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The Production of *Eucalyptus* Plantation Forests from the Perspective of Eco-Effectiveness, Eco-Efficiency, and Cleaner Production

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CONTENTS

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INTRODUCTION

Among the many successful activities of the Brazilian entrepreneurial and business sector, that corresponding to the production of plantation forests and manufacturing of the products derived therefrom distinguishes itself. This business segment is rather young in Brazil, corresponding to approximately one century of accomplishments, always with continued success and growth.

This whole story began in the early 1900's, with the *Eucalyptus* introduction for commercial plantations intended for wood supply to Cia. Paulista de Estradas de Ferro (Paulista Railway Company), in the State of Sao Paulo. As a consequence of their quick growth and high quality, those forests soon showed potential to supply with raw material other industrial sectors in the country. From the ’50s onwards, *Eucalyptus* woods gradually began to reach and conquer new markets for manufacturing of pulp, paper, fiber boards, wood panels, charcoal-based steel, etc. More recently, around the ’90s, the *Eucalyptus* made the leap required to conquer nobler wood markets, such as those for furniture production, construction of houses, floors, wood structures, veneers, high quality panels, MDF, etc., etc. Ultimately, a technological, as well as a marketing success, thanks to these plant immigrants that came from Australia and Indonesia. Other important immigrants joined them, as the *Pinus* species, which came from the United States of America, Mexico, and Central American and Caribbean countries.

However, it is important to stress that it was only from the ’60s onwards that the Brazilian Forestry gained the status of independent science, liberating itself from Agronomy to walk by its own, in spite of its many interactions with many other sciences. The introduction of the forest engineering career in Brazil has soon allowed to graduate professionals suitable for the realities of the sector and of the country. The creation of cooperative research institutes among companies and universities came to consolidate the necessary scientific and technological foundations for Brazil to begin to enjoy the worldwide technological and forest productivity leadership. IPEF (Institute of Forest Research and Studies – www.ipef.br), SIF (Forest Investigation Society - www.sif.org.br), CEPEF (Forest Research Center – www.ufsm.br/cepef), and FUPEF (Forest Research Foundation of the State of Parana – www.fupef.ufpr.br) helped with the generation of knowledge and the formation of professionals at the corresponding universities where they were installed (USP, UFV, UFSM, and UFPR).

All this development did not occur only with regard to plantation productivity, but also in the entrepreneurial and environmental management areas. The desired Sustainability has been striven after through the efficient management by certifications as IS0 9000, IS0 14000, OHSAS 18000 and forest certifications FSC and CERFLOR (ABNT/INMETRO, with mutual acknowledgement of PEFC – Programme for Endorsement of Forest Certification Schemes - www.pefc.org). Ultimately, we have gained much productivity and forest competitiveness, but at the same time we have gained quality, occupational health and safety, and environmental protection as well.

I am always referring to Sustainability as an endless way. It can never be said that Sustainability has been reached, because its concept involves extremely high dynamism and a constant and permanent vision of the future. After all, we will be always working present actions preventing them to cause troubles to the future generations. Therefore, as the future never arrives, because it is always ahead of the present, we should be always searching for Sustainability, no matter when and where!

One concept which is still little widespread in the forest-based sector is that of Eco-efficiency, which is intimately connected with what is called Cleaner Production (CP). Incredible as it may appear, when some research is done with the search tool of www.google.com.br or any other one, a large number of quotations is found for the expressions "eco-efficiency" and "cleaner production". However, when the search is refined to try to find clear examples of these environmental tools in the planted forest sector, in any place of our planet, the results are just a few. They are vague and have no orientation whatever about how to do the homework, in case one wants to make use of these methods in the sector. I particularly have written and spoken very much about this subject. I understand that the Brazilian planted forest sector has shown a strong involvement in the environmental themes, but to a certain extent it is guided and centered by ISO and FSC/CERFLOR certifications and guidelines. I believe that the introduction of the aspects of eco-effectiveness, eco-efficacy, eco-efficiency and cleaner production can improve even more the environmental performance of the sector. The reason for saying this, after having completed 10 years practicing these concepts is that I understand that these concepts help to see better the world. These environmental methodologies are interesting, intriguing, and motivating. They try to orient those acquainted with them towards solving the problems at the origin, and not to search for late alternatives to mitigate the effects after the problems have already occurred. With this working philosophy implemented, the interrelations in the productive chain become still more intimate, involving the complete life cycle, not just one phase of it. For example, when starting our life cycle evaluation still at the design of the seed or the clonal material for manufacturing MDF (Medium Density Fiberboard) from *Eucalyptus* wood, our focus should extend through the whole productive chain, MDF uses and final destinations, not only on the wood producing forests for manufacturing this product. Some decisions about the wood grade or the potential of the plantation forests to receive and have residues (composted sludge) from MDF manufacturing plants incorporated to the soil will be able to be understood as important and accepted as challenges by the involved people. In case we focus too much one area and forget the chain, the forest area people would hardly show to be interested in having organic residues from industrial sludge applied to their soils, as this would be aggregating significant costs. In this case, the productive chain or value network visibility would be minimal, everyone thinking on their own and just looking at their own navel.

In the case of paper manufacturing, for instance, the value network ends at them paper recycling itself. The recycled paper manufacturing rejuvenates the waste paper; it gives to the recycled fibers a new opportunity to be used; it aggregates environmental advantage and allows reducing garbage material to the sanitary landfills. This recycled paper manufacturing generates new residues, such as biological secondary sludge, fibrous-and-mineral-filler-rich primary sludge, biomass boiler ashes, etc. Some of these materials can return to the planted forest as fertilizing compounds, acting positively on the mineral richness and the forest soil structuration. Thus, the overall wastes in the productive chain which our trees are being planted for are reduced. All this is very nice and sustainable. However, these practices must be done with much science, to prevent the forest soil from assuming an undesirable role of industrial landfill for those liking to take advantage from the environment.

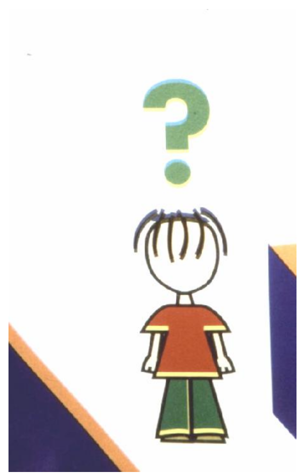
When we have a walk through our plantation forest areas, we feel an enormous pride in what we have done during these few decades of forest development in Brazil. Nevertheless, many opportunities for higher eco-efficiency can be noticed. This will be always like that. The rule that should be pursued is the same directing continuous improvement: "there will be always a simpler and more efficient way of doing something than that adopted at present". In Chapter 07 of this **Eucalyptus Online Book** I showed you the immense possibilities existing to recover large amounts of wood being at present wasted by the forest planters, who leave behind substantial volumes of good wood, able to be consumed ("Eco-efficient management of woody forest residues from the *Eucalyptus* plantation forestry" – http://www.eucalyptus.com.br/capitulos/ENG07.pdf). In that chapter, I mentioned loss values which may range from 2 to 8% of what the forest has produced. Values like this one surprise many people who are not seeing this enormous amount of wood which has been lost and left useless. Some people try even to display an environmentalist's vocation, by saying that it is very good to leave this lost wood in the forest ground, in order to help nutrient cycling and soil fertility. Although this is true to a certain extent, not every truth is the best of truths. There exist already many nutritive organic residues to be left as valuable forest harvesting residues: thin branches, barks, leaves, etc. They will be playing better this role than the wood from thin trees, treetops, and thick branches. Wood is nitrogen poor, it takes long to degrade and competes for the nitrogen of the soil for its biodegrading. Furthermore, the wood was produced by the forest in order to be used as raw material or as plantation forest product. In case it is not used and is left in the forest field, further forests will have to be planted to supply new amounts to replace those wasted, is it not so? Let's consider that if a mill requiring 100,000 hectares of forests effectively planted for its continuous supply assumes a 4% wood waste - it will no longer require 100,000 hectares, but 104,000. New costs, new impacts, further operations will be required, thus increasing the demand for goods of Nature. This is perhaps one of the most crying examples of our action in terms of eco-inefficiency. But there are further opportunities for me to bring to this dialogue with you along this chapter.

It was very good to have used the word dialogue in the previous sentence, because one of the basic foundations which I fight for in order that we practice eco-efficiency is what I call Dialogue with the process, with the mills, with the trees, and with the operators. To talk to the forest, to talk to the biodiversity, to try to understand their feelings, their difficulties and their problems is very important. We must learn to develop this ability, as this perception of what Nature tells us helps much to improve the environmental eco-efficiency. To enter into dialogue with other people helps as well - and helps a lot!

