ANALYSIS OF FORESTS' GENETIC VULNERABILITY AND ARGUMENTS TO REDUCE DEFORESTATION

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Introduction

Countries across the globe have been facing several challenges to lessen impacts on tropical forests due to changes resulting from deforestation, habitat fragmentation, global warming, climate change and risk of species endangerment. Forests play a key role in the environment, since they help protecting natural resources such as soil, water and environmental services (FAO, 2016). Trees grown in forest environments play an essential role in microclimate conservation and forest landscape; thus, changes in these environments, such as anthropogenic disturbance and fragmentation, can affect environmental dynamics and lead to environmental variations (PESSOA; ARAÚJO, 2014).

Silva et al. (2016) have highlighted the multiple use of forests and forest-related benefits to populations. They have also pointed out climate maintenance, improvements in quality of life, food, wood and medicine supply, as well as economic and social impacts, as means of subsistence.

Deforestation is described as tree-cover loss or removal from forests for timber production for trading purposes or soil use for agricultural purposes.

This environmental degradation results in the net loss of carbon stocks or in reduced forest density (CHEN et al., 2015). Habitat destruction is pointed out as one of the biggest threats to biodiversity, since it disturbs many species distributed in the en-

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vironment. The aforementioned loss can start from the edges, or within, and negatively affect species maintenance. (RIVERS et al., 2014).

Livestock is directly linked to deforestation in all Legal Amazon regions. Grain production accounts for forest area reduction in Northern Mato Grosso and Southeastern Pará states. Timber removal for trading and road opening purposes is also a negative factor; only areas under legal environmental protection remain untouched. (JUSYS, 2016).

Forest vulnerability can change based on tree species, size, age, growth rate and location. Larger and older trees are more vulnerable to the effects of drought in seasonal forests and to water stress; wetland forests are more susceptible, whereas shadow-tolerant species - which adopt a more conservative strategy for resource use - are less unstable (CORLETT, 2016).

Reducing the size of plant species populations can result in loss of rare alleles and in lower genetic diversity due to genetic variation in selection processes and to decreased inbreeding. It can happen to rare or endemic plants in a given region and allows their survival under self-fertilization and/or cloning conditions. Plant species grown in fragmented or isolated areas are vulnerable to the negative genetic consequences of deforestation (NOREEN; WEBB, 2013).

An important fact has been addressed in debates about changes taking place in forest areas worldwide, namely: the number of areas of planted forests has increased, whereas the number of areas of natural forests has decreased. This is a matter of concern, since natural forests contribute to genetic biodiversity conservation, tree species maintenance, as well as to ecological development and dynamics (JANES; HAMILTON, 2017). On the other hand, planted forests contribute to soil protection, provide environmental services and reduce the pressure on natural forests (FAO, 2016).

According to Hubert and Cottrell (2007), genetic variations observed in forest areas result from different environmental influences. These variations can be neutral and adaptive; the neutral ones result from differences between genes that do not affect individuals' reproductive and survival ability, whereas adaptive variations refer to differences in individuals' suitability.

There is concern about all herein reported factors due to risk of species endangerment and loss of diversity on the planet. No one knows the extinction level Earth can tolerate, and for how long, or whether changes in the terrestrial forest system are irreversible, or not, in the long term (STEFFEN et al., 2015).

Little attention has been given to the definition of different tropical forest management strategies such as reducing deforestation, genetic advancement of species strengthening and tree adaptability to climate changes. The aims of the current study were to investigate definitions involving the forest-cover issue in the tropics and its vulnerability, as well as to present recommendations and arguments focused on reducing deforestation in Legal Amazon.

Definitions involving the tree-cover issue and its vulnerability

Durães et al. (2013) have investigated a Neotropical forest biodiversity hotspot area and found that the most disturbed and fragmented region was also the one mostly

affected by the loss of species richness. According to the aforementioned authors, habitat loss by species was the main consequence on bird communities.

Wheeler et al. (2016) have investigated carbon sequestration and biodiversity in a rainforest undergoing restoration after 18 years. Their results revealed that forest restoration is beneficial to plant diversity; yet, tree and seedling richness remains greater in natural forests. Biodiversity improves as forests recover from disturbances, but it takes longer to reach natural forest biodiversity levels.

