dimensions, always based on a territorial approach.

The information to be colleceted by SITE will enable distinguishing several territories of mountain agriculture and support strategies for the sustainable exploitation of these environments. In addition, it will contribute to build scenarios and model public policies; to stimulate and adjust, in the territory, activities to combat rural poverty and misery; to promote productive inclusion and social interests in a coherent, convergent, and harmonic way, including approaches connected to food safety, agrobiodiversity, tourism, gastronomy, valuation of local production systems and ecosystem services; and to open new markets focused on agroindustry.

SITE will also enable to list priorities based on the equipotential and equiproblematic regions, as well as serve as a support for the appraisal or development of social technologies to the suitable production in mountainous environments. These strategic data and information collected and worked from a territory perspective will supply agents with qualified information for use in discussions and decisions based on the territorial dimension of problems to be identified.

Technical-scientific coordination

In the article *Agricultura de montanha: uma prioridade latente na agenda da pesquisa brasileira* (Mountain agriculture: a latent priority in the Brazilian research agenda), López et al. (2011) stated, in a provocative way, that "mountain agriculture" is still a latent theme in the Brazilian research agenda. In 2011, there were already various research and development initiatives with a systemic view of mountainous environments in the country, but it was necessary to coordinate them, not only in the national as well as in the international scenario. It is important to exchange experiences and information to subsidize and enrich different local initiatives.

To promote this coordination, Embrapa organized in Nova Friburgo, RJ, the two first editions of the *Workshop on Sustainable Development in Mountainous Environments* in 2010 and 2013. These events enabled strengthening the national researcher network coordination that was involved and motivated by the mountain theme; they also started the international coordination of this network, notably with the Centro de Investigação de Montanha (Mountain Research Center – Cimo), located in Bragança, Portugal. Thus, the creation of the Rede de Investigação de Montanha da Lusofonia (Lusophony Mountain Research Network – Lumont) became possible; it aimed to promote the disclosure and sharing of information between researchers and research institutions concearned with mountain topics, and it worked to create more and better partnerships and cooperation opportunities.

The launch of Lumont happened at Cimo's headquarters during the *I International Conference on Research for Sustainable Development in Mountain Regions* (Mountains, 2016), which was organized by the Portuguese institution with Embrapa participation, which, at that time, commited to organize *Mountains 2018* in Brazil. The event will occurr in December 2018 in Nova Friburgo, RJ, and consisted of the *II International Conference on Research for Sustainable Development in Mountain Regions* and the *Third Workshop on Sustainable Development in Mountain Environments*. Besides strengthening the exchange among Portuguese speaking countries, *Mountains 2018* also aims to expand the exchange among Latin American and Caribbean countries, and to promote the definitive inclusion of Brazil in the international scientific community studying mountain topics.

The process of organizing *Mountains 2018* has included Embrapa in the discussions on mountain environments dynamics. It was promoted by the United Nations (UN) through the association of Embrapa Agrobiology with Mountain Partnership, which consists in an initiative of the Food and Agriculture Organization of the United Nations (FAO) to add institutions (government and society) committed to work for the sustainable development of mountain environments in the whole world.

References

BORBA, M. F. S. Desenvolvimento territorial endógeno: o caso do Alto Camaquã. In: WAQUIL, P. D.; MATTE, A.; NESKE, M. Z.; BORBA, M. F. S. (Org.). Desenvolvimento territorial endógeno: o caso do Alto Camaquã. **Pecuária familiar no Rio Grande do Sul**: história, diversidade social e dinâmicas de desenvolvimento. Porto Alegre: Ed. da UFRGS, 2016. p. 187-214.

GALINARI, G. Inteligência territorial. **XXI Ciência para a vida**, n. 3, p. 55, 2016. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/146456/1/Revista-XXI-n13-AINFO.pdf>. Accessed on: Dec. 7, 2017.

LÓPEZ, A.; AQUINO, A. M. de; ASSIS, R. L. de. Definição de montanha. In: LÓPEZ, A.; AQUINO, A. M.; ASSIS, R. L. (Org.). **Agricultura de montanha**: uma prioridade latente na agenda da pesquisa brasileira. Brasília, DF: Embrapa Informação Tecnológica, 2011. p. 15-20. (Texto para discussão, 14). Available at: <https://www.alice.cnptia. embrapa.br/alice/bitstream/doc/901579/4/Texto41.pdf>. Accessed on: Dec. 10, 2017.

ROCHA, D. S. da; TRINDADE, J. P. P. **Cobertura vegetal e geomorfologia do Alto Camaquã, RS**. Bagé: Embrapa Pecuária Sul, 2015. 26 p. (Embrapa Pecuária Sul. Documentos, 143). Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/137913/1/DT-143-online.pdf>. Accessed on: Mar. 26, 2018.

UNITED NATIONS. **Life on land**: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

Chapter 7

Endangered species protection

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Introduction

This chapter deals with the contributions of the Brazilian Agricultural Research Corporation (Embrapa) to achieve target 15.5 of the Sustainable Development Goal 15 (SDG 15) (United Nations, 2018): "Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species."

Embrapa is continuously improving in order to develop a sustainable tropical agriculture and contribute with strategic actions that increasingly associate and appreciate the use and conservation of the national biodiversity wealth. It also searches for solutions to minimize the losses and threats of species extinction in their natural habitats under degradation risks.

This action is closely related with the advance of knowledge on specific biology of species aspects and challenges to surpass the gaps, extending to the identification and comprehension of the effects caused by anthropogenic modifications on ecosystems. Thus, research, development, and innovation (RD&I) are being performed in order to know, characterize, and contribute, effectively, for the generation and adoption of technologies for sustainable use and conservation of natural environments and their species, in order to minimize the negative impacts of the anthropogenic actions causing these processes.

Embrapa germplasm active banks and genetic resourses of animals, vegetation, and microorganism systems include timber, flowers, fruits, seeds, forage plants and semen of wild animals. The maintenance of passport data, characterization, and appraisal of these systems are entirely aligned to the reference of access and use of national genetic resources, and the treaties, agreements, contracts, and related proceedings, which are important indicators in the development of joint projects and actions to protect Brazilian biodiversity (Embrapa Recursos Genéticos e Biotecnologia, 2017).

In the future, these tools and proceedings application will be important to encourage the promotion of social and economic well-being in all Brazilian regions (Balanço..., 2015). In this regard, Embrapa develops its researches in partnership both with its Research Centers and with key-institutions to contribute for the elaboration of public policies and production of technologies to reduce vulnerability of threats arising from the environmental degradation, which deeply contributes to achieve target 15.5.

Some examples are the decreasing use of fires in the Amazon; several zoning systems suitable to Brazilian biomes (aiming a better territorial planning of land use); creation of softwares for agricultural, timber, livestock, and fishing sustainable management; and monitoring of native birds, bees, and wasps in different landscape scales.

This chapter presents a brief compilation of how Embrapa performes to comprehend and decrease the loss of habitats and biodiversity through its Research Centers located in all Brazilian regions.

Natural habitat degradation and biodiversity loss

Environmental degradation processes (such as deforestation, fires, predatory exploitation of timber, and hunt) and indiscriminate use of pesticides tend to isolate plant, animal, and microorganism populations, which reduces genetic variability and, consequently, the adaptive ability of species. Anthropogenic disturbance effects (changes in land use and fragmentation of natural habitats) from these actions decrease the biodiversity (Barlow et al., 2016), and contribute to the extinction of species in local, regional, and global scopes (Moura et al., 2014; Solar et al., 2015). Non-planned agricultural expansion also causes biodiversity loss. One of these negative consequences is the expansion of distribution of invasive species. Any of these effects can determine changes in important ecologic processes, such as the pollination and dispersion of seeds (Ferreira et al., 2012).

Endemism is considered in tropical regions when there is a degradation of singular habitats, in which disordered use of land promotes vulnerability or extinction of numerous species.

Degradation processes do not affect only terrestrial environments. They also affect the biodiversity of aquatic, rural, and savannah environments. They can be caused by soil erosion resulting from the changes of land use, interruption of water flows (Leal et al., 2016), predatory fishing, effects of chronic disturbances of anthropogenic origin in these environments, among others.

The Atlantic Forest is one of the Brazilian biomes with the most fragmentation of its natural landscape, due to the conversion of its forests in areas of agricultural production strongly based on the use of agrochemicals, resulting important changes in the interaction of biotic and abiotic components. Besides, these forest fragments work as barriers to the traffic of several animal species, acting as a subsequent threat to their conservation (Uzêda et al., 2016, 2017).

Disorderly forest exploitation became a typical example of the main causes of biodiversity loss all over Brazil. Particularly in the Amazon biome, where it became an important economic activity, there was a reduction of natural populations of several species of economic value, creating a comprehensive list of threatened or under extinction risk tree species (Martini et al., 1998).

Ex situ conservation of seeds is one way of minimizing the biodiversity loss in environments changed due to logging. However, for most tropical species, there is little information on ideal conditions of conservation and storage by means of this tool. Species such as the *acapu* tree (*Vouacapoua americana Aubl*.), *maçaranduba* tree (*Manilkara huberi*) and *ucuúba* tree (*Virola surinamensis*) (Figure 1) are some exemples with this limitation (Cruz, 2016; Cruz; Barros, 2016; Cruz; Pereira, 2016).

These barriers make conservation and reduction of habitat degradations difficult, which invariability require the production of seedlings, both to recovery of anthropized areas and to commercial reforestation.

The *Caatinga*, which has a significative vegetation diversity, is also one of the Brazilian biomes susceptible to threats of anthropogenic changes on its ecosystems. Among endangered native species, there is *cumaru* or umburana--de-cheiro (*Amburana cearenses*), which has an important medicinal and cosmetic potential, and the stingless bee (*Melipona subnitida*), which has an important ecologic-economic function due to the production of honey and crop pollination in conditions of confinement in northeast Semiarid region (Silva et al., 2014).