I would like to give you some simple examples about this point. I will give you the first two examples now, which will be called examples 01 and 02. Along this chapter, I will use many other examples to show you how to reason from the perspective of eco-effectiveness, eco-efficiency, and cleaner production. These two examples refer to the <u>Dialogue with the Forest Inhabitants</u>.

<u>Example 01</u>:
For some years, I have been consultant for Nobrecel S/A., in the Paraiba Valley, State of Sao Paulo. As I started there my activities in the year 2000, the company had no clonal *Eucalyptus* plantations. The whole production was based on *Eucalyptus grandis* plantations, the seedlings being obtained from seeds acquired from IPEF (www.ipef.br). There occurred serious phytosanitary problems with this species in that region, which is very favorable to the attack of the disease known as *rust* (caused by *Puccinia psidii* fungus). Productivity was much impaired thereby. We decided to introduce, as well the planting by seedlings obtained from seeds, the clonal planting of the *Eucalyptus urograndis* hybrid, which is much more tolerant to this disease, as well as to the *Eucalyptus* canker (caused by *Cryphonectria cubensis* fungus). We obtained excellent clonal seedlings from Riocell S/A, who sold the seedlings with a "technical profile" about the material. Initially some thousands of clonal seedlings/saplings of this clone were acquired, which were produced in the State of Rio Grande do Sul. Excellent seedlings, very suitable for immediate planting as they arrived at Paraiba Valley. At that time, the company had no tradition in planting clones and the forest technology was experiencing a quick process of changing for better. Curiously, one of the forest area supervisors, my dear friend Saul da Silva Garcez, immediately did not show to like the recently arrived clone seedlings. He said to me that they seemed to be small and that "they were too much green", meaning thereby that the seedlings should have suffered more before being directed to the forest field for planting purposes. When the first rural area was planted, about 25% of the seedlings did not resist and died. On my first visit after this occurrence, Saul told me: "Prof. Celso, as he calls me, those seedlings weren't really good, many of them died at the first planting we made". And I said to my friend Saul: "Did you by chance talk to them, asking the seedlings why they died?". Saul was intrigued by this question and asked me how to do this, since "a seedling does not speak, it is inherent in its nature to be dumb", apart from the fact that they could not speak because they were dead. Then I said to him: "let's visit them, to see why they died. We climbed intrepidly the strongly sloping hill in the farm where they had been planted *(Fazenda Estiva)*. On our way we gradually found many plants alive, vegetating well and forming their new crowns, as well as roots. Effectively, there were many dead seedlings, above the level

expected for a situation as that one. There were neither indications of an attack by ants, or other insects, nor of hydrological deficit or mechanical damage. Then, I took a wooden twig and began to ask a dead seedling the reason of its death. I began to dig the soil around it and to caress it, and suddenly it fell down into the pit made at the planting time. Saul was surprised at the discovery. We did this with other dead seedlings, with the same result. The seedlings produced in plastic tube containers had been badly planted, the roots were not in contact with the soil. The planting operator, possibly a new employee, or ill-trained, or else in a hurry to do the job, had put only enough soil to reach the seedling young stem basis, in order to sustain it on the ground surface. Below the ground level, exactly below the transition region between stem and roots of the potential new tree, it remained with its roots suspended in the air of the opened pit hole. They died because of lack on water and food, even though there was water, as well as fertilizer nutrients, so near to them. Saul, a remarkable and very religious person, said quickly: "God is always teaching us new things, from now on I am going to talk more to Nature". I am absolutely sure that he is doing this very well, from that time onwards.

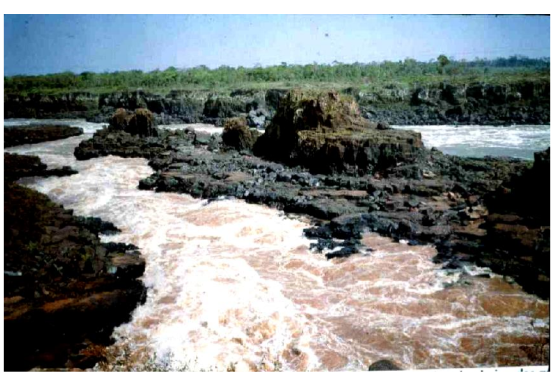


Example 02:
In the scope of a consulting work I performed for International Paper do Brasil, in the municipality of Tres Lagoas, State of Mato Grosso do Sul, at a certain moment we visited the plantation forest area. The *Eucalyptus* forests were magnificent and the forest engineer Leonardo Bertola Abreu, who accompanied me in the visit, was very enthusiastic. I expressed several times my admiration for what they were doing at that time (in 2006). However, I was able to notice that there were two planting stands of a single *Eucalyptus* clone, exactly beside each other, having the same genotype and the same planting period. They differed widely from the forest understorey. In one of them there was practically "an infestation" of a very leafy native

shrub, which was vegetating very much. In the other one nothing could be noticed. They were a few meters apart, the type of soil was the same, but the vegetation was distinct in the forest understorey. We stopped and decided to talk to the forest. All indications were that the seed bank of the soil had endured some kind of seed dormancy break specifically for that type of vegetation. I asked these plants whether or not their seeds had been activated by some fire in the place, prior to the *Eucalyptus* planting. Leonardo intervened in advance, saying to me: "This field has really endured a fire and we decided to reestablish and to replant the whole area, including that adjacent planting field, which did not suffer under the action of the fire". Once more, among the many examples all of us have to tell, we can see that dialogue is one of the best ways of understanding Nature.

A point that worries me a little is that many forest engineers from the new generation are too much occupied with their computers, checking their e-mail messages, or working out nice statistical graphs for the daily meeting with their bosses. They visit less and less the forests. I am afraid that they will not learn to read the messages from Nature, or will never enter into dialogue with the elements and beings of the planted forest.

Through these very simple examples and many further ones that each one of you has, it is possible to see that we can talk to our forests all right, be it with the planted or the native trees. It is also possible to enter into dialogue with our rivers and water courses, with the fauna, the flora, etc. Consider the case of our rivers. If we note that a small streamlet or a river crossing our forest farm presents muddy waters in a day of heavy rain, we should not look at it as though we had nothing to do with this fact. On the contrary, we must go up to it and ask it where all these sediments that are dirtying its waters are coming from. Is it by chance a soil erosion in some of our forest areas? Where would it be happening? If it is not occurring in our area, but in one belonging to a neighbor, what should we do? Should we think that the problem is only his? Completely wrong! If the problem is in a third party's land, it is the exact moment for us to practice the so-called "Corporate Social Responsibility", going there in order to tell them about the erosion prevention and soil conservation techniques.




"Soil erosion is one of the greatest causes of pollution in our rivers"

In conclusion, my friends, there exist thousands of opportunities in our forest day-by-day life. It is a privilege to work in a forest area. We should give many thanks to God every day we move through these forests and interact with the environment. How wonderful it is to be able to go to work enjoying the beauties of our forest eco-mosaic, where protected areas of Nature are mixed with plantations oriented to production and productivity. However, if when going to our forests our mind is just concerned with cost figures, man-working hours, number of men.hours per activity, audits and other tools rather belonging to the operational management area, we may be neglecting this marvelous opportunity consisting in seeing the signs displayed by Nature of its health and vigor. We have just to balance the following: the management tools are important and to sit in front of the computer, to be able to better prepare ourselves, as well. However, a good engineer and forest technician cannot fail to talk to his forests, all right? Have you already spoken to them recently?

The concepts of eco-effectiveness, eco-efficiency, and cleaner production have been emphasized enough in Chapter 09 of our **Eucalyptus Online Book** ("Eco-efficiency and cleaner production for the *Eucalyptus* pulp and paper industry" - http://www.eucalyptus.com.br/eucaliptos/ENG09.pdf). Now, I intend to write a little and to reflect with you on their practice in forestry. I have not the purpose of writing a treatise on forest engineering, I promise. It would be impossible to present in a chapter of approximately 120 pages all the hundreds of opportunities existing to optimize the forest operations through eco-efficiency and cleaner production. I will leave this task to you, after reading this chapter. What I have in mind is to present to you some situations of our daily life in the planted forest area and to insert the fundamental concepts of eco-effectiveness, eco-efficiency, and cleaner production into them. By means of them, I hope that many readers will begin to reflect on management and on their professional life somewhat in a new way, as a function of these inserted concepts. Evidently, I am referring to those who do not yet know and do not yet practice these environmental techniques. Even those practicing them under another name may eventually become once more motivated for the more eco-efficient management in their professional activities.

We will begin by reminding that whenever we lose eco-efficiency we will be wasting inputs, raw materials and/or time and impairing our production. All this means to waste Natural Resources, which are becoming more and more scarce. Natural resources are all we have at our disposal to operate and manage our forest plantations. If we misuse them, if we waste them, we will be contributing to exhaust this bank of Nature. Furthermore, wastes generate additional costs and lower business results.

We will exemplify this with our examples 03 and 04.

