Identification of Areas for Afforestation in Brazil

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1. BACKGROUND — THE GREENHOUSE EFFECT

The effects of pollution from several sources have been intensely studied in the last decades. Water pollution has been substantially reduced in numerous cases in terms of suspended solids, biochemical oxygen demand, pH, and a long list of chemicals. Many fish species are returning to previously degraded rivers, lakes, estuaries, and oceans. In overdeveloped cities and heavily industrial areas, however, there is much to be done. This applies to developed, developing and underdeveloped countries alike.

Air pollution has also been bought under control in many plant chimneys and exhaust pipes thanks to electrostatic and sleeve filters that trap dust in suspension, while chemical scavengers and catalysts remove polluting gases. All of these techniques are employed to reduce sulfur and nitrogen oxides, hydrocarbons, carbon monoxide, chlorine, fluoride, ammonia, heavy metals, and organic chlorides, just to list the major parameters. On the other hand, it is much harder to improve the quality of air in certain areas not periodically windswept.

Pollution control efforts now concentrate on garbage disposal sites and on industrial and mine wastes. Unlike liquid and gas effluents, they are not diluted in the environment. Rather, they accumulate dangerously in city dumps increasingly closer to suburban areas, where serious contamination problems have occurred. The funding required from governments and private sources to remove and clean these areas is enormous.

Other forms of pollution constitute a new challenge to officials, technicians, and scientists. Apparently harmless and inert substances like carbon dioxide and chlorofluorocarbon go beyond the local or regional level. Their effects are global, a threat to the whole biosphere as they disturb its weakest point — the atmosphere.

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The magnitude of problems requires solutions of the same dimension. The need to control the consequences of depletion in the stratosphere's ozone layer caused by CFC gases (chlorofluorocarbons) has led to a concerted world effort. A major international commitment was made in the Vienna Convention (1985) and the Montreal Protocol (1987), effective since early 1989. Both treaties set a physical goal to gradually phase out CFC production, currently estimated at over one million tons annually, by the end of the century.

Despite the magnitude of the physical goals and targets, the problem can be solved by changing or replacing industrial processes employed in plants located all over the world but belonging to a mere dozen companies. They are all now endeavoring to find soft, ozone-friendly technologies to replace the current CFC-based products.

The "greenhouse effect" is a much more complex issue because of its many sources. CO_2 emissions are widespread and originate from big, medium and small polluters.

A sizable part of the "greenhouse effect" will be controlled by replacing CFC products that now account for 17% of the phenomenon, provided that alternatives being developed manage to trap less heat than the CFCs.

Methane (CH_4) is another important component of the "greenhouse effect" equation, contributing 19% to the phenomenon. Since its main anthropogenic sources are irrigated crops (e.g. rice), it is difficult to control the problem from this side. Other major CH_4 sources are mangroves and swamps and therefore the Mato Grosso Pantanal constitute a significant natural generator.

The CO_2 emissions are the primary cause of the greenhouse effect, accounting for 50% of it. Other anthropogenic sources are industrial plants that burn fossil fuels (oil, charcoal, and natural gas) thermoelectric plants, automobiles, and home heating during winter. Slash-and-burn farming practices and massive fires in natural forests are also important factors.

2. CARBON IN THE BIOSPHERE

Ever since the start of the industrial revolution in 1850, the excess carbon spilled into the atmosphere in the form of carbonates and bicarbonates has been disposed of in the ocean bottom where 41,000 Gt (41×10^{12}) of carbon now lie (97% of total). The atmosphere retains 700 Gt (1.6%) and land-based biomass only 600 Gt (1.4%) (see Annex A).

The transfer of atmospheric CO_2 emissions to oceans does not occur at the same rate as emissions from anthropogenic sources into the atmosphere. From 1850 to date, this imbalance has caused a concentration increase from 290 to 345 ppm, totalling 115 Gt (115 billion tons) of excess carbon in the air. At this rate, climate disturbances and a significant rise in ocean levels as a result of the greenhouse effect can be forecast with a high degree of certainty (see Annex B).

Reversal of this process is urgent, lest it cause other synergistic effects on the elasticity of meteorological phenomena or abrupt changes to climatic equilibrium that might spur calamities of unpredictable dimensions.

A break in climatic equilibrium might be triggered by a variety of mechanisms. The most commonly studied effect is that of positive feedback of global warming on itself.

A break in climatic equilibrium might be triggered by a variety of mechanisms. The most commonly studied effect is that of "positive feedback" of global warming on itself. Photosynthesis changes little under heat; it is sensitive chiefly to light, water, and nutrients. Respiration, however, and especially decay, increases considerably with heat and more so in temperate and cold climates during winter. This phenomenon has disastrous consequences at the medium and high latitudes of the northern hemisphere where the largest land mass is located (75% of the planet), with vast tracts of broad-leaved and coniferous forests, boreal plains, and tundra.

The photosynthesis-respiration imbalance and the resulting gradual heating are localized phenomena in temperate and cold northern hemisphere, where the forecast temperature rise is estimated at twice the global average.

Another worrying synergistic effect is the rise of evaporation resulting due to higher temperatures. Since water vapor also produces the "greenhouse effect," higher humidity concentration in the air tends to increase the trapped heat further and hence cause more evaporation. In this regard, studies are focusing on the "arresting" effect of this process represented by more widespread cloud formation resulting from the higher humidity. It must be determined whether additional clouds will reflect the same amount of heat retained by the extra humidity and thereby infer whether or not this will cause a cumulative heating feedback cycle.

Twenty to thirty years would be required to revert CO_2 levels in the atmosphere. This is too short to carry out the necessary energy matrix changes, considering the extent, cost, and other impacts involved in such changes.

Given the urgency of the matter, two simultaneous and complementary actions are vital if we wish to reduce CO_2 emissions drastically: 1. atmospheric carbon trapping by phytomass through massive forestry programs to extend the lead time; and 2. new energy generation technologies (e.g. hydrogen, among others).

Reforestation provides a quick response in terms of carbon fixation. It has the disadvantage of returning a significant amount of CO_2 to the atmosphere over the medium term as biomass generated is processed or biologically decayed until it reaches a balance and a set amount of carbon trapped for a given period of time.

Hydro power does not release CO_2, only H_2O and NO_x. Therefore, it is the ideal fuel to finally bring the greenhouse effect produced by CO_2 dumped into the atmosphere under control. Even NOx emissions can be reduced or eliminated. Since water breaks down into hydrogen and oxygen at the exact ratio at which each of these elements are required, in certain circumstances pure oxygen could be used instead of atmospheric air for combustion purposes.

3. THE MISSION

The aim of the present study is to determine how the first measure indicated above must be sized to achieve carbon fixation through a massive reforestation program in Brazil. Its extent and conditions must be consistent with world efforts, in which the Brazilian program would account for just 5%. Above all, it will be a cutting edge process involving definition of design methodologies and forestry development procedures. These methodologies must be unique to each region and often applied to areas already under human settlement, where care must be taken not to disturb agriculture and native forest reserves.

The time available to stabilize CO_2 between the current 345 ppm and the preindustrial 290 ppm levels through reforestation should be devoted, in parallel, to turning fossil fuel processes (charcoal, oil, and natural gas) into harmless low CO_2 emitters. The basic technology has already been developed. There are now third generation prototypes of hydrogen-powered automobiles in Europe. Russia is testing an airplane (the TU155) driven by hydrogen alone, and in California solar and wind energy generators are under intensive testing. All of this signals that hydrogen will be definitely added to the energy matrix in the near future (see Annex C).

