The importance of large primary forests on the global climate

On the precipitation regime, on global warming ...

By Benjamin LISAN, on 06/21/2020

"*Tree should not leave us indifferent. The sage has boundless admiration for him. There is a model of existence to consider. It is silent, it is discreet, it is of indisputable usefulness, it is of great beauty and it is completely non-violent. Human beings should be inspired by it"*. Francis Hallé, botanist.

"

No forest, no rain", Professor Dominick Spracklen, climatologist[1].

1 Introduction

Recently, I was surprised by the argument of a surfer claiming that the Brazilian president Bolsonaro has perfectly the right to develop, "economically speaking", the Amazonian territory, by replacing the forests with fields of soybeans or meadows for cattle breeding (meat zebus), which will bring wealth (in foreign currency) for export, for Brazil.

It is as if these people were not aware of the importance of large primary forests, on the regulation of the global climate and of the fact that he forgets to balance the advantages and disadvantages of the choice between the Bolsonaro solution (deforesting for agricultural land) and the advantages of preserving the Amazon rainforest.

This document will therefore describe all the services that trees and forests bring to the planet and to men, which are not limited to their beauty, their soothing and relaxing nature felt, for example, during Sunday walks. I would address scientific data and considerations, not necessarily scientific

Part of the data contained in this document are taken from the video *"a world of forests", from the "underside of the cards"* broadcast by ARTE [4 a)].

2 My motivations for the preservation of trees and forests

My motivations for preserving them are partly linked to my passion for forests and trees.

Before the age of 6, my first memories are bush fires, burns which, caused in the fields and forest by Malagasy peasants, ravaged the big red island of Madagascar.

Then I was a **child of the city**, living in Champigny-sur-Marne, then in Montesson, where there was not much forest.

Scouting and its camps in the forests, which I really appreciated, have totally changed my life, making me love nature, greenery and trees and forests. I immediately felt love for these great natural cathedrals of forests.

To the point of wanting to immediately protect them and dreaming of creating ecological green scouts, whose role would be to protect and raise awareness about environmental protection. My environmental motivation started with scouting.

In the forests and in the undergrowth, I always immediately noticed the freshness and humidity, the shading effect which reduces the temperature by a few °C, relatively to that of a bordering plain, totally exposed to the sun.

[1] Cf. https://environment.leeds.ac.uk/see/staff/1548/professor-dominick-spracklen

I also have the memory on the Sainte-Marie island in Madagascar of a place where the primary forests are very threatened and which passed from an area deforested by the man in the middle of the dodger where it was very hot and dry, the forest cover of one of the last primary and relict forests on the island. And I could see that the temperature there was at least 5 ° C lower than that of the deforested area and that the forest floor was constantly muddy and that the humidity was high.

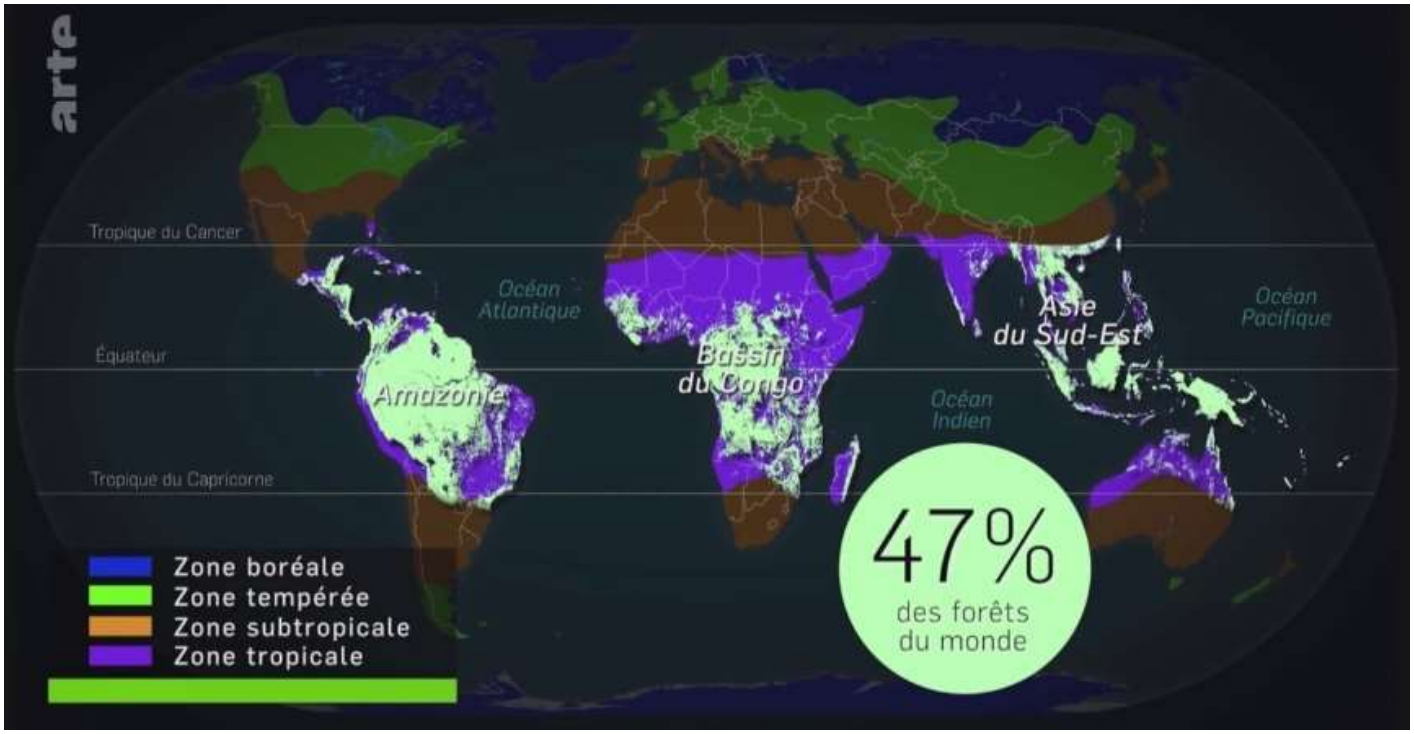
Deforestation of one of the last two primary forests on Sainte-Marie Island, located 10 km north of Ambodifotatra, Madagascar. September 2011. Photos © Benjamin LISAN.

Because of their deforestation in the world, I am worried about primary forests.
Because even if for some time (especially in wealthy, economically developed countries) has emerged an (ecological) awareness of the **urgency of protecting forests as a precious commodity b**efore it is too late, I also unfortunately know that deforestation continues, in certain regions of the world (Brazil, DRC, Indonesia…).

Fortunately, in other parts of the world, I know that we protect forests and we replant because the inhabitants are convinced that 80% of the terrestrial biodiversity is in forests, that they are an invaluable carbon sink, that they support the needs of more than a billion human beings and that they still have many other advantages.

