Biodiversity and Floram Project: Yield *vs.* Environmental Conditions

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1. BACKGROUND

Floram Project has elicited substantial support from the very beginning, and particularly so after the papers containing its basic philosophy, key goals, and its outline and scope of action were published. Such expressions of support, to a greater or lesser extent, have brought some extremely valuable contributions and highly pertinent constrictive criticism to enrich its background papers when it came the time to review and revise them. We are grateful and acknowledge each contribution received.

Floram coordinators have detected, among the suggestions made, a common denominator: a concern with the need to detail further the operational side of the Project.

The wide diversity of the mosaic of areas contemplated for reforestation adds a high degree of complexity to its actual operationalization. The number of information gaps and a dearth of reliable surveys for development of more detailed programs is indeed a constraint. Therefore, caution recommends that any operational plan be limited to a general outline, and that executive details be deferred to a later date when information starts to flow in from the many regional research programs involved. Outlining such programs is a top priority (as is their actual performance) among many others in Floram. Fast dissemination of these research findings, designed to serve as guidelines and to reduce the level of risk (or increase the chances of the Project succeeding), will strengthen the executive decisions required as reforestation actions develop.

However, the concerns expressed needed a response and Floram is intended as a merger of several "mini-Florams," some of which already under way while others are to go on stream shortly. So it seemed advisable to internalize into Floram the operating expertise built up by these forestry developments in giving shape to the guidelines of the broader Floram. A special meeting was called to explore and take note of the ideas of everyone involved in reforestation projects.

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It became clear at the meeting that one of the primary tasks of the Floram team at IEA/USP would be to draft a conceptual framework to work as a guideline and signal the direction desirable for the many operational branches of the Project.

Contributors, supporters and critics of Floram Project alike have all insisted on just such an overall approach expected to provide consistent operating guidelines. The time had come to fill the gap or oversight of the Working Group that had developed the preliminary papers on Floram Project.

The mass media have been generous in publicizing knowledge, facts and events regarding the environment. However, statements by environmentalists have not always provided the proper foundation or groundwork for an objective interpretation of the information disseminated.

Misplaced or misleading statements or interpretations often result in widespread controversy artificially fed for demagogic reasons. It is hard to take an unbiased stand in a context pregnant with accusations of longstanding — over five centuries — gross mismanagement of forestry resources. Add to this almost absolute neglect for ecological issues and an inexcusable slowness in raising collective awareness about regional, and more importantly, global environmental issues.

A balance must be struck between innovative initiatives and the inertia fed by the passion and prejudice caused by the absence of a rational and skillfully preservation-oriented forestry policy.

The loss of native forest masses of vital strategic ecological importance was a consequence of legislative and/or controlling zeal which passively accepted a whole series of harmful activities. This attitude made room for increasingly faster and more extensive destruction of soil fertility in vast portions of the Brazilian territory.

Furthermore, mini-properties (slashed off of bigger ones) were settled with the idea of maximizing total yield through cattle raising activities. They in fact steam-rolled in with no regard for preserving natural sanctuaries that helped sustain the environmental balance and thus the genetic heritage of our regional native flora.

This somewhat troublesome backdrop now recommends redoubled efforts in developing new conceptual approaches. They must be very clear, objective and current to effectively and convincingly show that there can be consistency between apparently opposing interests resulting from outdated biases.

The aim is to bring conceptual consistency and to show the strong mutual benefits between: industrial processing of forest products and environmental preservation; plant breeding with differentiated clones and conserving biodiversity; forestry activities by major corporations and social forestry to benefit small and medium forestry enterprises.

A balance between such needs must find its way into the conceptual framework required to firmly establish (in a long-term horizon) the economic feasibility of initiatives that Floram Project hopes to encourage. In other words, if the sale of processed forest products cannot generate enough cash to stimulate continued planting, a first forestry cycle will never lead to a second one, and the sequence of cycles which denotes sustainability will be interrupted.

2. FORESTRY AS A SET OF SYSTEMS

The techniques used on an industrial or craft-like scale to process forest products constitute a major step in the sequence of events making up the forest resources development systems. The initial stage in this sequence — the biological development of forest inputs to feed such processing activities — must be properly adjusted to the conditions and installed plant capacity. In turn, conditions and installed capacity are a "bridge" stage between forest assets available (now and in the future) and the demands (historical and forecast) of the consumer market. These will define and determine the final stage of the sequence.