Chen et al. (2015) have investigated tropical forest deforestation and degradation timeframe patterns resulting from a hydroelectric power plant built in the Amazon basin. They concluded that forest losses observed over 25 years were triggered by human actions, mainly by settlements, which turned these forests into areas for agricultural and livestock activities, as well as for road and dam building.

According to the 2015 Global Forest Resource Assessment report (FAO, 2015), forested areas worldwide have decreased by 3.1% - from 4.1 billion hectares to less than 4 billion hectares - over the past 25 years.

The process of opening new roads in different regions such as the Amazon, Asia and Africa in order to open borders is responsible for biodiversity loss involving several species. The fragmentation of forest areas opens clearings in dense forests rich in species that specifically inhabit treetops and avoid the edges of clearings; thus, this process hinders animals' moves and, consequently, the development of plant propagules (LAURANCE et al., 2009).

According to Gross (2016), deforestation is a global issue that threatens wildlife, multiple services provided by forests and benefits to economic activities. The aforementioned author has highlighted the disappearance of forests in Indonesia, Australia, Eastern Europe, as well as of mangrove forests and of the Amazon rainforest. He has also emphasized that since biodiversity plays a key role in environmental services, preservation and conservation efforts should be the focus of everyone involved.

Deforestation derives from many processes driven by excuses, whose underlying causes encompass economic development, demographic trends and technological elements, and whose direct causes include pasture and urban development. Deforestation takes place mainly in the tropics; agricultural expansion is one of the main excuses to do so (ANNUNZIO et al., 2015).

According to Stork et al. (2009), deforestation and environmental degradation lead to significant forest vulnerability, since epiphyte, monoecious, hermaphrodite and mammal species are more susceptible to extinction. Animals play a key role after forest disturbance processes, since they help dispersing 70% of seeds in tropical forests. Vertebrate animals can also pollinate several plant species; however, when this group declines due to slow growth and low density, there are fewer pollination systems available for plants in the forest and, consequently, the number of pests and hermaphrodite individuals increases. (FAO, 2017).

According to Allen et al. (2015), global warming has led to the death of several trees, whereas drought and high temperatures in terrestrial ecosystems have favored the emergence of ecological imbalances, whose consequences encompass reduced number of

leaves, stress and forest mortality (ESQUIVEL‐MUELBERT et al., 2019). Assumingly, temperature fluctuations change species distribution in plant ecosystems; some species become endemic to certain areas, whereas others face extinction (STORK et al., 2009).

Climate change modifies forest ecosystems at large scale, since it triggers disturbances such as wildfire, flood, drought and extreme weather conditions such as frost and winds. These stressful situations affect tree growth and have impact on timber supply and prices due to decreased plant yield (HANDMER et al., 2012).

Chart 1 lists the main articles indicating risk factors responsible for forest vulnerability in the tropics.

Chart 1- Analysis of articles indicating the main risk factors responsible for forest vulnerability and death in the tropics.

