Unraveling the landscape. What do the Brazilian tropical biomes show us?

Before the adoption of any agricultural practice it is important to take into account the geographic context where the production will take place. Practices adopted in the temperate climate will not always be suitable for the tropical climate. Thus, for the construction of the ART methodology, we took into account the characteristics of the tropical landscape. The posture adopted was the Goethean, starting from the macro – the planet Earth – to the micro – the wet tropical Brazilian climate.

The path taken to the conclusion that the tropical landscape points to an agroforestry organism will be presented next.

I - The geography of the Northern and Southern Hemispheres: the proportion of land x water

The comparison between the two hemispheres reveals the action of important evolutionaries forces. Those forces point to different directions in each one of the hemispheres:

Continental shape Observations	North hemisphere	South hemisphere
Geography: How does the continental masses show up	Predominance of large and interconnected continental lands, which point to the North direction. Europe, Asia and Africa, separated from North America, only by the Bering Strait .	Continental lands squeeze towards the South. The lands are isolated by seas, which separate the continents: South America, South Africa, Indonesia and Australia. Even the continental masses of India and Southeast Asia taper to the south, indicating a pattern.
The ocean: size and forms	Smaller and segmented seas shaped like bays and straits; often the salt water overpasses the continental masses. Species such as the brown bear spread across several continents: North America, Europe, and Asia.	Larger and impassable seas for animals and plants lead to an evolutionary "individuation" of the species in each continent. Ex. Araucaria, which evolved into different species in Brazil, Chile and Australia; or the evolution of the jaguar in BR x the evolution of the leopard in Africa
Proximity to the Tropic	Strictly speaking only part of Africa, Central America, India and Southeast Asia are close to the tropics; a proportionately minority area of land in the Northern Hemisphere is close to that region.	Basically all Latin America, South-Central Africa and Australia are close to the tropics. The proportion of land in the Southern Hemisphere close to this region is the majority.
Proximity to the Poles	The mainland gets closer to the North Pole from all sides, the cold climate landscapes predominate.	The South Pole is distant from the continental masses of the Southern Hemisphere, but acts on them through cold and rainy fronts.
How does rains show up	The continental climate prevails with weak rainfall. Rare exceptions.	Abundant rains predominate, except in Australia and small parts of Southern Africa and Latin America.

Landscapes and biomes	Frequent steppe and desert landscapes: Hungary, Ukraine, Asia, North Africa and the Upper Midwest in North America.	Frequent presence of forests: Amazon, Southeast Asia, Indonesia, Congo Basin and Central America.
Evolution of the evolution (sum vector of all aspects): resulting in animal and plant evolution	Slowed evolution of plants, but accelerated evolution of animal	Accelerated and symbiogenic evolution between plants and animals, forming aggregates of varied magnitudes.

ART research and formulation: the reasons for the differences between the vegetation in the Northern and Southern Hemispheres.

1. The distance from the Equator / Warmth influence:

The warmth is a characteristic of the equator region. The distance of the continental masses of the Northern Hemisphere from the equator is the reason for the slow evolution of forest which is expressed in little biodiversity and reduced vegetation size.

The proximity of the continental masses of the Southern Hemisphere from the Equator brings the stimulus of heat necessary to intensify the forest evolution in that hemisphere.

2. The presence of great extension of water / Moisture influence:

The large continental extensions of the Northern Hemisphere divert the mainland from the sea fluidity and humidity. The result is a simplification and standardization of the vegetation which leads to the savanna or desert-steppe landscapes. Consequently the agriculture practices follow the savanna inclination, being even dependent on ruminant breeding. Typical of this region.

The continental masses in the Southern Hemisphere blend themselves with the seas. It allows the moisture to flout through extensive areas resulting in frequent and abundant rains. The flow of water favors the evolution of forests, consequently agriculture has an agroforestry vocation.