Example 03:

When we fertilize badly our recently planted forests, without a suitable soil fertility evaluation, without knowing the nutritional demands of the plant or without knowing how to distribute well the fertilizer for the plant to consume it, we will be wasting natural resources triply. Why? It is easy to understand, just follow my reasoning. Firstly, the expensive fertilizer, which will be badly taken advantage of by the plant. Secondly, in the productivity loss of the plant, which will grow less quickly than it should. This is aggravated by the weed competition, which will be more intense, requiring more herbicide treatments. We will lose triply, in all cases, due to reduction in natural resource stocks.

The good mineral seedling nutrition is very important for them to grow well.

Example 04:

We must seriously develop the conscience of reaching the potential and viable forest productivity in our forest areas. If the feasible target is a productivity of 45 m^3/ha.year, with forest harvesting foreseen for 7 years of age, we should endeavor to keep effectively such targets. If this does not occur, the consequences for Nature will be perverse. The first one is that there will be wood shortage and the company managers will most probably opt for aggression on younger forests, harvesting them at 5 or 6 years of age, in spite of the lower productions they will offer. "After all, they will say, our mills cannot stop for scarcity of wood". When doing this, we will be impacting a lot on Nature. The impact on the soil will be much more pronounced, since the period for the well-known nutrient cycling phenomenon will be reduced. Besides, the lower productivity and produced wood supply will require more areas to be planted. This means further environmental impacts: more agricultural inputs, higher fuel consumption by the machines, etc., etc. I believe that not everybody working in this sector imagines that the lower the forest productivity in terms of growth rate, the higher may be the environmental impact. Highly productive forests, implanted with suitable sustainable techniques, are much more eco-efficient than forests of low annual growth rates. It is just a question of evaluating how these productive forests were planted, managed, and harvested. If the principles of a good forest management were followed, they are definitively more eco-efficient than those of lower growth rate.

The decisions made in operation planning are often the factors impairing the environmental performance of our business undertaking. By choosing unsuitable options we will be ineffective, which will result in higher environmental damages. Our following example 05 will show you how ineffectiveness in the decision may result in an escalation of environmental problems.

Example 05:

It is very common for a pulp or paper mill project to consider using tree bark as a source of biomass fuel, in addition to the thin firewood, utilized as well. Our mill project in question foresees that when the trees are felled the harvested logs are taken from the forest field to the mill with bark. The small diameter logs, like those of treetops, thick branches, and thin trees, are also harvested and taken to be burned. Furthermore, wood processing inside the mill generates new sources of biomass fuel, consisting of woods resulting from log chipping: wood slivers, over-dimensioned chips, sawdust, etc. The result has been very common in the vast majority of the companies: biomass fuel is in excess at the mill. In general, it is the bark that is left over, since its quality is the worst one among these mentioned types of biomass. At present, the modern pulp and paper mills are much more eco-efficient in terms of electric power and thermal energy consumption. For this reason, demand for these types of energy dropped very much at the recently built mills. In case the company has not projected any ways of burning the whole biomass and selling electric power to the market, the excess of biomass will be inevitable. Then, there appear fantastic biomass composting projects to return it to the forest in the form of organic fertilizer. Or else, there appear external customers to purchase the residual bark, paying in general a miserable price for it. This occurs because the purpose of the company is to get rid of the bark waste, to prevent it from accumulating, so as to avoid paying an extremely high amount to dispose of it into a landfill. The worst and the most eco-inefficient solution found by many companies is to place all this bark in careless garbage deposits or industrial landfills of the mill. Should this occur, it should be at least avoided mixing the bark residues with other chemical industrial residues (dregs, grits, etc.), because if this is allowed to happen we will be condemning the bark to sleep in the landfill forever.

Some people go so far as to use this biomass bark residue to level areas, a fully inadvisable procedure, as it is an organic matter that will decompose and lose volume in the course of time. Besides, when this decomposition is anaerobic it will generate methane, a gas which is undesirable for the atmosphere.

Area of disposal of surplus bark in an industrial landfill

I have seen many projects for composting this surplus bark. When just the bark removed at debarked log washing is involved I consider this procedure to be very good. The bark is nutrient rich and improves the structuration of the stack to be composted. The ideal procedure is to associate its composting with that of the sludges from the effluent treatment area. However, to remove the biomass bark in large amounts, to compost it and to take it again to the forest is a procedure I consider to be a second-class environmental measure, because we assume that the bark should come to

the mill and be left over there in the form of a waste. Both energy, machinery and labor are consumed to transport it, handle it, store it, and return it to the forest field. Every residue generation involves high expenses with machines, areas of disposal and storage, operations, etc. All this involves costs and generates environmental impacts.
In such a situation, it is enough for the eco-efficient forest and project area engineers to make a suitable energetic biomass supply and demand balance. When this balance is made, it is known how much bark will be or is in excess. So, it is enough to redesign the forest harvesting for this part in excess to remain in the forest field, on the forest soil. This means to have a mixed forest harvesting system, one part harvesting the trees without debarking them and another part debarking them at the forest field. In this way, just the necessary amount of logs with bark would be sent to the mill.

This is a very simple example for the practice of eco-effectiveness, with economy of costs, investments, simplifications and lower environmental impacts.

It is so simple to reason on the basis of the principles of eco-effectiveness and eco-efficiency, is it not?

An unsuitable behavior in our way of management is that whenever a problem appears we try to solve it where it is showing the face. Consider the recently mentioned example concerning the bark. If bark is in excess, as next step we think: what will I do with it? Compost it? Take it to the forest? Sell it? Level an area with it? Few people are oriented towards finding the origin of the problem, which in this case is exactly to send the bark in excess to the mill. Then the solution is to send the exact quantity of bark to be used as biomass fuel and nothing else. When it is left over as a waste, this bark surplus is being treated as residue, "it will change hands in terms of management" and consume resources, impairing both the business and the environment.

I believe that now, after these initial arguments, we will be able to begin our chapter itself. Initially I will make some considerations about the concepts of eco-effectiveness, eco-efficiency, and cleaner production, trying to continue to associate these concepts with the planted forest production. Thereafter, I will try to have a walk through the forest area with you. We will visit the most different forest operations, with the purpose of finding improvement opportunities together. Finally, I will provide some further examples, with more detailed evaluations of how should they be evaluated in the light of the concepts we are presenting.

Some readers may be questioning themselves why I am just showing points to improve and to optimize. I do this with the best possible intention. I am absolutely sure about the enormous gains and the wonderful technology we have in Brazil for the planted forest sector. But I have already said before: it is always possible to improve still more. Hence my focus are placed just on some items, which I suspect that can be significantly improved by adopting the perspective from eco-effectiveness, eco-efficiency, and CP. Therefore, do not be sad or irritated with my examples of eco-inefficiencies.

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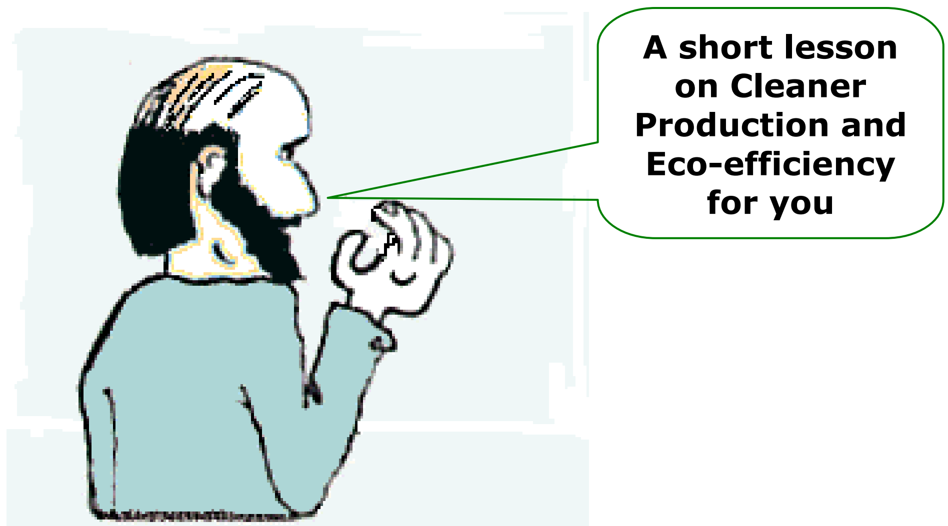
REVISING CONCEPTS OF ECO-EFFECTIVENESS, ECO-EFFICIENCY, AND CLEANER PRODUCTION



In this section I intend to provide some basic concepts for the beginners in terms of these tools of business management associated with the environmental management. There is a great deal of publications about eco-efficiency and cleaner production. Some of my previous chapters have tried to detail these concepts enough. I suggest you to have a look at them again, they are free and can be downloaded by you, just by clicking on the corresponding URL address.