3 Some figures on forests, in the world

Forests occupy about a third of the land area, but their distribution is uneven according to the regions of the world. This is primarily due to the climate.
Large forests are mainly distributed on both sides of the equator.
Large tropical forests account for 47% of the world's forests.



Large tropical forests account for 47% of the world's forests.
Source: The underside of the cards, ARTE: A world of forests.

Brazil, the DRC, Canada, Russia, the United States, Peru, Indonesia, China, India, Australia alone account for two-thirds of the world's forests. In terms of forest cover: first Russia, second Brazil, third Canada ...

Currently, in 2019, forests occupy 4 billion hectares, while around 1850, they occupied 5 billion hectares. Because in the meantime, forest areas have become agricultural land, cities, shopping centers, roads, for an ever-increasing population, which consumes more and more wood and paper ...

There are still 3,000 billion trees in the world[2].

- Almost half (1.39 trillion) of the trees grow in tropical and subtropical forests, 0.74 trillion in the boreal regions and 0.61 in the temperate regions. The remaining 10% grows in large areas of prairie or tundra, mangroves or even deserts.
- If we consider that the world human population is 7.2 billion, there are approximately 422 trees per person on earth.
- It is estimated that more than 15 billion trees are cut each year.
- **About 46% of the forest area has disappeared since the start of human civilization 8,500 years ago[3].**

[2] a) *How many trees on Earth? 3,000 billion, 7 times more than expected! Jean-Luc Goudet,* 05/09/2015, https://www.futura-sciences.com/planete/actualites/foret-arbres-terre-3000-milliards-7-fois-plus-prevu-59644/
b) *How many trees are there on earth?* https://www.wsl-junior.ch/fr/la-foret/la-foret-en-chiffres/combien-y-a-t-il-darbres-sur-terre.html
[3] The Neolithic begins in the Near East around 8,500 years BC. AD in the Fertile Crescent.
Cf. *Néolithique*, https://fr.wikipedia.org/wiki/N%C3%A9olithique

4 Services provided by trees and forests, according to Dominick Spracklen

Large rainforests provide a large number of ecosystem services. They serve as a climatic "buffer" against the risks of drought and flooding. They are water and humidity sponges, just like wetlands.
They are a conservatory of species providing molecules, which could be useful to humans ....

For **Dominick Spracklen**, climatologist at the University of Leeds (Yorkshire), in the United Kingdom, forests provide many services[4] [1] :

1) They provide medicines,
2) They improve the quality of air, water, climate,
3) If forests are large, in size and density, they store carbon.
4) They provide building materials.
5) They provide biomimetic solutions for humanity

Trees are extraordinary biological machines, endowed with a certain plasticity, in the face of climatic and physical hazards, with a capacity for resilience, reiteration1, frugality, recycling, permanent regeneration.
These are biological pumps, extracting water from the basement, more efficient than our electric pumps.

They can reach a venerable age, like the bristlecone pines of the White Mountain region of California, which can live more than 3500 years.

Giant sequoias can pump up to 2,000 to 3,000 liters of water a day (!). But they are not just vacuum cleaners of water (according to Janine Benyus, biologist), because the humid air which they produce generates the rain.

Then, this humid air is driven by the wind and has an impact on the continental precipitation regime, over a hundred km, beyond the forest territory which generated this humid air.
These forests make the environment better.

5 The evapotranspiration of forests acting on the increase in precipitation

According to Professor **Dominick Spracklen**, the forest helps generate rain. Large forests have a great impact on the climate on a continental scale [1].

It has a real link between rain and forest, scientifically proven by Dominick Spracklen and his team[5], with the analysis of several hundred thousand data, coming from observation satellites:

a) The distribution of forest areas on the globe,
b) Variations in temperature and precipitation on the earth's surface.

---

[4] The tree, starting from a unitary structure, will create on itself other structures allowing it to develop more in space, thus giving a competitive advantage for the race towards light. The botanist Francis Hallé calls this phenomenon reiteration and defines it thus: "mechanism by which the tree creates its structures, architectural units, which it repeats at will and adds to previous units". See Trees and their structure, 03/01/2019, https://www.legoutdusauvage.com/2019/03/les-arbres-et-leur-structure.html

[5] His research group combines models of the Earth's atmosphere, Earth's surface and climate with observations and satellite remote sensing.

His team cross-tabulates data on (continental) forest areas, air, humidity levels.

6 The phenomenon of "flying rivers"

6.1 Presentation

- The Amazon sees masses of water vapor passing over its trees with impressive volumes and flows. These are the flying rivers, a phenomenon described in 2006 by Brazilian scientists.
- This phenomenon highlights the crucial role that trees play in the formation of clouds, both by emitting water vapors into the atmosphere but also by emitting aerosols [9].
- These flying rivers exist wherever there are forests but in central South America, they play a crucial role in preventing this region from being a desert.

"We speak of rivers because they are concentrated transports of immense volumes of vapor, as constant as the meanders of a river," describes Aurélien Francisco Barros. This phenomenon has been identified by Brazilian climatologists since 2006. It is more and more studied by the world scientific community, but remains however little known to the general public "[…]" A large tree with a span of twenty meters in diameter can send up to 1,000 liters of water into the atmosphere in one day, just by sweating, "says Antonio Nobre. In total, all of the trees in the Amazon rain forest would return 20 billion tonnes of water to the atmosphere per day, when at the same time the Amazon gives back to the Atlantic Ocean "only" 17 billion tonnes of fresh water [5] to [8].

6.2 The crucial role of aerosols

"But the role of forests in the formation of flying rivers is not limited to this phenomenon of perspiration, which has also been known for a long time," insists Aurélien Francisco Barros. **Trees also emit aerosols, airborne microparticles that promote cloud formation.** They rise in the atmosphere and aggregate above the forest until forming microscopic grains which would have a great capacity to attract the vapors of water present in the air. »Condensation nuclei which form a drop then another and, little by little, a cloud, then the rain [5].