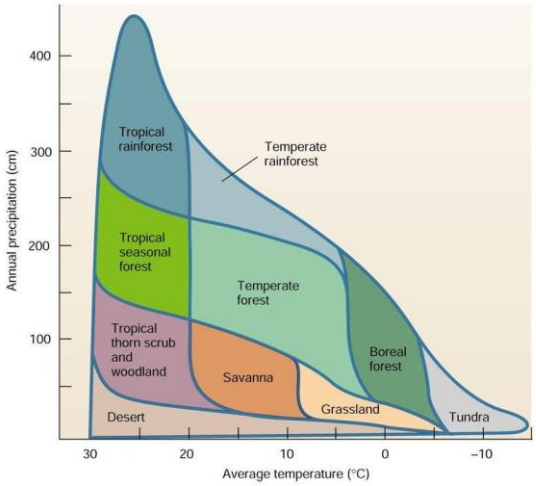
3. The Landscape evolution/ Symbiosis influences

In the lands of the Southern Hemisphere, where the climate is warmer and rainier, life processes are more intense. Consequently, the evolution of landscapes is also faster and more complex. The mutualistic and symbiotic relationships take a leading role in the evolution of tropical forests, where the diversity and interaction among the species are greater than in the steppe-savanna landscapes of the Northern Hemisphere. When forests are present in the Northern Hemisphere they tend to form monocultures, such as the large coniferous forests.

The plant evolution along continental extension, reveals itself as a great evolutionary metamorphosis: the more intense the heat, accompanied by sufficient precipitation, the greater the size of the trees and the biodiversity.

II - The emergence of different biomes as a consequence of precipitation and heat interaction

Below is an illustration of the relationship between the shaping of large biomes according to temperature and precipitation.
For more details on the transition among biomes, see Annex I.



Source: www.mugansbiologypage.com , adapted from Whittaker

Bringing this information to the Brazilian Tropic, we find equivalences between those biomes and the Brazilian ones. But with some particularities:

- Tropical rainforest = equivalent to the Amazon perhumid rainforest and to the Atlantic Forest;
- Tropical seasonal forest = equivalent to the Cerrado, but with particularities*;
- Tropical thorn scrub and woodland = equivalent to the Caatinga;

*The Cerrado is a forest burned frequently. It is extended over very well-drained plateaus and has a typical quality that is an evolutionary adaptation to fire. The plants have underground trunks or aerial trunks with a thick layer of cork.

The combination of tropical heat and regular and abundant rains in almost all Brazilian territory leads to a high biodiverse and mutualistic forest evolution. It is a characteristic of the Brazilian landscapes even in precarious edaphic conditions (soil characteristics).

III - The polarity between the Savanna and the perhumid Forest

When comparing the Savanna, typical of the African Continent, and the South American Peruvian Rainforest we observe that despite being in a similar latitude, they presented different evolutionary aspects.

The ultimate expression of the African Savannah is its large fauna. Each one of the herbivores, notably the ruminants, forms an emancipated being. They have a ruminal microbiota with an incredible capacity to digest fibrous grasses. Later, they are food for an extensive chain of carnivorous animals.

Everything indicates that the great distribution of rains in the Peruvian Forests allowed the trees and small animals to evolve while large animals occupied the dry and open Savannah.

Thus, large animals are replaced by an immense Forest mosaic composed of trees, lianas and Epiphytes associated with social insects and small vertebrates (reptiles, birds and mammals). It is in this environment that the soul of the Tropical landscape realizes itself, just as the soul of the Savannah is revealed in large animals.

Below a comparison of the characteristics of the fauna and flora of the Savannah x Peruvian Forests

	Savannah	Perhumid Forest
Number of animal species	116 large species of animals, including mammals.	Only in the Amazon there are 300 species of mammals, not including other classes.
Animal species	Many ruminants and ungulate animals (with hooves)	Few ungulates, but many small mammals, many species of birds and reptiles. Many animals with frugivorous and insectivorous food habits.
Landscape overview	Open landscape, predominance of tropical grasses.	Dense forests with no grasses
Flora in the riparian forest	Predominance of trees	Predominance of palm trees
Predominance of fauna or flora	Territories demarcated by large animals: lions, rhinos, elephants.	Territories demarcated by plants. Only in the Amazon there are 70.000 species of gymnosperms and angiosperms. It means 850 species in 1 ha, possibly 2000 in 10 ha.
Symbiotic relationships	Large animals as a closed emancipated organism. The symbiotic relationship takes place into their organism, into the rumen.	Rainforest as a semi-open organism, rich in species including many human-beings. Many mutualistic relationships among species.
Historical human habits	Human beings from ancient times with nomadic habits	In the Amazon villages with 11 million inhabitants were formed in the past, with the presence of many roads and waterways.