I suggest you to read the following:

Industrial solid wastes from the *Eucalyptus* kraft pulp production –Part 01: Organic fibrous residues .(9.3 MB in PDF)
http://www.eucalyptus.com.br/capitulos/ENG05_residues.pdf

Eco-efficiency in managing the pulp fiber losses and the waste generated in paper manufacturing. (9.2 MB in PDF)
http://www.eucalyptus.com.br/capitulos/ENG06.pdf

Eco-efficient management of the woody forest residues from the *Eucalyptus* plantation forestry. (6.6 MB in PDF)
http://www.eucalyptus.com.br/capitulos/ENG07.pdf

Eco-efficiency and cleaner production for the *Eucalyptus* pulp and paper industry. (1.3 MB in PDF)
http://www.eucalyptus.com.br/eucaliptos/ENG09.pdf

Although there is a lot published about these basic knowledge foundations, they are still very little used or referred to the forest areas of the *Eucalyptus* forest-based companies. Apparently, the managers of this type of companies are so occupied and enraptured with using the standards of the series IS0 9000, IS0 14000, OHSAS 18000 and with the forest certifications of management and chain-of-custody (FSC, CERFLOR, or some other system recognized by PEFC) that they did not yet discover the advantages of eco-efficiency, eco-effectiveness and CP. I will not propose in this chapter that the tool that we will report on should become “the most important one” or the “only one” for the forest sector. I am sure that the Brazilian forest sector is being rather very much competent, as far as its accomplishments in search of sustainability are concerned. On the other hand, I will be very happy and fulfilled if the readers of this chapter will assimilate the conceptual essence of what I intend to transmit to them.

As a matter of fact, eco-efficiency and CP help, and help much, better perceive the world of wasting. They allow us to choose options to eliminate or reduce losses, reworks, wastes, residues, pollution, etc. They also lead us to solve the problems where they are being generated and not to look for mitigating measures for the consequences of these problems. From the common perspective, it is very usual for someone to question how to treat it, when a residue or pollution appears, whereas from the CP perspective, when a waste appears, the first question is “why is this residue appearing?” The following ones are: which are the causes of its generation and how to eliminate these generating causes at their root?

I will now give you two more examples to elucidate this.

Example 06:
In case I have a certain percentage of rejected seedlings in my forest nursery, which end up turning into an organic residue, also including a container substrate to be discarded, disposed of or reprocessed. The eco-efficiency and the CP will not only try to solve the problem of these residues (dead seedling organic matter and “lost substrate”). The CP will endeavor to discover the reason for so many off-grade or discarded seedlings. Were the seeds by chance of bad quality? Would it be the way of obtaining the mini-cuttings for cloning? Would it be the juvenility of the clonal garden material? Would it be the inadequacy of the substrate (pH, moisture, pathogens, etc.)?

Material that turned into residue taken from the plastic tube containers of seedlings that have been discarded due to quality or death

Example 07:

When implanting a forest stand, there are always some seedlings that die and must be replanted. The replanting indexes are low, ranging from 1.5 to 5% at good forest companies. However, this is a rework, a loss of seedlings, inputs, and forest growth. The eco-efficiency does not acquiesce in accepting this replanting operation as though it were a necessary operation for the plantation forestry: its goal is to put an end to it. The eco-efficiency determines us to look for all causes of the seedling death in the forest field, as well as to find solutions for them. This replanting operation is vicious, it does not add anything, it just consumes natural resources, it means cost and it means waste. The more extensive the replanting operation, the more eco-inefficient is our action. The recently planted seedlings should not die. We must ask them once more why they are dying.

*Eucalyp*tus seedlings: planting in a pit on the left and in a furrow on the right

The eco-efficiency oriented management consists in the constant search for better technologies, supposed to generate less losses, less offgrades, less wastes, less residues, less pollution, and less rework. The purpose is not to act just on controlling pollution and on disposing the residues; or accepting rework as a part of the process. The purpose is to eliminate them or to reduce them, and only after doing so to accept to treat what was impossible to be reduced (for the time being!!).

Conceptually, when we introduce this way of reasoning, we begin to perceive in another manner our operations, machines, the people working with us, etc. We aggregate very much to our management by continued improvements. We no longer get along passively with the problems, believing that they always existed, so that they might go on existing.

Effectiveness or Efficacy is associated with the sentence "to choose correctly what should be done", whereas efficiency is related to the phrase "to do well what should be done". This means that although our decision, due to the little use of effectiveness, has not been good, when choosing an unsuitable process, if we are able to operate it very well, we will be acting efficiently. Effectiveness and efficiency should be practiced together. First of all we should endeavor to be effective, selecting well the alternatives presented to us. This can be also called Strategy. We analyze strategic alternatives and select those appearing to be more favorable for our business, our life, and the environment that will be impacted. After electing the alternatives we want to implement, we must try to do it well, in the best possible way. It is at this point that efficiency comes into action i.e. to do this implementation in the best possible way. Efficiency is a result of Management, so that these words may be confused in the entrepreneurial life. Therefore, Eco-effectiveness consists in electing the best process alternatives for both company and environment. We should not choose an alternative that only privileges the environment and result in an economically unsustainable or in a socially unfair production. Nor should we choose an alternative only yielding results for the company and which is extremely harmful to the environment or to the company personnel and the community people.

I have seen these concepts of eco-efficiency and eco-effectiveness being considered as if they were the same thing. It is kind of candor from whom considers it this way, since these words have a definitively distinct origin. For this reason we will emphasize very much in this chapter of our book that our technicians must evaluate very well the technological alternatives available to them, so as to choose the best ones (eco-effectiveness in strategy), and after choosing them, when using them they should do this with the least possible wastes, minimizing losses and residues (eco-efficiency in operations).

We have already mentioned several times that our purpose, with this series of chapters about eco-efficiency and cleaner production, is to give our contribution, which added to other ones, may help the sectors relying on the *Eucalypti* as basis of their businesses to be able to move quicker in search of the dreamt Sustainability.

As we keep moving forward, looking from the perspective of these concepts, we begin to perceive more and more problems to be attacked and solved. Do not yield to despair if they will seem to be a lot, you are just beginning to perceive better what you were losing because you were not paying due attention to. This challenge is stimulating; the more people involved, the better it is.

It is curious that we begin to see the problems under a completely different prism than the usual one. The change might be compared to the little example in the following: "my car is out of order, its engine is failing. I take it to the workshop, in order to fix the engine, I spend a lot of money with the supposed repair and adjustment, but the problem persists. I change by chance the gas station on a trip and remark that the problem disappears." The problem was not in the engine, but in the adulterated fuel. It would not be very difficult to quantify this problem in terms of its economical values wasted with the worse performing gasoline, with the engine adjustments, etc. This is also very important to the manager. Not to be satisfied only with changing the gas station, but to compare this new station to the previous one. For this purpose, he will create indicators to measure the efficiencies. Who can guarantee us that he will not be able to find soon another gas station with better results for these created indicators? Eco-efficiency implies measuring, quantifying, comparing, and developing key indicators, in order that the management of the problem can be done in a better way.

Now we will finally define these concepts in a very objective way to those reading us for the first time:

⇒ <u>Cleaner production (CP)</u> is related to reduction of pollution or of the waste at its origin. In other words: if a residue or a waste exists, where was it or is it being generated and what should be done to avoid it at its origin?"

⇒ <u>Cleaner production</u> may be understood as a strategy to continuously improve the processes, products, and services, the operational efficiency, and the environmental quality, increasing economic results by cost reduction; and finally, allowing us to head towards the sustainable development.

⇒ <u>Eco-efficiency</u> can be summarized by putting into practice the MLB procedure: to do **M**ore, with **L**ess, and **B**etter. It means to include the best possible efficiency in our processes, whichever they are: administrative, industrial, forest-related, managerial, etc. It means to do the best product with the least use of inputs, such as wood, fibers, energy, water, etc., and with the minimum losses. Little efficiency results in residues, pollution, wastes, and reworks – and additional costs.

⇒ Eco-effectiveness fundamentally consists in choosing better among the alternatives available to us when managing our activities – in the case in question, our forests. The chosen alternatives should focus not only on the production, the process, and the costs involved, but also on the impacts on Nature and on people. We will be eco-effective when we will learn to ponder well over these three pillars of the sustainable development, focussing on the long run and not only on the immediate perspective of the short or extremely short run.

There is a very tiny conceptual difference between Eco-efficiency and Cleaner Production. Eco-efficiency place focus on the technological process, it tries to make it more efficient by consuming less water, raw materials, energy, etc. With more eco-efficient operations there will be less generation of residues, losses, pollution. The CP place focus directly on the waste, the residue, the loss. Knowing the value considered as "destroyed" by them, the CP tries to find the solutions to change processes, methods, procedures, etc., so as to eliminate or reduce these wastes. Both concepts are interdependent and look for better ways of producing something, anything, in whichever kind of human activity: a forest-related, an industrial, a service-related activity, or even routine activities of our domestic life. For this reason, they are more than necessary in our planted forests.