The Brazilian *Cerrado* is the second largest biome in the country, and one of the priority areas for biodiversity conservation and protection on the planet. However, failures in extensive cattle production in the region since the 1960s have been

Photos: Eniel Cruz

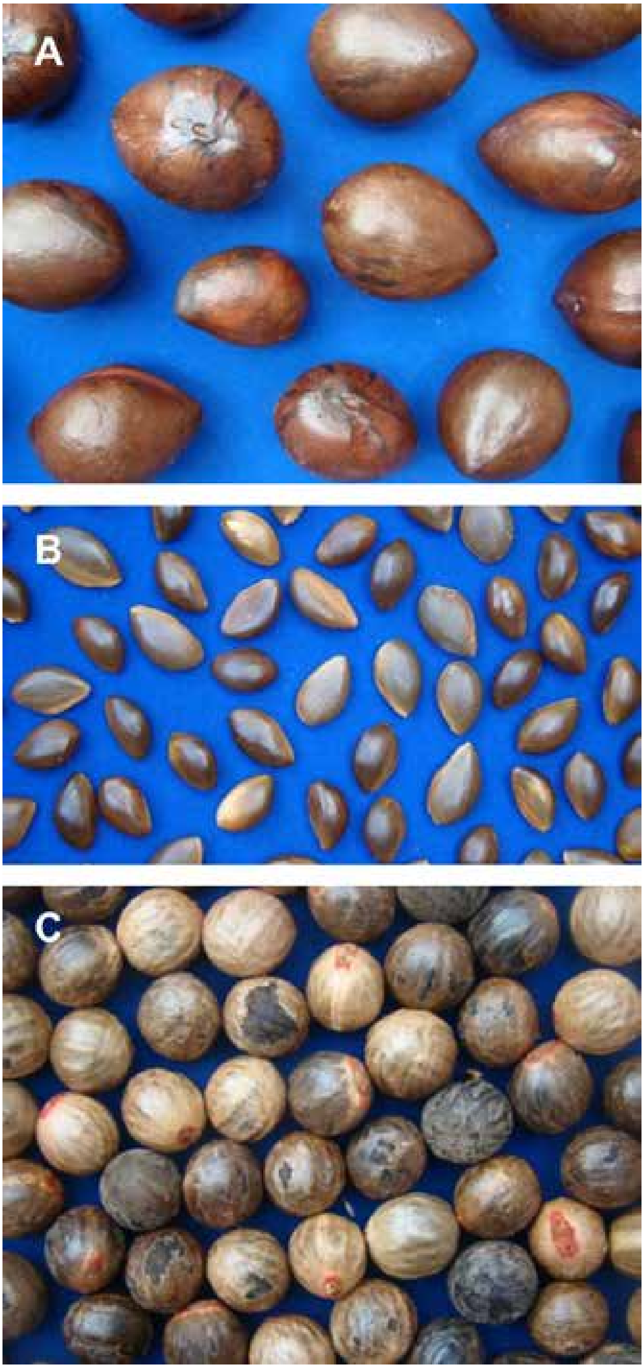

Figure 1. Seeds of Amazon species: *acapu* (*Vouacapoua americana* Aubl.) (A); *maçaranduba* (*Manilkara huberi*) (B); and *ucuúba* (*Virola surinamensis*) (C).

one of the main vectors of biodiversity losses, besides water and soil erosion, and degradation of its several types of vegetation.

The *Pampa* biome's biodiversity also suffered serious consequences due to the conversion of natural fields in other forms of land use. Its main characteristic vegetation is herbal-shrub vegetation types constituted by common hemicryptophytes, geophytes, and nanophanerophytes on surfaces of flat or gently corrugated terrain. One of the main consequences has been the infection of invasive species on natural fields.

In the *Pantanal* biome, one of the biggest challenges is to reconcile traditional management of livestock with biodiversity conservation and ecosystem services, once the region has diverse populations of threatened species both in national and global scenario (Harris et al., 2005). Lack of information determining threatened species status of conservation is one of the difficulties to protect them.

Animal species emphasized in Embrapa research in *Pantanal* are: giant otter (*Pteronura brasiliensis*), giant anteater (*Myrmecophaga tridactyla*), marsh deer (*Blastocerus dichotomus*), pampas deer (*Ozotoceros bezoarticus*), and southern three-banded armadillo (*Tolypeutes matacus*). In addition, it is included actions to halt the substitution of native pasture for exotic forages that increase productivity, since they can cause biodiversity losses and, in some situations, change the water flow. This is a serious common consequence to Brazilian biomes.

Endangered species protection

Embrapa has an important role in the promotion of economic growth and food safety in Brazil, which are topics society, has increasingly demanded. Thus, Embrapa research prioritizes the maintenance of germplasm active banks and compilations in the animal, vegetation, and microbial aspects to supply demands of genetic variability to improvement programs, especially those related to food safety (Gimenes; Barbieri, 2010; Albuquerque; Lanella, 2016).

Particularly in relation to endangered species (classified by international systems), studies on the diversity of native species have been consolidated, as an example, there is the conservation of Brazilian pine [*Araucaria angustifolia* (Bertol. (Kuntze)], pollination of Brazil nut [*Bertholletia excelsa* Humb. & Bonpl.] (Maués, 2002; Cavalcante et al., 2012; Maués et al., 2015) or reproduction of pirarucu (*Arapaima gigas* Schinz).

In some cases, Embrapa research strongly influenced public policies in favor of habitats conservation. These are some examples:

- Legislation guidance for timber exploitation that, as of decades of research in the Amazon region, encouraged the law for protection of mature secondary forests (Normative Rule No. 14/2015 of State Secretariat of Environment and Sustainability of the State of Pará).
- Assistance to the Ministry of Environment (MMA) in the evaluation of endangered species or groups of species in the *Pantanal* (Ibama, 1989, 1992; Brasil, 2014c).
- Collaboration in the elaboration and monitoring of the Plano de Ação Nacional para Conservação da Ariranha (National Action Plan for Giant Otter Conservation) (Brasil, 2014b) (Figure 2) and Plano de Ação Nacional para a Conservação dos Cervídeos (National Action Plan for the Cervid Conservation) (Brasil, 2014a) also in the *Pantanal* (Tomas et al., 2001, 2012).

Photo: Fabiano Aguiar

Figure 2. Giant otters (*Pteronura brasiliensis*) are subject of studies of Embrapa Pantanal researchers in subsidize to the National Action Plan for Giant Otter Conservation.

Embrapa has also carried out studies on the biology and populational of caimans (*Caiman sp.*) in the *Pantanal* biome (Mourão et al., 2000; Campos et al., 2006, 2014, 2015). This knowledge was used by the Centro Nacional de Pesquisa e Conservação de Répteis e Anfíbios (National Center for Research and Conservation of Reptilia and Amphibious – RAN) of MMA to elaborate a set of technologies called Sistema de Criação Semiextensiva do Jacaré-do-Pantanal (System of Semi-Extensive Pantanal Caiman Creation), which was expanded to other species in the Amazon biome.

The valuation of the socio-biodiversity products of different Brazilian regions are certainly the starting point of natural environments protection. Researches that valorize the use of such products and increase its aggregated use are improving, especially for the agro-industry production of Amazon tropical fruits, as acai (*Euterpe sp.*) – a food product with important demand in several Brazilian states –, and *Cerrado* native fruit species.

Several actions are being established for forest restoration of degraded environments. This is a significant strategy to restore biodiversity loss due to changes in land use occurring thoughout Brazilian biomes (Moraes et al., 2006; Sansevero et al., 2011). In this sense, Embrapa has promoted the consolidation of research networks approaching the theme of endangered species in a comprehensive and multidisciplinary way. Some approaches are: the search of solutions to halt biodiversity losses due to livestock in Brazilian biomes (Evaluation Project for Environmental, Economic, and Social Impacts of Cattle Production Systems in *Cerrado*, Amazon, and *Pantanal* — Avisar Project); emphasis on studies of important products of the socio-biodiversity for the support, food safety and generation of income to traditional populations (Environmental Service Arrangements in the Brazilian Rural Landscape); valuation of the use and conservation of non-timber species (Kamukaia Network); and the broad production of technical-scientific knowledge to subsidize the regional biodiversity protection (Sustainable Amazon Network) (Bentes-Gama et al., 2013; Ferreira et al., 2015; Prado et al., 2015; Wadt et al., 2017).

As an institutional strategy, it should be emphasized that Embrapa representatives should be included in international panels, seeking to evaluate the biodiversity status of the planet, its ecosystems, and essential services to human well-being. As example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and especially the thematic report on pollination, pollinators, and food production (Potts et al., 2016).

Approaching the multifunctionality of the rural landscape is one of the strategies of Embrapa research in the Atlantic Forest biome (one of the most fragmented in the country) to encourage management practices of control with ecological reinforcement, searching biodiversity conservation, ecosystem processes, and food safety (Uzêda et al., 2016, 2017).

Even in regions whose landscape is rather preserved, such as the *Pantanal* biome, initiatives of research promote the preservation of high-quality native pasture of these humid areas. The utilization of the natural aptitude of the *Pantanal* region for low-impact livestock and extensive areas of natural fields become, in this sense, opportunities for conservation of biological diversity in livestock farms and, consequently, rendered ecosystem services.

The impact evaluations of invasive species in the *Pantanal* and elaboration of measures for mitigation and control are a research priority (Oliveira et al., 2006). In the same way, distribution models of endangered species, such as jaguar (*Panthera onca*), cougar (*Puma concolor*), among other felines (Cavalcanti et al., 2012; Azevedo et al., 2016), are being developed by Embrapa. They aim the definition of areas with higher biological value (priority areas to establish public policies) and/or for compensation of conservation of landscapes and habitats in the *Pantanal* biome (Camilo, 2011) (Figure 3).

Techniques of molecular biology are making it possible for the Amazon endangered native species populations, such as acapu tree (*Vouacapoua americana* Aubl.), pau-amarelo tree (*Euxylophora paraensis* Huber), mahogany (*Swietenia macrophylla* King), cedro (*Cedrela odorata* L.), ucuhuba [*Virola surinamensis* (Rol. ex Rottb.) Warb.], Brazil nut (*Bertholletia excelsa* Bonpl.), maçaranduba [*Manilkara elata* (Allemão ex Miq.) Monach.], and cipó-titica (*Heteropsis* spp.), to be evaluated as for their degree of genetic variability. Thus, with the evaluation of bio-ecologic and genetic-behavior relevant aspects involved in the conservation of species it is possible to stop biodiversity loss. Embrapa also prioritizes the improvement of technologic processes aiming the adoption of best practices in production systems, as in the case of Brazil nut (Wadt; Silva, 2014).

In the Brazilian *Pampa*, the characterization, evaluation, and conservation of its rich biodiversity upon the management that evaluates agricultural, fruits, medicine, and field germplasm species of natural occurrence provides the biome ecosystem goods and services in the present, focusing on the future. In the *Cerrado* areas, Embrapa has emphasized actions of conservation and valuation of native species, which has contributed to the maintainance of the sustainable

Figure 3. Collection of blood and ectoparasites from an ocelot (*Leopardus pardalis*) equipped with a GPS for its monitoring in *Pantanal* area.

life of rural communities located in the biome. In the same way, in the *Caatinga*, actions of research contribute to evaluating the economic potential of biodiversity, emphasizing native fruits and forage of multiple uses. It is worth mentioning imbu (*Spondias tuberosa*), an exclusive species of this biome that, besides to be used as food, is an alternative source of family income (A Embrapa…, 2017).