7 Forests as giant biological pumps

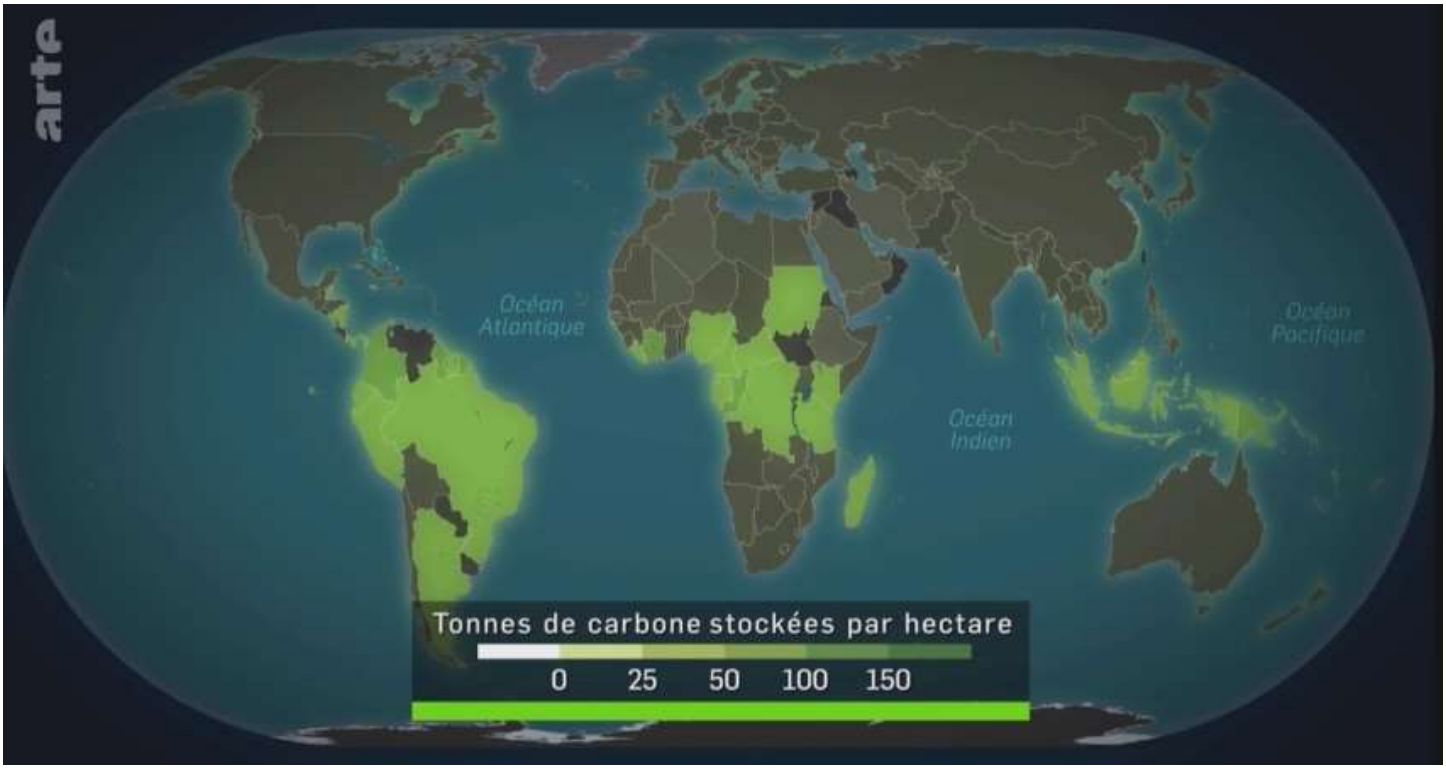
One of the most striking and controversial hypotheses to emerge in the past decade is the notion that intact tracts of rainforest, stretching from coastal regions to inland regions, **can help suck the ocean humidity far inland - functioning as a giant "biotic pump"** [4].

8 Why should forests be protected?

Because:

1) They are a common good for all living beings,
2) They are home to more than 80% of terrestrial biodiversity - that is to say 80% of the species of animals, plants, insects that make up the whole planet, according to the UN.
3) 1.6 billion people (indigenous peoples, etc.) depend on it for their livelihood.
4) Large primary forests limit global warming.
5) They provide construction and firewood (if at least they are well managed),
6) They provide places to walk and relax,
7) They prevent soil erosion,
8) They sanitize the water.
9) By producing oxygen (almost on a par with the oceans), through photosynthesis _ which absorb carbon dioxide (CO2) from the atmosphere and reject oxygen _, they allow us to breathe.

The carbon stock thus trapped by living matter in the forest is called biomass.
This forest biomass is the second largest carbon sink, just behind the oceans.



Tons of carbon stored per hectare,
Source: The underside of the cards, ARTE: A world of forests.

The forests of Amazon, Central Africa and Southeast Asia have the highest density of carbon dioxide stored per hectare. They can store 15 tonnes of carbon dioxide per hectare per year[6]. They are the green lungs of our earth. Now these precious forests are threatened from all sides.

[6] a) By way of comparison, in France, the ADEME institutions and the Ministry of Ecological Transition, over the past few years, have estimated that the average **carbon footprint** of a French person is around 12 tonnes of CO2 equivalents per year. Cf. *Carbon footprint:*

Between 1990 and 2015, 800 forest football fields have disappeared around the world every hour.

When forests decrease, their ability to trap CO2 decreases.
When burned, they release greenhouse gases that are very harmful to the climate.
20% of greenhouse gases come from the destruction of forests.

9 Threats to primary forests (recalls)

The forests have been over-exploited. 40% of deforestation in the world is attributable to four sectors:

1) Palm oil, 2) wood and paper products, 3) soybeans and 4) cattle farming.

Many factors threaten the large primary forests in the world, among others: poverty, which pushes to cut trees, for firewood and charcoal and for the construction of houses, which pushes to clear forests, for slash-and-burn cultivation to recover land for cultivation and for pasture for animal husbandry. Burns are a source of carbon dioxide and livestock a source of methane, two greenhouse gases.

Among the threats, there is also the extension of cities, under the effect of the explosion of the world demography (currently, 50% of human beings live in cities), droughts and fires (forest fires being in increase), insect pests, some trees becoming more fragile due to global warming and droughts.

Droughts, disruption and global warming, caused by global deforestation, risk causing the exodus of millions of climate refugees (fleeing their lands).
In addition, this number may be increased due to terrorist threats (including Islamic threats in the Sahel and others in Africa).

10 The causes of deforestation in Brazil

62% of the Amazon is in Brazil. The causes of this deforestation are:

1) Intensive industrial agriculture: growing soybeans and raising livestock for export.
2) Crops for agrofuels (cultivation of sugar cane, etc.),
3) The construction of roads and dams,
4) Mining,
5) The timber trade,
6) Fires (for clearing…).

Since the election of the Brazilian climatosceptic president, Jair Bolsonaro, on January 1, 2019, all the measures, taken by the previous presidents (Luiz Lula ...), to protect the primary forests, fall. **And in June 2020, more than 9,000 ha of forest had already been deforested, an increase of 85% compared to 2018.**

---

how much CO2 does a French person emit each year? Clément Fournier, 11 décembre 2018, https://youmatter.world/fr/emissions-co2-francais-empreinte-carbone/
b) One hectare of primary forest can permanently store up to 150 tonnes of CO2.

11 The causes of deforestation in the Congo Basin in the DRC

Le bassin du Congo, avec 220 millions d'hectares de forêts, est le deuxième poumon mondial après l'Amazonie.

The large primary forest in the Congo Basin is shrinking because of:

1) Monoculture (mono-forestry) of rubber trees,
2) The illegal trade in precious woods destined for China, the EU and the USA,
3) Poverty: which pushes to cut the forest for the production of charcoal (coal), for obtaining land, for cultivation, by the devastating technique of shifting cultivation on slash and burn.