By a fortunate coincidence, highly sunlit and arid or semiarid climates prevail in several oil-producing regions and countries such as northern Africa, the American southwest, and northeastern Brazil. They would all be adequate sites for solar energy developments. This coincidence would soften the possible impact of a low CO_2 energy standard on oil-producing nations. The strong capital reserves available in these economics could in fact be an asset in funding the much-needed and major changes in energy use.

From this approach, massive reforestation to bring down CO_2 levels in the air can only work if the measures outlined above or others like nuclear fusion can be carried out from the economic, social and environmental standpoints.

4. PRELIMINARY CONSIDERATIONS ABOUT REFORESTATION IN BRAZIL

Among the many problems afflicting Brazil at the turn of this century, special care must be directed to reforestation of degraded areas and to development of the proper locations for multipurpose silviculture.

In intertropical Brazil, a national reforestation plan should focus on open spaces where agriculture is not extensive yet.

On the one hand, the concern is to develop the proper national forestry policy. On the other, cooperative actions must be sought to trap carbon in the shortest possible time span and according to rational spatial organization criteria. Such criteria should be based on guidelines careful to avoid encroaching on productive agricultural sites as well as interference with reconstruction and reclamation programs directed to critical areas damaged by several cycles of directly or indirectly harmful agricultural practices.

Data on the success and failure rates of empirical reforestation programs developed under subsidies over the past 20 years advise a pan-Brazilian reforestation program. With the proper technical and scientific criteria, along with consistent impact assessment procedures, the master plan's individual actions will be both feasible and acceptable to all involved.

Considering its size and overall geoecological features, Brazil is admirably suited to a global plan to expand phytomass in open plant cover spaces or where the land is under heavy bearing loads because of agricultural and/or cattle raising practices. Given the current land and soil utilization patterns prevailing from north to south, careful identification of sites suitable for reforestation is crucial if we wish to curb the gradual depletion of vast masses of native Amazonian vegetation currently threatened by unnecessary and chaotic deforestations.

In this regard, a national reforestation plan can stem and stop destruction of the Amazon forest at the current level.

5. INCLUSION AND EXCLUSION CRITERIA

Target sites and exclusion zones can be defined with careful consideration for Brazil's four vast domains of intertropical environment, its two natural subtropical regions and their different ecosystems, and the patchwork pattern of soils found in each such region as well as past silviculture experiments and rare cases of ecological reforestation

In intertropical Brazil, a national reforestation plan should focus on open spaces where agriculture is not extensive yet, and where cattle raising can be improved through breeding and containment practices. This will provide considerable inputs for the planned introduction of planted forest.

Silviculture based on fast growing, suitable, high phytomass species should be discarded in regions where annual rainfall is less than 850 millimeters, mostly located in the semiarid Northeast. For this immense dry section of intertropical Brazil, a special plan is proposed to replenish narrow gallery forests known as *c'raiba* woods. Massive reforestation with species like the mesquite along mountain slopes and inland mountain river basins would achieve nearly perennial vegetation with multiuse species.

In regard to the Amazon, it has been excluded (in general though not entirely) because it is the largest standing reserve in tropical America and requires protective actions instead of sweeping reforestation plans. It is impossible to target the entire Amazonian geoenvironment as a whole for potential reforestation. Nevertheless, degraded belts around major cities (Belem, Manaus, Santarem, Imperatriz, and Macapá, among others) as well as vast pre-Amazonian areas spattered with unsuccessful cattle raising ventures deserve special attention in the plan. Through the intention is not to duplicate the Jari Project, the plan provides an opportunity to protect what is already established. The technical expertise already gained will help redirect more rational silviculture practices to heavily devastated sections, e.g. some points along the Belem — Brasilia Highway and more recently the Maranhão plateaus along the Carajá — São Luiz railway.

Obviously, no conscientious ecologist would endorse local silviculture developments at the cost of natural forests clearing. On the other hand, all enlightened environmentalists know that it is vital to encourage environmentally-oriented reforestation projects or planted forests at severely degraded areas around the cities, in sections of poor soil quality, and where the watershed is seasonal at most (dry sections).

While examining topographical charts combined with pedological and phytogeographical maps (based on field data accumulated over many years of research), we have identified exclusion areas and selected a few priority target areas suitable for silviculture according to topography, soil properties, and current land criteria.

Simultaneously, degraded sites of tropical and subtropical Brazil urgently requiring hybrid and strongly environmental forest replanting programs were identified.

As far as more unbroken exclusion zones, we selected the following for a number of different criteria: the Amazon in general; the Mato Grosso Pantanal; and the semiarid Northeast. The latter in fact originated a special reforestation program partly environmental and partly utilitarian.

Once the major exclusions were completed, we considered the effectively productive agricultural regions for extensive silvicultural development. They include: northern Paraná, western São Paulo, eastern parts of Paraná. and Santa Catarina, northwestern Rio Grande do Sul, the Bahian lowlands and northeastern forests, the western Mato Grosso do Sul *cerrados* and expanding agricultural districts of Minas Gerais; Barreiras and Irecê in Bahia, among others for which it is not possible to consider a forestry approach. Evidently, these areas can accommodate some measure of interstitial reforestation along river and stream banks, at headwaters, and escarpment belts. Here some cropping changes are envisaged as well as modification of the sugarcane slash-and-burn practices. These are actions scheduled for the second and more detailed phase of the overall reforestation plan.

6. PRELIMINARY SURVEY OF AVAILABLE SITES

Identifying areas for reforestation and silvicultural development throughout the Brazilian territory involves several basic assumptions. With the knowledge gathered and analyzed from the two-fold criteria of physical and ecological spaces and site rehabilitation through economic activities, a simple typology can be defined on three primary targets: 1) environmental reforestation sites; 2) industrial forest development zones; and 3) mixed potential areas, partly scheduled for industrial silviculture and partly for focused and basically environmental reforestation (springs, steep slopes, riverside forests, gallery forests, etc.). This third group includes urban districts suitable for landscaping and reforestation efforts (housing developments, institutional green areas, metropolitan parks, woods, landscaping of streets and squares, condominiums, housing tracts, etc.)

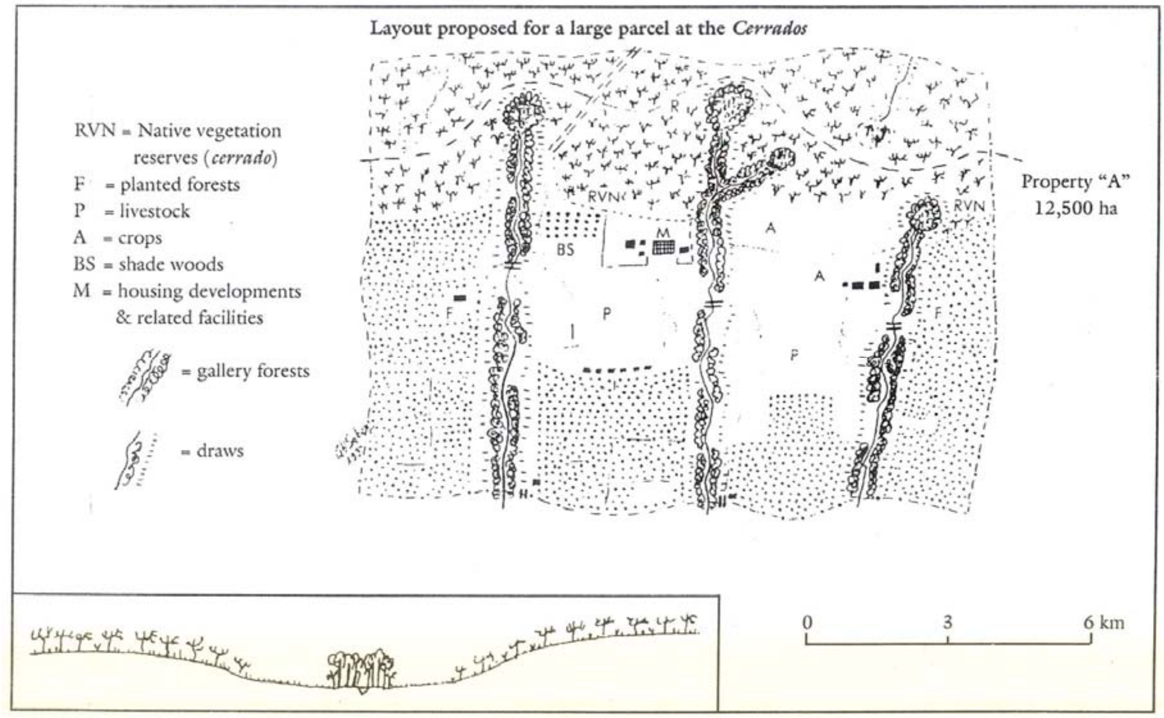
In terms of available and priority sites for the reforestation and/or silvicultural program, a more diversified set of typology criteria must be simultaneously developed. After lengthy discussions about the inland spaces truly available for reforestation —