Achieving gradual and consistent social development requires the events involved in all three stages to be harmoniously intertwined without causing a harmful impact on the environment. The activities must also have the properly efficiency and effectiveness needed by each and every event along the chain of production. This concern with operating efficiency and effectiveness is vital if we hope to meet the expectations of consumers relative to satisfactory performance of the end product.

In short, forestry can be visualized as a system consisting of processes that turn forest raw materials into crafted or industrialized goods, whose satisfactory functional performance will induce consumers to buy them for an amount greater than the cost of the respective processing. If the differential (profits) reinvested show attractively enough returns, the growth and development of the forestry industry and its products will be ensured.

2.1. The Concept of Value

As a system, the forestry industry combines all the values involving the goods it produces throughout the entire sequence of steps: biological genesis, industrial processing, and sale.

Protective shading for cattle; the aesthetic pleasure of seeing a lush and generous forest displaying a wealth of genetic variety; the visual charm of tree strips to act as windbreaks or to shore up river banks — these are all both aesthetic and utilitarian values difficult to translate into economic terms. The forestry approach focuses on the biological and productive side of the system (planting, growth, inventory, forestry management, cutting and removal of logs). The technologists concentrates on the many industrial processes used to change the phytomass removed (or specific portions of it) into products or inputs whose distribution and sale are areas of economic concern also forming an important part of the forestry industry. Another major component involves human resources. The know-how built up along years of professional practice provide the skillful and ingenious management and control of production flows to accomplish and optimize expected yields.

Integration between the different parts of the system leads to a need to seek and ensure the internal harmony conducive to another more encompassing form of harmony: that of ecological values which accommodate and sustain the basic biological processes. The harmony of this whole prepares the ground for a well structured and lasting social development.

The efficiency of a productive system does not have to be necessarily high when its output is in very great demand by the consumer market. Unfortunately these are exceptional cases among forest by-products and give rise to another set of issues. Generally speaking, the value of forestry products is either relatively low or under tough competition, where high production efficiencies are a key and crucial factor if the enterprise is to survive.

It should be stressed that forest-based products have relatively steady characteristics, supply and a biologically renewable availability. Due to their natural origin, however, they may display surprising changes along the years.

All of the above shows that the value of forest commodities is determined by a complex set of factors. A major one is human expertise in managing those natural resources which have renewability as their common denominator.

2.2. Viability Considerations

Aside from the quantitative data on production flows, any analysis of the overall value of forest products must include also qualitative data. Though difficult to quantify, they are extremely important for proper decision-making on the strategies for the industry.

Floram Project should originate new diversified industrial centers whose location will be strategically directed toward optimizing the processing of forest products.

From this standpoint, feasibility studies are an excellent analytical tool as they increasingly incorporate qualitative evaluations to decision making.

Some of the basic classes of feasibility to be considered are:

— economic feasibility, to identify the probability of having the funds available to achieve a project's goals;

— technical feasibility, which looks into the probability of meeting the technical-scientific goals of a project;

— social feasibility, looking into the probability of mobilizing enough of the human resources available, on the one hand, and making sure that the consumers, society or their representative will accept the technological alternative proposed on the other.

Included under social feasibility is an area of concern regarding the environment. This concern initially came out of technical feasibility studies which uncovered obviously negative impacts with short-term effects on the environment. Later, the high social costs of some of these effects in the long run became apparent (though at first they seemed harmless). Thus ecological concerns crept into the category of social feasibility and riding on uncertainty and fear of the unknown, they quickly gained ground. Environmental feasibility studies became an entirely new category in themselves.

2.3. Social/economic feasibility

The contribution to be made by the forestry industry to Brazilian economic development has great potentials and unique features, which make it doubly attractive. On the one hand, forestry products account for a growing share of the Brazilian exports, a reflection of their good acceptance by international markets. Some reasons for this sustained performance are: high sunlight rates; high temperatures favoring high yields; large areas of land and adequate soils suitable for forestry developments; last but not least, available human resources skilled in the technological and forestry know-how essential to the success of the Plan. All these factors open clear opportunities for regional development in Brazil.