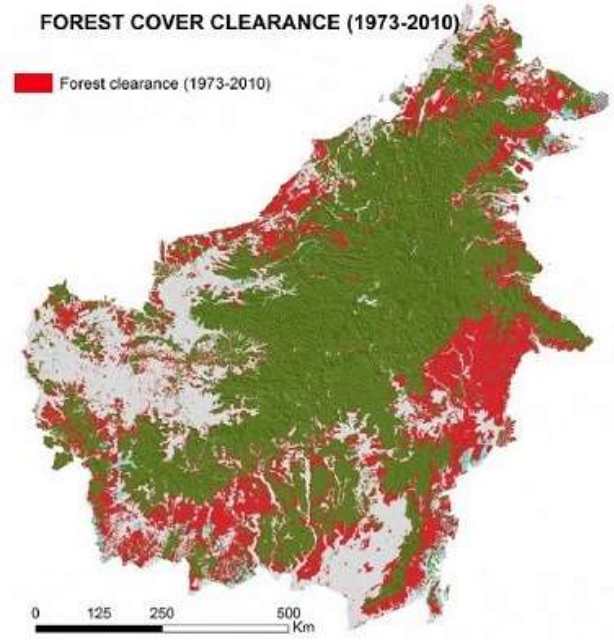
Trees like **Afrormosia** (*Pericopsis elata Afrormosia*)[7], highly prized in the lumber industry and growing in Guinean-Equatorial forests, is in danger of disappearing. The great bonobo monkeys are also in danger.

To avoid this, **poverty should be reduced and indigenous peoples should be relied on for sustainable forest management.**

[7] Cf. https://fr.wikipedia.org/wiki/Pericopsis_elata

12 Deforestation causes in Borneo

Borneo has the highest rate of deforestation in the world. Fire is one of the main causes of deforestation. Nearly a quarter of Borneo's forests (among the richest in the world in biodiversity) have burned at least once in 10 years. Some of these fires are deliberately started by palm oil companies to plant oil palms. While there are four states on the island, and the forest seems to be homogeneous there, as well as the uses of the ground, the fire touches much more the vast region of Kalimantan _ the Indonesian part of the island _ (in average five times as a percentage of total area, over 10 years). In addition, under the El Niño regime, fires only increased in Kalimantan and not in Brunei and Sabah. About 73% of the island is in Indonesian territory. Borneo is a place of great biodiversity, but the regression of the tropical rain forest is a threat to many plant and animal species (including the orangutan). Half of the world's annual tropical timber production comes from Borneo[8].



30% Borneo forest cover clearance, between 1973 and 2010[9].

[8] Cf. a) https://fr.wikipedia.org/wiki/Born%C3%A9o#D%C3%A9forestation_et_feux

[9] *30 % des forêts tropicales de Bornéo détruits depuis 1973*, Rhett A. Butler, 8 mai 2015, https://fr.mongabay.com/2015/05/30-des-forets-tropicales-de-borneo-detruits-depuis-1973/

13 Save forests, reforest

According to the IPCC, one billion trees should be reforested to limit global warming to 1.5 ° C, which are the objectives of COP21 (COP24).

13.1 In China

Since 1978, China has reforested at the borders of the Gobi Desert, in order to limit the advance of the desert (and the desertification of the surrounding regions). The objective of the project was to create a plant belt of 4500 km long, which allowed the return of the rains and to reduce the sandstorms.

The disadvantage is that this *Great Green Wall*[10], intended to fight against the advance of the Gobi desert, was to be made up of a monospecific plantation of poplars and pines, which, because the lack of biodiversity of these plantations, make these trees more vulnerable to diseases and insects[11].

In addition, this green belt has also caused occasional drying of the water tables, because certain selected trees, consuming a lot of water (poplars, etc.) were in fact ill-adapted.

[10] a) *The Green Wall Of China*, 2003, https://www.wired.com/2003/04/greenwall/
b) *Three-North Shelter Forest Program* [Three Forest Shelters / Refuges in the North Program], https://en.wikipedia.org/wiki/Three-North_Shelter_Forest_Program
[11] Cf. https://fr.wikipedia.org/wiki/Grande_muraille_verte_(Chine)

Map of countries having reforested between 1990 and 2015.
Source: The underside of the cards, ARTE: A world of forests.

13.2 In the Sahel

The "*Great Green Wall*[12]" intended to prevent the advancement of the desert in the Sahel and fight against climate change, was launched in 2007. Developed by the African Union, the initiative aims to transform the lives of millions of people by creating a mosaic of green and productive ecosystems in North Africa, the Sahel and the Horn of Africa. Initially designed as a long corridor 15 km wide crossing the entire African continent over 7,800 km passing through 11 countries, this wall should link Dakar (Senegal) to Djibouti; this will represent approximately 117,000 km2, or 11.7 million hectares.

Listed in Senegal, the project produces 1.5 million plants per year.

Many reforestation techniques have been tested there by the Great Green Wall Agency.

To prevent the planted trees from pumping too much water into the groundwater (see bellow):

- Locally adapted species are chosen (*Acacia senegal*), Desert date palm (*Balanites aegyptiaca*) [3] etc.
- The spacing between the trees is 6 to 8 meters.

Depending on the areas of reforestation, project workers, for example, fence 5,000 hectares to prevent cattle from eating the young shoots, but also multipurpose gardens or simply community nature reserves.
Comme 20% des jeunes plants ne prennent pas, des essais de mycorrhization des racines ont été testés avec succès[13].

[12] Cf. a) https://fr.wikipedia.org/wiki/Grande_muraille_verte_(Afrique)
b) https://en.wikipedia.org/wiki/Great_Green_Wall
c) https://www.greatgreenwall.org/about-great-green-wall
[13] Symbiosis between the tree and a certain type of mushroom, which helps the tree to better absorb nutrients from the soil.

1,000 km of firewalls have been installed per year, which employees maintain or open. Firewalls are used to fight bush fires that would destroy young plantations.

Only the Senegalese part has been completed[14]. However, the Islamic terrorist threat, present in the Sahel, prevents its prolongation, in Niger, Mali, Burkina Fasso, Chad ...

13.3 To USA

There have been significant reforestation programs in the United States, although this movement has been curbed, since the election of President Donald Trump on January 20, 2017.

13.4 Other countries

France, Spain and Italy benefit from reforestation programs.
A third of France is covered with forests.
The disadvantage of reforestation in Spain is that it is done to the detriment of traditional forests, by monospecific plantations (monocultures) of eucalyptus, which do not protect biodiversity.

13.5 Mangrove plantation

The Senegalese NGO for the protection of the environment, Océanium, working in collaboration with Livelihoods, restores the mangrove forests in Casamance, by planting millions of mangroves[15].
There are other mangrove restoration programs in Madagascar, Eritrea.