leaving out primary forests (the Amazon) and areas improper for industrial forestry projects — priority types of land were defined according to their potentials. A first breakdown identified several large parcels suitable for industrial silviculture (sandy soils covered by *cerrados,* located between the Paraná River Valley and the Campo Grande Plateau; and low agricultural yield soils spanning from the southern/southeastern tip of Goiás to southeastern Mato Grosso do Sul).

A second group includes potential silviculture areas in southeastern Minas Gerais, western Bahia, and northwestern Minas Gerais, poor soil plains in the southwestern *cerrados* of Goiás, Triângulo Mineiro, and Midwestern Minas Gerais. A third type of region more modest and scattered than the other two involves the degraded portions of the southeastern and eastern highlands where overcropping with coffee and overgrazing have caused extensive damage.

These sites can have 40-50% of each parcel set aside for commercial forests with no risk of negative environmental impacts. However, enlargement of local homogeneous forest must be combined with replanting of heavily degraded areas or belts (riversides, headwaters, cave systems, steep slopes). Finally, tree crops are planned for any area able to bear small or medium size woods for additional family income. This includes parcels ranging from 10 to 5,000 hectares. The same kind of woods is envisaged for sections of parcels where primary forests were partially felled and the farming or ranching activities attempted have failed. Through proper clone selection to avoid negative environmental impacts, the partial reforestation of individual properties or at severely damaged spots within properties can boost the budgets of small, medium and even big landowners. Adequate organization of planting fields or wooden belts in each parcel will help the local farming economy and reclaim land to enable these parcels to become organized farms or ranches. The idea, therefore, is not to plant homogeneous forests haphazardly anywhere in rural properties. This is rather a plan to rationally plant wooden strips or belts using species suitable to each parcel, considering the unique local topographical and soil peculiarities.

In regard to hydro power plant reservoirs, the plan calls for full reforestation of the lake banks according to special blueprints tailored to each site and to local environmental conditions.



7. IDENTIFICATION OF SELECTED SITES

As soon as the typologies of available spaces and the recommended reforestation and/or silviculture actions had been outlined, maps were drawn with indication of the priority site layouts targeted for a consistent and viable program for rehabilitation or selective introduction of forest biomass. For a better overview of the sites, a South American vegetation map (Hueck and Siebert) and a recent Brazilian vegetation map (1988) in the appropriate scale were used. The latter chart represents a summary of data compiled in research studies carried out by the Botany and Phytogeography groups of Project RADAMBRASIL (currently incorporated by Instituto Brasileiro de Geografia e Estatística — IBGE).

Annex E lists the sites selected and Annex I shows a smaller scale copy of the Brazilian map indicating the geographical location of each selected site.

8. QUANTITATIVE CONSIDERATIONS

Annex E displays a table with the estimated surface areas of each selected site, complete with occupancy rates and planned utilization. The notes below are annotations on the table to supplement the summarized quantitative overview:

- 45.5% of total selected sites are reserved for diversified agricultural activities and preservation of unique local ecosystems in belts or preselected sectors;

- Corrective actions for sites involving major discontinuities focus on areas requiring special treatment (the southern rim of the Amazon and semiarid parts of the Northeast). These sites cover 39% of the total surface of selected areas;

- Forestry activities amount to 17.5% of the selected areas and comprise: *corrective* afforestation; *industrial* reforestation featuring cloned seedlings, high yields sometimes with the help of fertilizers; reforestation and/or mixed afforestation at the following ratios:

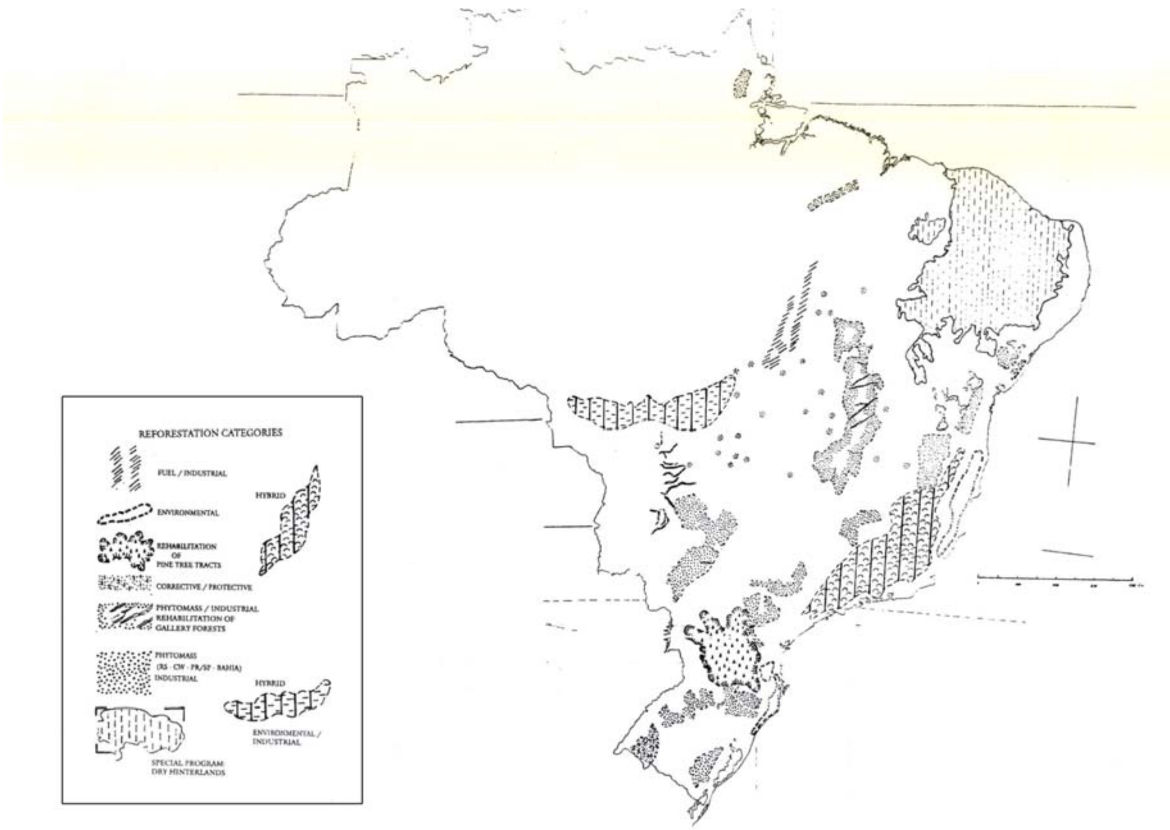
Corrective afforestation	14.4%
Mixed reforestation	13.8%
Industrial reforestation	71.8%
Total (201,480 Km^2)	100.0%

The above percentages show very clearly how essentially environmental actions must be considered under massive reforestation plans such as Floram.