Aside from its quantitative aspects, expansion of the forest cover will help ensure the **sustainability** of forest commodities. This in turn can induce newer and greater opportunities for rational implementation of industrial ventures. In this regard, Floram Project should originate new diversified industrial centers whose location will be strategically directed toward optimizing the processing of forest products.

It should be noted that all industrial developments based on our forests under Floram Project will be committed to preserving the native forest and/or reclaiming environmentally depleted areas.

The forestry industry comprises the following subsections:

Paper Pulp
short fiber (broad-leaved)
long fiber (conifers)

Wood Paneling
plywood
fiberboard
chipboard

Lumber

Plywood

Plant Extracts

Medicinal Extracts
tannins rubber
tar and turpentine
waxes

Soluble Cellulose

Polymers for Synthetic Fibers

Explosives

Hydrocolloids

Essential Oils

Fruits and Seeds

The industry also includes processes contemplating the use of timber as an energy source, to wit:

Partial Combustion (charcoal) Total Combustion (firewood)

Quality of life improvements resulting from reforestation developments are often linked to higher returns thanks to the verticalized industrialization of the basic commodities produced.

There is a wide gamut of economic scales available in forestry developments between two possible extremes. On the one end, heavy industrialization demands high skills and expert knowledge in processing technology and forestry biotechnology, a strong and innovative symbiosis requiring major capital investments up front. At the other extreme are the small and medium developments or family crafts, which require manual skills and a locally inspired aesthetics. In this case, backyard ventures demand investments quite affordable by household savings.

Within this broad spectrum of potential ventures, the forestry industry must make every effort to offer the market goods with the following strengths: assured uninterrupted supply in quantitative terms; international quality standards; and competitive and transparent pricing.

To reach this goal, the following strategic guidelines are proposed:

1. To assign priority to industrialized goods with the highest potential for supply growth;
2. To disseminate quality assurance standards via programs to reduce operating discrepancies;
3. To boost productivity (both in forestry and in industrial processing) by focusing attention and available resources on the highest value-added products.

The above goals demand firm participation of the staff in charge of identifying the innovations most suitable to production on an industrial scale.

Activating this important stage in the development of Floram is a key element for its success.

To do so, the idea is to encourage researchers involved in Floram Project to join a nation-wide information network like ANSP, for example. This data base is linked to the international network BITNET (and its ramifications EARN, NETNORTH, and AsiaNet) and will greatly enrich the exchange of qualitative and quantitative data on display.

2.4. Ecological Feasibility

The great variety of native species in tropical rain forests — one of their key assets — can be visualized as the current stage in a infinite number of evolutionary paths opened by a succession of bioclimatic changes that occurred along time, especially during the Quaternary.

From this standpoint, forests offer a much richer mosaic than had been assumed. It involves a pattern of heterogeneous species symbiotically surviving in an environment conditioned by the intensity of heat, moisture and sunlight rates. An infinite number of delicate and interdependent balances further underscore how fragile the whole truly is.

Once under way, Floram will make a significant contribution to the preservation of the genetic, biochemical, and physiographic heritage in our environment as well as other elements whose balance might eventually prove vital. This environmental heritage forms part of a set of value issues without a price tag in the economic market. However, they cannot be neglected by projects such as Floram for their concrete significance and importance from the standpoint of social development. Under Floram, the concern for quality of life and a decent survival requires extremely broad and diversified benchmarks to help balance between the extinction and speciation processes that make up the biodiversity developed on earth throughout its long evolution.

Ecological feasibility studies, therefore, aim at determining whether or not the impact caused by human activity (both short and especially long term) will indeed be harmless.

Harmless here is construed to mean not affecting global evolution negatively due to uncontrolled changes or impacting the several levels of our environmental heritage to the extent of harming or threatening the quality and sustainability of much-desired social development.

Historical data on production processes — both craft-like and industrial — show that from the start, attention has focused on leading products while the by-products generated were simultaneously neglected.

As time went by and production escalated, some of these by-products became grossly and increasingly harmful due to several forms of aggression against the environment. Some examples are the problems caused by mountains of wastes hard to dispose of without giving rise to other ecological problems. Others involve polluting trace elements. Because of their high toxicity levels, they require expensive measures of early preventive detection to ensure their proper elimination.