13.6 Planting trees in cities

Planting trees in the city helps fight against:

[14] *What news from the Great Green Wall? Interview with Chérif Ndianor* [chair of the Supervisory Board of the National Agency for the Great Green Wall in Senegal], Pierre Gilbert, March 13 2019, https://lvsl.fr/quelles-nouvelles-de-la-grande-muraille-verte-entretien-avec-cherif-ndianor/

[15] *Senegal : the largest mangrove restoration program in the world* , https://www.livelihoods.eu/fr/projects/oceanium-senegal/

- Urban pollution (they absorb fine particles, etc.)[16],
- The heat in the streets, thanks to their shading effect, and global warming.

We then choose species that will be able to resist heat and global warming (such as the silver linden, the hop charm or ostryer with charm leaves, the flowering ash or ornate etc. ... instead of the chestnut trees, maples that will not resist not global warming).

14 Reforestation is not enough, preserving old-growth forests is essential

There is not the same ecological richness between artificial forests and old forests (the former being much poorer in biodiversity).

The awareness and action of environmental activists has saved:

1) Redwood forests in the USA
2) The primary forest of Bialowieza, UNESCO heritage, located between Poland and Ukraine, saved by environmental activists and a judgment of the European court of justice.

The EU has introduced laws on the illegal timber trade.
The FSC (Forest Stewardship Council[17]) label makes it possible to trace the wood and to guarantee that it has been harvested, respecting the rules of sustainable forest preservation.

We see that there is an EMERGENCY to plant trees in cities where more than half of humanity lives.

Numerous scientific studies demonstrate the beneficial effects of forests on health[18].

15 Impossible to replace old primary forests with forests entirely created by man

A recent study has shown that disappeared primary (old) forests will not be replaced by forests recreated from scratch, even by promoting diversity as much as possible [16], as with the following reforestation methods:

1) that of the Japanese botanist Akira Mirawaki[19], expert in plant ecology,
2) that of "Framework trees" by Stephen Eliott (Chiang Mai University, Thailand).

We will always get recreated forests less rich in biodiversity than old growth forests. So one more reason to preserve the old primary forests.

---

[16] *Xenius -Urban pollution: what if we planted trees?* 26 mn, 2020, https://www.arte.tv/fr/videos/078164-035-A/xenius-pollution-urbaine-et-si-on-plantait-des-arbres/
[17] a) https://fr.wikipedia.org/wiki/Forest_Stewardship_Council, b) http://www.fsc.org/
[18] Y compris via des thérapies psychosomatiques : « bains de forêts » au Japon, « tree hugging » therapy, sylvothérapie.
[19] Cf. https://fr.wikipedia.org/wiki/Akira_Miyawaki

16 Global warming and its possible consequences

Global warming, global warming, global warming or climate change is the phenomenon of increasing average ocean and air temperatures, induced by the amount of heat trapped on the Earth's surface, measured for several decades, due to emissions from greenhouse gases (CO2, etc.). This term commonly designates the global warming observed since the beginning of the 20th century. We frequently come across the expression “climate change” used to designate global warming, whereas in principle climate change designates episodes of natural heating or cooling which occurred before the industrial era. In 1988, the UN created the Intergovernmental Panel on Climate Change (IPCC) to synthesize scientific studies on the climate. In its fourth report, in which more than 2,500 scientists from 130 countries participated, the IPCC says that global warming since 1950 is "very probably" due to the increase in greenhouse gases linked to human activities (of origin anthropic).
The latest projections from the IPCC are that the surface temperature of the globe could increase by an additional 1.1 to 6.4 ° C during the 20th century. The differences between projections come from different model sensitivities for greenhouse gas concentrations and from different estimates for future emissions.

Among its causes, there are anthropogenic carbon dioxide emissions due to tropical deforestation [19] [20].

Multiplication of fires and droughts of great magnitude, over time, including cases never seen:

Location	**Date**	**Extent of damage / Causes**
California	11/2018	Drought has been raging for 10 years in this large state in the western United States.
Groenland	07/2017	Tundra fire. Lots of CO2 release. 15 km2
Alaska	2007 2015	. Tundra fire in 2007. Lots of CO2 released. . 2 million hectares, early 2015.
Russia	07-08/2010 & 2018	. Taiga and bog fire. 800,000 hectares in 2010 due to a heat wave. . 150,000 hectares, Love region, in 2018.
Australia	. 02/2009 10-11/2015 10/2013 12/19-01/20	. More than 231 dead, 365,000 hectares burned and 1,000 houses (Victoria region). . October - November 2015: Bush fires from 2015 to Esperance (More than 200,000 ha). 5 natural reserves and a large part of the Cap Aride national park impacted. . October 17 - 28, 2013: 2013 bushfires in New South Wales (over 100,000 ha): at least 248 buildings destroyed, etc. etc. . More than 5.4 million hectares since September 2019. Exceptional drought.
Amazonia	08-09/2016 01/1998	.12,500 fires, due to severe drought in the Amazon basin in Bolivia, Peru (10,000 ha) and Brazil. Otherwise, these fires are often voluntary. . 600,000 hectares, in January 1998, linked to the cultivation of burns and to an El Niño climatic phenomenon causing an unusual drought.
Indonesia	10-11/2015 09/2019	These fires were mainly located on the islands of Kalimantan and Sumatra, and on the Indonesian part of the island of Borneo. They decimated 26,000 km² of forest[20]. Great forest fires in Sumatra and Borneo[21].
Pantanal22	01-09/2020	16,000 fires started from January to September 2020. In 9 months, the Pantanal has lost 20% to 25% of its wooded area, or 3 to 4 million hectares[23].

[20] *Indonesian fires of 2015*, https://fr.wikipedia.org/wiki/Incendies_d%27Indon%C3%A9sie_de_2015
[21] *Forest fires in Indonesia* [Sumatra, Bornéo], 18/09/2019, https://www.lepoint.fr/video/feux-de-foret-en-indonesie-18-09-2019-2336455_738.php
[22] The largest wetland on the planet, a plain with an estimated area of between 140,000 km2 and 195,000 km2.
[23] a) cf. https://fr.wikipedia.org/wiki/Pantanal#Incendies_de_2020
b) *Le Pantanal, au Brésil, paradis de biodiversité ravagé par les flammes* [The Pantanal, in Brazil, a paradise of biodiversity ravaged by flames], 29/09/2020, https://www.lemonde.fr/planete/article/2020/09/29/le-pantanal-paradis-de-biodiversite-ravage-par-les-flammes_6054087_3244.html

17 Assumption of droughts causing the end of civilizations because of too much deforestation?

According to an international team, the northern tropical zone experienced a period of severe drought between 700 and 900 AD, curiously simultaneous with the fall of two great civilizations, the Mayas, in Mexico, and the Tang dynasty, in China [16] .

An unscientific hypothesis that I put forward, is that too much deforestation, especially of a large primary forest, in a given region, can cause serious droughts there, by the end of the phenomenon of evapotranspiration in this region.

I wonder if dramatic droughts, caused by the demographic increase of the populations of certain civilizations - these inducing a vast deforestation - were not the cause of their fall [17]?