Article	Risk factors	Authors	Main Conclusions
Genetics and genetic resources. Population, Conservation and Ecological Genetics, In Encyclopedia of Forest Sciences.	Adaptation	Mátyás (2004).	Genetic diversity determines the adaptation and microevolution rates within a given population.
The Role of Forest Genetic Resources in Helping British Forests Respond to Climate Change.	Climate change	Hubert and Cottrell (2007).	Strategies focused on helping forests to adapt to effects of climate change.
Impacts of roads and linear clearings on tropical forests	Anthropogenic fragmentation	Laurance et al. (2009).	Fragmentation of forest areas opens clearings in forests, hinders animals' moves and the development of plant propagules, and leads some species to extinction since isolation can reduce genetic variability in populations.
Vulnerability and Resilience of Tropical Forest Species to Land-Use Change.	Global warming	Stork et al. (2009).	Temperature fluctuations lead to changes in plant ecosystems such as extinction, endemics, adaptive and phenological changes.
Effects of forest disturbance and habitat loss on avian communities in a Neotropical biodiversity hotspot.	Anthropogenic fragmentation	Durães et al. (2013).	The greater the disturbance, the greater the fragmentation and the biodiversity loss.
High Genetic Diversity in a Potentially Vulnerable Tropical Tree Species Despite Extreme Habitat Loss.	Genetic erosion	Noreen and Webb (2013).	Reduced population size leads to loss of rare alleles, lower genetic diversity and, consequently, to smaller genetic variation in selection processes.
Do species conservation assessments capture genetic diversity? *Global Ecology and Conservation*.	Deforestation	Rivers et al. (2014).	Habitat destruction is one of the main threats to biodiversity.
Tree community dynamics in a sub-montane forest in Southeastern Brazil: growth, recruitment, mortality and changes in species composition over a seven-year period	Anthropogenic fragmentation	Pessoa and Araújo (2014).	Changes in forest environments, such as anthropogenic disturbances and fragmentations, can influence variations and dynamics.
Spatiotemporal patterns of tropical deforestation and forest degradation in response to the operation of the Tucuruí hydroelectric dam in the Amazon basin.	Deforestation	Chen et al. (2015).	Environmental degradation leads to net loss of carbon stocks or to reduced forest density.
On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene	Global warming	Allen et al. (2015).	Tree mortality in associated forests due to drought followed by high temperatures.
Planetary boundaries: Guiding human development on a changing planet.	Lack of resilience	Steffen et al. (2015).	Human activities have been affecting the functioning of terrestrial ecosystems to the point to threaten their resilience and survival.

How can we save forest biodiversity?	Deforestation	Gross (2016).	Global environmental issues threaten wildlife and biodiversity, and their relevance to environmental services.
Climate-Related Local Extinctions Are Already Widespread among Plant and Animal Species	Global warming	Wiens (2016).	Anthropogenic climate changes will be one of the main causes of biodiversity loss on the planet in the next 100 years.
Carbon sequestration and biodiversity following 18 years of active tropical forest restoration	Anthropogenic actions: restoration	Wheeler et al. (2016).	Results have shown that forest restoration is beneficial to plant diversity, however, tree and seedling richness remains higher in natural forests.
Global climate change impacts on forests and markets.	Anthropogenic actions: economic and trade	Sohngen and Tian (2016).	Available timber derives from forest plantations; regions investing in forestry can benefit from climate change.

Source: The authors (2017).

Recommendations for issues such as tree genetic vulnerability and rainforest survival in Legal Amazon

Genetic Conservation

Genetic conservation enables species survival, evolution and adaptation to environmental changes and conditions (FAO, 2016). Likewise, it enables the formation of genetic reservoirs, increases forest yield and health, and plays a key role in tree species' functioning. Diversity allows species to evolve during periods of extensive genetic change, based on their adaptation to different climate regimes (RATNAM et al., 2014; FAO, 2014). Genetic material also enables forest resilience and survival after anthropogenic disturbances (STEFFEN et al., 2015).

Plant tissue culture and micropropagation are methods adopted for germplasm storage purposes; they are based on biological factors such as morphology, organogenesis and embryology. Morphogenesis enables producing transgenic plants and reducing their commercial value. On the other hand, organogenesis and embryology can affect the genetic variation of species.

According to Sebben et al. (2008), the effects of logging on genetic diversity can only be measured and understood in meta-populations, since many tropical tree species have long-range gene flow based on pollen and seeds.

Understanding plants' genetic system is of paramount importance to enable planning and managing forest resources, although many species resort to vegetative regeneration.

The use of Payment for Environmental Services (PES) as forest protection instrument

Environmental or ecosystem services can be defined as the set of benefits ecosystems provide to individuals, such as: soil erosion control, CO^2 capture, climate regulation,

prevention of the desertification phenomenon, improved air quality, culture, leisure, landscape, among others (MEA, 2005).

The concept of ecosystem services encompasses the idea of economic or use value, as well as the environmental benefits resulting from human interventions in ecosystems' dynamics (ANDRADE; ROMEIRO, 2009).