The practice of both eco-effectiveness and eco-efficiency requires quantification's, which should measure environmental, economic, and social impacts. It is very difficult to make decisions only based on feelings. For the manager of our planted *Eucalyptus* forests it is always important to evaluate the alternatives to be more effective. As we are technicians, the figures help very much, as far as decisions are concerned. Therefore, the suitable measurement of costs, returns, risks, losses, and waste generation is fundamental for the practice of cleaner production. By the way, to quantify the value of a loss, a waste, or a residue is the basic tool in cleaner production application. Thus, we can reach safer decisions (by practicing the eco-effectiveness) and try to achieve as well economic results, for the company to grow and to improve, as to minimize its environmental impacts.

Any quantification implies measuring with suitable tools and methods, without empiricism and without bias or prejudices. The quantification should be made with the best possible quality and without the undesirable practice of trying to prove our ideas and what we are thinking. The quantification's will orient us in the decisions to be more eco-effective and to choose the most correct things to do. When we are inefficient, these inefficiencies appear in the form of losses of production, energy, raw materials, etc. When having losses, as in Nature nothing disappears without trace, we generate more pollution, more effluents, more residues. In short, we impact more and damage more the environment (little eco-efficiency in the process). We spend more to treat this pollution and increase our costs by the higher use of raw materials, inputs, energy, etc. We spend still more to treat and to dispose of the residues. In brief, the minus world is created and we will be responsible for it.

A suitable quantification involves obtaining the following data:

- Negative value of the physical and economic loss of production;

- Negative value of the wasted raw materials;

- Negative value of the cost aggregation along the process, which we discard along with the loss or residue;

- Negative value to handle, treat and dispose of this residue generated by our inefficiency or eco-inefficiency, since the residues will impact on the environment;

- Positive economic value of the eventual sale of the residue;

- Negative physical values of the environmental impacts caused by the eco-inefficiency in question (Chemical Oxygen Demand, water consumption, effluent generation, energy consumption, reduction in quality of life of the fauna and flora, etc.)

- Negative values for the company personnel and the community people (ergonomics, unsafe and difficult work, odor and discomfort, dissatisfaction with the difficult work in handling the residue, toxicity in the environment, diseases resulting from the inefficient operation, etc.)

The section about "Case studies for new opportunities in terms of eco-efficiency and CP in the forest area", still in the present chapter of our book, will include, by way of examples for you, some case studies presented with this type of quantification's.

Any implementation of an eco-efficiency and CP program at a company requires two basic fundamental rules or principles:

- "Managerial commitment";
- "Sensitization and awareness" of all involved persons.

This order is very important and the first one to be sensitized is exactly the managerial body of the company. The achievement of results depends necessarily and decisively on the level of awareness and commitment of the company managers.

The following step is to "Evaluate the culture" and "Identify the possible barriers" that may exist at the company and in the company personnel. Entrepreneurial culture is something very important. The culture that developed at a company is often too focussed on costs and results. Everybody works hard for this purpose, as this is strongly demanded from the managers. When this occurs, people tend to let escape important indicators of how our *Eucalyptus* plants are growing in the forests. When a technician with a comprehensive cost and result culture enters a forest plantation, he only perceives operations costing monetary values and understands that he must minimize the respective expenses. He also focus very much his action on the forest inventory, accompanying the average annual growth rates and the current increments, imagining the time at which he should cut the forest for the maximum economic result. In short, his mind is deviated to cost spreadsheets, operational performance indicators, and forest inventory results. Thus, he fails to enter into dialogue with the forests and maybe even never has experienced such a happiness. But it is never too late to learn this, even because it adds an enormous happiness to our forest technician's life.

Precisely because it is necessary to define the scope of our study, it is important to begin a step of "Process description". The ideal procedure is to make initially an overall description of the general productive flow sheet of the company, from the seed or cutting preparation until the wood leaving through the forest farm gates. Then this macro-process may be divided into smaller processes, in most cases associated with a management area. Then, the work of creating a description must be repeated for each process area.

A new and very important step in any eco-efficiency program is the one of "identifying all losses, wastes, reworks, and generation of residues and pollution" occurring at the company. This may be even a part of the so-called "Environmental diagnosis of losses and wastes in the processes", where the losses are not only identified, but also quantified by the operational teams. It may be understood by process any company phase that one wishes to evaluate. It may be the nursery, the planting operation, the forest harvesting, the log transportation, the previous planning of the forest area, the area of human resources, the training of employees, etc., etc. There are companies trying to apply the concepts of eco-efficiency only in critical sectors, which are great raw material consumers and/or great residue generators. This is also an option. It is better than not to do anything. As the general productive process description is already available, as well as that of the areas to be evaluated, it becomes much easier to occupy oneself with these areas, already well-known and identified as to their limits and scopes.

I am quite sure that even certified and environmentally correct the company may be, with the company team evaluating its processes with all its creativeness, some hundreds of inefficiencies will be identified. One should not be afraid of stating them, since everybody will be looking for their solutions. It is not a matter of "hunting guilty persons", but of chasing after our recognized capacity of wasting things, an attribute inherent in the human being.

At most companies where we carried out this work there always appear lists containing hundreds of inefficiencies. Every inefficiency consumes more resources than it should, thus generating further losses and economic and environmental damages. As a result of it, pollution increases, as well as the amount of wastes and the costs to process all this. The production costs also increase, due to the higher consumption of energy, raw materials, labor, etc.

After identifying the wastes and inefficiencies in our processes, the following step is among the most important ones: "<u>Quantification of losses</u>".

The "<u>Use of mass and energy balances</u>" help us better understand each of our losses. Who is in a better position to make these balances than the technicians of the company and of the sectors being evaluated? Many of them have never done this before, have always believed that mass balances were things belonging to chemical engineering, not to the forest area. However, the mass balance tool is so simple and so useful that it can and must be used by anyone of the company. It is just a way of better perceiving the inputs and outputs of any process.

After identifying the losses and quantifying them in their dimensions, the next step is that of "<u>Understanding the causes of these losses and wastes</u>". This step is sometimes the most difficult one, as it may stir up the vanity of some people, who do not admit to be responsible for the inefficiency generation. This is how an area manager reacts when it is discovered that his area is losing much wood due to procedures that he himself had established. This is how he would react when the figures of quantification's that he had never carried out and ignored completely are suddenly disclosed. For this reason, it is very important to carry out a work at behavioral level while implementing the culture of working for the eco-efficiency and cleaner production. By doing so, it will be possible to help people to understand that the weaknesses and debilities may become a sort of drivers to conquer fortresses soon after. And they are vital parts for these new conquests.

After becoming acquainted with the problems; after quantifying them in terms of their economic, environmental and social values; after identifying the causes; now it is the moment of "<u>Identifying the opportunities</u>" and "<u>Selecting the most relevant ones</u>", in order to be faced and solved.

Thereafter, the next step is to "Define the changes required" for the selected opportunities, in order to eliminate or reduce the inefficiency. These changes may refer to technologies, procedures, people, process simplifications, management, maintenance, etc., etc. Once more the quantification's are vital. With the new technology or the new methodology, by how much do we expect to reduce the losses? Which will be the investments? Which will be the new costs? Which will be the expected productivity values? Which will be the payback from the modifications suggested for implementation? Which are the indicators to evaluate, in order to follow the success of the change? How will the perpetuity of the obtained gains be guaranteed? How will the process be monitored?

Another extremely important thing, which should be never forgotten, is the interdependency existing among the various areas of a forest company. We cannot just try to solve our problems without a complete evaluation of the implications of our actions in the areas related to ours. For example, the forest harvesting area is very much related to the silviculture area. An activity of low eco-efficiency at the forest logging may impair the silvicultural procedures. When replacing the semi-mechanized forest harvesting with the mechanized one, with heavy machinery, there can be an effect of soil compaction which would aggravate the silviculture operations when carrying out operations for plantation reestablishment of the recently harvested area. For this reason, there should always exist a strong and honest dialogue between the areas, so that the changes are made to improve the whole, not just a part of the whole.

The mechanized forest harvesting may bring the soil compaction problem for the subsequent silviculture operations – Something to be studied and avoided.

I like very much to use the "Productive Process Description" step associated with the "Quantification of Losses and Eco-inefficiencies", availing myself of "Mass Balances" to calculate both efficiencies and inefficiencies. Let's have a look at an example of a clonal seedling production nursery by way of a very brief exemplification.