- Potential areas for reforestation (201,480 Km^2) account for 12.6% of selected sites and equal 2.4% of the Brazilian territory (8.5 million Km^2); approximately 0.5% of world's forests (41.4 million Km^2); or 0.75% of the earth's densely forested area (26.6% million Km^2);

- It should be stressed that the 201,480 Km^2 selected for special forestry activities actually represent a 17.5% occupancy rate — half the arithmetic average of recommended occupancy rates for the selected parcels. It follows that the actual occupancy rate was set according to careful and conservative criteria.

- The surface areas listed for selected sites are a result of educated estimates at an approximate accuracy rate of plus or minus 10% of the averages used in the quantitative computations.



9. QUALITATIVE CONSIDERATIONS

In most of the sites under consideration, forests constitute a common vocational denominator arising from prevailing environmental conditions. All sites have the necessary ingredients for photosynthesis. However, some transition zones between *cerrados* and *caatingas* suffer the effect of seasonal rain shortages to the extent that water has become an environmental constraint. Poor soil conditions can be another limiting factor in setting and raising productivity levels.

The literature on forest yields contains reports on several attempts to capture the enormous flow of photosynthetic energy in the form of molecular structures in organic matter that traps atmospheric carbon in phytomass. These data were used in estimating forest yields. For purposes of this study, five possible yield levels were arbitrarily set: high, high/medium, medium, medium/low, and low. A breakdown of the selected sites by potential yield levels is found in the table below:

POTENTIAL PRODUCTIVITY FOR SELECTED SITES

Site	High	High/ Medium	Medium/ Medium	Low	Low	Total
I					3,200	
II				4,800		
III	1,680					
IV	1,125					
V	2,100					
VI			1,350			
VII	2,450	1,062				
VIII						
IX	2,200			.		
X			18,750			
XI						
XII	1,050					
XIII		3,250				
XIV						
XV		30,000				
XVI			6,250			
XVII				3,000	3,000	
XVIII			48,000			
XIX					10,500	
XX				1,575		
XXI		1,625				
XXII					700	
XXIII						
XXIV						
XXV						
XXVI						
XXVI						
km^2	10,605	35,937	74,350	4,575	19,200	144,667
	7.3%	24.8%	51.4%	3.2%	13.3%	100%

The following potential yields were considered for these soils, as shown in item number 10 of the forest yield comparative table in Annexes G and H:

Yield	$tC.ha^{-1}.year.^{-1}$
High (H)	13.1
High/Medium (H/M)	10.1
Medium (M)	7.3
Medium to low (M/L)	4.7
Low (L)	1.3

The chart in Annex H provides a better visualization of the consistency of averages computed for a set of yield figures relative to forests located at different latitudes. It also measures yield estimates for the two species most likely to be used in industrial reforestation (pine and eucalyptus).

The above figures show a total carbon fixation equal to a weighted average of $7.5tC.ha^{-1}.year^{-1}$ (or $28.3\ m^3.ha^{-}1year^{-1}$). This value is considered reasonable according to Brazilian and international literature (item 11 of the comparative table on forest yields).

As an additional benchmark, item 12 of the forest yield comparative table records 6.3tC.ha^{-}1.year^{-1} as the average world forest yield. This figure results from dividing the estimated global biomass for tropical forests (789 billion tons of organic matter) by the surface area covered by these forests (1,838 million hectares), multiplying the quotient by the conversion factor 0.45 and dividing the result by 34 (i.e., the number of years estimated until steady state is achieved).

Forest yield values shown in this study will help prepare a reliable quantitative estimate of the Brazilian contribution toward the global effort needed to revert the climate changes resulting from the greenhouse effect.

The proposed values are based on the published results and observations of several authors (Annex F). They are in fact mere statistical expressions helpful in forecasting photosynthetic production potential of certain organic structures at a given set of environmental conditions.

It is known that high yields depend on available solar energy for photosynthesis and on elements imprinted in the genetic codes of plant organisms, which govern the utilization of captured energy by the chlorophyll system and its distribution among the different physiological functions (e.g. growth, differentiation, lift, respiration, and reproduction). Yield further depends on soil fertility levels, i.e., the physical and chemical pattern resulting from the lengthy geochemical and meteorological processes that modify the original rockbed; in short, it hinges on all six soil formation factors involved in the process. Current climatic conditions reflect the geological continuity of their modifying interaction on the geomorphology of large domains, microregions, and ecosystems. Their quantitative and qualitative effect translates into phytomass development.

Thus, forest yields potentially attained by Floram Project should be considered indicative of a more or less intelligent optimization of the balance struck between the potential embodied in the genetic code of seeds or clones selected for planted forests, and the set of environmental conditions found at selected planting sites.

Optimization levels achieved, therefore, will be the result of basic research studies done in support of applied research projects urgently needed. The entire effort must be very carefully coordinated and planned, involving experts in plant physiology, silvicultural biotechnology, and forest by-product processing.

The comparative table shows yield broken down into two main groups: values over 10.6tC.ha^{-1}.year^{-1} (40 m^{3}.ha^{-1}.year^{-1}) and values below that level. This breakdown was chosen because figures above the cutoff line drawn on the table usually indicate the use of fertilizers to offset special soil deficiencies. These actions represent initial costs ranging from US$ 400 to 1,000 per hectare planted. Rework or replanting at the end of each cycle usually demands additional fertilization at costs never below US$ 100-200 per hectare.

10. THE POTENTIAL CONTRIBUTION BRAZILIAN ESTIMATION OF CARBON FIXED BY REFORESTATION

By the end of its last year, a reforestation program with annual crop areas (whose size will be determined on the basis of total area available divided by the n number of years considered), will have involved a total area equal to n2+n times the annual planted area.

So, in a 30-year reforestation program with the available area broken down into subsections by soil class (20.148 x 10^6 ha), each subsection will have an area set aside annually to be reforested calculated at 1/30 of the original parcel. The annually reforested area should provide repeated utilization over the program's 30 years, totaling 465 times the area set aside for annual planting.

This total, multiplied by the estimated potential yield determined for the respective soil class, should provide the amount of carbon fixed during the 30-year period.

The table below illustrates how this figure was estimated.