To solve these problems, the latest ecological feasibility studies have been using the proper analytical techniques to detect the presence of potentially harmful substances down to the level of parts per trillion. This approach has increased substantially the number and variety of polluters that must be under careful monitoring. At the same time, these studies have unveiled a mesh of interdependencies requiring the use of advanced statistics and mathematical models which until a short while ago were employed only in meteorological surveys or for actuarial estimations by insurance companies.

On the one hand, the complexity of models utilized in our preliminary prospective studies led to a variety of alternative interpretations, which in turn fed conflicting views and gave rise to controversies not entirely constructive at times. On the other hand, these prospective techniques have gradually matured and improved by virtue of the weight of the mathematical logic embodied in their models, thus resulting in more consistently developed forecasts.

Conditions such as sunlight, moisture, temperature, and soil nation-wide are extremely favorable and attractive for forestry activities in most areas still available in Brazil in terms of economic and environmentally-friendly development. Both native and planted forests have always been seen as key tools for control of several classes of environmental pollution. In addition to fixing atmospheric CO_2 in the form of phytomass, forests play a number of important preventive roles, e.g.: minimizing river and dam silting; headwater protection; fixation of dunes, etc.

3. BIODIVERSITY AND FLORAM PROJECT

The term biodiversity essentially means the stock of biological diversity present in the living planet Earth.

Atoms and molecules are nature's basic building blocks for everything, including living beings. Any vital elemental process involving cells entail changes in one or more molecules, and it can be said that the infinite number of activities taking place in living organisms are determined and guided by a set of molecules made up of several different atoms. Arranged in a specific sequential and three-dimensional order, they provide a coded "blueprint" to chromosomes and genes.

Understanding the patterns or spatial arrangements of atoms in shaping biologically complex and physiologically well-differentiated molecules, however, is not enough to understand life itself. It is certainly useful nonetheless to improve our grasp of biochemical processes and enhance our rational interpretation of objective observations recorded on the evolution of life.

The distribution of plants and animals in space and time results from a series of ecological factors of a physical, chemical, and biological nature. Together or separately, they trigger complex and time-consuming evolutionary processes in the many forms of life. At times a set of ecological conditions favored certain organisms and induced their widespread propagation. On the other hand, they have constituted a barrier to the survival of other living organisms causing not only their extinction but also the rise of gradual adaptations. Through long evolutionary processes, living species became increasingly differentiated from one another originating new species more flexible in terms of ecological demands for survival.

Thus biological diversity grew under the stimuli and action of the flows and refluxes of the many physical, chemical, and biological factors acting and interacting on the evolving life forms. The sequence of fossils collected in successive and overlapping geological strata record and bear witness to the characteristics of the main evolution lines and their occurrence.

Sunlight, moisture, and temperature conditions prevailing in tropical zones encourage the development of a remarkably high level of biodiversity. At these regions, biodiversity constitutes a unique characteristic of tropical rain forests, where a vast number of plant and animal wildlife species live in close symbiosis. In addition to a great number of tree species, grasses, saprophytic plants, and abundant microflora, tropical forests host several families and a variety of animal species living in close symbiotic interaction with the plant cover and infinite numbers of miscellaneous microorganisms.

At tropical and subtropical forests, ecosystem diversity is associated to the complex interactions among species. When this is broken by deforestation imbalance takes hold and may result in the extinction of species, and further generate a whole chain reaction leading to the extinction of whole groups of species.

There are tropical forests in 76 countries, covering 97% of the total area of tropical countries, but they are being destroyed at the rate of 7.5 million hectares each year. Open shrub formations *(cerrados,* savannas, and marshlands) are being devastated at the rate of 3.8 million ha per year.

The world population growth and the fast depletion of forest resources account for an acute energy shortage hitting 96 million people in 1980. The total annual firewood deficit is estimated at about 95 million cubic meters. By the year 2000, this acute energy deficit will probably affect 150 million people with unforeseeable consequences.

The term biodiversity essentially means the stock of biological diversity present in the living planet Earth.