Embrapa has paid attention to the rich biological diversity of Brazilian biomes. They are directly connected to the need to protect and ensure the access of natural resources to all society both in the present and in the future. The national agricultural research is strategic to make Brazil advance in medium- and long- -term policies and to contribute, effectively, to decrease degradation of natural habitats, biodiversity loss, and extinction of endangered species, to achieve the 2030 Agenda targets to the sustainable development.

References

A EMBRAPA nos biomas brasileiros. Brasília, DF: Embrapa, 2010. 16 p. Available at: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/82598/1/a-embrapa-nos-biomas-brasileiros.pdf>. Accessed on: Dec. 27, 2017.

ALBUQUERQUE, M. do S. M.; IANELLA, P. (Ed.). **Inventário de recursos genéticos animais da Embrapa**. Brasília, DF: Embrapa, 2016. 108 p.

AZEVEDO, F. C. C. de.; OLIVEIRA, T. G. de; PAULA, R. C. de; CAMPOS, C. B. de.; MORAES JUNIOR, E. A. M.; CAVALCANTI, S. M. C.; TOMAS, W. M.; BOULHOSA, R. L. P.; CRAWSHAW JUNIOR, P. G.; BEISIEGEL, B. de M.; SANA, D. A.; PASCHOALETTO, K. M.; FERRAZ, M. de B.; POLISAR, J. Estado del jaguar (*Panthera Onca*) en Brasil. In: MEDELLÍN, R. A.; TORRE, J. A. de la; ZARZA, H.; CHÁVEZ, C.; CEBALLOS, G. (Coord.). **El jaguar en el siglo XXI**: la perspectiva continental. Ciudad de México: Universidad Nacional Autónoma de México, 2016. p. 366-391.

BARLOW, J.; LENNOX, G. D.; FERREIRA, J.; BERENGUER, E.; LEES, A. C.; MAC NALLY, R.; THOMSON, J. R.; FERRAZ, S. F. de B.; LOUZADA, J.; OLIVEIRA, V. H. F.; PARRY, L.; SOLAR, R. R. de C.; VIEIRA, I. C. G.; ARAGÃO, L. E. O. C.; BEGOTTI, R. A.; BRAGA, R. F.; CARDOSO, T. M.; OLIVEIRA JUNIOR, R. C. de; SOUZA JUNIOR, C. M.; MOURA, N. G.; NUNES, S. S.; SIQUEIRA, J. V.; PARDINI, R.; SILVEIRA, J. M.; VAZ-DE-MELLO, F. Z.; VEIGA, R. C. S.; VENTURIERI, A.; GARDNER, T. A. Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. **Nature**, v. 535, n. 7610, p. 144-147, July 2016. DOI: 10.1038/nature18326.

BENTES-GAMA, M. de M.; VIEIRA, A. H.; ROCHA, R. B. Ecological features of titica vine (*Heteropsis flexuosa* (Kunth) GS Bunting) in Rondônia State, Northwest Brazilian Amazon. **Anais da Academia Brasileira de Ciências**, v. 85, n. 3, p. 1117-1125, Sept. 2013. DOI: 10.1590/S0001-37652013000300015.

BRASIL. Ministério do Meio Ambiente. **Portaria nº 381, de 19 de agosto de 2014**. Institui o Grupo de Assessoramento Técnico para acompanhar a implementação e realizar monitoria do Plano de Ação Nacional para Conservação dos Cervídeos Brasileiros - PAN Cervídeos. 2014a. Available at: <http://www.icmbio.gov.br/portal/images/stories/docs-plano-de-acao/pan-cervideos/portaria-381-gat-cervideos.pdf>. Accessed on: Dec. 17, 2017.

BRASIL. Ministério do Meio Ambiente. **Portaria nº 433, de 16 de setembro de 2014**. Institui o Grupo de Assessoramento Técnico para acompanhar a implementação e realizar monitoria do Plano de Ação Nacional para Conservação da Ariranha - PAN Ariranha. 2014b. Available at: <http://www.icmbio.gov.br/portal/images/stories/docs-plano-de-acao/pan-ariranha/portaria-gat-433-ariranha.pdf>. Accessed on: Dec. 17, 2017.

BRASIL. Ministério do Meio Ambiente. **Portaria nº 444, de 17 de dezembro de 2014**. Reconhece como espécies da fauna brasileira ameaçadas de extinção aquelas constantes da "Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção. 2014c. Available at: <http://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2014/p_mma_444_2014_lista_esp%C3%A9cies_ame%C3%A7adas_extin%C3%A7%C3%A3o.pdf>. Accessed: Dec. 17, 2017.

CAMILO, A. R. **Distribuição atual de Onça-Parda (*Puma concolor*) e Onça-Pintada (*Panthera onca*) no Pantanal Brasileiro**. 2011. 29 f. Dissertação (Mestrado) – Centro de Ciências Biológicas e da Saúde, Universidade Federal de Mato Grosso do Sul, Campo Grande. Available at: <https://posgraduacao.ufms.br/portal/trabalho-arquivos/download/640>. Accessed on: Dec. 15, 2017.

CAMPOS, Z.; COUTINHO, M. E.; MOURÃO, G.; BAYLISS, P.; MAGNUSSON, W. E. Long distance movements by *Caiman crocodilus* yacare: implications for management of the species in the Brazilian Pantanal. **Herpetological Journal**, v. 16, n. 2, p. 123-132, Apr. 2006.

CAMPOS, Z.; MOURÃO, G.; COUTINHO, M.; MAGNUSSON, W. E. Growth of *Caiman crocodilus yacare* in the Brazilian Pantanal. **Plos One**, v. 9, 2014. DOI: 10.1371/journal.pone.0089363.

CAMPOS, Z.; MOURÃO, G.; COUTINHO, M.; MAGNUSSON, W. E.; SORIANO, B. M. A. Spatial and temporal variation in reproduction of a generalist crocodilian, *Caiman crocodilus yacare*, in a seasonally flooded wetland. **Plos One**, v. 10, n. 6, p. 1-14, 2015. e0129368. DOI: 10.1371/journal.pone.0129368.

CAVALCANTE, M. C.; OLIVEIRA, F. F.; MAUÉS, M. M.; FREITAS, B. M. Pollination requirements and the foraging behavior of potential pollinators of cultivated Brazil nut (*Bertholletia excelsa* Bonpl.) trees in Central Amazon Rainforest. **Psyche**: a journal of entomology, v. 2012, article ID 978019, 2012. DOI: 10.1155/2012/978019.

CAVALCANTI, S. M. C.; AZEVEDO, F. C. C. de; TOMÁS, W. M.; BOULHOSA, R. L. P.; CRAWSHAW JR., P. G. The status of the jaguar in the Pantanal. **Cat News**, v. 7, p. 29-34, Jan. 2012.

CRUZ, E. D. **Germinação de sementes de espécies amazônicas**: maçaranduba [*Manilkara huberi* (Ducke) A. Chev.]. Belém, PA: Embrapa Amazônia Oriental, 2016. 3 p. (Embrapa Amazônia Oriental. Comunicado técnico, 276).

CRUZ, E. D.; BARROS, H. S. D. **Germinação de sementes de espécies amazônicas**: ucuúba [*Virola surinamensis* (Rol. Ex Rottb.) Warb.] acapu (*Vouacapoua americana* Aubl.). Belém, PA: Embrapa Amazônia Oriental, 2016. 4 p. (Embrapa Amazônia Oriental. Comunicado técnico, 273).

CRUZ, E. D.; PEREIRA, A. G. **Germinação de sementes de espécies amazônicas**: acapu (*Vouacapoua americana* Aubl.). Belém, PA: Embrapa Amazônia Oriental, 2016. 4 p. (Embrapa Amazônia Oriental. Comunicado técnico, 288).

EMBRAPA RECURSOS GENÉTICOS E BIOTECNOLOGIA. **Alelo recursos genéticos**. Available at: <https://www.embrapa.br/alelo>. Accessed on: Dec. 27, 2017.

EMBRAPA. Secretaria de Comunicação. Secretaria de Gestão e Desenvolvimento Institucional. **Balanço Social Embrapa 2015**. Brasília, DF, 2016. 44 p. Available at: <https://www.embrapa.br/memoria-embrapa/balanco-social>. Accessed on: Dec. 27, 2017.

FERREIRA, J. N.; GUARIGUATA, M.; KOH, L. P.; MANSOURIAN, S.; PARROTTA, J.; SASAKI, N.; SCHMITT, C. B. Impacts of forest and land management on biodiversity and carbon. In: PARROTA, J. A.; WILDBURGER, C.; MANSOURIAN, S. (Org.). **Understanding relationships between biodiversity, carbon, forests and people**: the key to achieving REDD+ objectives. Vienna: IUFRO, 2012. p. 53-80. (IUFRO world series, 31).

FERREIRA, J.; BLANC, L.; KANASHIRO, M.; LEES, A.; BOURGOIN, C.; FREITAS, J. V. de; GAMA, M. M. B.; LAURENT, F.; MARTINS, M. B.; MOURA, N.; D'OLIVEIRA, M. V.; SOTTA, E. D.; SOUZA, C. R. de; RUSCHEL, A. R.; SCHWARTZ, G.; ZWERTS, J.; SIST, P. **Degradação florestal na Amazônia**: como ultrapassar os limites conceituais científicos e técnicos para mudar esse cenário. Belém, PA: Embrapa Amazônia Oriental, 2015. 29 p. (Embrapa Amazônia Oriental. Documentos, 413).

GIMENES, M. A.; BARBIERI, R. L. **Manual de curadores de germoplasma-vegetal**: conservação em BAGs. Brasília, DF: Embrapa Recursos Genéticos e Bioteconologia, 2010. 14 p. (Embrapa Recursos Genéticos e Bioteconologia. Documentos, 320; Embrapa Clima Temperado. Documentos, 331).

HARRIS, M. B.; TOMAS, W.; MOURÃO, G.; SILVA C. J. da S.; GUIMARÃES, E.; SONODA, F.; FACHIM, E. Safeguarding the Pantanal wetlands: threats and conservation initiatives. **Conservation Biology**, v. 19, n. 3, p. 714-720, June 2005. DOI: 10.1111/j.1523-1739.2005.00708.x.

IBAMA. **Portaria Ibama nº 1.522, de 19 de dezembro de 1989**. Dispõe sobre a lista oficial de espécies da fauna brasileira ameaçada de extinção. Available at: <http://licenciamento.cetesb.sp.gov.br/legislacao/federal/portarias/1989_Port_IBAMA_1522.pdf>. Accessed on: Dec. 17, 2017.