11. AREA ESTIMATION PER YIELD LEVEL

Class of Soil Yield Level	**Industrial Reforest** (km^2)	**Corrective Reforest** (km^2)	**Mixed Reforest** (km^2)	**Totals** (km^2)	**Total** (10^6 km^2)
High	10,605	575	700	11,800	1,180
High/Medium	35,937	15,325	16,188	67,450	6,745
Medium	74,350	5,027	7,375	86,950	8,695
Medium/Low	4,575	7,375	750	12,700	1,270
Low	19,200	600	2,700	22,500	2,250
Totals	144,667	28,900	27,913	201,913	20,148

12. ESTIMATION OF FIXED CARBON BY PRODUCTIVITY AREAS

Productivity	Annualy Planted Area (10^6ha)	Cumulative Annual Areas (10^6ha)	Potential Yield ($tC.ha^{-1}.year^{-1}$)	Fixed Carbon (10^6t)
High	0.0396	18.418	13.1	241.2
High/Medium	0.2248	104.547	10.1	1055.9
Medium	0.2898	134.772	7.3	983.8
Medium/Low	0.0423	19.685	4.7	92.5
Low	0.0750	34.875	1.3	45.3
Total	0.6715	312.293		2418.7

Carbon fixed by reforested areas:

2.418×10^9tC

with a mean yield of:

$$\frac{2.418 \times 10^9 \text{ tC}}{312.29 \times 10^6 \text{ ha}} = 7{,}7 \text{ tC.ha}^{-1}.\text{year}^{-1}$$

In addition to this carbon, we must also consider the amounts fixed at sites selected for special projects directed to corrective environmental actions or reclamation as a result of these projects. The additional carbon trapped was computed as follows:

13. TOTAL FIXED CARBON

Surface of Sites (10^6ha)	Potential Yield ($tc.ha^{-1}.year^{-1}$)		Fixed Carbon (10^6ha)
South/ Southeast Amazon Rim (XVI)	15.0	1.32	306.9
Semiarid Northeast (XXV)	30.0	1.32	613.8
Total	45.0	2.64	920.7

Therefore, the total carbon fixed by the phytomass canopy will be:

$2.418 + 0.920 = 3.338 \times 10^9$ tC

Since the canopy accounts for 2/3 of the phytomass the total amount fixed will be:

3.338×10^9 tC x 1.5 = 5.00×10^9 tC

This amount represents approximately 4.3% of excess atmospheric carbon.

14. BENEFITS OF MEGAREFORESTATION

In addition to the proposed undertaking's broader environmental goal (reducing the greenhouse effect), a program of this size can cause a variety of other effects that must be considered and addressed:

- The impact on forest balances and related consequences;
- Economic impact on the pulp and paper industry due to an increased supply of raw materials;
- Impact on the home construction industry due to a rise in the supply of timber and by-products;
- Impact on the timber industry caused by the increasing supply of planted species to the detriment of other more traditional species;
- Impact on the energy business caused by the rising supply of raw materials for methanol automotive fuel production;
- The environmental impact resulting from the foreseeable growth of the timber and pulp and paper industries; and
- Ecological impacts in terms of the balance between clonal forests and preservation of the local biodiversity.

The program is expected to generate several benefits to the environment, such as:

- Protection of native forests against the traditional plunderers (timber dealers, charcoal producers, and loggers) due to supply of new and abundant forests;
- Preservation of the Amazon Forest for rational utilization by means of environmentally-friendly development models;
- Increased biomass stocks in existing forests;
- Rehabilitation of old forest areas for protection of neighboring native forests;
- Reclamation of degraded areas (depleted soils or slopes) through sustainable use directed at soil rehabilitation, erosion and desertification control, and economic alternatives to local exploit;
- Protection of water sources against improper farming practices through the use of the forest canopy as an alternative;

- Protection of watersheds against river silting, erosion and flooding, among other things;
- Preservation of water resources;
- Micro and macroclimate corrections;
- Increase and enlargement of refuges and establishment of sanctuaries;
- Better preservation of genetic diversity;
- Protection of wildlife (fauna and flora) in mixed afforestation developments, preserving ciliary forests around rivers, creeks, escarpments and mountain ranges;
- Recovery of threatened species found in perennial forests of the ciliary type, for example;
- Increase the availability of raw materials to encourage industrialization and diversification of forest-based durable goods;
- Decentralized economic development through new plants to process forest products;
- Strengthening of local forest-based plants already in operation;
- Increase the number of recreational areas;
- Landscape improvement as a result of urban and rural reforestation; and
- Strategic plans to prevent the emergence of a "global village" and to break the trend toward overconurbation.

15. INDUSTRIALIZED FOREST PRODUCTS

Given its high potential for diversification and powerful driving force behind local progress, proper industrialization of forest by-products could be the cornerstone of sweeping social and economic development. These potential benefits are acknowledged and repeatedly pointed out by international agencies engaged in defining and recommending optimum solutions for consistent regional development. FAO has recently published several reports on a Forestry Action Plan for tropical countries. It spells out the key advantages of a social and economic development effort based on silviculture and on a number of industrial possibilities for the exploitation of forestry raw materials.

For its diversity and versatility, the processing of forestry products could be seen as a cascade of crafts in performed in stages and in demand by small and medium size companies (depending on how vertical and independent their structure is). These plants lie at one end of a broad spectrum, with the bigger, investment-intensive companies requiring leading-edge processing technology at the opposite end.

Operations involved in the processing of reforestation and forestry products and by-products provide a powerful lever for social and economic development. Because of their flexibility they are especially suitable to wide range of features offered by the areas discussed in this paper.

A remarkable example of this flexibility is found in the state of Sao Paulo, where silviculture is practiced in two well-differentiated areas in terms of forest development and separated by an imaginary line lying SE-NW. Locations along the N-E side of this line are worked according to a rural approach in terms of the economic use of its natural biodiversity, under organic phytosanitary protection. To the S-W of the dividing line are areas developed by agribusinesses, involving large land holdings attractive to big business for their scale. These sites require heavy investments, state-of-the-art technologies, careful and detailed planning, and monitoring of every activity needed to ensure high output levels. Such levels can only be achieved usually through carefully selected differentiated clone plantations requiring proper preventive phytosanitary protection. The standardization of forest products obtained at the "new" sites and the assurance of their specifications' continuity boosts the added value of these goods. This more than offsets the additional investments required for phytomass development control and monitoring, R&D, and the purchase of nutrients and fertilizers. These investments are far higher in modern silviculture than in traditional reforestation developments.

It should be noted here that high yields can only be achieved through painstaking efforts of multidisciplinary research (silviculture biotechnology, physiology, botany, soils, etc.). This in turn demands highly qualified human resources unfortunately scarce because their training takes time as well as a strong and unwavering vocation to begin with.

Staffing constitutes an additional investment per hectare of reforestation that cannot be neglected since a shortage of human resources may turn out to be a constraint for the project.

In short, the two reforestation styles illustrate the two extreme of a wide and open range of reforestation styles. Halfway between them new options are starting to emerge as a result of positive interactions between the two extremes. Thus, the traditional style may be incorporating the benefits of modern biotechnology that have proven their effectiveness in modern reforestation efforts.

The cooperative alternative should be mentioned in this regard. It may meet the demands of larger-scales operations at traditional sites while avoiding the risk of increasing land ownership concentration in the hands of a few.

16. PRELIMINARY CONCLUSIONS

Reflecting a concern with global environmental issues and with local ecological peculiarities, 201,000 km^2 of land suitable for forestry development have been identified, 144,000 Km^2 of which for industrial reforestation.

Site selection was accomplished by cutting through a maze of heterogeneous and diverse regional and interregional conditions to finally arrive at both general and specific solutions for each region.

The complexity of this patchwork of selected sites will require constant monitoring through remote sensing imagery if efficiency and reliability are to be achieved. It will also help determine the advisability of institutionalizing informative, advisory, and technical activities at the regional level through strategically located centers.