The characteristics of each landscape point to an agricultural vocation. While the Savannah agricultural organism is suitable for cultivated pastures and cereals, usually in monoculture; the Perhumid agricultural organism indicates a vocation for agroforestry systems. The proper agriculture management in the savannah is crop rotation, while in the ~~n~~ perhumid organism, the emphasis is on polycultures. *The herb-fruit-forest organism is the great inspiration of* ART.

IV – The tropical forest as a plant-animal-human organism

In addition to high temperature and water disponibility, biodiversity is another characteristic that draws attention to Tropical Biomes. The variation in the number of species is huge. Heat and rain are factors that multiply exponentially the number of species.

BIOMES (from the coldest to the hotter and wetter)	PLANT	MAMMALS	BIRDS	SOCIAL INSECTS
Tundra	20	48	400	0
Taiga	40	85	550	14
Broadleaf forest	8.000	140	1500	150
Mediterranean vegetation	8500	30	700	180
Desert / Sahel	4000	70	100	220
Dry savannah and Wet Savannah	40.000	220	2000	450
Perhumid Tropical Forest	190.000	550	4000	700

Source: Manfred von Osterroht, 2017: calculations and estimates after years of studies and research.

Qualitative Biodiversity: Mutualistic Symbiosis

The greater the diversity, the greater the interaction among species. The tropic's biodiversity grows not just quantitatively but also qualitatively. It is expressed by the mutual support among species by joining plants, insects and animals in small "teams". Together, they form communities or circles of interconnected and complex companionship. They are stable as they are dynamic.

It is essential to characterize these interactions which are: long-lasting, mutual and beneficial to everyone. They last so long that they lead to a co-evolution, when configuring mandatory relationships.

ART research and elaboration: mutualism acting as alchemical preparations

1. In a simple and generic way we can say that, in the tropics, no living-being lives by itself, one species helps another. An example is the *Araucaria angustifolia*, which is almost always accompanied by the *Podocarpus spp* and frequently by the bracatinga (*Mimosa scabrella*), as observed in Southern Brazil and in the Mantiqueira chain of mountains. Besides that, they are dispersed by birds, rodents and monkeys being in relationship with those species. The reason for those and other relationships still need to be better studied. The fact is that they do occur. It is only necessary to take a close look at the landscapes to notice.

2. The more tropical and forested a landscape, the more its species prefer to be surrounded by different beings. An example is the Juçara (*Euterpe edulis*) which is usually seen growing encircled by dozens of different families and hundreds of species. It never appears alone in a spot as do the nettles of the Temperate climate or the grasses of the Savannah.

3. Sometimes a new multiple being appears. It means: a living being associated with others transforming themselves in just one. That is the case of Embaúba (*Cecropia spp*), a myrmecophyte which lives in symbiosis with *Azteca spp* (ants) forming a unique organism. The Embaubá provides shelter and food to ants. The ants, in turn, defend the

host plants against attack by herbivores and climbing plants. We can say that they are on the path to symbiogenesis (Margulis).

Those characteristics of the humid Tropic point to distinguished processes that promote food quality. The evolution of the humid tropics indicates a transition from alchemical to living preparations: living beings acting on other beings in the context of an agroforestry organism. The strengths of the alchemical preparations are introduced by other suitable relationships in the context of mutualistic associations.

V - The Animal Gesture: shape and behavior in different biomes

The size and food habits of the animals are an expression of the landscape as shown in the table below. Europe, Asia, North America and Africa are characterized by having medium and large herbivores which live in meadows and savannas. In Brazil, medium to small animals that live in forests predominate. Those forests are sometimes denser and other times thinner.