The pressure on tropical and subtropical ecosystems will be tremendous, therefore. Preservation and conservation of the gene pools of forest plant species *in situ* will hinge on basic research on their diversity as well as on protection policies. There is a need to establish forest reserves, permanently preserved areas, environmental protection areas, ecological reserves, national parks, etc. This can be achieved through a series of rational studies and approaches consistent with their well-differentiated functional roles.

Traditional forestry management methods (developed for the simpler ecosystems of the northern hemisphere) for sustained timber production are inappropriate for the short cycle harvest or tropical and subtropical timber, in addition to conflicting with the conservation of these same ecosystems.

Traditional forestry is governed by ecology. It employs solely native species, regeneration must be based on natural methods, there is no intensive soil preparation or low cutting over extensive areas. To think about fertilizing, wide spacing of crop rows or short cutting cycles would be tantamount to heresy. It is a type of forestry applicable to nearly pristine and predominantly conifer forests.

Traditional forestry does not apply to the southern hemisphere countries, where mixed forests of extremely complex make-up, management and conservation prevail. New methods developed around properly tailored studies are required. The feasibility of "sustained timber production" in mixed forests is still questionable. Countries that practice traditional forestry have extended to the limit their ability to produce timber. In order to expand plant capacity, these countries must break away from traditional forestry and adopt intensive forestry practices.

It was thanks to intensive forestry that the importance of preserving and conserving biodiversity became a world concern. Studies on genetic variety in forest species (hardly touched by traditional forestry) are a top priority for intensive forestry. *In situ* and *ex situ* conservation of genetic forest resources and their use in afforestation and reforestation programs are among the main activities of FAO. It hosts a panel of experts on genetic forest resources working in close cooperation with several international agencies such as: UNEP — the United Nations Environmental Program, IUCN — the International Union for the Conservation of Nature, and Unesco — the United Nations Education, Science, and Culture Organization.

The natural variety of forest species, of the source of seeds within species (strains, ecotypes, and clones), of scions in a population, and of trees originating from those scions, are the foundation of intensive forestry. The existence of such genetic variability, preservation and conservation of diversity *in situ* and *ex situ,* knowledge of the possible causes affecting genetic variety, and its proper handling are the foundation for sustainability and yield increase under intensive forestry through genetic breeding in forests.

The broader objective of a forest breeding program is skillful and expert handling of the differentiated elements that make up the viability of a forest (be it native or exotic). The goal is to improve one or more of the following characteristics: growth rate, disease resistance, shape, adaptability, ease of propagation, etc.

These characteristics are unique to each tree species in a forest. They are phenotypic expressions resulting from the interaction between the genotypes of each species and their local environment.

The goal of forest improvement ultimately involves breeding a complex of genes with cloned material in such a way that the new phenotype will represent an improvement over the average phenotype of the forest in question. In other words, forest improvement should "tame" the best possible set of genes supplied by the forest biodiversity available.

This "taming" involves a sequence of careful manipulations, starting by a survey of all elements that determine the biodiversity (the genetic stock).

Preliminary selection follows, as well as a check of the validity and consistency of the segregated expressions. This leads to the design of cross breeding procedures to obtain hybrids firmly incorporating a number of genes whose totality (or genetic pattern) will have a phenotype with all the characteristics aimed at by the breeding scheme.

The task of selecting the genes to be added to the genetic pool for use in cloning assumes that there is a minimum of biodiversity. Only then will it be possible to separate out some of the elements involved in genetic complexes and, through the proper recombinant techniques, to obtain new complexes whose phenotype will meet the plant breeder's expectations.

It is easy to see that each and every successful forest improvement program will reach a homogeneous state from which it is theoretically impossible to achieve any further improvement. This point is reached when the best option among all recombinations possible within a given forest's biodiversity has been "tamed."

There are tropical forests in 76 countries, covering 97% of the total area of tropical countries, but they are being destroyed at the rate of 7.5 million hectares each year.

Not only does the original biodiversity level have to be preserved in order to retrace alternatives discarded for circumstantial reasons in the past; it is crucial in fact to enlarge the genetic base of the original biodiversity by incorporating new elements or gene pools.

It should be recalled here that preservation or conservation of a genetic base (gene pools, genotypes) must not be confused with measures conducive to ecological or environmental preservation in which interactions with a genotype cause a corresponding phenotypic expression.