ANNEX A

GLOBAL CARBON INVENTORY (billion tons)		
CARBON IN THE CONTINENTAL PHYTOMASS		
Decaying (Humus)	1,000	— 3,000
Forests, live plants	600	— 830
Total for the continent		
(fossil fuels: 10,000)	1,600	— 3,830
CARBON IN ATMOSPHERIC GASES		
In carbon dioxide, CO_2	640	— 700
OCEAN PHYTOMASS		
In surface layers		
Decaying	1,620	
Live	30	
Carbonates and bicarbonates	600	
In deep layers		
Organic matter	1,700	
Carbonates and bicarbonates	38,000	
Total carbon in oceans	41,950	
Overall Total	44,665	
	44,190	— 46,500

ANNEX B

GLOBAL CARBON TO BE FIXED

Estimation:

Current CO_2 concentration (1998)	346 ppm
Acceptable CO_2 level (preindustrial level)	292 ppm
Reduction to be achieved	54 ppm

Equivalence:

1 ppm CO_2 2.130 GtC = 2.130 x 10^9 tC

(U.S. Department of Energy, Carbon Dioxide Information Center, ORNL/CD IC-10, p.24)

Therefore, 54 ppm equals:

54 x 2.13 = 115x 10^9tC,

or the carbon mass to be fixed globally.

ANNEX C

HYDROGEN FOR ENERGY GENERATION

Research under way at pilot hydrogen power generation facilities have been looking at ways to offset the gaps between peak production and demand of solar energy. The technique involves the storage of 11_2 and 0_2 obtained from water electrolysis during peak sunlight periods, to be reconverted into electricity by a reverse process during demand peaks. Major research in this field is being done at "Neunburg vorm Wald" Bavaria, Germany. It consists of a 500-kW pilot plant with 5,000 m^2 of solar cells using a variety of technologies. The 60 million DM (US$ 32 million) required were jointly financed by the Bavarian State government (60%) and four private companies (BMW, MBB, Linde, and Siemens) each contributing 10%.

With the same purpose a 200-megawatt pilot plant is in operation in the Mojave desert, California, by Luz Internacional Ltda.

The estimated energy cost in the German experiment is 1 DM (US$ 1.85) per kWh of photovoltaic energy or 15 DM per liter of fuel oil energy equivalent. These figures signal a 12- to 15-fold increase in energy prices, roughly the same impact on the market as the oil price shocks caused by OPEP in 1973 and 1979, when crude jumped from US$2 to US$35 per barrel. The difference now is that increases are predictable, brought on by a much-needed and prescheduled change, unlike past OPEP shocks which ESTIMATED SURFACE AREAS OF SITES SELECTED, OCCUPANCY RATES, AND PURPOSE.

ANNEX D

LIST OF SELECTED SITES

Code	SELECTED SITES	Selected Area (km^2)	Occupancy Rate (%)	Available for Reforestation (km^2)
I	SE tip of Rio Grande do Sul and SW Campanha	16,000	60%	9,600
II	SE tip of Rio Grande do Sul, SE Mountains & Coxilhas	12,000	50%	6,000
III	São Francisco de Assis Prairies, Rio Grande do Sul Prairies and West of Santa Catarina	4,800	35%	1,600
IV	NW Prairies of Rio Grande do Sul, infertile land in NW Rio Grande do Sul	4,000-5,000	30%	1,350
V	Vacaria Prairies - Midlands, Vacaria Plateau & Campos of	6,000-8,000	35%	2,450
VI	Lajes Sao Joaquim High Plateau & Lajes Meadows	4,000-5,000	35%	1,575
VII	Purunã - Castro, Jaguariaiva, second plateau of Paraná - Altos Campos de Purunã	6,000-8,000	40%	2,800
VIII	Old Northern Parana bridged with Castro, Jaguariaíva, and Middle-Upper Paranapanema	4,000-4,500	30%	1,275
IX	Second Plateau Depression, São Paulo	10,000-12,000	20%	2,200
X	Eastern Mato Grosso do Sul, Upper Paraná Plateau in Mato Grosso do Sul	60,000-65,000	35%	21,875
XI	Gallery Forests of Western Mato Grosso do Sul Cerrados, Waterfalls of Rivers feeding the Greater Mato Grosso Pantanal	N/A		
XII	Subcoastal sections of NE Rio Grande and Eastern Santa Catarina, Subtropical Atlantic Coast of Santa Catarina, Upper Itajai Valley in NE Rio	6,000-8,000	20%	1,400
XIII	SO-SE Minas Gerais, Southern Headwaters of the São Francisco, area located between the Upper Rio Grande, Canastra Range and Quadrilátero Ferrífero	12,000-14,000	30%	3,900

XIV	SO-SE Rim of the Amazon, SO-SE tip of the Amazon Lowlands - Northern Mato Grosso/Rondônia	150,000		
XV	SE Brazil Mountains and Slopes; SE			
XVI	Upper & Middle Doce Valley, Polyconvex Mountains of the Middle	25,000	30%	7,500
XVII	Cool Woods - Liana Woods Transition Zone in Southern Bahia	15,000	30%	4,500
XVIII	Western Plateau of Bahia & Northwest Minas Gerais (up to Piaui border), Western Bahia & Northwest Minas Gerais Cerrados	150000-170000	35%	56,000
XIX	North-South Railroad Tracks in Tocantins State (the former Great North of Goiás)	30,000-40,000	35%	12,250
XX	Maranhão Plateau section of the Carajás-São Luís Corridor	4,000-5,000	40%	1,800
XXI	NE Bahia North & NE of the Lowlands, Expansion of Planted Forests	6,000-7,000	35%	2,275
XXII	Amapa Meadows & Slopes, Rolling Cerrado Savannas in Southeast	3,000-4,000	30%	1,050
XXIII	TROPICAL CENTRAL ATLANTIC BRAZIL - Subcoastal Zone extending from Northern Rio de Janeiro to the Lower Jequitinhonha in Bahia, where silviculture has been developed for years by several pulp			
XXIV	SUB-AREAS FOR FUTURE DE-VELOPMENT AT THE CERRA-DO **DOMAINS** **GROUP** 1. Montes Claros Area & Surroundings **GROUP** 2. Area located N-NE of Brasilia **GROUP** 3. Extreme SE of Goiás (discontinuous spaces throughout the Cerrado Domain)			
XXV	NE Backland (semiarid hinterland) Reforestation sites with adaptable species & ecological reforestation of river banks	300,000		
XXVI	Rehabilitation of the Parana Pine Domain, Araucária Plateau	100,000	20%	20,000

XXVII	Humid tropical islands inserted in NE Badlands 7 small massifs of tropical forests in Central Brazil			
XXVIII	Urban & Suburban landscape arborization	1,153,050	17.5%	201,480

ANNEX E

ESTIMATED SURFACE AREAS OF SITES SELECTED, OCCUPANCY RATES, AND PURPOSE								
Area Code	Surface (km^2)	Misc. Agro-Ecosystems (km^2)	Occupancy Rate (%)	Discontinuous Rehab. Sites/ Special Areas (km^2)	Forestry Activities (km^2)	Corrective Reforestation (km^2)	Mixed Reforestation (km^2)	Industrial Reforestration (km^2)
I	16000	64000	60	--	9600	6400	--	3200
II	12000	6000	50	--	6000	600	600	4800
III	4800	3120	35	--	1680	--	--	1680
IV	4500	3150	50	--	1350	225	--	1125
V	7000	4550	35	--	2450	350	--	2100
VI	4500	2925	35	--	1575	225	--	1350
VII	7000	4200	40	--	2800	--	350	2450
VIII	4250	2975	30	--	1275	--	213	1062
IX	11000	8800	20	--	2200	--	--	2200
X	62500	40625	35	--	21875	--	3125	18750
XI	--	--	--	--	--	--	--	--
XII	7000	5600	20	--	1400	--	350	1050
XIII	13000	9100	30	--	3900	--	650	3250
XIV	150000	--	--	150000	--	--	--	--
XV	200000	160000	20	--	40000	10000	--	30000
XVI	25000	17500	30	--	7500	--	1250	6250
XVII	15000	10500	30	--	4500	750	750	3000
XVIII	160000	104000	35	--	56000	4800	3200	48000
XIX	35000	22750	35	--	12250	--	1750	10500
XX	4500	2700	40	--	1800	225	--	1575
XXI	6500	4225	35	--	2275	325	325	1625
XXII	3500	2450	30	--	1050	--	350	700
XXIII	--	--	--	--	--	--	--	--
XXIV	--	--	--	--	--	--	--	--
XXV	300000	--	--	300000	--	--	--	--
XXVI	100000	80000	20	--	20000	5000	15000	--
XXVII	-	-	-	--	--	--	--	--
	1,153,050 100%	501,570 43.5%	- -	450,000 39.0%	201,480 17.5%	28,900 2.5%	27,913 2.4%	144,667 12.6%