17.1 Mayan civilization

The geochemical archives of a lake in Yucatán, in the middle of the Mayan country, keep traces of a prolonged drought at that time. This is perhaps one of the main causes of this collapse. ... The Mayans were not united and the population was divided into city-states, often at war with each other
The study of gypsum has made it possible to firmly establish that annual precipitation has decreased from 41% to 54%, with peaks of reduction of 70% during the period when the Mayan civilization collapsed [15] [16].

The hypothesis of environmental degradation due to agricultural activities

As the population continued to increase, the system would have been pushed to its limits. In a more elaborate form of theory, demographic pressure would have forced the Mayans to find new arable land, clearing more and more fragile land on the hillsides, like in Copan. Deforestation would then be accompanied by erosion and rapid depletion of the soil [11] [12] and [13].

17.2 Khmer Empire

Several factors have been proposed to explain the decline of the Khmer empire: wars, the arrival of Theravada Buddhism, changes in trade routes, overcrowding, ecological constraints ...

The work of Mary Beth Day, University of Cambridge, in Britain, and colleagues **support the thesis of the role played by climatic fluctuations. Analyzes also corroborate drought episodes** (in the 14th and 15th centuries) which had been deduced from the study of tree rings in Vietnam. These events alternated with unusually heavy rain periods [14].

17.3 In partial conclusion concerning this hypothesis

The hypothesis of a change in the precipitation regime, caused by excessive deforestation, which is at the origin of the collapse of great civilizations (Maya, Khmer, etc.), is only a hypothesis. Probably, the causes remain multiple.

18 Conclusion

Before thinking that we are going to realize the jackpot, by replacing large primary forests (old), by crops for export _ soybean crops, grazing for the breeding of beef cattle, palm plantation to oil (in Indonesia, Borneo…) _ we must think carefully about the impact on the local climate that such destruction would cause.

In the appendix, I have presented solutions to economically develop large primary forests without destroying them.

"When they have cut down the last tree, polluted the last stream, caught the last fish. Then they will realize that money cannot be eaten". Sitting Bull.

19 Bibliography

19.1 Videos and documentaries

[1] Large format science: *The genius of trees* (documentary), directed by Emmanuelle Nobécourt, © Hauteville Productions - INRAE, 2020, 93 mins, https://www.france.tv/documentaires/science-sante/1452709-le-genie-des-arbres.html & https://www.franceinter.fr/emissions/capture-d-ecrans/capture-d-ecrans-14-mai-2020

[2] The documentary series: History of trees.
a) The survivors[24], 45 min, 2017, https://www.youtube.com/watch?v=xi89cLQifDk
b) on VOD, at 2 € 99, https://boutique.arte.tv/detail/histoires_arbres_S02
[3] The documentary series: *Planète sable*:
a) *Sahara, reclaiming lost lands*, Author Thierry Berrod, Director Paul-Aurélien Combre, 2017, 44 min, https://www.arte.tv/fr/videos/053446-005-A/planete-sable/

[4] The underside of the cards, ARTE (documentaries):
a) *A world of forests*, 13 mins, https://www.arte.tv/fr/videos/091146-017-A/le-dessous-des-cartes-un-monde-de-forets/
a2) *Forest a common good*, https://www.facebook.com/watch/?v=1233960743602522
d) History of Forests: France *(1/2)*.
https://boutique.arte.tv/detail/le_dessous_des_cartes_histoire_des_forets_la_france_1
c) *History of forests: Europe and the world* (2/2),
https://boutique.arte.tv/detail/le_dessous_des_cartes_histoire_des_forets_europe_et_le_monde_2
d) *State of the forests* (1/3), https://boutique.arte.tv/detail/dessous_des_cartes_etats_forets_1
e) *the timber trade* (2/3), https://boutique.arte.tv/detail/dessous_des_cartes_commerce_bois
f) *Forests and climate* (3/3), 2010. 3/ https://www.youtube.com/watch?v=1DcSamDWJZ0

[24] "Tree Tales" leads us to the discovery of remarkable trees, through those who protect them. This section features two surviving trees: a giant sequoia tree in California, which escaped felling thanks to the combat at Julia Butterfly Hill, and a centuries-old juniper tree found in Japan.
In Redwood National Park, California, a giant redwood tree escaped slaughter thanks to Julia Butterfly Hill, who lived two years at the top to save it. On the other side of the Pacific, a few hundred kilometers from Tokyo, a centuries-old juniper grabs the attention of the bonsai master Shinji Suzuki. These two surviving trees, one giant, the other dwarf, illustrate the resilience of nature thanks to the exceptional commitment of two people.

[5] Documentary "*The Flying Rivers*", Director Aurélien Francisco Barros, 52 minutes, 2017 (Ushuaia, TV), https://www.festivaldufilmvert.ch/fr/suisse-romande/communiques/rivieres-volantes-remporte-prix-tournesol-du-documentaire-vert-2019
[6] The "flying rivers" of the Amazon threatened, Gérard Moss (Swiss pilot), 2014, 1h43,https://www.youtube.com/watch?v=xDzq8C5rcxs

19.2 Articles

[7] What are the *"Flying rivers", this incredible phenomenon created by the trees of the Amazon? SCIENCE This is a little-known and yet crucial role: the Amazon sends considerable masses of water vapor and aerosols essential to the formation of clouds into the air. A documentary, broadcast on Ushaïa TV Sunday evening, retraces these flying rivers… Fabrice Pouliquen, 11/26/17,* https://www.20minutes.fr/planete/2174375-20171126-quoi-rivieres-volantes-incroyable-phenomene-cree-arbres-amazonie

[8] *Flying river*, https://www.wikiwand.com/en/Flying_river

[9] Sahara: What if man had caused his desertification? STUDY The deforestation of the "Green Sahara" by tribes of breeders in the Neolithic era would have contributed to transform the region rich in vegetation into a desert… 16/03/17, https://www.20minutes.fr/planete/2032339-20170316-sahara-si-homme-cause-desertification

[10] Forests decreased by almost 300,000 km2 worldwide in 2016, a record year. DEFORESTATION A report by the NGO Global Forest Watch is alarmed by the decline in global forest areas in 2016 ... 24/10/17, https://www.20minutes.fr/planete/2157211-20171024-forets-diminue-pres-300000-km2-monde-2016-annee-record

[11] a)Have the Mayans succumbed to prolonged drought? Laurent Sacco, 08/17/2018, https://www.futura-sciences.com/planete/actualites/terre-mayas-ont-ils-succombe-secheresse-prolongee-10190/
b) Has a drought got the better of the Mayans? Jean-Luc Goudet, 05/01/2007,https://www.futura-sciences.com/planete/actualites/terre-mayas-ont-ils-succombe-secheresse-prolongee-10190/

[12] Extreme droughts are behind the collapse of the Maya. New data confirms the role of climate in the disappearance of classical Mayan civilization. Bernadette Arnaud, 07/08/2018, https://www.sciencesetavenir.fr/archeo-paleo/archeologie/des-secheresses-extremes-sont-a-l-origine-de-l-effondrement-des-mayas_126539