Payment for Environmental Services (PES) involves the relationship between user and provider. User is the individual, or community, paying for the offered environmental services, whereas provider is the one supplying environmental protection services for a specific environmental resource, water or even for an ecosystem. Such relationship requires cooperation and/or coercibility, and it can be voluntarily or coercively structured.

The voluntary model is based on cooperative relationship in its purest sense, according to which, individuals motivated by their personal beliefs willingly "pay" for environmental protection, or even implement environmental protection in their property – this process goes beyond legal determinations such as launching a Private Natural Heritage Reserve.

The coercive model is based on state imposition supported by laws that can present different forms such as legal impositions and the establishment of legal reserves or of permanent preservation areas. These imposed laws force citizens to embody their share of responsibility for protecting the environment.

The Brazilian legislation addresses Payments for Environmental Services as one of the lines of action or strategies of the Support and Incentive Program for Environmental Preservation and Recovery, highlighted in Art. 41, I of the current Forest Code (BRASIL, 2012).

According to Wunder et al. (2008), PES implementation in the Legal Amazon is often hindered by lack of agrarian regulation for private properties, a fact that makes it difficult putting PES in practice, since it is not viable for public lands. According to the aforementioned study, PES implementation in the Legal Amazon could help reducing deforestation rates.

Payments, or incentives, for environmental services may, or may not, be monetary. In order to better illustrate such possibilities, the current study presents some models that clearly show the joint incidence of these payments, which are introduced as interesting forest environment management models.

Bolsa Floresta (BFP) Program /AM

Bolsa Floresta Program, which was implemented in Amazonas State, is an example of voluntary model. The Program was launched by Amazonas State Law N. 3.135/2007, which implemented the State Policy on Climate Change, and by Complementary Law N. 53, both enacted on June 5th, 2007.

This policy aims at establishing the "payment for environmental services and products by traditional communities for the sustainable use of natural resources, for environmental conservation and protection, as well as at encouraging voluntary policies focused on reducing deforestation" (AMAZONAS, 2007).

Bolsa Floresta Program is managed by Sustainable Amazonas Foundation (FAS - Fundação Amazonas Sustentável) - which is a non-governmental and non-profit institution - in partnership with Amazonas State Secretariat of the Environment. It is important emphasizing that these laws were presented in an innovative way to legally structure the economy of forest-associated environmental services and products and to achieve social justice through environmental conservation.

The program operates through four subprograms: Income, Social, Family and Association. After the voluntary adhesion of families as providers who live inside and around conservation units (CUs) and, after the fulfillment of their duties, these subprograms assure direct gains to these families, social benefits at community level, support to associations, as well as sustainable production and income generation activities.

Thus, providers participate in workshops aimed at training individuals on climate change and environmental services; they promise not to open new planting areas in primary forests, and commit to enroll, or keep, their children in school. The program aims at supporting and enhancing responses to social and economic demands from riverside populations living in Amazonas state CUs in order to empower the assisted communities through the valorization of standing forests (AMAZONAS, 2007).

According to the 2011 Sustainable Amazonas Foundation report, results of the Program can be exemplified by reduced deforestation in CUs where it was implemented in comparison to CUs where it was not implemented. CUs where BFP was implemented recorded deforestation rate equal to 0.011%, whereas CUs where BFP was not implemented recorded deforestation rate equal to 0.036% (FAS, 2011, p. 5).

Therefore, it is possible stating that PES is an efficient economic instrument significantly contributing to environmental protection, to the sustainable use of common goods and to the preservation of ecosystem services provided by the environment.

Crop-Livestock-Forest Integration (CLFI)

Crop-Livestock-Forest Integration (CLFI) is a voluntary strategy that attributes sustainability features to the agricultural sector, since it encompasses economically viable production elements, protection of natural resources and improvements in individuals' quality of life (social element). It integrates agricultural, livestock and forest activities in a single area subjected to intercrop, succession or rotational system. In addition, it has several benefits such as recovery and maintenance of productive environments; production diversification; reduced costs and risks, and reduced pesticide use due to the maintenance of green cover throughout most of the year; recovery of degraded areas that reach 80% of the territory used for this purpose in Brazil; year-round production; increased profitability and diversification without increasing the planting area (HERMANN, 2014).