Landscape elements	Europe	African and Asia	Brazil
Size of predominant fauna	Medium to large	Large	Small to medium
Medium to large herbivores	Cattle, equine, mule, red deer, moose, musk ox, reindeer.	Antelopes, gazelles, wildebeests, zebras, giraffes, buffaloes, rhinos,	Tapir is the biggest; all others are smaller.
Usual Landscapes	Grassland, meadows and forests.	Desert, dry and wet savanna, and forests.	Dry and wet forests
Preferred habitat of most quadrupeds	Ground, meadows and forests.	Open savanna	Tree tops, the canopies themselfs
Pastures for oxen, goats, horses and donkeys.	Native and planted	Grasses from savanna	Planted pastures with grasses imported from the African savanna.
Effect of large herbivores in the forest	Coexist harmoniously	Generate open and savannah spaces	They damage and destroy the entire underwood. They compromise the entire ecology.
Carnivorous species	bear, lynx and wolf	leopard, lion and tiger	Jaguar, Ocelot and Moorish Cat
Carnivorous ants food	Feed insects	insects and small vertebrates	Insects, small and medium vertebrates
Bees	Predominance of *Apis sp*; few subspecies	Predominance of *Apis sp*; few subspecies	Predominance of meliponines (stingless bees): 300 species.

<u>ART research and elaboration:</u>

1. Ruminants and horses play an important role in European culture. Since the beginnings of farming cattle, mules and horses have been present in the landscapes. We see them represented in the oldest cave paintings on the Iberian Peninsula. In North Europe other ruminants are present such as the Scandinavian elk, musk ox and reindeer.

2. In Africa the herbivores, antelopes, gazelles, zebras, wildebeests, buffalos and rhinos are herds, giraffes and elephants are seen across the savanna landscape.

3. The largest Brazilian land herbivore is the tapir which is the size of a calf and lives in riverside forests. Much of the Brazilian fauna is small and agile and inhabits the tops of trees, rarely stepping on the ground. There are few ungulate animals (with hooves). Birds, reptiles and arboreal mammals predominate.

4. Some surprises when observing social insects. Army ants form gigantic mobile colonies. Considering the colony one being, it is among the largest carnivores in the forest, being dangerous even to humans. One colony could be considered a proper phalanx capable of devouring an animal in a few minutes. They do not live at fixed spots. They migrate according to forest cycles. They make their nests with their own body. Are they the equivalent of the lion or the tiger, representing the great carnivore of the forest? If it is the case they still preserve the agility of small size animals.

5. Among bees the meliponines are a bigger surprise. Hundreds of stingless species adapted to different parts of the forest mosaic. Why did the evolution of bees in the forest go in the direction of losing the stinger? They left behind an important defense tool which is kept in the bees outside the forest environment. Nowadays we understand that each small mosaic in a forest has its own defense structures releasing the bees from the sting. And if present it is atrophied. The defense of each mosaic is done by other beings and so they live in cooperation. Another consequence of this evolution is the tiny size of the colonies and of each individual insect.

If each mosaic piece defends its bees and if it is complete in itself then each mosaic is a forest organism at the same time open and closed in itself. Each part of the mosaic has specific plants, animals and human elements. Humans cannot be left out. The Amazon sheltered a vast indigenous culture for millennia. It was once inhabited by 11 million indigenous, according to estimations. Landscapes without humans are rare. The most common in tropical forests is the indigenous culture associated with the evolution of forests.

VI – The management of the cultivated Brazilian Tropical landscape

The Brazilian landscape shows archetypal evidence that calls for an agroforestry organism. Instead of grazing cattle as successors to the forest, which would be an evolutionary setback, the evolution points to a community of trees and shrubs with birds, insects and all arboreal fauna.

European teachings do not fit into the Brazilian landscape in an organic way and they are not proving to be promising. It seems that the Brazilian Tropical landscape rejects European agriculture due to the lack of both a productive and cultural sense. More than moving towards tropical evolution, agroforestry is in

line with the cultural aspect, being very well accepted and understandable to most Brazilians.