IBAMA. **Portaria Ibama nº 45-N, de 27 de abril de 1992**. Dispõe sobre a inclusão da espécie *Leontopithecus caissara* na Portaria nº1.522 de19 de dezembro de 1989. 1992. Available at: <https://www.google.com.br/search?q=CONAMA+Portaria+n%C2%BA+45-N%2C+de+27+de+abril+de+1992&rlz=1C1GGRV_enBR751BR751&oq=CONAMA+Portaria+n%C2%BA+45-N%2C+de+27+de+abril+de+1992&aqs=chrome..69i57.5559j0j4&sourceid=chrome&ie=UTF-8>. Accessed on: Dec. 17, 2017.

LEAL, C. G.; POMPEU, P. S.; GARDNER, T. A.; LEITÃO, R. P.; HUGHES, R. M.; KAUFMANN, P. R.; ZUANON, J.; de PAULA, F. R.; FERRAZ, S. F. B.; THOMSON, J. R.; MAC NALLY, R.; FERREIRA, J.; BARLOW, J. Multi-scale assessment of human-induced changes to Amazonian instream habitats. **Landscape Ecology**, v. 31, n. 8, p. 1725-1745, Oct. 2016. DOI: 10.1007/s10980-016-0358-x.

MARTINI, A.; ROSA, N. de A.; UHL, C. **Espécies de árvores potencialmente ameaçadas pela atividade madeireira na Amazônia**. Belém, PA: Instituto do Homem e Meio Ambiente da Amazônia, 1998. 35 p. (Imazon. Amazonia, 11).

MAUÉS M. M. Reproductive phenology and pollination of the Brazil nut tree (*Bertholletia excelsa* Humb. & Bonpl. lecythidaceae) in Eastern Amazônia. In: WORSHOP ON THE CONSERVATION AND SUSTAINABLE OF USE OF POLLINATORS IN AGRICULTURE, WITH EMPHASIS ON BEES, 1998, São Paulo. **Pollinating bees**: the conservation link between agriculture and nature: proceedings. Brasília, DF: Ministry of Environment, 2002. p. 245-254. Edited by Peter G. Kevan, Vera L. Imperatriz-Fonseca.

MAUÉS, M. M.; KRUG, C.; WADT, L. H. O.; DRUMOND, P. M.; CAVALCANTE, M. C.; SANTOS, A. C. S. dos. **A castanheira-do-brasil**: avanços no conhecimento das práticas amigáveis à polinização. Rio de Janeiro: Funbio, 2015. 84 p.

MORAES, L. F. D. de; ASSUMPÇÃO, J. M.; LUCHIARI, C.; PEREIRA, T. S. Plantio de espécies arbóreas nativas para a restauração ecológica na Reserva Biológica de Poço das Antas, Rio de Janeiro, Brasil. **Rodriguesia**, v. 57, n. 3, p. 477-489, 2006.

MOURA, N. G.; LEES, A. C.; ALEIXO, A.; BARLOW, J.; DANTAS, S. M.; FERREIRA, J.; GARDNER, T. A. Two hundred years of local avian extinctions in Eastern Amazonia. **Conservation Biology**, v. 28, n. 5, p.1271-1281, Oct. 2014. DOI: 10.1111/cobi.12300.

MOURÃO, G.; COUTINHO, M. E.; MAURO, R. A.; CAMPOS, Z.; TOMÁS, W.; MAGNUSSON, W. Aerial surveys of caiman, marsh deer and pampas deer in the Pantanal Wetland of Brazil. **Biological Conservation**, v. 92, n. 2, p. 175-183, Feb. 2000. DOI: 10.1016/S0006-3207(99)00051-8.

OLIVEIRA, M. D. de; TAKEDA, A. M. ; BARROS L. F. de; BARBOSA, D. S.; RESENDE, E. K. de. Invasion by *Limnoperna fortunei* (Dunker, 1857) (Bivalvia, Mytilidae) of the Pantanal Wetland, Brazil. **Biological Invasions**, v. 8, n. 1, p. 97-110, 2006. DOI: 10.1007/s10530-005-0331-0.

POTTS, S. G.; IMPERATRIZ-FONSECA, V. L.; NGO, H. T.; BIESMEIJER, J. C.; BREEZE, T. D.; DICKS, L. V.; GARIBALDI, L. A.; HILL, R.; SETTELE, J.; VANBERGEN, A. J. **Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and**

Ecosystem Services on pollinators, pollination and food production. Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2016. 36 p.

PRADO, R. B.; FIDALGO, E. C. C.; FERREIRA, J. N.; CAMPANHA, M. M.; PARRON-VARGAS, L. M.; MATTOS, L. M. de; PEDREIRA, B. da C. C. G.; MONTEIRO, J. M. G.; TURETTA, A. P. D.; MARTINS, A. L. da S.; DONAGEMMA, G. K.; COUTINHO, H. L. da C. Pesquisas em serviços ecossistêmicos e ambientais na paisagem rural do Brasil. **Revista Brasileira de Geografia Física**, v. 8, p. 610-622, 2015. Número especial. DOI: 10.5935/1984-2295.20150018.

SANSEVERO, J. B. B.; PRIETO, P. V.; MORAES, L. F. de; RODRIGUES, P. J. F. P. Natural regeneration in plantations of native trees in lowland Brazilian Atlantic forest: community structure, diversity, and dispersal syndromes. **Restoration Ecology**, v.19, n. 3, p. 379-389, Apr. 2011. DOI: 10.1111/j.1526-100X.2009.00556.x.

SILVA, G. R. da; PEREIRA, F. de M.; SOUZA, B. de A.; LOPES, M. T. do R.; CAMPELO, J. E. G.; DINIZ, F. M. Aspectos bioecológicos e genético-comportamentais envolvidos na conservação da abelha Jandaíra, *Melipona subnitida* Ducke (Apidae, Meliponini), e o uso de ferramentas moleculares nos estudos de diversidade. **Arquivos do Instituto Biológico**, v. 81, n. 3, p. 299-308, jul./set. 2014. DOI: 10.1590/1808-1657000812012.

SOLAR, R. R. de C.; BARLOW, J.; FERREIRA, J.; BERENGUER, E.; LEES, A. C.; THOMSON, J. R.; LOUZADA, J.; MAUÉS, M.; MOURA, N. G.; OLIVEIRA, V. H. F.; CHAUL, J. C. M.; SCHOEREDER, J. H.; VIEIRA, I. C. G.; NALLY, R. M.; GARDNER, T. A. How pervasive is biotic homogenization in human-modified tropical forest landscapes? **Ecology Letters**, v. 18, n. 10, p. 1108-1118, Oct. 2015. DOI: 10.1111/ele.12494.

TOMAS, M. A.; TOMAS, W. M.; RODRIGUES, F. H. G. Densidade e uso de recursos por veado campeiro (*Ozotoceros bezoarticus*) em três paisagens diferentes no Pantanal, MS. **Oecologia Australis**, v. 16, n. 4, p. 914-932, 2012. DOI: 10.4257/oeco.2012.1604.14.

TOMAS, W. M.; SALIS, S. M.; SILVA, M. P.; MOURÃO, G. M. Marsh deer (*Blastocerus dichotomus*) distribution as a function of floods in the Pantanal Wetland, Brazil. **Studies on Neotropical Fauna and Environment**, v. 36, n. 1, p. 9-13, 2001. DOI: 10.1076/snfe.36.1.9.8877.

UNITED NATIONS. **Life on land**: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

UZÊDA, M. C.; FIDALGO, E. C. C.; SOUZA MOREIRA, R. V. de; FONTANA, A.; DONAGEMMA, G. K. Eutrofização de solos e comunidade arbórea em fragmentos de uma paisagem agrícola. **Pesquisa Agropecuária Brasileira**, v. 51, n. 9, p. 11120-1130, set. 2016. DOI: 10.1590/s0100-204x2016000900011.

UZÊDA, M. C.; TAVARES, P. D.; ROCHA, F. I.; ALVES, R. C. (Ed.). **Paisagens agrícolas multifuncionais**: intensificação ecológica e segurança alimentar. Brasília, DF: Embrapa, 2017.67 p. (Texto para discussão, 48).

WADT, L. H. de O.; SANTOS, L. M. H.; BENTES, M. P. de M.; OLIVEIRA, V. B. V. (Ed.). **Produtos florestais não madeireiros**: guia metodológico da Rede Kamukaia. Brasília, DF: Embrapa-STC, 2017. 133 p.

WADT, L. H. de O.; SILVA, M. P. de. **Tecnologias para o fortalecimento da cadeia de valor de valor das castanha-da-Amazônia**. 2014. Available at: <https://www.infoteca.cnptia. embrapa.br/infoteca/bitstream/doc/1018266/1/25668.pdf>. Accessed on: Dec. 15, 2017.

Chapter 8

Alien species: economical use, control and impact reduction

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Introduction

This chapter deals with the contributions of the Brazilian Agricultural Research Corporation (Embrapa) to reach target 15.8 of the Sustainable Development Goals 15 (United Nations, 2018): By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

Alien species are those outside of their natural origen zone. Alien species become invasive when they threaten the biological diversity and environmental balance. Alien species with potential to cause damages and economic losses are considered a "quarantine pest," in accordance with the International Standards for Phytosanitary Measure (ISPM) No. 5 of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization of the United Nations (FAO).

Species' introduction mechanisms may be deliberate or accidental. Intentional introductions are always with the main purpose of obtaining economic gain, both from profiting from the cultivation and sale of these organisms and from biologically controlling pest species that threaten environmental balance or agricultural production. Therefore, due to its economic importance, alien species are largely used, and its escape is a problem to be avoided with good practices identified in research studies and technical follow-ups, with monitoring and correction if intervention is necessary. Non-intentional introductions can occur by several means, such as by packaging materials and merchandise display made of wood, propagation materials as seeds and seedlings, agricultural machines and implements, means of transportation (airplane cargo compartment, containers, trucks), water discharge from ship ballasts. Even deforestation and degradation of green areas provide opportunities for invasions, and climate changes may as well foster or force the migration of species that try to survive.

Besides pressures of predation and competition exerted on native species, invasive alien species may also cause changes to the environment, resulting in losses of agricultural and forest production, soils and pastures, and dissemination of parasites and pathogens whose vectors are alien organisms. Invasive species are therefore one of the most important environmental challenges in the world. It is not always possible to combat them; generally, complex and expensive proceedings without guaranteed results are necessary. To reduce the impact of alien organisms on the environment, management strategies are used aiming to create mechanisms of environmental resistance.

Control and impact reduction

Dispersion assessments of introduced alien species are important both for monitoring the environmental quality and for elaborating control measures and impact mitigation. These assessments can be combined with germplasm, gamete, and tissue databases, which are important for the preservation of information on genetic diversity.