The regulatory framework of policies that set up such systems lies on the voluntary commitment made by Brazil at COP-15, Copenhagen, in 2009, to reduce greenhouse gas (GHG) emissions, which were projected to reach from 36.1% to 38.9%, by 2020. This commitment was ratified by Law 12.187/2009, which instituted the National Climate Change Policy (NCCP). This policy was regulated by Decree N. 7390/2010, whose art.

6 defined actions to be taken in order to achieve the proposed reduction. Among these actions one finds the expansion of crop-livestock-forest integration systems by 4 million hectares.

ABC Program

The ABC Program was structured based on COP 15 - the United Nations (UN) Conference held in 2009. The Program is an important element of national public policies aimed at mitigating climate change and at continuously improving agricultural practices capable of reducing GHG emissions at national level. Thus, it is worth emphasizing two important mitigation actions focused on achieving the aforementioned purpose, namely: the previously mentioned CLFI and the land tenure regularization aimed at identifying landowners across the country in order to encourage proper and responsible land use. This action would help avoiding deforestation and the adoption of agricultural practices responsible for low productivity and high environmental cost.

Thus, based on Resolution N. 3896, the National Bank for Economic and Social Development (BNDES - Banco Nacional de Desenvolvimento Econômico e Social) has established the National Program for Reducing Greenhouse Gas Emissions in Agriculture (ABC Program), which is ruled by general rural credit rules, among others. Rural producers and their cooperatives are the beneficiaries of this program; they transfer credits to cooperative members (Res. N. 3896, art. 1) to enable the CLFI system, among others.

The goals of the ABC Plan (Sectoral Plan for the Mitigation and Adaptation to Climate Change for a Low-Carbon Emission Agriculture) are described in art. 6 of Decree N. 7.390, according to which, in order to meet the voluntary national commitment referred to in art. 12 of Law N. 12.187/2009, it is necessary implementing actions aimed at reducing the total emissions estimated for 2020 by 1,168 to 1,259 million t CO2eq (3,236 million t CO2eq).

Rural Territorial Property Tax (ITR - Imposto sobre a Propriedade Territorial Rural)

ITR is an example of coercive model imposed by law. Federal Law N. 9393/1996 determines that the Rural Territorial Property Tax (ITR), which is calculated on a yearly basis based on bare land value (BLV), has ownership, useful domain or possession of property located outside the urban area of a given county on January 1st of every year as generating factors (BRASIL, 1996).

It is necessary taking into consideration the exclusion of items listed in the subparagraphs of article 10 of Federal Law N. 9393/1996, such as Permanent Preservation Areas (PPA), Legal Reserves (LR), as well as areas covered by native, primary or secondary forests at intermediate or advanced regeneration stage, in order to calculate the BLV of rural properties. That being said, it is possible stating that the legislation guarantees economic incentives (in form of taxes) for rural landowners who are in compliance with the environmental rules, or in the aforementioned cases, who keep their PPA and LR areas duly regularized.

Thus, landowners can count on economic benefits such as decreased number of taxes to be paid and the protection of community's right to enjoy the social and environmental benefits provided by forest resources in the category of common goods.

Rationale for reducing deforestation in the tropics

The main claim for changing society's behavior in a generic way, instead of pointing out the ones to be blamed for all the imbalance experienced all over the planet, lies on the fact that changes in the environment will affect forests in many ways. It is so because tree species can be extinct if these changes persist for long periods and if they continue to advance rapidly.

The next generations will likely witness multiple environmental disasters. Nowadays, many researchers assume that the planet is in the "Anthropocene" era. This term was used by Paul Crutzen and Eugene Stoermer in 2000 to refer to geological processes facing substantial changes due to anthropic actions (WORKING GROUP ON THE 'ANTHROPOCENE', 2017).

Global warming changes plant and animal behaviors; for example, plants are blooming in early spring and this imbalance can affect species' phenology and ability to inhabit new areas. Changes resulting from global warming can increase the likelihood of introducing pathogenic and invasive species, as well as pests and insects; this imbalance can lead the population to extinction (MORTON; RAFFERTY, 2017).