1. Guidelines for designing an Agroforestry Organism

- Trees and shrubs support soil productivity through the use of RCW - ramial chipped wood.
- More durable green manures and broadleaf herbs are a complement to MRF by forming abundant biomass.
- Trees and shrubs act as windbreaks
- Native shrubs and broadleaf herbs complete the biodiversity. They are necessary to support part of the physiological comfort. Every group is an authentic polyculture and also a piece of the mosaic.
- Forest strips interspersed with crop polycultures.
- Tree strips provide the best distribution and availability of water for the crops photosynthesis.
- A light nitrogen deficiency and the abundance of useful micronutrients provide a full physiological fruit finish.
- The integration of several productive stratum: trees + shrub + herbaceous, shelters and supports many agents of biological control. Insects, social insects, spiders, birds and bats prevent the proliferation of pests.

ATTACHMENT I

II – Analysing the biomes from North to South

The creation of an overview of the landscapes and biomes from the Northern Hemisphere, starting from the Polar Circle to the African Equatorial Zone, helps us to discover the main drivers of the vegetation and animal evolution pushed by heat and rain.

1. From the Polar Circle to broadleaf Forest

If we look closely at the *Tundra* vegetation we will see a more or less dense herbaceous layer grazed by reindeers, elks and musks. That layer is streaked by bushes and tiny arbors, usually conifers (pine trees). Between the vegetation and the Cosmos we observe the sky with a sun closed by ever-present rain clouds. Definitely, the weather is not hot.

Traveling from the Polar Circle in direction to the temperate climate, we cross an immense pine forest in Sweden and Finland, the Taiga. Finally, in the latitudes of France and Germany, we reach the temperate broadleaf forests where nature points to the plant evolution: whitin little heat the grasses evolve to clumps, bushes until trees. "In each plant lives the will to become a tree" (Steiner).

ART researches and observations:

1. Moving from the Arctic to the Temperate climate the trees show up in the landscape.
2. The path of plant evolution goes through steps. It starts from lichens and mosses that rise a few centimeters above the ground giving space to grasses and bushes. Then appear the coniferous trees, the arbors and finally the broadleaf trees.

2. From broadleaf Forest to Savannah

The broadleaf forests of Central Europe form an intermediate landscape towards the Tropics. Leaving Southern Europe (Spain, France, Italy and Greece), the landscapes are characterized by the Mediterranean climate. There is a considerable increase in heat but not in rain. The lack of humidity causes a reduction in the height of the trees which are replaced by arbors. The landscape returns to the predominance of underbrush species and small trees such as Olive tree, Lebanon cedar and Chestnut trees.

The size of the plants is now decreasing due to the pronounced water deficit. The intense sunlight creates the right climate for the production of sweet grapes and aromatic herbs. Continuing to the South, the Mediterranean vegetation reveals itself as the Aurora of the Sahara desert.

With the successive increase in heat and decrease in rainfall, the Mediterranean landscape is transformed into a desert, which continues towards the warm South. With the increase in rainfall a little savanna is formed in the Sahel zone. This region is the transition from the Desert to the Savannah. The savannah can be described as a steppe landscape streaked by clusters of shrubs.

3. From the Savannah to the Tropical Rainforest

On the path towards the Equator, the dry savannah succeeds the Sahel and turns itself into a wet savanna as the rains increase. Now it is not the heat that is transforming the landscapes, but the rains. The water expands the size of the vegetation and the biodiversity grows with the vegetation.

The union of rising heat and abundant rainfall culminates in the wet savannah of the Congo Basin which can be compared to a “green hell”. We arrived at the Perhumid Tropical Forest as we know it in Brazil, from the Atlantic Forest to the Amazon.

In those forests biodiversity grows exponentially showing a new way of boosting life: coexisting, interacting and co-evolving. Each living-being is interdependent on others. They live in intense physiological and ecological relationships, in mutualistic associations.

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