At Embrapa, research studies are performed to seek conservation, characterization, and documentation of native and alien species with potential for use in agriculture. Environmental and economic losses due to the presence of alien species already happened in Brazil in planted *Pinus* and *Eucalyptus* forests. In 1988, forest heritage of *Pinus* spp. was put at risk by the introduction of sirex woodwasp (*Sirex noctilio*), which caused the death of 60% of the trees. However, Embrapa coordinated an integrated pest management program (IPM) applied to sirex woodwasp involving the monitoring and biological control associated to silviculture control, which reduced the occurrence of trees attacked by the pest, with significant economic returns to foresters.

In the same way, an IPM program for controlling giant conifer aphids (*Cinara pinivora* and *Cinara atlantica*) introduced in Brazil in 1996 and 1998 was developed with emphasis on biological control. The balance of pest population was restored, and they are now completely under control. In 2008, bronze bug (*Thaumastocoris peregrinus*) and eucalyptus gall wasp (*Leptocybe invasa*) (Wilcken, 2008; Wilcken; Berti Filho, 2008; Wilcken et al., 2010) were introduced. Damages caused by the attack of *T. peregrinus* led to reductions of 14% in volume increase, 5% in diameter increase, and 3% in height increase of eucalyptus trees. The estimated average potential loss caused by *T. peregrinus'* outbreak was R$ 1,400/ha (Junqueira, 2016). Biological control is the main strategy to manage *T. peregrinus* in commercial eucalyptus crops. In Brazil, this program started in 2009, through a cooperation project between the Forestry Science and Research Institute (Ipef), the São Paulo State University (Unesp, Botucatu campus) and Embrapa, which developed the methodology for mass creation and studied bioecological parameters using egg parasitoids (*Cleruchoides noackae*) from Australia. Companies associated with Ipef's Program of Forest Protection (Protef) have made releases in fields.

Biological control is widely used to combat pests and, for this reason, it is the subject of research studies developed by the Company in its Units, such as Embrapa Temperate Agriculture (*Anastrepha fraterculus; Fopius arisanus*), Embrapa Western Agriculture (*Helicoverpa armigera*), Embrapa Environment (*Ipomoea* spp.), Embrapa Genetic Resources (*Harlequin succinea*) and Embrapa Soybean.

In cargo transportation using vessels, water from the environment is collected in the vessel's ballast tanks. This proceeding is used to compensate the weight lost by the unloading of cargos, and makes it possible to control the vessel's draft and stability. Both water collection and discharge proceedings occur mainly in harbor areas, where small invertebrates, plants, seaweeds, eggs and larvae of several animals, cysts, spores or other types of resistant cells, besides bacteria and viruses, that is, many small organisms, may be and pass through this system, so as to be transferred between geographical areas.

Because of the comprehensiveness and intensity of international maritime traffic, ballast water is considered one of the main vectors of interoceanic and transoceanic movement of coastal species. Vessels that transport the largest volumes of ballast waters are tankers and bulk carriers, which are responsible for around 85% of Brazil's harbor exchange (both import and export). Several factors determine the future of organisms introduced in a new environment through ballast water, such as the diversity and local environmental parameters (water temperature, nutrients, and local pollution). Therefore, it is practically impossible to forecast which will be the next species to be introduced or when and where this will occur. On a daily basis, over 3 thousand species of organisms are transported in ballast water through the world.

The golden mussel (*Limnoperna fortunei*), a species from Southeast Asia, probably came to South America in ballast water of vessels that sail commerce routes between Asian countries and Argentina. In 1991, this mollusk reached the Río de la Plata Estuary, in Argentina, where it thrived and from where it spread to the Paraguay, Paraná, and Uruguay rivers and their respective affluents. In 2015, the area of occurrence of the golden mussel in South America was mapped with the collaboration of Embrapa Pantanal, which studies the species since 1998 in the Paraguay River Basin, within the scope of the Fundo Setorial de Recursos Hídricos (Sectoral Fund for Water Resources) (CT-Hidro), led by Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM). It detected that the sectors most challenged by the species are electric power (due to their encrustation in the power plants' refrigeration system), tank-net system fishing (Figure 1) and water collection. A new program for restraining the species is being drafted by MMA and Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Ibama) with the collaboration of Embrapa Pantanal.

Quarantine processes are necessary for the introduction, cultivation, establishment, and control of alien species and their pests. In this sense, the Company performs extensive work by means of research studies carried out by Embrapa Genetic Resources & Biotechnology (plant germplasm quarantine), Embrapa Forestry (monitoring and control of alien pests in pine and eucalyptus), Embrapa Environment (alien pests in eucalyptus forests), Embrapa Amapá (carambola fruit fly, *Bactrocera carambolae*), Embrapa Roraima (ching bug, *Blissus* sp.), Embrapa Agrobiology (alien parasitoid in commercial orchards, *Diachasmimorpha longicaudata*), Embrapa Grape & Wine (fruit fly, *Anastrepha fraterculus*), Embrapa Southern Livestock (*Eragrostis plana*), Embrapa Wheat (genetic variation and virulence of *Magnaporthe oryzae*), among others. Embrapa Swine & Poultry and Embrapa Pantanal have jointly worked for structuring and implementing systems for population management and epidemiological surveillance of feral swine.

It is worth emphasizing that necessary governmental actions to face issues related to the introduction of alien pests sometimes divert budget resources that could be applied in health, education, research, etc. Thus, prevention (performed through a system of legal measures combined with strong inspection, surveillance and alternatives for quarantine treatments) will strengthen Brazilian forest and agricultural defense, avoiding economic, environmental, and social losses.

Photo: Márcia Divina Oliveira

Figure 1. Cleaning of a tank-net with golden mussel (*Limnoperna fortunei*) encrustation in the Canoas Reservoir, Paranapanema, São Paulo.

Economical use of introduced species

In order to benefit from the economical use of alien species with reduced environmental impacts, Embrapa and partners have been working in research studies and technical guidances for the application of good practices in agricultural systems, making income generation and sustainable regional development possible.

Although river basins may act as physical barriers and limit the occurrence and spread of aquatic organisms, anthropogenic and environmental events frequently promote the exchange of species among biomes. Many species of fish were introduced in reservoirs, lakes, and rivers as a way of strenghthening the fishing potential and the production of animal protein for human food. In other cases, alien species were created in confined artificial environments, but failures in management allowed their escape to neighboring natural environments.

Another mechanism of introduction is the facilitation through physical change in the environment, as recently occurred after the construction of the Itaipu dam, which eliminated a natural barrier of dispersion of aquatic organisms: Guairá Falls (located in the Brazilian state of Paraná). Consequently, 33 species of fish went up the Paraná River Basin beyond the pre-existing natural barrier (Júlio Júnior et al., 2009; Vitule et al., 2012).

In *Pantanal*, two examples of introductions due to operational failures in crop systems are the successful establishment of peacock bass (*Cichla piquiti*) (Resende et al., 2008), a fish originary of the Amazon, and tambacu, a cross-breeding between the tambaqui female (*Colossoma macropomum*) with the pacu male (*Piaractus mesopotamicus*). Besides these fishes, since 2013, the presence of *Gymnotus sylvius* has been regionally noticed over the Upper Paraguay Basin; until 1999, this species had not been found beyond the Miranda River Basin. Embrapa Pantanal studies reported that such species did not cause impacts on the places where it was captured, the aquatic community did not change its structure or environment to integrate it, and it is among the most fished for the commercialization of baits. This is a successful example of the economical use of alien species (Sousa et al., 2017).

Initiatives connecting economical use and reduction of the impact of alien species presence in the environment result in economic, social, and environmental benefits, and they have been developed by Embrapa in several Brazilian geographic regions.

The Western honey bee (*Apis mellifera*) is a polyhybrid originated from the random naturally occurring cross-breeding of sub-species *Apis mellifera scutellata*, of African origin, and *Apis mellifera* and *Apis mellifera ligustica*, of European origin, which were brought to Brazil after 1956 with the purpose of establishing beekeeping as an income and development source in the Country. Despite displaying a marked defensive behavior as compared to that of European sub-species, the Western honey bee is more tolerant to pests and diseases, and it has been the most effective for obtaining honey products (honey, propolis, pollen, wax, etc.), which fosters the development of beekeeping in most regions of Brazil.

Embrapa Pantanal and its partners have been conducting research studies to adapt the production system of these bees to the region's conditions, to monitor the effects of their presence in the ecosystem and to promote honey production as a sustainable income source for inhabitants of rural settlements, riversides, traditional communities and other farmers in general, thus fostering regional development and fighting poverty (Figure 2).

Sodom apple (*Calotropis procera*) and *Leucaena leucocephala* are alien species originary of Africa and Central America, respectively. In Brazil, they frequently occur in the Corumbá region, MS. These species were studied by Embrapa Pantanal with the participation of small farmers, who used them as hay to supplement animal fodder in the dry season (Figure 3), with the aim of achieving sustainable milk cattle production in rural settlements in the region (Lisita et al., 2009). Under the same perspective (regional development promotion), Embrapa Mid-North has performed research studies aiming at the introduction and evaluation of alien plants in irrigated areas of the state of Piauí.

Because of the importance of livestock for Brazil, alien pastures have been increasingly used due to their efficiency to feed cattle. For example, this happens in the Midwestern region of the country, where, since the 1970s, in *Pantanal*,

Photo: Vanderlei Doniseti Acassio dos Reis

Figure 2. Collection of Western honey bees' honey in a production system adapted to the regional conditions of *Pantanal* in the state of Mato Grosso do Sul.

Photo: Frederico Olivieri Lisita

Figure 3. Production of Sodom apple hay (*Calotropis procera*) in Taquaral settlement, in Corumbá, MS.

the most used species are *Panicum maximum* (Guinea grass and green panic grass), *Cynodon nlemfuensis* (Bermuda grass), *Paspalum notatum* (Bahia grass), *Panicum repens* (Torpedo grass), *Digitaria decumbens* (Pangola grass), *Pennisetum purpureum* (elephant grass), *Saccharum officinarum* (sugarcane), *Cynodon dactylon* (Bahama grass), *Hyparrhenia rufa* (Jaragua grass), *Paspalum plicatulum* (brown-seed paspalum), *Andropogon gayanus* and, more recently, brachiaria (*Urochloa decumbens*, *Urochloa humidicola*, and *Urochloa brizantha*). Over the last 10 years, the use of species of the *Urochloa* gender (Santos et al., 2005) was intensified.

To minimize the risks of environmental impacts caused by the presence of these alien grasses without affecting livestock production (which is crucial for economy and food production regionally and nationally), Embrapa Pantanal and Embrapa Beef Cattle perform research studies aiming at their rational use by following good practices. Besides, the outcomes of their georeferencing monitoring analyzed by Embrapa Agricultural Informatics show that only 12% of the *Pantanal* biome has been modified since the 1970s.