Example 08: **Description of the productive process of a clonal seedling nursery**

Inputs		Operation		Outputs
Water Plastic tube containers Substrate Fertilizer Electric power	→	**Container preparation and filling**	→	Full containers Liquid effluents Solid wastes Defective plastic tubes Evaporated water Water lost to the soil
Water Fertilizers Agrochemicals Sun light Electric power	→	**Mini-cutting production in a clonal mini-garden**	→	Mini-cuttings Liquid effluents Organic matter (plant residues) Evaporated water Water lost to the soil
Mini-cuttings Water Agrochemicals Eventually hormone Electric power	→	**Mini-cutting planting**	→	Mini-cuttings planted in plastic tube containers Liquid effluents Solid wastes of organic matter and substrate discarded Evaporated water Water lost to the soil
Plastic containers with substrate and mini-cuttings Water Agrochemicals Fertilizers Electric power	→	**Rooting phase and initial growth in an green-house**	→	Rooted seedlings Liquid effluents Organic matter as residues Evaporated water Water lost to the soil

Inputs		Operation		Outputs
Rooted seedlings Water Agrochemicals Fertilizers Electric power	→	**Growth and adaptation phase** **Selection of seedlings/saplings**	→	Ready seedlings Liquid effluents Solid wastes from off-grade or dead seedling disposal Evaporated water Water lost to the soil

Inputs		Operation		Outputs
Ready seedlings Seedling holding containers Water Agrochemicals	→	**Ready seedling storage**	→	Seedlings for planting Liquid effluents Evaporated water Solid wastes Spoilt plastic containers Water lost to the soil

All these inputs and outputs must be quantified by the area which is trying to improve the operational efficiency.

For example:

- © How many plastic tube containers are used in each process phase?
- © How many plastic tube containers are lost in the various process phases: why do they become spoilt? Are they defective, etc.?
- © How much water is used in each process phase?
- © How much water is actually taken advantage of by the plants and how much water is lost by evaporation, by soil infiltration, and through the effluent?
- © How much of fertilizers and agrochemicals are used in each process phase or step?
- © How much of fertilizers and agrochemicals are lost? By which outputs? To the soil? In the solid wastes? In the liquid effluents?
- © Etc., etc.

These evaluations can be made with direct production data or else measurements can be requested to the company laboratories. Make yourselves ready for great surprises, my friends, we are almost always wasting much water, agrochemicals, fertilizers in these more conventional nurseries.

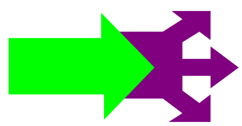
In a following phase, we can come back to the same process flow sheet of the above described nursery and insert the raised quantitative data. It is important to define which will be the mass balance basis, in the form of a production period: it may be either one day or one week. It cannot be too long, because the seedling production period is short, lasting 90 to 120 days at the most.

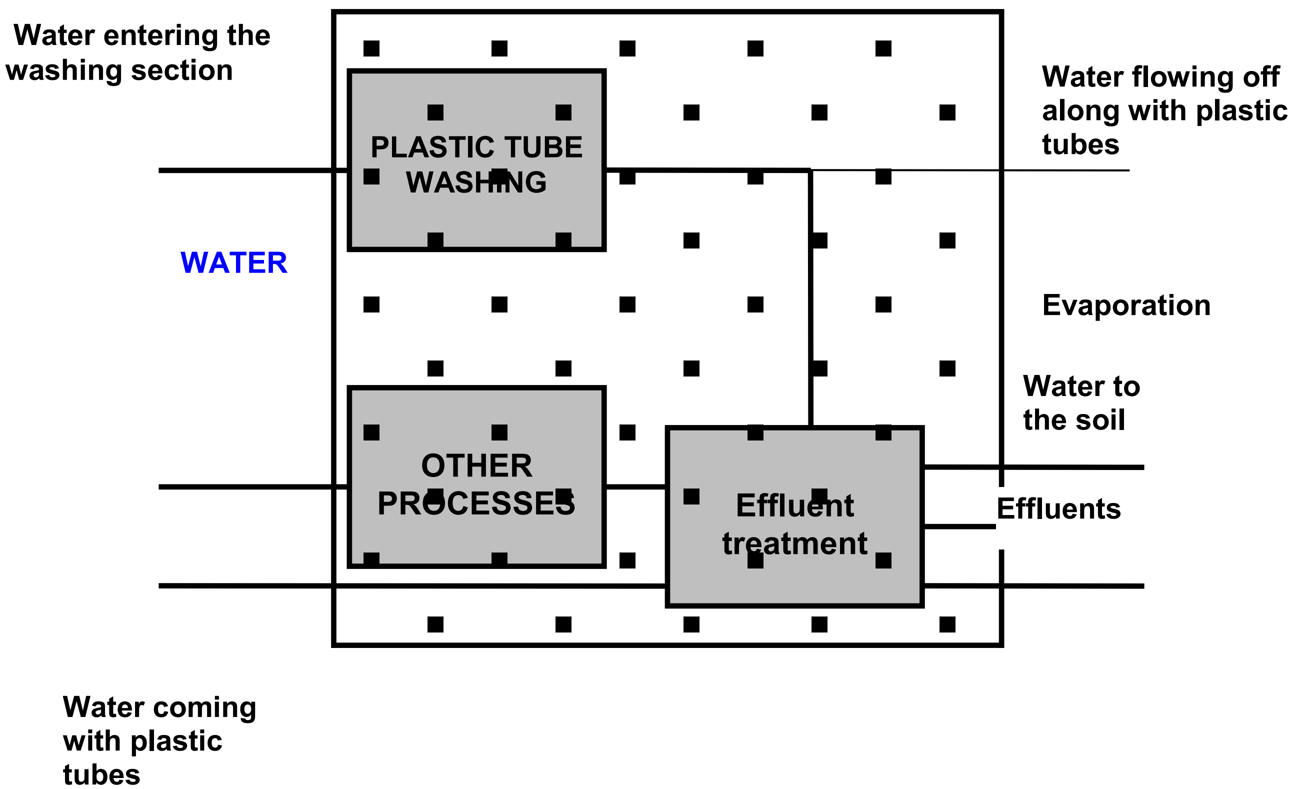
To obtain such data it is often necessary to use our dear friends, the Mass Balances. They are based on input and output quantification's, whichever they are: of raw materials, water, etc. The outputs flow in the liquid effluents, soil infiltration, evaporations, along with the seedlings, in the solid wastes, etc. It cannot be forgotten to also compute in the calculations the data concerning the stocks and accumulations built-in in the process, whichever they are: of products, raw materials, etc.

Seedling/Sapling production operations in seed and clonal nurseries

We will now give a little example of how to make a material or mass balance in our above studied nursery. The water collection value is in general easy to obtain as a function of the pump used to get the water at the source of supply, in general a watercourse or a dam. However, very few people know where this water flows to and how efficiently it is used in the nursery, in its different sections. Also, just a few people know or have already calculated how much water migrates to the soil, or evaporates without even reaching the seedlings or the soil, etc. These quantification's are fundamental, since they will help us know how efficient or inefficient we are in using the collected water. The purpose of our balance will be to clarify, to identify, and to help make decisions. At some moments it may be based on the best estimation, since it is not needed to be stoichiometric balances, nor is it intended to have a topographical precision.

Example 09: **Water balance in the plastic tube containers washing section**





Would this be difficult to quantify? Certainly not! Some simple measurements are enough, even by empirical means. The most difficult of them is perhaps the moisture determinations to be performed in the laboratory. As in every good mass balance, the evaporated water may be calculated by difference.

With this type of balance model and same way of procedure, we can make the balances of each nursery area and thus become very well acquainted with our efficiencies and inefficiencies in using the water collected for it.

Dirty plastic tube containers waiting substrate removal and later washing

Considering the water consumption of a seedling/sapling nursery, we cannot forget that the little young seedlings have very few leaves, they do not do much transpiration. The ways of losing water are different. Most water used for irrigation either evaporates or falls on the soil, or else joins the nursery effluents. It is a part of the process which wastes much water. The worst of it is that water is a vehicle to capture everything it comes across: fungicides, herbicides, insecticides, fertilizers, clay, sand, pathogens, etc., etc. It enters the nursery as clean water, but most of it is lost and turns into a pollution loaded effluent. This effluent deserves even a special effluent treatment station because of the hazardous materials it contains.

Then I ask: What is more expensive and more inefficient? Or more eco-efficient?

© To lose water, fertilizers, agrochemicals, and to have still to treat the contaminated effluents in a special station for this type of effluents, as the above mentioned case;

or else

© To look for a way of irrigating the seedlings without wasting water, finding still mechanisms of internal reuse of the waters susceptible of recovery. At present there are already hydroponic and semi-hydroponic nurseries and the dripping techniques are also feasible according to the situation.

Based on the eco-efficiency teachings and on our intellectual creativeness, we can evaluate the various alternatives to check which of them would cost less in economical terms and which would be their environmental and social gains when compared to each other. Thus, our decisive capacity would be more effective.

I hope that this example may have been useful for someone thinking about enlarging their seedling producing nursery, something very common at present in Brazil. The *Eucalyptus* plantation based forest sector grows quickly and the seedling requirements as well.