4. IMPLEMENTATION COSTS

Budgets for implementation of forestry management programs can vary widely. Several factors affect cost estimations for reforestation to different degrees. Given their importance and as an illustration, some of these factors are listed below:

- Research and survey of preliminary data.
- Cost of land.
- Soil preparation.
- Road building.
- Seedlings.
- Planting.

- Fertilizers.
- Ant control.
- Crop treatment.
- Fire prevention and fighting.
- Training.
- Transportation.
- Return on capital invested.

Each of the factors listed above vary to a large extent and this explains why the total costs of different reforestation programs vary widely.

There is an additional key element worthy of mention among the causes behind such variations: the cost estimation method. The cost of land may be excluded depending on the accounting practices adopted. The same is true of R & D expenditures and of surveying and preliminary data gathering. Costs involved in road building will depend on the terrain topography and on the technology employed. Careful thought must be given here to proposed cuts and savings because floods and heavy rains may eventually take their toll (with interest and at escalated prices) on amounts "saved." Additional funding may be required to correct soil losses due to erosion and silting at undesirable locations (i.e. rivers and reservoirs), while higher maintenance costs for roads and transportation fleets may also be involved.

Costs incurred in the acquisition and/or preparation of seedlings will depend on the propagation technology employed for the plant material selected. Seedlings may be available at negligible costs for the small farmer — they are often supplied free of charge by major corporations and forestry development agencies. However, there is a cost involved in the work and resources tapped to prepare those seedlings before they can be delivered freely to beneficiaries.

One of the heaviest and most variable cost items is fertilizers used to boost the yield of a forest development via additional soil nutrients. Careful thought must be given to how much the anticipated extra output will offset the cost of fertilizers. This is no easy estimation. It involves consideration of all benefits arising from an increase in yield, all the way from energy savings achieved thanks to shorter mean distances required to ship logs to a central processing plant, to a reduction in maintenance costs for roads and shipping and handling equipment.

Within the heterogeneous mosaic of soils available throughout Brazil, the highest yields have resulted from favorable natural soil and climate conditions. They more than offset the use of fertilizer supplements and additional operating investments (higher investments per unit of area) in terms of expected yield increases.

There is an apparently paradoxical correlation between potential soil yields and the costs involved in creating a forestry development: the lower the potential yield, the lower the implementation cost (investment); the higher the potential yield, the higher the acceptable cost level (or total attractive investment) per unit of reforested surface.

The following table was prepared according to the five soil yield levels considered in Floram Project, and to the data already available:

Yield Rates average	**$tC.ha^{-1}$ $year^{-1}$ Ratios**	**Implementation maximum**	**Cost average**	**US$ per ha minimum**
High	13.1	2,000	1,750	1,500
High/Medium	10.1	1,600	1,400	1,170
Medium	7.3	1,270	1,060	860
Medium/Low	4.7	940	750	570
Low	1.3	500	350	200

In estimates on standing timber, the cost values utilized range from US$1,000 to US$1,500.

5. FOREST YIELDS VS. ENVIRONMENTAL CONDITIONS

There are data — though sparse — on forest yield fluctuations as a function of environmental conditions existing in the different world regions. Yield variations can be quantified with reasonable accuracy on the basis of available information on production forests. When reports obtained from different developments under distinct conditions are compared, the magnitude and significance of yield fluctuations become readily apparent.

The factors underlying variations in forest yields are reasonably well understood when taken individually. However, they are very difficult to interpret as they interact. Sets of factors show ranges of variation from region to region and even case by case. A listing of the main factors affecting yield rates, irrespective of the multiple combinations among them, includes: sunlight intensity, CO_2 concentrations, water supply, soil composition, ambient temperature, plant genotypes, and human intervention in forest production.

As solar energy hits the green surface of a plant leaf carbohydrates are synthesized from carbon dioxide (CO_2) and water (H_2O). These molecular structures will soon undergo enzymatic changes (catalyzed by trace elements found in the soil supporting the plant organism) according to highly precise instructions contained in the genetic code. They will guide cell multiplication and differentiation into distinct organs (e.g. the sensorial, motor, and reproductive systems, among others) in the sequence and at the rate unique to each species. The entire sequence of biochemical reactions suffers the effects of ambient temperature, an extremely important factor in terms of achieving high forest yields.