Final considerations

Facing the challenges for productivity increase in food production without environmental and social losses, since its creation in 1972, Embrapa has been performing research studies to find paths and solutions for Brazilian agriculture to achieve sustainability and the highest technological standards. The development of research projects for mitigating impacts related to the effects of introducing alien species and to its economical use in all national territory is part of this scenario. The examples presented in this chapter show the continuous and improving work of several teams distributed in Embrapa Units in varied regions.

References

JÚLIO JÚNIOR, H. F.; TÓS, C. D.; AGOSTINHO, Â. A.; PAVANELLI, C. S. A massive invasion of fish species after eliminating a natural barrier in the upper rio Paraná basin. **Neotropical Ichthyology**, v. 7, n. 4, p. 709-718, 2009. DOI: 10.1590/S1679-62252009000400021.

JUNQUEIRA, L. R. **Quantificação de danos causados por *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae) em eucalipto**. 2016. 86 f. Dissertação (Mestrado) – Faculdade de Ciências Agronômicas, Unesp, Botucatu.

LISITA, F. O.; TOMICH, T. R.; CAMPOLIN, A. I.; FEIDEN, A.; CONCEIÇÃO, C. A. da; NASCIMENTO, V. R. do; TRINDADE, L. L. **Recursos forrageiros regionais conservados como feno para a alimentação de bovinos na região de Corumbá, MS**: 1996 a 2004. Corumbá: Embrapa Pantanal, 2009. 5 p. (Embrapa Pantanal. Circular técnica, 87). Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/CPAP-2010/57325/1/CT87.pdf>. Accessed on: Dec. 31, 2009.

RESENDE, E. K.; MARQUES, D. K. S.; FERRREIRA, L. K. S. G. A successful case of biological invasion: the fish *Cichla piquiti*, an Amazonian species introduced into the Pantanal, Brazil. **Brazilian Journal of Biology**, v. 68, n. 4, p. 799-805, nov. 2008. DOI: 10.1590/S1519-69842008000400014.

SANTOS, S. A.; DESBIEZ, A.; CARVALHO, L. A.; CRISPIM, S. M. A.; COMASTRI FILHO, J. A.; POTT, A.; OLIVEIRA, M. D. *Panicum repens* no Pantanal: ocorrência nas unidades de paisagem e prováveis impactos. In: SIMPÓSIO BRASILEIRO SOBRE ESPÉCIES EXÓTICAS INVASORAS, 1., 2005, Brasília, DF. **Anais**... Brasília, DF: Ministério do Meio Ambiente, 2005. Available at: <http://www.mma.gov.br/estruturas/174/_arquivos/174_05122008112113.pdf>. Accessed on: Dec. 31, 2009.

SOUSA, T. P. de; MARQUES, D. K. S.; VITORINO, C. de A.; FARIA, K. de C.; BRAGA, G. da S. F.; FERREIRA, D. C.; VENERE, P. C. Cytogenetic and molecular data support the occurrence of three *Gymnotus* Species (Gymnotiformes: Gymnotidae) used as live bait in Corumbá, Brazil: implications for conservation and management of professional fishing. **Zebrafish**, v. 14, n. 2, p. 177-186, 2017. DOI: 10.1089/zeb.2016.1356.

UNITED NATIONS. **Life on land**: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

VITULE, J. R. S.; SKÓRA, F.; ABILHOA, V. Homogenization of freshwater fish faunas after the elimination of a natural barrier by a dam in Neotropics. **Diversity and Distributions**, v. 18, n. 2, p. 111-120, Feb. 2012. DOI: 10.1111/j.1472-4642.2011.00821.x.

WILCKEN, C. F. **Percevejo bronzeado do eucalipto (*Thaumastocoris peregrinus*) (Hemiptera: Thaumastocoridae)**: ameaça às florestas de eucalipto brasileiras. Botucatu: Instituto de Pesquisas e Estudos Florestais, 2008. Available at: <http://www.ipef.br/protecao/alerta-percevejo.pdf>. Accessed on: Dec. 11, 2017.

WILCKEN, C. F.; BERTI FILHO, E. **Vespa-da-galha do eucalipto (*Leptocybe invasa*) (Hymenoptera: Eulophidae)**: nova praga de florestas de eucalipto no Brasil. Botucatu: Instituto de Pesquisas e Estudos Florestais, 2008. 11 p. Available at: <http://www.ipef.br/protecao/alerta-leptocybe.invasa.pdf>. Accessed on: Dec. 10, 2017.

WILCKEN, C. F.; SOLIMAN, E. P.; SÁ, L. A. N.; DIAS, T. K. R.; FERREIRA-FILHO, P. J.; OLIVEIRA, R. J. R. Bronze bug *Thaumastocoris peregrinus* Carpintero and Dellapé (Hemiptera: Thaumastocoridae) on *Eucalyptus* in Brazil and its distribution. **Journal of Plant Protection Research**, v. 50, n. 2, p. 201-205, 2010. DOI: 10.2478/v10045-010-0034-0.

Chapter 9

Ecosystem conservation and poverty reduction

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Introduction

This chapter addresses the contributions of the Brazilian Agricultural Research Corporation (Embrapa) in operating public policies to achieve target 15.9 of the Sustainable Development Goals 15 (United Nations, 2018): By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

The ability of generating and maintaining environmental services (climate and water regulation; pollination; water, fibers, timber, and food supplies; erosion control, among others) in several environments can be affected by inappropriate or overrated uses and climate change. The Economic Commission for Latin America and the Caribbean (Cepal), in December 2017, released a report apprising that levels of extreme poverty in the region increased between 2015 and 2016, and remained stable in 2017. This represents approximately 10% of the population, with a predominance of children, teenagers, young adults, women, and communities in rural areas. Such numbers illustrate the great importance of elaborating public policies for this population. In rural areas, some initiatives have been set up; among them are the payment for environmental services or ecosystem services (PES) and the management strategies for reducing the negative impacts of an agriculture based on the high demand for synthetic inputs.

For Wunder (2017), PES scheme, simply stated, is a voluntary, conditional agreement between at least one “seller” and one “buyer” over a well-defined environmental service – or a land use presumed to produce that service. So, PES emerges as a way to place monetary value on environmental services, to make them part of the decision-makers strategies, once farmers and rural owners receive a direct incentive to make their practices more sustainable (Pagiola et al., 2002).

Public policies and ecosystem services

There have been many governmental initiatives acknowledging ecosystem services provided by, for example, the rural environment. In addition, there have been many initiatives pursuing some payment for such services.

The approval of Novo Código Florestal (New Forest Code) (Brasil, 2012) – in which wording Embrapa actively took part – allows the Federal Government to establish a program of support and incentives for the environment conservation. Article 41 Item I specifically refers to the payment for environmental services. Article 41, § 4 includes maintenance activities in Permanent Preservation Areas (PPAs), Legal Reserve Areas (LRAs), and Restricted Use Areas (RUAs) (in detail in its Chapter 3) as eligible for any payments or incentives for environmental services. Article 41, item I, § 7 specifies that the payment or incentives for environmental services will be primarily for family farmers. Thus, the New Forest Code is a public policy with a strong connection with the search for poverty reduction.

In support of public policies, the Brazilian Platform on Biodiversity and Ecosystem Services (BPBES) is an initiative of Brazilian researchers whose mission is to produce syntheses of the best available knowledge by academic science and traditional knowledge on Biodiversity, Ecosystem Services and its relations with human well-being. BPBES is part of the Intergovernmental Platform on Biodiversity and Ecosystem Services, an international mechanism to provide scientific information in response to requests from decision makers. The Diagnóstico Brasileiro de Biodiversidade e Serviços Ecossistêmicos (Brazilian Assessment on Biodiversity and Ecosystem Services) has a core team and guest authors, Embrapa researchers among them.

Other governmental actions for poverty reduction are initiatives for financing rural owners, as Linha de Crédito para Investimento em Energia Renovável e Sustentablidade Ambiental (Line of Credit for Investment in Renewable Energy and Environmental Sustainability – Pronaf Eco) and Linha de Crédito para Financiamento de Custeio para Agroecologia (Line of Credit for Cost Financing for Agroecology – Pronaf Agroecology). Both are part of the Programa Nacional de Fortalecimento da Agricultura Familiar (National Program for Strengthening Family Agriculture – Pronaf), which provides financing and technical support to family farmers (limited income and small property areas) who adopt a sustainable property management not only to produce food and fibers, but also to offer environmental services. The Linha de Crédito de Investimento para Sistemas Agroflorestais (Line of Credit for Agroforestry Systems – Pronaf Forest) and Linha de Crédito de Investimento para Convivência com o Semiárido (Line of Credit for Coexistence with SemiArid Region – Pronaf Semiarid) are also part of the National Program. Other initiatives along with these are the Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura (Sectorial Plan for Mitigation and Adaptation to Climate Change for Consolidation of a Low Carbon Emission Economy in Agricultures – ABC Plan) and the Plano Nacional de Agroecologia e Produção Orgânica (National Plan for Agroecology and Organic Production).

Contributions of Embrapa

The main role played by Embrapa in terms of ecosystem conservation was to include, in its research studies, the issues of environmental impacts of production systems and of radical changes in producing and planning soil use. These were part of the mapping of Brazilian soils and the search for understanding the agriculture-livestock-forest connections with water, soils, and biodiversity. The very existence of Embrapa Research Units shows its concern with the subject. Thus, several Embrapa initiatives and contributions can be mentioned.

Research projects are been conducted, in a participatory way, to recover traditional knowledge and local biodiversity as local assets. Uzêda et al. (2017) are conducting studies on the implementation and management of production systems based on native tree species and spontaneous plants able to enhance ecosystem services that help in the production process (such as pollination and biological control), generate income and allow food sovereignty.

The decision support system Trees in Agriculture allows the user to select, based on soil type of its production unit, the native tree species from the Atlantic Forest for different purposes: food species; wood species; honey species; soil bio-attractive and fertilizer species. The decision support system may be an important contribution to the environmental regularization of rural properties, helping to design agroforestry systems for PPA, as is the case of riparian forests, and RLA recovery.

In addition to actively attending the New Forest Code discussions, Embrapa was also an important player in discussions for approving the Sistema de Incentivos a Serviços Ambientais (Incentive Systems for Environmental Services) (Sisa) of the state of Acre (Acre, 2010). Amaral et al. (2015) made recommendations regarding this experience in conducting the system, which could be considered as a Brazilian subnational standard.

The fact that the Brazilian government ratified the Paris Agreement under the United Nations Framework Convention on Climate Change, in 2016, led to an increase in the target of ABC Plan: an added 5 million hectares with integrated crop-livestock-forest system (ICLF), totaling 9 million hectares by 2030. Research requested by the Rede de Fomento ILPF (ICLF Development Network) estimated an area of 11.5 million hectares with ICLF in Brazil, with around 19 Technological Reference Units (TRU) covering all Brazilian biomes and with the participation of 20 Embrapa Units.