Macro-cuttings in rooting process and recently irrigated

Nursery irrigated by hydroponics and with ferti-irrigation
(minimum waste of water and nutrients – minimum pollution as well)

Hydroponic clonal seedlings

The evaluations and quantification's give support to the "Technical, economical and social evaluations", as well as to the "Selection of technological opportunities susceptible of implantation".

In the Technical Evaluation of the productive process it is very important to answer the following questions:

© Are the measured and quantified data reliable? Are there important data not being measured? Which ones?
© Is the process working as projected? Is it above its limits? Where?
© Has the process machinery maintenance been suitable?

- © Are there unnecessary process phases or operations?
- © Is any technological information relevant to the process operation missing?
- © Are the used raw materials in accordance with the quality and reliability standards demanded?
- © Are there constant shortages in the input supplies?
- © Does the operation planning allow working within reasonable standards? Or is one always "running after the machine" to meet new and unforeseen requirements?
- © Are the internal stocks in the process at a suitable level, planned in order not to be over-dimensioned? Are storage conditions suitable?
- © Is there much residue and waste generation? Which? Where? How much? Why?
- © Are there hazardous products being lost to the soil, effluents, etc.?
- © Are there suitable loss prevention systems?
- © Are there suitable treatment systems for effluents, solid wastes, noise, air emissions, etc.?
- © Is the product packaging suitable? Are there product losses due to it at storage and transportation?
- © Are handling and transporting operations suitable? Are there losses in these operations? Which types of losses? Do they generate rework?
- © Is there an excessive focus on costs (minimum cost) and not on cost optimization (cost effectiveness)?
- © Is there scarcity of resources at the company, making difficult the changes for process improvements?
- © Is there the culture of working out careful technical reports, justifying the new investments for technical process upgrades?
- © Is there electric power waste in the process? Where? Are there electric power consumption measurements in the most important phases of this consumption in the process? Does anyone evaluate and optimize these consumption's, or is the electric power considered to be a "gift of God"?
- © Is water also considered to be a "free gift" and therefore no controls of its quantities and qualities are done?
- © Is any care taken with regard to health, safety, and ergonomic aspects for the workers?
- © Are the human resources for operation suitable in terms of qualification, motivation, and commitment?
- © Is the work always done under pressure, so that the quality is not the ideal one?
- © Are the raw material suppliers reliable and do they always supply products in accordance with the specifications? Are there clear specifications from our part?
- © Is there good relationship and technical interchange among the areas composing the productive process flow sheet? And with suppliers? And with clients?

- © Is there an appropriate level of technological mastership for the processes which we are working with at the company at present?
- © Which is the technological level of such a process? Are there obsolete technologies being used? Which ones? Do they generate much waste and many inefficiencies? Which ones? Have they already been quantified? Are there valuations for these inefficiencies, losses, etc.?
- © Etc.; etc.

As to the "Environmental Evaluation", it involves having a clear vision of:

- © Generated amounts of residues, wastes, effluents, air emissions, pollution, losses of raw materials, etc.;
- © Larger use of raw materials than it would be necessary;
- © Internal recycling of water, materials, organic compounds, soils, substrates, composts, etc., which might have been implemented, but have not, no plans even existing for such a purpose;
- © Evaluation of the positive and negative impacts of the activities we are putting into practice (in any process phase, even in those not directly connected with the production);
- © Activities of loss prevention which are implemented or in the course of evaluation;
- © Activities of loss prevention and combat which we know that could be adopted, but we are not doing anything for such a purpose;
- © Reduction of environmental threats that may result in fines, environmental liabilities, legal penalties, etc.;
- © Evaluation of the real adequacy and conformity to the pertinent legislation;
- © Etc., etc.

In the Social Evaluation it is important to consider at least the following points:

- © Labor quality (occupational health, safety, risks, etc.);
- © Operators' qualification;
- © Dominant behavioral aspects in the labor relations;
- © Organizational climate;
- © Motivational aspects;
- © Company culture with regard to the employees' participation in decisive aspects of the business (empowement);
- © Company culture with regard to environmental aspects in the operations;
- © Etc., etc.

In the Economic Evaluation it is important to consider:

- The demand of investments for the required modifications;
- The investment payback, or rather the period of time in which these investments will pay by themselves as a function of the economic gains they will provide;
- The present operational costs and the new operational costs according to the implementation of the proposed eco-efficiency measures. In such a case, all process costs must be raised, not only the costs corresponding to the area where the measures will be implanted, because the processes are very interconnected and a change in one area results in effects in some other areas of the company. For example, an alteration in tree spacing affects the silviculture area, but it also affects the nursery (seedlings to be produced) and the forest logging (trees to be harvested).
- The reduction in onerous environmental liabilities;
- Etc., etc.

As already seen previously, after the perfect identification of the opportunities, with their technical, environmental, and social quantification's, it is now opportune for the phase of "Selection of the opportunities to be implemented" to occur. It should be very clear within the managing team that not all improvement projects will be able to be implemented. After all, the management of any business is based on scarce resources. For this reason, those people who have worked much for a certain opportunity, if it is not selected for implementation, should not be revolted, heart-sick or sad. They should bear in mind that they helped build up an important database at the three levels of sustainable development: economic, environmental, and social. Due to the bare fact that these quantification's have been made and considering the attention paid to this phase of the process, it should have already evolved somewhat in its operations. The operators' vision awoke and they will be certainly operating more attentively. Furthermore, it cannot be said that in the near future, in a new round of decisions, this opportunity will not be implemented. This may even occur in a still better way, due to the longer time to study alternatives.

I also consider to be very important that a process of "Jubilee and commemoration" takes place with regard to the improvements achieved. Everybody in the company should celebrate the eco-efficiency improvements in some way. It is up to each company to choose the best way to show the gains obtained and to commemorate this with the team of cooperators.

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ASPECTS OF THE TECHNOLOGICAL SUCCESS OF THE *EUCALYPTUS* FOREST PLANTATIONS IN BRAZIL AND THEIR POTENTIAL OPTIMIZATION BY ECO-EFFECTIVENESS, ECO-EFFICIENCY, AND CLEANER PRODUCTION

Photo: Aracruz, 2005

There is a series of good reasons for the plantation forestry in Brazil to have acquired the present technological status and that of successful utilization of these technologies by the forest planting sector. I intend to "navigate" a little over each of them, showing some potential points of eco-efficiency for these key factors of success. Thus, we hope to provide you with some reflections, in order to make these activities still more effective and efficient.

- **Forest and forest operation planning**

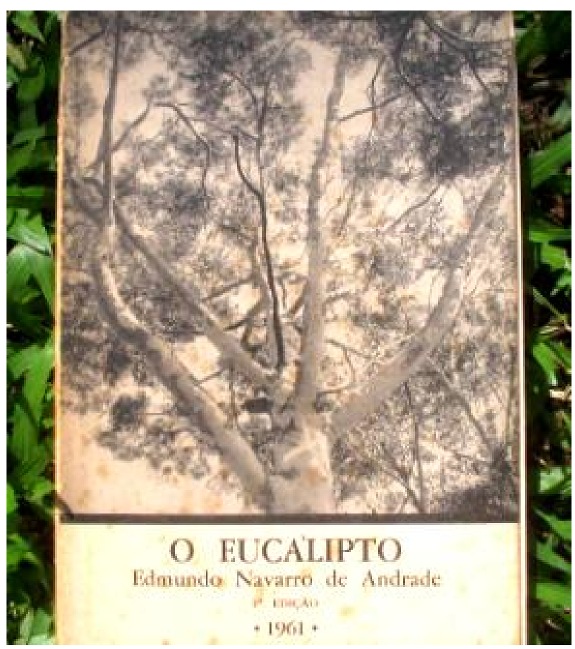
I will start my considerations by this important forestry area, as it may be a reason for much forest eco-effectiveness and eco-efficiency. Or inefficiency and ineffectiveness as well. Many decisions are reached in this area, which may impact on the eco-efficiency of our forests. An important point for those who plan is to foresee the impacts caused by what they plan. In case the operations are carried out in the way they are being planned, which are their possible impacts, bottlenecks, and generated wastes? Where and how might they come to accumulate inefficiencies? In which related areas will there be real chances of losses due to these operations planned in this way?

From the moment the forestry planner begins to reflect on this, he may have an important influence on operations improvement, not only as to the physical and economic aspects, but also as to the environmental one, because he will be able to associate operation productivity with better and more efficient use of natural resources. The same happens about social issues and gains (or losses).

It would be possible to exemplify numerous opportunities for this area, but I will restrict myself to only 5 of them, by way of example.