ANNEX F

LIST OF VALUES USED IN THE YIELD SURVEY			
SPECIES	LOCATION	SOURCE	YIELD $tCha^{-1}\ year^{-1}$
E. globulus	Spain	FAO-81	0.2 (min.)
E. occidentalis	Italy	FAO-81	0.26 (min.)
P. caribae	Caribbean (n=13)	LAMB-73	0.63 (min.)
E. camandulensis	Morocco	FAO-81	0.79 (min.)
E. globulus	Portugal	FAO-81	0.79 (min.)
E. grandis	Brazil	FAO-81	1.06 (min.)
P. patula	Uganda	ANON-76	1.13 (min.)
P. patula	Kenya	ANON-76	1.13 (min.)
Picea abies	Europe	SEDJO-84	1.32
E. grandis	Brazil	EVANS-82	1.32
E. occidentalis	Italy	FAO-81	1.59 (max.)
E. microtheca	Sudan	FAO-81	1.85 (min.)
P. caribaea	Venezuela	HEUVELDOP-77	1.89 (min.)
Gmelina arborea	Malawi	LAMB-68	1.91 (min.)
Gmelina arborea	Sierra Leone	LAMB-68	2.17 (min.)
P .caribaea	Venezuela	HEUVELDOP-77	2.21 (0)
Pinus	Brazil - Bahia	BARRICHELO-89	2.25
Tropical Forest		GOLLEY-72	2.34
Gmelina arborea	Sierra Leone	LAMB-68	2.48 (0)
P. caribaea	Venezuela	HEUVELDOP	2.52 (max.)
E. camandulensis	Morocco	FAO-81	2.65 (max.)
Grazing Land	Temperate	WHITTAKER-72	2.70
Gmelina arborea	Sierra Leone	LAMB-68	2.8 (max.)
P. taeda	USA	SEDJO-84	3.15
Forests		BRYANT-88	3.18 (0)
Cerrado & capoeira		WHITTAKER-73	3.20 (0)
P. patula	Uganda	ANON-76	3.38 (0)
Pseud. menziesii	USA	SEDJO-84	3.38
P. patula	Kenya	ANON-76	3.38 (0)
E. grandis	So. Africa	FAO-81	3.44
Boreal Forest		LUGO-73	3.60 (0)
Boreal Forest		WHITTAKER-73	3.60 (0)
E. grandis	Uganda	FAO-81	3.70 (min.)
P. caribaea	Asia	SEDJO-84	3.71
Gmelina arborea	Malawi	LAMB-68	3.83 (0)
E. globulus	India	FAO-81	3.97 (min.)
Gmelina sp.	Senegal	SEDJO-84	3.98
Eucalyptus	S.Francisco (MG)	BARRICHELO-89	4.08
Savannah		WHITTAKER-73	4.10 (0)
P. patula	So. Africa	SEDJO-84	4.24
P. caribaea	Brazil (AM)	SEDJO-84	4.24
Broad-leaf For.	Temperate	JORDAN-83	4.44
Eucalyptus	Brazil	ANDPC-88	4.50 (0)
Tropical For.		WHITTAKER-75	4.50 (min.)
Eucalyptus	Senegal	SEDJO-84	4.50
Tropical For.		WADSWORTH-60	4.54 (min.)

Long Fiber	Brazil	GPEF-82	4.60 (min.)
E. cloeziana	Zambia	FAO-81	4.76
E. microconys	Brazil	PRODEPEF-77	4.76
Gmelina arborea.	Brazil (AM)	SEDJO-84	4.77
Tropical Forest		BROWN-82	4.82 (min.)
P. caribaea	Puerto Rico	LIEGER-76	4.95
Pinus	Brazil (SP)	BARRICHELO-89	4.95
Rain Forest	Subtropical	LUGO-78	4.95
Rain Forest	Tropical	MULLER-65	5.00
P. radiata	Australia	SEDJO-84	5.30
P. taeda	Brazil (South)	SEDJO-84	5.30
Deciduous For.	Temperate	WHITTAKER-73	5.40
Perennial For.	Temperate	WHITTAKER-73	5.40
Eucalyptus	Brazil (MG)	BARRICHELO-89	5.40
Short Fiber	Brazil	GPEF-82	5.40 (min.)
Pinus	Brazil (PR, SC, RS)	BARRICHELO-89	5.40
P. patula	Kenya	ANON-76	5.62 (max.)
Broad-leaf For.	Boreal	JORDAN-83	5.62 (0)
P. patula	Uganda	ANON-76	5.62 (max.)
Rain Forest	Tropical	MALAISSE-81	5.67
Gmelina arborea	Malawi	LAMB-68	5.75 (max.)
Rain Forest	Tropical	HUTTEL-75	5.81
Forests	Temperate	LUGO-73	5.85 (mean)
P. radiata	Chile	SEDJO-84	5.83
Broad-leaf For.	Temperate	JORDAN-83	6.06 (max.)
E. microtheca	Sudan	FAO-81	6.09 (max.)
Broad-leaf For.	Subtropical	JORDAN-83	6.31 (mean)
Rain Forest	Tropical	JORDAN-80	6.48
Rain Forest	Tropical Pre-mount.	HUTTEL-75	6.57
P. radiata	New Zealand	SEDJO-84	6.63
E. saligna	Brazil	PRODEPEF-77	6.75
P. resinifera	Brazil	PRODEPEF-77	6.77
Long Fiber	Brazil	GPEF-82	6.80 (max.)
E. robusta	Brazil	PRODEPEF-77	6.88
Rain Forest	Subtropical	BANDHU-73	6.89
Eucalyptus	Brazil (ES) 1984	BRANDÃO-84	6.90
Eucalyptus	Brazil (MG)	BARRICHELO-89	7.20
Rain Forest	Tropical	HUTTEL-75	7.25
P. caribaea var. hond.	Brazil (SP) Agudos	BARRICHELO-89	7.42
Broad-leaf For.	Tropical	JORDAN-83	7.62 (mean)
E. grandis	Portugal	FAO-81	7.67
Eucalyptus	Brazil (23 exper.)	EMBRAPA-80	7.80 (0)
E. urophylla	Brazil	PRODEPEF-77	7.94
Broad-leaf For.	Boreal	JORDAN-83	8.01 (max.)
Short Fiber	Brazil	GPEF-82	8.05 (max.)
Eucalyptus	Brazil (Bahia)	BARRICHELO-89	8.10
Eucalyptus	Brazil (PR, SC, RS)	BARRICHELO-89	8.10
Rain Forest	Tropical	KIRA-78	8.19
Eucalyptus	Brazil (15 exper.)	EMBRAPA-80	8.20 (0)
P. caribaea	Caribbean (13 countries)	LAMB-73	8.28 (0)
Broad-leaf For.	Subtropical	JORDAN-83	8.34 (max.)