[13] Collapse of classical Mayan civilization,
https://fr.wikipedia.org/wiki/Effondrement_de_la_civilisation_maya_classique

[14] Angkor, between droughts and torrential rains. The decline of Angkor is due, at least in part, to the extreme variability of weather conditions to which the Khmers have not been able to adapt their hydraulic network, however very elaborate, Loïc Mangin, 04/01/2012, https://www.pourlascience.fr/sd/archeologie/angkor-entre-secheresses-et-pluies-torrentielles-11187.php

[15] *Do forests function like 'biotic pumps' for rainfall*,
http://alert-conservation.org/issues-research-highlights/2014/2/10/do-forests-function-like-biotic-pumps

[16] *Miyawaki forests are no substitute for natural ones: Experts. The Japanese technique of growing dense plantations in a short time is being used by activists and cosmpanies to increase green cover[The forests of Miyawaki do not replace natural forests: according to experts. The Japanese technique of growing dense plantations in a short time is used by activists and companies to increase green coverage]*, Tushar Kaushik, Jun 13, 2019, https://www.google.nl/amp/s/m.economictimes.com/news/politics-and-nation/miyawaki-forests-are-no-substitute-for-natural-ones-experts/amp_articleshow/69766810.cms

[17]Human influence on the climate, Benjamin LISAN, 3/10/05, http://benjamin.lisan.free.fr/jardin.secret/EcritsScientifiques/climat/InfluenceHommeSurClimat.htm

[18] Forest gardens _ humid tropical climates. Tropical agroforestry, Agro-forests. Landscaping of forest gardens and forested forests. Humid tropical climates (in Africa, Madagascar, Central and South America, Oceania, Asie tropicale …), B. LISAN, 22/03/2015, 67 pages, http://www.doc-developpement-durable.org/documents-agronomiques/jardins-forets_climats-tropicaux-humides.pptx

19.3 Books, magazines

[19] Collapse: How societies decide their disappearance or their survival, essay by the American writer Jared Diamond published in 2005 and translated into French, Gallimard, 2006, https://fr.wikipedia.org/wiki/Effondrement_(essai)

[20] *1491: new revelations about the Americas before Christopher Columbus*, Charles C. Mann, 2005, Albin Michel, 2007.

[21] a) The life of trees, Francis Hallé (botanist), Bayard Culture, 2011.
b) "Advocacy for the rainforest", Francis Hallé, Actes Sud, 2014.
c) "Advocacy for the rainforest", Francis Hallé, Actes Sud, 2005.

[22] CARTO magazine n ° 54: The future of animals, July / August 2019.

20 Annex: Associations defending primary forests or rain forests

(1) Sanctuary forest, http://sanctuaryforest.org/
(2) Rainforest alliance, https://www.rainforest-alliance.org/
(3) Rainforest action network, https://www.ran.org/
(4) Rainforest foundation, https://rainforestfoundation.org/
(5) Rainforest trust, https://www.rainforesttrust.org/
(6) Rainforest rescue, https://www.rainforest-rescue.org/about-us
(7) Rainforest concern, https://www.rainforestconcern.org/
(8) Amazon Watch, https://amazonwatch.org/
(9) Amazon Conservation Team, https://www.amazonteam.org/
(10)Amazon Conservation Association, https://www.amazonconservation.org/

Source : *7 Organizations You Can Support to Protect the Amazon Rainforest*, https://www.globalcitizen.org/fr/content/organizations-donate-amazon-rainforest/

21 Annex: solutions to develop large primary forests economically

The idea is to "intensify" there edible plants and trees useful for humans, without destroying the biodiversity of the primary forest (see book 1491, by Charles C. Mann [20]). To garden the primary forest.

Under the forest cover of a primary forest, we can grow rain-bearing plants (coffee trees, cocoa trees, peppers, gingers, guava trees etc.).

How to harvest the fruit (on trees which can exceed considerable sizes)?

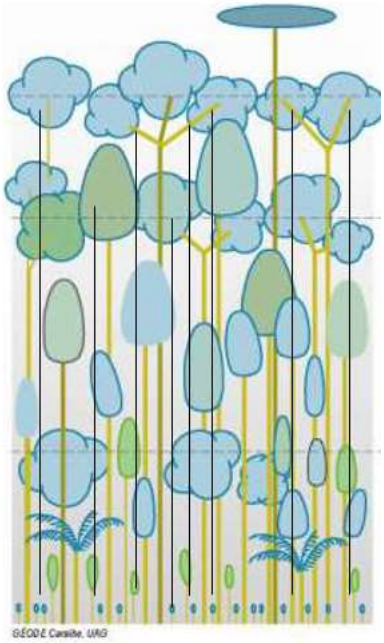
- It should be ensured that the local populations can live on it, no longer necessarily as a hunter-gatherer, but as a “gardener”, from this forest, which would favor certain plants or trees with edible fruits or vegetables, but without destroying the rest of the biodiversity of the place (with a view to sustainable development). It is a question of education and development of ecological awareness and limiting the demographic pressure on the environment.
- These "gardeners" would garden and gather with the help of ladders, tree climbing devices, rope bridges, long poles or sapling equipped with shears or lassos or grippers for picking up objects to distance, actuated by a handle located at the bottom of the pole ... or a vibrating device which causes the fruit to fall into nets (but also insects for that matter) or the fruit falls, itself.
- Against pests, they would only use natural biological control and the plant companions already existing in this forest and using it for its benefit.

The choice of the method and the height of harvest and the time spent can condition the comfort at work.

<table>
<tr>
<td> 
Zipline
  </td>
<td> 
 
Rope ladders (tree climbing)</td>
<td> 
Bamboo scaffolding</td>
<td> 
Bamboo scaffolding</td>
</tr>
<tr>
<td> 
Climbing claw solution (climbing) ↑↓ ↗→</td>
<td>  </td>
<td> 
Harvester monkey or macaque solution (can this operation be carried out by a maki catta ?)</td>
<td> 
Rope bridge</td>
</tr>
</table>

			 Lianas bridge

Different solutions to access the fruits.



Nylon strings or kevlar lines are attached to the high branches of the canopy, installed by a rope access technician (pulling on the strings, which move the fruit branches, you can then drop the fruit).