Embrapa has a research network so-called Serviços Ambientais na Paisagem Rural (Environmental Services in Rural Landscape), whose main purpose is to develop knowledge and tools to subsidize actions and policies of restoration, maintenance, and expansion of ecosystem services and enhance sustainably-based production systems in rural landscapes.

In 2015, the book *Serviços ambientais em sistemas agrícolas e florestais do bioma Mata Atlântica (Environmental services in agricultural and forestry systems for Atlantic Forest's biome)* (Parron et al., 2015) was released, and became an institutional reference on the theme, because it provided methodological subsidies for the definition and monitoring of indicators and valuation of ecosystem services.

Brauman et al. (2007), starting from the concepts of environmental services (ESs), defined "hydrologic or terrestrial hydrologic services" as the benefits received by human beings and provided by the action of ecosystems on continental and non-oceanic water bodies, that is, on freshwater (Figure 1). According to Pagiola et al. (2013), payments for hydrologic environmental services are one way to financially compensate for conservation of hydrologic environmental services. They have been expanding throughout the country since the Programa Produtor de Água (Water Farmer Program) was launched by the National Water Agency (ANA) (Santos et al., 2010). One of the projects that were part of this network and led by Embrapa was the Fortalecimento do Conhecimento, Organização da Informação e Elaboração de Instrumentos de Apoio aos Programas de Pagamentos por Serviços Ambientais Hídricos no Meio Rural (Knowledge Improvement, Information Organization and Support Tool Design for Hydrologic Environmental Service Payment Programs in Rural Areas), in partnership with other Embrapa Units and external institutions, such as ANA, The Nature Conservancy (TNC), and O Boticário Foundation. The purpose of this project was to develop support tools for payment for hydrologic environmental service in Brazil; it resulted in the publication of the *Manual para pagamento por serviços ambientais hídricos: seleção de áreas e monitoramento* (Fidalgo et al., 2017), released in July 2017 and that may be read free of charge in Embrapa Soils homepage or website. It may become a standard and subsidize ongoing and new initiatives of payment for hydrologic environmental service since there is no other similar publication in Brazil in such simple and educational language.

Photo: Caren Henrique

Figure 1. *Cerrado* biome riparian forest in natural regeneration, Rio Jardim, DF.

Brazilian agriculture has been liable for a great part of greenhouse gas emissions (GGE). At each 100 kg of nitrogen fertilizer applied on soil, around 1 ton of CO_2 equivalent gases are released to the atmosphere. To revert this situation, the biological nitrogen fixation (BNF) is one of the actions that comprise Brazil's voluntary commitments to the *United Nations Climate Change Conference* (*COP15*) and which predict a 1.0 billion tons reduction of CO_2 equivalent GGE emissions through ABC Plan. Research studies in this area have already created many biological inputs, but, for effective technology transfer and communication, activities and the market must be integrated, and relationship with target audiences must be improved, comprising varied strategic agendas (market, society, and environment) and great themes that affect agriculture and Brazilian society. Within this challenge, Embrapa approved a project aiming to increase the dissemination of inoculant technology based on BNF's process in national agriculture and, consequently, to increase its adoption to promote a low carbon emission agriculture in soybean, maize, common beans, and cowpea (*Vigna unguiculata*) crops (Figure 2). The dissemination network is structured with the support of 14 Embrapa Decentralized Units. The abandonment, or even the lack of knowledge as to technology use (either for the absence of qualified technical assistance to properly recommend its use, for product unavailability in local agricultural stores, or for the lack of workforce to deal with biological material) is among the toughest challenges for disseminating and promoting it. Therefore, this network intends to continue its actions taking advantage of this window of opportunity (Amâncio et al., 2016).

Bem Diverso (Diverse Asset) is a project aiming to contribute for conservation of the Brazilian biodiversity in multiple use areas by means of sustainable management of socio-biodiversity and agroforest systems (AFSs), in order to ensure the ways of life of traditional communities and family farmers, generating income and improving the quality of life. This is an Embrapa initiative in partnership with the United Nations Development Programme (UNDP), and funded by the Global Environmental Facility (GEF). Among the expected outcomes, are the training to promote an increasing adoption of good practices in sustainable management and the creation of Bem Diverso - Market and financing frameworks to foster the production of non-wood forest products and AFSs in high-conservation-value forest areas.

Photo: Jefferson Christofoletti

Figure 2. Cowpea crop (*Vigna unguiculata*) inoculated in Semiarid.

A case of success of payment for environmental services is the projeto Estradas com Araucária (Roads with Brazilian Pine project). The intensive timber exploitation during decades in Brazil's South area, allied to the deforestation for the expansion of agriculture, caused a strong populational decrease of *Araucaria angustifolia* (*araucária*, Brazilian pine) (Figure 3). As a consequence, species of fauna depending on pine nuts during winter also became threatened. The project had intended to stimulate family farmers in the states of Paraná and Santa Catarina, *araucária*'s natural habitat, to plant seedlings in the borders of their properties with roads. Small farmers can plant up to 200 seedlings and, thus, they receive R$5.00 for each one, totaling an income of R$1,000 per year. DSR - Soluções e Inteligência Logística Group pays for this environmental service; it voluntarily pays for the carbon sequestered by trees to compensate for greenhouse gas emissions. Payment is on an annual basis until the trees reach 15 years of age, when they will already produce pine nuts that can be traded, which allows the farmer to keep his financial gains. Until the moment, 68 rural properties of four cities of the region joined the project, and around R$ 300 thousand are involved so far (Oliveira, 2015).

References

ACRE. **Lei nº 2.308, de 22 de outubro de 2010**. Cria o Sistema Estadual de Incentivos a Serviços Ambientais - SISA, o Programa de Incentivos por Serviços Ambientais - ISA Carbono e demais Programas de Serviços Ambientais e Produtos Ecossistêmicos do Estado do Acre e dá outras providências. 2010. Available at: <http://www.al.ac.leg.br/leis/wp-content/uploads/2014/09/Lei2308.pdf>. Accessed on: Nov. 23, 2017.

AMÂNCIO, C. O. da G.; HUNGRIA, M.; ZILLI, J. E.; PRANDO, A. M.; CIPRIANO, R.; BARBOSA, R.; ARAGÃO, T.; AURAS, N.; MOTTA, R.; ARAUJO, S. C. A rede "FBN ABC": compromisso com a promoção dos benefícios da fixação biológica do nitrogênio (FBN) através dos inoculantes. In: REUNIÃO DA REDE DE LABORATÓRIOS PARA A RECOMENDAÇÃO, PADRONIZAÇÃO E DIFUSÃO DE TECNOLOGIAS DE INOCULANTES MICROBIANOS DE INTERESSE AGRÍCOLA, 17., 2014, Londrina. **Anais**… Londrina: Embrapa Soja, 2016. 112 p. (Embrapa Soja. Documentos, 369).

AMARAL, E. F.; LEAL, M. J. L. R.; BARDALES, N. G. Sistema estadual de incentivos aos serviços ambientais do Acre: lições para a construção de instrumentos econômicos nacionais. In: INCENTIVOS econômicos para serviços ecossistêmicos no Brasil. Rio de Janeiro: Forest Trends, 2015. p. 65-71.

BRASIL. Lei nº 12.651, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa; altera as Leis nº 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nº 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória nº 2.166-67, de 24 de agosto de 2001; e dá outras providências. **Diário Oficial da União**, 28 maio 2012. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm>. Accessed on: Nov. 23, 2017.

Photo: Edelberto Gebauer

Figure 3. *Araucária* Forest (*Araucaria angustifolia*) in Brazil's South area.

BRAUMAN, K. A.; DAILY, G. C.; DUARTE, T. K.; MOONEY, H. A. Nature and value of ecosystem services: an overview highlighting hydrologic services. **Annual Review of Environment and Resources**, v. 32, p. 67-98, July 2007. DOI: 10.1146/annurev.energy.32.031306.102758.

FIDALGO, E. C. C.; PRADO, R. B.; TURETTA, A. P. D.; SCHULER, A. E. (Ed.). **Manual para pagamento por serviços ambientais hídricos**: seleção de áreas e monitoramento. Brasília, DF: Embrapa, 2017. 78 p. Available at: <http://ainfo.cnptia. embrapa.br/digital/bitstream/item/160960/1/Manual-PSA-hidricos-2017.pdf>. Accessed at: Mar. 2, 2018.

OLIVEIRA, E. B. de. Projeto Estradas com Araucárias. In: PARRON, L. M.; GARCIA, J. R.; OLIVEIRA, E. B. de; BROWN, G. G.; PRADO, R. B. (Ed.). **Serviços ambientais em sistemas agrícolas e florestais do Bioma Mata Atlântica**. Brasília, DF: Embrapa, 2015. p. 271-277. Available at: <https://www. embrapa.br/busca-de-publicacoes/-/publicacao/1024446/projeto-estradas-com-araucarias>. Accessed on: Mar. 3, 2018.

PAGIOLA, S.; BISHOP, J.; LANDELL-MILLS, N. **Selling forest environmental services**: market based mechanisms for forest conservation and development. London: Earthscan, 2002. 299 p.

PAGIOLA, S.; VON GLEHN, H. C.; TAFFARELLO, D. **Experiências de pagamentos por serviços ambientais no Brasil**. São Paulo: Secretaria do meio ambiente/Coordenadoria de Biodiversidade e Recursos Naturais, 2013. 336 p.

PARRON, L. M.; GARCIA, J. R.; OLIVEIRA, E. B. de; BROWN, G. G.; PRADO, R. B. (Ed.). **Serviços ambientais em sistemas agrícolas e florestais do Bioma Mata Atlântica**. Brasília, DF: Embrapa, 2015. 370 p. Available at: <https://ainfo.cnptia. embrapa.br/digital/bitstream/item/131969/1/Livro-Servicos-Ambientais-embrapa.pdf>. Accessed on: Mar. 3, 2018.

SANTOS, D. G.; DOMINGUES, A. F.; GISLER, C. V. T. Gestão de recursos hídricos na agricultura: o programa produtor de água. In: PRADO, R. B.; TURETTA, A. P. D.; ANDRADE, A. G. (Ed.). **Manejo e conservação do solo e da água no contexto das mudanças ambientais**. Rio de Janeiro: Embrapa Solos, 2010. p. 353-376.

UNITED NATIONS. **Life on land**: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. Available at: <https://sustainabledevelopment.un.org/sdg15>. Accessed on: Mar. 26, 2018.