Following along the footsteps of agriculture, forest managers have opened new inroads in understanding and grasping the metabolic sequences that determine tree growth, the chemical composition of organic materials developed, the physical characteristics of the timber produced, the strength and resistance to pests and diseases to which plant organisms are prone, as well as other features considered in a forestry management program.

The continuing progress of science based on new knowledge gained from carefully planned and successful research has resulted in a whole series of improvements in forest assets represented by the genetic enhancement of yield rates. As an illustration, the table below shows the substantial progress made in Brazil in regard to the annual yields of eucalyptus plantations over the past half century:

Years	**Improvements made in forestry practices**	**Average Yield ($tC.ha^{-1}$ $year^{-1}$)**
1960-65	Hybrid seeds	3.3
1966-70	Hybrid seeds & fertilizers	4.6
1970-75	Pure imported seeds & fertilizers	5.9
1975-80	Same as above, from selected strains	9.28
1980-85	Use of fertilizers, cloned garden seeds vegetative propagation	11.9
1985-90	Same as above & additional selection	15.9

The data above indicate that human intervention has helped increase the potential annual yield of eucalyptus plantations on average by 5.4% over the past 30 years.

6. FORESTRY MANAGEMENT PROSPECTS

The continuity of forestry activities will depend on the viability of several factors (ecological, social and economic). Since the latter is vital to support the other two, special attention must be paid to yield projections and hence to the factors affecting yield figures.

First, as regards sunlight, no change is expected other than the usual fluctuations between day/night, winter/summer, solar spots every eleven years, etc. CO_2 concentration in the atmosphere has certainly increased, but the effects of higher concentrations of this prime ingredient on the rate of photosynthesis have been detected only under tightly controlled experimental conditions. Another ingredient crucial to photosynthesis is water and it deserves a special comment. It is a known fact that water is becoming increasingly scarce and should be treated as such, even at locations where it is still apparently abundant. Any policy to subsidize its consumption will merely increase improper use or overuse, and thus speed up its depletion.

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Another major factor affecting yield is the chemical and physical structure of soils. To ensure the preservation of both composition and texture, soils must be addressed in their entirety. It is estimated that depletion caused by erosion will ultimately result in soil fertility losses in the not too distant future, threatening the yield gains achieved lately. Measures to contain such losses must be encouraged (contouring, etc.), and soils selected for certain farming or forestry activities must be kept uniform with the aid of periodical fertilizer applications. It should not be forgotten that erosion from runoff may remove the surface soil layer which contains the fertilizers, chemical and biochemical compounds that makes for tillable lands. Their depletion may even cause harmful and polluting impacts elsewhere (silting of waterways, biocidal effects of pesticides in lakes, etc.).

Another known fact is that the area available for managed forestry will probably shrink over the next decades as a result of road building, of new dams for river training or power generation. The upward trend in demand at urban centers and recreational sites is also expected to rise. There will surely be an expansion of areas set aside for farming in response to the rising demand for food by a growing population.

As far as temperature is concerned, aside from the warming caused by the greenhouse effect and subsequent climate changes — which in fact was the concern behind creation of Floram Project — no other variations in this factor are expected.

The genetic material used in planted forests must be researched in carefully planned studies oriented not only to preserving the gains already achieved in past decades, but also to reached higher levels of forest yields. Research and development should place special emphasis on the following areas: new hybrids or clones; higher efficiency of photosynthesis; drought-resistant plants.

Man's intervention, the scientific and technological expertise amassed on natural and industrial production processes have brought about tremendous productivity gains to benefit the entire society. The practice of clone-based forestry management is an example of major gains. They have been accomplished despite challenges like the need for more stringent preventive actions to minimize the probability of impending risks. Some areas to be encouraged are:

1. Creation of native wildlife refuges in areas scheduled for extensive single-crop farming.
2. Maintenance of diversified collections of selected seeds.
3. Improvement of germplasm collection and storage programs to provide rapid response in protecting against endemic diseases or pests.
4. Strengthening and multiplication of varietal selection programs.
5. Improved monitoring to detect the onset of diseases and pests.

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