Knowing the forest type, and the species grown in it before degradation, are the first steps to enable forest regeneration and resilience. The beginning of the regeneration process demands investments in seed and seedling purchasing, the hiring of companies specialized in restoring forest areas or in organizing local communities, costs and methods to manage different soil types, as well as it depends on social and economic contexts (DURIGAN; GUERIN; COSTA, 2013).

The association between climate change and increased deforestation in the Amazon rainforest can lead to changes in its vegetation, since the forest depends on an annual rainfall regime. Moreover, environmental impacts, such as decreased rainfall rates, can unbalance forest resilience (ZEMP et al., 2017).

Despite the large number of methods focused on enabling forest conservation and biodiversity, it is noteworthy that sustainability fields do not exchange previous experiences and knowledge to assure future preservation. The economic field uses business parameters different from the ones used by the ecological and social fields. This process may lead to human actions focused on satisfying a momentary need, without thinking about future consequences, just for the sake of increasing one's profits without taking into consideration the growing need of environmental preservation.

Based on data provided by the Amazon Man and Environment Institute (IMAZON - Instituto do Homem e Meio Ambiente da Amazônia), deforestation has increased by 20% from August 2018 to April 2019; however, according to the Deforestation Alert System (SAD- Sistema de Alerta de Desmatamento) from March 2019, deforestation has decreased by 10% in comparison to values recorded for April 2018 in the Legal Ama-

zon. Mato Grosso State was leader in deforestation practices (37%) during this period; it was followed by Roraima (21%), Amazonas (18%), Rondônia (18%), Pará (4%) and Acre (2%) states. Deforestation was recorded in private areas (58%), settlements (31%), CUs (9%) and indigenous lands (2%) (IMAZON, 2019). The Amazon rainforest covers eight Brazilian states: Mato Grosso, Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins; as well as some counties in Maranhão State. Deforestation in the Legal Amazon is based on vegetation cover removal by logging companies, as well as enables agriculture and livestock systems, and forest fires (INPE, 2017).

Figure 1 presents two different areas - one deforested for cattle breeding and the other one featuring a preserved forest (closed forest) in Alta Floresta County – MT.

Figure 1- Area deforested for livestock purposes and preserved forest in the Legal Amazon - Alta Floresta County / MT.

Source: The authors.

According to FAO (2017), the area covered by forests in Brazil was 509,642 hectares in 2004. However, its size was reduced by 15,120 hectares in 2014 and the forest area decreased to 494,522 hectares. Such decrease was mainly explained by the fact that Brazil became reference in food production.

According to the Union of Concerned Scientists (2014), some initiatives can help protecting forests grown in the tropics from climate change; among them one finds reducing CO_2 emission (regardless of the generating source) and deforestation rates, since deforestation can result in the extinction of several plant and animal species, as well as in natural disasters such as floods and droughts. In addition, deforestation can directly affect populations whose income derives from vegetal extractivism in forested areas.

According to Wiens (2016), anthropogenic climate change will be one of the main causes of biodiversity loss on the planet over the next 100 years. Annual temperatures have increased by approximately 0.85°C from 1880 to 2012; according to estimates, annual temperatures will increase by 1°C to 4°C until 2100. It is important emphasizing that no one knowns how species will respond to climate change; an example to be taken into consideration lies on how species, whose ecological niche is subjected to changes, will adapt to abiotic conditions in the new environment.

Nobre (2001), in his study about global climate change, has concluded that impacts on ecosystems in developing countries such as Brazil derive from climate and environmental changes, as well as that the poorest populations are the most vulnerable to this imbalance. The aforementioned author also suggested that studies should be conducted to investigate different vulnerabilities integrating the environment and society, mainly the ones that can affect food production, agricultural activities and the environment.