UZÊDA, M. C.; TAVARES, P. D.; ROCHA, F. I.; ALVES, R. C. (Ed.). **Paisagens agrícolas multifuncionais**: intensificação ecológica e segurança alimentar. Brasília, DF: Embrapa, 2017. 67 p. (Texto para discussão, 48).

WUNDER, S. **Payments for environmental services**: some nuts and bolts. Bogor Barat: Center for Internacional Forestry Research, 2005. Available at: <http://www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf>. Accessed on: Aug. 29, 2017.

Chapter 10

Future challenges

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Main advances

As a leader in the transformation of Brazilian agriculture over the last 45 years, the Brazilian Agricultural Research Corporation (Embrapa) has dedicated itself to producing viable research, development, and innovation (RD&I) solutions in order to overcome challenges for the development of products, technologies, and knowledge to ensure the sustainable use of Brazilian biomes (Embrapa, 2015). Thus, the protection, recovery and promotion of sustainable use of the terrestrial ecosystems are crystallized in its mission. Embrapa RD&I actions have contributed for Brazil to meet the 17 Sustainable Development Goals (SDG) based on the eight Millennium Development Goals (MDG).

Its experience over almost half a century has paved the way for Embrapa's international recognition and presence, and turned it into a world-class company. Over this time, Embrapa met the great challenge of integrating agricultural research with social development, conservation and sustainable use of natural resources from different Brazilian ecosystems, in alignment with agreements and global policies towards poverty reduction and sustainability assurance. The effective attendance of the Company's researchers in discussion groups in preparation for international forums, in Brazilian delegations that subsidized negotiations of conventions on climate, biodiversity, desertification, and in the United Nations Forum on Forests substantiated these commitments of Embrapa. This participation has been important, since the technical-scientific perspective contributes to qualifying diplomatic decision making.

Main challenges

Different ecosystems are vital spaces for the development of economic activities and for human survival. However, these ecosystems are also vulnerable primary targets for global transformations of all kinds. Future scenarios regarding political and social areas, the use of natural resources, climate changes and increasing challenges in biological, food safety, and agricultural defense areas, and with the purposes of interacting with the international community and understanding such transformations, Embrapa opened virtual laboratories (Labex) abroad. Those located in Europe, United States, China, and Korea aim to foster geographical integration and North-South cooperation; and those in Africa (Gana) and Latin America (Venezuela) aim to foster geographical integration and South-South cooperation. As Embrapa outposts, the Labex have already organized and taken part in several projects.

For the future, it is expected that integration among researchers, through global research networks such as the International Union of Forest Research Organizations (IUFRO), will be improved, since the technological means for that are available. IUFRO, in partnership with Embrapa and the Brazilian Forest Service (BFS), is organizing the *XXV IUFRO World Congress*, to be held in 2019 in Curitiba, PR, Brazil.

In Embrapa latest competitive processes, some projects gained room in social networks and different platforms and apps dedicated to scientific discussion. Live and virtual meetings as congresses and workgroups also make it easier to exchange information and knowledge, which are increasingly compartmentalized and complex. The continuous participation of Brazilian researchers in international discussions on the future of agricultural and forest research only will be possible if their direct and frequent attendance in discussion forums, the publication of impressive works, and the organization of consistent teams are maintained.

Brazil is a key country because it is home to one of the biggest and most important biodiversity repositories on the planet, and because it manages its forests in accordance with strict regulations. Its efforts to develop and adopt public policies that combine environmental protection with the development and reduction of social inequalities shall be expanded, so as to ensure the availability of resources for future generations. The sustainable forest management of Brazilian biomes encompasses these concerns, and the advances obtained through research shall not be restricted to supporting the design of standards and technical guidelines; they shall effectively help broaden the population's access to technological innovations developed for improving their means of living, which directly rely on the use and management of natural resources to the benefit of all society. In this sense, Embrapa took an important step, for example, in sponsoring the Projeto Especial Soluções Tecnológicas para a Adequação da Paisagem Rural ao Código Florestal Brasileiro (Special Project Technological Solutions for the Adequacy of the Rural Landscape to the Brazilian Forest Code), which resulted in a publication on the Internet entitled *Forest Code: Contributions for the Adequacy of Rural Landscape*, which discusses concepts and offers guidance on PPAs, LRAs, and RUAs, different biomes and vegetation of Brazil. It is expected that this webpage will be increased to include, in the future, other solutions, protocols, and models developed by Embrapa researchers and partners.

Within the Forest Code, there is also the opportunity to broaden the property management concept (including the management model for each landscape), once the areas already mapped by the Cadastro Ambiental Rural (Rural Environmental Enrollment – REE), a system managed by BFS, one of Embrapa's partners, have already been disclosed. Models for resource management from this new perspective, which surpasses farm gates, are under development by Embrapa.

Contributions of Embrapa to the development of environmental regularization programmes (ERP) set forth in the New Forest Code should also be considered as opportunities. ERP is the set of actions or initiatives that farm owners and tenants should take to adapt and achieve environmental regularization. Each of the country's states shall implement its own state ERPs, and adapt them to the New Forest Code. This is a unique opportunity for Embrapa to consolidate its role as a solution supplier for rural properties, appointing models for the restoration of PPAs, LRAs, and RUAs, and species/origin for forest farming and ICLF projects.

Embrapa has also advanced considerably in the delivery of solutions for timber and non-timber product sustainable management, mainly in the Amazon and *Caatinga*. It is part of ongoing long-term research studies, whose results deserve attention. Along with an even higher commitment on studying these biomes, substantial efforts on *Cerrado*, whose landscape analyses would be very important, are also expected. Furthermore, protocols to demonstrate the possibility and feasibility of sustainable forest management in secondary forests and Brazilian pine planted forests in the Atlantic Forest biome scenario are also expected.

Therefore, an interdisciplinary involvement of research and technology transfer areas should be promoted as a means to improve strategic actions addressed to regional matters and challenges, such as those already established to increase agricultural productivity, to combat deforestation, land degradation, and to protect living organisms. Such activities may be performed by applying models for sustainable management, environmental restoration, and ICLF in Technological Reference Units managed in partnership between researchers and technology-transfer experts and farmers. Furthermore, the appointment of native or alien species for afforestation or reforestation is a powerful instrument to promote forest cultivation in small or large properties, thus contributing to achieving the target established in negotiations at the *21st Conference of the Parties (COP 21) of the United Nations Climate Change Conference* in Paris, after which a new agreement aiming to strengthen the global answer to the threat posed by climate change was reached.

Among other commitments, Brazil will have to restore and reforest 12 million hectares of multiple purpose forests by 2030 by means of the so called nationally determined contributions (NDCs). This is a niche of great importance for Embrapa, whose experts on the matter are producing information on the adaptation of species to different ecosystems. A strong investment to strengthen this line of business is expected, including partnership with other institutions that could also be involved in providing environmental services. In this sense, the existence of degraded lands is one of the hardest challenges to achieve sustainability. Embrapa strategies for the future (Embrapa, 2015) embrace this challenge by stimulating its teams to improve generation, transfer, innovation, and validation of technologies aimed to revert scenarios of direct threat to biodiversity, food safety, and life on Earth.

The anthropogenic changes, which occurred more strongly in specific biomes and ecosystems, stimulated the development of plans and projects emphasizing sustainable management practices and valuation of ecosystem services. This shall be a strategy to make production and protection compatible in mountainous regions. The recognition of Local Productive Arrangement of Sheep and Tourism at *Alto Camaquã* and the geographical indications of wine territories at *Serra Gaúcha* are successful efforts. In Rio de Janeiro, the example comes from the Fluminense mountainous region. These examples could and should be repeated and adapted, but, above all, it is expected that the technical-scientific integration be a priority, because it is expert diagnosis that widens the exchange of experiences in mountainous regions. Thus, a massive attendance at *Mountains 2018* congress, to be held in Nova Friburgo, RJ, is expected. It is an initiative of the Food and Agriculture Organization of the United Nations (FAO) to gather governmental institutions and society to work for the sustainable development of mountain environments in the whole world.

In Embrapa, the search for and protection of threatened native species takes place in varied environments, such as inner continental waters (rivers, lakes), fields and natural forests. Strategies to protect national biodiversity depend on advancing the knowledge on issues related to the biology of species and their answers to ongoing anthropogenic modifications. Thus, many technological solutions are being offered, such as reduction of fire use in the Amazon; zonings of land use; and development of software for timber forest management. Other initiatives are related to collecting materials maintained in herbaria, wood galleries, fruit galleries, and spermathecae. There are studies that contributed to elaborating public policies, so as to help avoiding extinction of threatened species, as are the cases of timber exploitation in the Amazon and of the maintenance of active germplasm databases.

For the future, initiatives gathering, in a network, experts on different scenarios and species to discuss the reduction of anthropogenic impacts on weakened areas are expected. Evaluating the tourist potential of certain areas and species, and valuing them as sustainability indicators for property certification and tax incentives seem to be options for the near future too.

It is worth emphasizing that, besides food production (*commodities*), farmers must be valued for trading ecosystem services (*non-commodities*) so as to continue preserving the region. Embrapa has been investing in studies for this purpose, for example, by organizing the research network named Serviços Ambientais e a Paisagem Rural (Environmental Services and Rural Landscape) and by releasing books and projects such as Bem Diverso (Diverse Asset), which aims to contribute to the conservation of Brazilian biodiversity in multiple use landscapes through the sustainable management of socio-biodiversity and agroforest systems (AFSs). It is a promising area that offers solutions closely related to other of Embrapa initiatives, which can be conducted with the aims of gathering contributions to specific ecosystems and, at the same time, addressing poverty reduction.

Alien animal and plant species always cause discussions and often distorted understandings regarding their importance for food safety and their threat to ecological balance. Because of their economic importance, alien species are largely used, and their uncontrolled spread shall be monitored using good practices defined by research projects and technical follow-ups. Monitoring systems (including, if possible, spatial information and strict certification processes) are the ideal instruments for managing invasive species. However, training people involved in field activities is vital to disseminate information on dealing with the landscape and environment. Technical documentation, such as booklets and folders, also contributes to spreading knowledge on management techniques and control of alien species with invasive potential. The organized civil society shall also access technical information based on scientific research.

The aspects mentioned in this chapter serve as landmarks for Embrapa to continue improving its processes and management tools, aiming to offer excelling support to both public and private sectors of society. In this process, Embrapa must focus on meeting the needs of society by establishing public policies for landscape and habitat conservation, which involve a permanent follow-up on the impacts and suitable practices for protecting biodiversity species in the varied biomes in Brazil.

Reference

EMBRAPA. Secretaria de Gestão e Desenvolvimento Institucional. **VI Plano Diretor da Embrapa**: 2014-2034. Brasília, DF, 2015. 24 p.

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