21.1 Example of fruit forest, garden

↗ The edible forest copies the characteristics of forests, such as the occupation of space in strata (large trees, shrubs, lianas, etc.) and of time (ecological succession), to have their properties (resilience, stability, etc.) while having a more abundant production directly useful to Man (fruits, nuts ...), thanks to the choice of edible varieties. Plants used here: Papaya, Nikau palm (Rhopalostylis sapida, badger palm), Tropical guava, Ginger, bignay or "tropical cranberry" (Antidesma bunius), peppers (Capsicum), eggplant, basil, rosemary, broccoli, beet, tomatoes (in English: Papaya, Nikau, Tropical guava, Ginger, Cranberry, Capsicum, Eggplant, Basil, Rosemary, Broccolli, Beet Root, Tomatoes). Nursery greenhouse (English: Propogation house).
Source : http://revolution-lente.coerrance.org/permaculture.php

21.2 Examples of fruits that can be grown in the Amazon rainforest et du bassin du Congo

 *Custard apple (Annona reticulata)*	 Sugar-apples or sweetsops (*Annona squamosa*) / Sugar-apple "zat"	 Cattley guava (*Psidium cattleianum*) **O**	 Papaya (*Carica papaya*)
 Kaffir lime (*Citrus hystrix*)	 Graviola or soursop (*Annona muricata*)	 Graviola or soursop (*Annona muricata*)	 Tamarillo or tree tomato (*Cyphomandra betacea*)

 passion fruit or maracujá (*Passiflora edulis*) (flower and fruit)	 Fruits of the Arabian coffee tree (*Coffea arabica*) **O**	 Cocoa bean (*Theobroma cacao*) **O**	 Cape gooseberry, goldenberry, physalis (*Physalis peruviana*)
 Jackfruit (*Artocarpus heterophyllus*)	 Seagrape or baygrape (*Coccoloba uvifera*)	 Java plum, Rotra (*Syzygium cumini*)	 Asian raspberry (*Rubus rosifolius*)
 Yam (gender) *Dioscorea)*	 Cassava (*Manihot esculenta*)	 Yam (*Ipomoea batatas*)	 *True sago palm (Metroxylon sagu)*
 (Use of Molucca bramble or broad-leaf bramble (*Rubus alceifolius, Rubus moluccanus*), if the species has already invaded the forest).	 Oil palm tree (*Elaeis guineensi*)	 Coconut tree (*Cocos nucifera*) (à voir)	 Ambarella or June plum (*Spondias dulcis*)
 Mango (*Mangifera indica*)	 Avocado tree (*Persea americana*)	 Durian (*Durio zibethinus*)	 Duku (*Lansium domesticum*)
 Petai (*Parkia speciosa*)	 Seeds and sap of the doub palm, palmyra palm, tala palm, toddy palm, wine palm, or ice apple (*Borassus flabellifer*)	 Biriba (*Rollinia deliciosa*)	 Mombin plum (*Spondias mombin*)

 Acerola cherry (*Malpighia emarginata*)	 Acerola (suite)	 araçá (*Eugenia stipitata*) **O**	 araçá (suite)
 Acai berries (*Euterpe oleracea*) **O**	 Caju, cashew nut (*Anacardium occidentale*)	 Camu-camu (*Myrciaria dubia*) **O**	 Camu-camu (suite)
 **O** Capuacu - cocoa tree (*Theobroma grandiflorum*)	 Cuatrec (*Endopleura uchi*)	 *Endopleura uchi* (suite) **O**	 Inga pod (*Inga edulis*) sweet peas, Pacaye, sucrin **O**
 Goyaves (*Psidium guajava*)	 Murici *(Byrsonima crassifolia*) **O**	 Palm-peach (*Bactris gasipaes*) **O**	 Palm-peach or tapereba **O**
 Bacuri (*Platonia insignis*) **O**	 Bacuri (suite)	 Kola nut (*Cola acuminata*)	 Pitaya (*Hylocereus undatus*).
	 Grenadella (*Passiflora ligularis*)	 mamón, cotoperí *(Melicoccus bijugatus)*	

 Grenadilla(*Passiflora edulis*)			Brazilian walnuts or from amazonia (*Bertholletia excelsa*)
  Yellow pitaya with white flesh (*Selenicereus megalanthus*)	  Bread nuts or Mayan walnut (*Brosimum alicastrum*)	  Cajá, mombin plum (*Spondias mombin*)	  Guaraná (*Paullinia cupana*)
 Aguaje, tarpaulin palm (*Mauritia flexuosa*)	 Bilimbi (*Averrhoa bilimbi*) Biri-biri	 Carambola, star fruit or five-corner (*Averrhoa carambola*)	

Examples of fruit trees that may be present in the primary forested garden.
Analyze by botanists and scientists and see if their introduction in another forest could be without risk.
Source: MADATRANO, http://www.madatrano.com/PBSCCatalog.asp?CatID=752749 & http://www.baobabs.com/Fruitiers.htm

O : Rain plants.

Source: *Forest gardens _ humid tropical climates. Tropical agroforestry, Agro-forests. Landscaping of forest gardens and forested forests. Humid tropical climates* (in Africa, Madagascar, Central and South America, Oceania, tropical Asia, etc.), B. LISAN, 22/03/2015, 67 pages, http://www.doc-developpement-durable.org/documents-agronomiques/jardins-forets_climats-tropicaux-humides.pptx

The nut-bread or Mayan walnut tree (*Brosimum alicastrum*[25]) can be more than 50 m tall and produce more than 180 kg of nuts, each year, which, prepared like chestnuts, will taste like chestnuts. You can make bread with the flour from these nuts. This tree, with deep roots, can grow on all types of soil, even very poor, even salty soil. It is drought tolerant. It plays a key role in protecting biodiversity. It remains productive for 120 to 150 years.

[25] Cf. http://benjamin.lisan.free.fr/projetsreforestation/Fiche-presentation-Brosimum-alicastrum.pdf

Inga (*Inga edulis*[26]), from the legume family (*Fabaceae*), a tropical forest tree, around 30 m tall, fast growing, producing pods, with edible sweet pulp, called sweet or sweet pea. This sweet pulp, whose taste is reminiscent of vanilla ice cream (hence the English name of "*ice cream bean*"), is generally eaten raw. This tree can grow on all types of soil, even very poor soil. It is also remarkably resistant to drought and cold, reproducing in regions with a drought of 6 months. Inga edulis have been introduced into many tropical regions around the world, including Africa, Madagascar and the West Indies.

As certain tropical fruits, however delicious, do not keep well, we could then export them in frozen foods, sorbets, jams, fruit juices, smoothies ... (or even dried fruits, when possible).

21.3 Be careful when planting non-native plants

You must be careful in choosing and mixing the species to plant there (even if they are useful and edible):

- For example, **gingers**, especially wild ones (which can be delicious and which are often very popular with local populations), can be invasive. You have to know how to control them, for example, by regularly removing its roots / rhizomes (perhaps to be sold on the markets).
- The aromatic plant, **Perilla** (Vietnamese mint), can also be invasive.
- The **winged yam or large yam** (*Dioscorea alata*) variety can also be invasive.
- Normally, it is better to use species [of key trees] which already grow on site and which promote and attract biodiversity (ie birds, insects, fruit bats…, and all animals likely to disperse , transport seeds from other plants).

Source : http://www.invasive.org/weedcd/species/5535.htm

Table des matières

[26] Cf. *Projet de création de forêt littorale jardinée*, B. LISAN, page 91 / 177, http://www.doc-developpement-durable.org/documents-agronomiques/projet-de-creation-de-foret-littorale-jardinee.pptx