Final Considerations

The following causes of forest tree genetic vulnerability were identified: deforestation; reduced forest tree cover; genetic erosion caused by biodiversity loss, monoculture implementation and loss of natural databases; global warming, which changes the habitat and the ecosystem where forests are located in, besides changing temperature and rainfall rates and leading to droughts; and lack of plant adaptability due to environmental fragility, since environments are often fragmented or unable to reproduce. Anthropic, economic and social actions, such as implementing settlements and increasing urban areas due to rural exodus; increasing agricultural areas without implementing environmental protection techniques, in association with increased herd size and extensive cattle breeding; and building roads that cross forest areas, cause their fragmentation and, consequently, lead to genetic loss.

Thus, it is recommended taking mitigating and compensatory measures, as well as implementing environmental programs, to help preserving tropical forests. In addition, innovations should be made, and further research should be conducted to help improving scientific knowledge about tree genetic vulnerability.

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Original Article

ANALYSIS OF FORESTS' GENETIC VULNERABILITY AND ARGUMENTS TO REDUCE DEFORESTATION

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ANALYSIS OF FORESTS' GENETIC VULNERABILITY AND ARGUMENTS TO REDUCE DEFORESTATION

Abstract: Forests play an essential role in protecting natural resources such as soil, water and environmental services. The aims of the current study are to analyze definitions involving issues such as forest cover and its vulnerability, as well as to present arguments to help reducing deforestation. Solutions focused on mitigating tree vulnerability are herein presented, namely: genetic conservation and local creation of genetic databases on natural forests; pursuit of maximum genetic diversity to maintain reproduction index and avoid cloning effects; scientifically investigating how to help trees to adapt to environmental changes; use of genetic improvement and programs such as Payment for Environmental Services, Bolsa Floresta Program, Crop-Livestock-Forest Integration and ABC Program to reduce deforestation in tropical forests.

Keywords: Tropical forest; Legal Amazon; deforestation; genetic conservation.

ANÁLISE DA VULNERABILIDADE GENÉTICA DAS FLORESTAS E ARGUMENTOS PARA REDUÇÃO DO DESMATAMENTO

***Resumo*:** As florestas têm um papel importante para o meio ambiente, em razão de oferecerem proteção aos recursos naturais, incluindo solo, água e serviços ambientais. O objetivo deste estudo foi compreender as definições que envolvem a problemática da cobertura florestal e sua vulnerabilidade e apresentar argumentos para redução do desmatamento florestal. Como atenuantes, são apresentadas soluções para a vulnerabilidade arbórea: a conservação genética e a criação local de bancos de dados genéticos de florestas naturais, busca por máxima diversidade genética para manter índice de reprodução evitando os efeitos da clonagem; estudar cientificamente como auxiliar a adaptabilidade das árvores frente a

alterações ambientais; utilizar o melhoramento genético e programas como Pagamento por Serviços Ambientais, Programa Bolsa Floresta , Integração Lavoura-Pecuária-Floresta e Programa ABC que contribuíram para redução do desmatamento nas florestas tropicais.

***Palavras chaves*:** Florestal tropical; Amazônia Legal; desmatamento; conservação genética.

ANÁLISIS DE LA VULNERABILIDAD GENÉTICA DE LOS BOSQUES Y ARGUMENTOS PARA REDUCIR LA DEFORESTACIÓN

Resumen: Los bosques desempeñan un papel importante en la protección del medio ambiente, incluidos los servicios del suelo, el agua y el medio ambiente. El objetivo de este estudio fue comprender las definiciones que rodean el problema de la cubierta forestal y su vulnerabilidad y presentar argumentos para la reducción de la deforestación forestal. Como factores atenuantes, se presentan soluciones para la vulnerabilidad de los árboles: conservación genética y creación local de bases de datos genéticos de bosques naturales, búsqueda de la máxima diversidad genética para mantener el índice de reproducción evitando los efectos de la clonación; estudiar científicamente cómo ayudar a la adaptabilidad de los árboles a los cambios ambientales; uso de mejoras genéticas y programas como el Pago por Servicios Ambientales, el Programa Bolsa Floresta, la Integración de Cultivos, Ganadería y Bosques y el Programa ABC que contribuyó a reducir la deforestación en los bosques tropicales.

Palabras clave: bosque tropical; Amazon legal; deforestación Conservación genética.