Rain Forest	Tropical	KIRA-67	8.69
Eucalyptus	Brazil (ES) 1984	BRANDÃO-84	8.70 (0)
E. globulus	India	FAO-81	8.73 (max.)
Eucalyptus	Brazil (Bahia)	BARRICHELO-89	9.00
Eucalyptus	Brazil (SP)	BARRICHELO-89	9.00
P. caribaea	Puerto Rico	LIEGEL-76	9.11 (0)
E. grandis	Brazil (ES)	CAMPINHOS-74	9.26
Rain Forest	Tropical Pre-mount.	NYE-61	9.36
Forest	Tropical	LUGO-73	9.72 (mean)
Rain Forest	Tropical	WHITTAKER-73	9.90
E. globulus	Portugal	FAO-81	10.05 (max.)
Broad-leaf For.	Tropical	JORDAN-83	10.48 (max.)
E. gran dis	Brazil	PRODEPEF-77	10.48
Forests	High Yield	BRYANT-88	10.58
E. saligna	Brazil	FONSECA-79	10.58
Tropical For.		MURPHY-75	10.80 (0)
E. propin qua	Brazil	SIMÕES-80	11.38
Tropical For.		GOLLEY-72	11.39 (0)
E. globulus	Spain	FAO-81	11.64 (max.)
Tropical For.		WESTLAKE-63	11.70 (min.)
Eucalyptus	Brazil (19 exper.)	CAMPINHOS-80	12.00 (min.)
Tropical For.		RODIN-67	12.15 (min.)
E.grandis	So. Africa	FAO-81	12.17 (max.)
Tropical For.		WADSWORTH-60	12.32 (0)
E.grandis	Uganda	FAO-81	13.23 (max.)
Eucalyptus	Brazil	ANFPC-88	13.23
Eucalyptus sp.	Brazil	MELLO-77	13.2
P. caribaea	Puerto Rico	LIEGEL-76	13.28 (max.)
E. urophylla	Brazil	SIMÕES-80	13.49
Swamp		WHITTAKER-73	13.50 (0)
Eucalyptus	Brazil (ES) 1984	BRANDÃO-84	14.00 (max.)
Tropical For.		BROWN-82	14.21 (0)
Eucalyptus	Brazil (ES) 1984	BRANDÃO-84	14.30 (min.)
Tropical For.	Sarawak	MURPHY-75	14.45 (max.)
E. grandis	Brazil	SIMÕES	14.55
E. grandis	Brazil	FAO-81	14.82 (max.)
Eucalyptus	Brazil (19 exper.)	CAMPINHOS-80	14.91 (0)
E. grandis	Brazil (1967)	FERREIRA-83	3.97
Tropical For.		RODIN-67	15.53 (max.)
Tropical For.		WHITTAKER	15.75 (max.)
E. grandis	Brazil	FERREIRA-83	17.05
Eucalyptus	Brazil (ES) 1984	BRANDÃO-84	18.60 (0)
E. viminalis	Brazil	FONSECA-79	19.85
E. grandis	Brazil (RJ) Resende	KAGEYAMA-80	19.85
Tropical For.		BROWN-82	20.00 (max.)
E. grandis	Brazil Forestry Tech.	FERREIRA-83	21.00
Tropical For.		GOLLEY-72	21.78 (max.)
Eucalyptus	Brazil (19 exper.)	CAMPINHOS-80	22.20 (max.)
E. caribaea	Caribbean (13 countries)	LAMB-73	23.04 (0)
Tropical For.		MURPHY-77	23.22 (0)
Tropical For.		WESTLAKE-63	23.40 (max.)

Tropical For.		BRhNIG-69	25.20 (min.)
Eucalyptus sp.	Brazil - Center South	SEDJO-84	26.40
Tropical For.		WADSWORTH-60	26.57 (max.)
Eucalyptus	Brazil (ES) 1984	BRANDAO-84	29.90 (max.)
E. grandis	Brazil Selection	FERREIRA-83	40.00
Tropical For.		BRhNIG-69	40.05 (max.)

ANNEX G

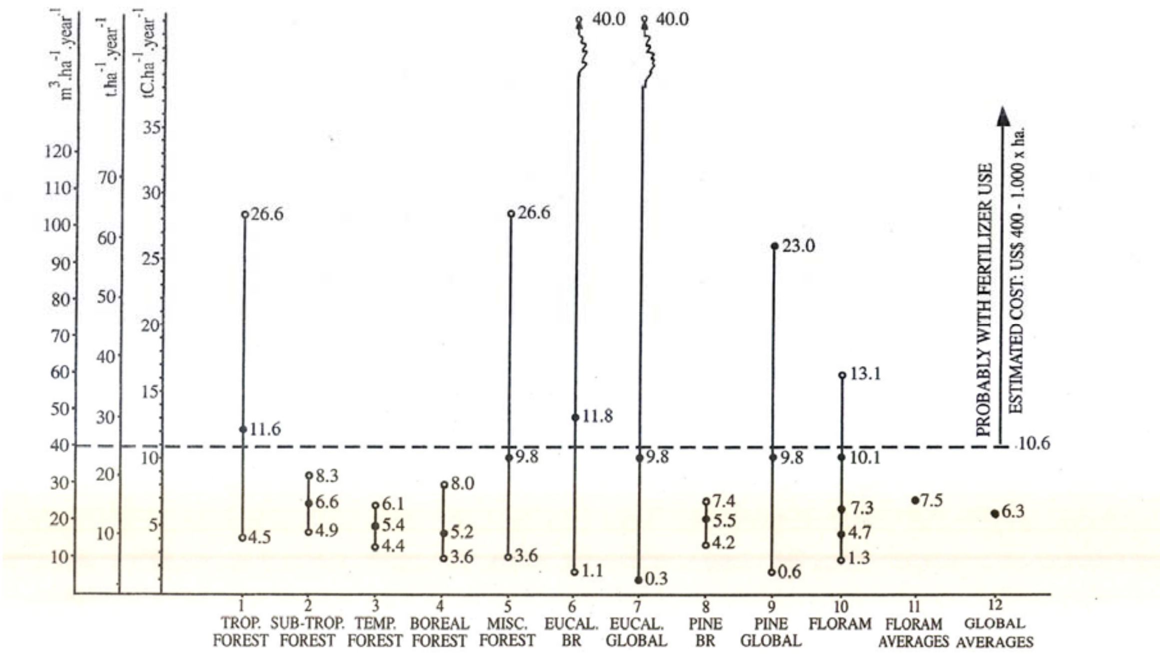
FOREST YIELD

($tC.ha^{-1}.year^{-1}$)

(Table of Values) (Revision 02.21.90)

	X	Value Max	Value Min	N
1. Tropical Forests	11.6	26.6	4.5	30
2. Subtropical Forests	6.6	8.3	4.9	4
3. Temperate Forests	5.4	6.1	4.4	5
4. Boreal Forests	5.2	8.0	3.6	4
5. Miscellaneous forests	9.8	26.6	1.1	43
6. Eucalyptus - Brazil	11.8	40.0	0.3	44
7. Eucalyptus - Global	9.8	40.0	4.2	64
8. Pine - Brazil	5.5	7.4	0.6	5
9. Pine - Global	9.8	23.0		26
10. Estimated Yields for Floram Project				
High			13.1	
High/Medium			10.1	
Medium			7.3	
Medium/Low			4.7	
Low			1.3	
11. Weighted Average of Estimated Yields	7.5			
12. "Global" Average for Tropical Forests	1.3			

ANNEX H



ANNEX H GRAPHIC ILLUSTRATION OF YIELD VALUES

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