<u>Example 10</u>: **The planting spacing definition**

When Edmundo Navarro de Andrade, the father of Brazilian silviculture, delivered us the *Eucalyptus* planted forests according to his developments in his book "O Eucalipto", he recommended tree spacings of 2x2 meters i.e. 4 m² per tree for its effective use. At that time, there were practically no mechanized operations and the genetic materials were rather inferior to those available at present. The forest productivity rates ranged from 15 to 20 m³/ha.year for logs with bark. From the ’70s, with the gradual forest mechanization and improvements of our genetic materials, the forest productivity increased to 30 to 35 m³/ha.year and the forest spacing jumped to 3x2 meters, 3 meters being the distance between lines and 2 meters between plants in the same planting line. Then, an area of 6 square meters per plant resulted therefrom. This spacing continues to be very much practiced up to the present days, with some slight variations. The most usual ones are those where either 3x3 meters (9 m²/plant) or 3.5x3 meters (10.5 m²/plant) are adopted. There are also some odd spacings like 4x1.5 meters or 4x2 meters, which did not show to be successful due to the fact that they caused an intense competition between very close roots and crowns in the same planting line. The soil preparation is, in most cases, done by soil furrowing operation using a ripper. In case of too clayish or compacted soils, the plants tend to develop their roots in the planting line whose soil was prepared and presents the most loosened structure. For this reason, a plant begins quicker to compete with another one for soil nutrients and water. Thus, it is very common that a dominance of some plants over other ones begins to occur. The forest stand becomes very irregular in that type of rectangular spacings. It is much more convenient to try to use “more square spacings”, such as 3x3 meters or 3.5x3 meters, rather than spacings such as 3.5x2.5 m, or 4x2m, or 4x2.5 meters.



Book by Navarro de Andrade – The *Eucalyp*tus – Second edition of 1961

Too close a spacing in the planting line (4x1.75 meters), causing competition and growth variation between the plants – Observe the variation in tree diameters

Anyhow, let's have a look at the situation offered to us in terms of eco-efficiency by spacing definition, observing the levels of productivity among the various historical situations commented:

Historical average productivity	Planting spacing	Number of plants per hectare
15 to 20 m³/ha.year	2x2; 2.5x2	2,000 to 2,500
25 to 35 m³/ha.year	3x2; 3.5x2	1,428 to 1,667
40 to 45 m³/ha.year	3x3	1,111
45 to 55 m³/ha.year	3.5x3; 4x3	833 to 952

It is quite clear to me that if we have a genetic and environmental potential for high productivity rates we cannot and should not plant many trees per hectare. If we do so, very soon they begin to compete for nutrients, water, and sunshine. In this way, although the Current Annual Increment (CAI) is high in the first two to three years of age of the forest stand, CAI soon drops sharply (4 to 6 years) and the forest stand stops growing. Very "intelligently" the technicians recommend, based on their well-prepared inventory spreadsheets, to harvest the forest at 5 or 6 years of age. They consider the forest rotation age of maximum productivity to be reached. The managers become euphoric, as the age of 5 to 6 years means an advance of economic incomes. This results in the intriguing and inappropriate suspicion that the *Eucalyptus* may have its cycle abbreviated to 5 or 6 years of age for forest logging. Unfortunately there is a general managerial happiness, merely due to the tight and wrong tree spacing.

Well, my friends, the sooner we harvest our plantations, the more we will be preventing the nutrient cycling from occurring more effectively. More anthropic operations causing damage to the soils will occur. The loss of soil fertility will increase, as well as compaction, erosion, etc. It is definitively better to work with wider spacings and thus to extend the forest rotation in age, harvesting the forest stands at more advanced ages. We will have new CAI values which will stagnate and drop at higher ages, do you agree? My recommendation is to wisely evaluate the expected productivity based on the genetic material available and on the availability of water and nutrients. Based thereupon, to establish the most suitable number of trees to arrange per hectare. It should be remembered that when too many trees are arranged per hectare, they will be very soon competing among each other. If we are not going to manage our forests with thinning operations and the way of forest harvesting will be based on clear cutting and coppicing, it is better to further widen the spacing. The plants will further grow in diameter, each tree will be more volumous and the handling, harvesting, and transportation costs will also be lower.

Furthermore, when arranging less plants per hectare we will be saving natural resources such as forest seedlings, machine fuels, herbicides, etc., etc.

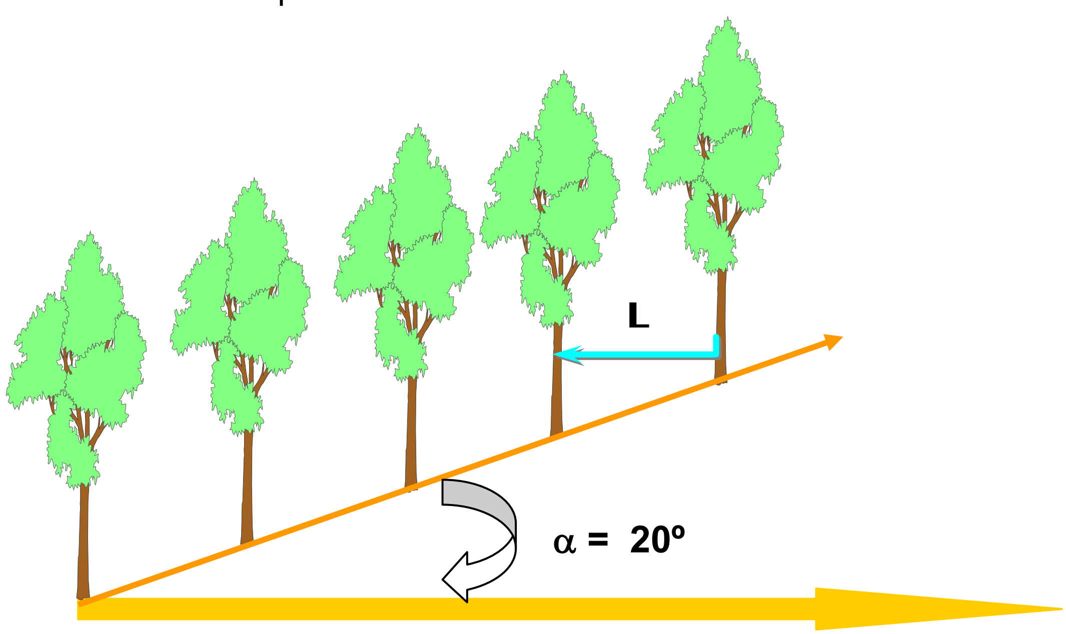
Remember, with wider spacings and less plants per hectare, there will be savings in terms of:

- amount of seedlings;
- soil preparation;
- weed competition control;
- replantings;
- all operations involving manual or machine work (covering fertilizing, weeding, pruning, harvesting, etc.)

When the spacing between plantation lines is increased from 3 to 3.5 meters, there will be a 14% reduction in the number of furrows to be produced by the ripper in soil preparation. Likewise for the number of pits to be dug, if this is the case. These are fantastic eco-efficiencies that are achieved in so simple a way! Now, those people who cannot see these achievements as eco-efficiencies, end up perceiving them just as cost reductions. As a matter of fact, eco-efficiency leads undoubtedly to cost reductions; but it also leads to reductions in environmental impacts, such as in the above example: 15% less soil preparation, machine fuel consumption, sediment losses, etc., etc. Now, as far as irrigation and fertilizing are concerned, we can even maintain the same amounts of water and fertilizer of the closer spacings. Thus, we will supply more vital resources to the plants, improving their initial growth.

Another thing many technicians forget about is that the land declivity affects the tree spacing, and does it to a great extent. When we define a spacing of 3x3 meters i.e. 1,111 trees per hectare, we are referring to an even land, or to values of flattened area. The declivity/slope is here not considered. The trees grow vertically, independently of the land declivity or slope. Let's suppose that there is a declivity of e.g. 20º. If we plant based on rulers of exactly 3 meters between lines, in order to measure directly the distance on the land, the spacing will be in fact 2.82x3 meters, in case we are planting the lines on level curves. On the level curve line there will be no influence of the declivity, but it will influence the spaces between plantation lines, and even to a great extent. Now, if the planting is downhill, the spacing might become 3x2.82 meters. In conclusion, there are many other situations, depending on the way the planting lines are marked in the ground.

Look how it is easy to understand why the spacing changes as a function of the land slope:



Cosine 20º = (Spacing L) : 3 (inclined hypotenuse)

L = 0.94 x 3 = **2.82 meters**

Thus, instead of 1,111 trees per hectare as planned, there will be 1,182 i.e. 6% more. Then, it is easy to understand why the planned number of seedlings sometimes does not correspond to the one effectively planted. The greater the declivity, the greater the mistake made. As a matter of fact, at each change in land declivity the spacing on the soil should be recalculated, in order to guarantee the theoretical spacing in the flattened land projection. Something like that done by topography. As already seen, to plant more trees per hectare then needed is an eco-inefficiency measure. We will be spending more natural resources than we should. We will be also stimulating an earlier competition among the plants. It is for this and many other reasons that ultimately CAI is impaired.

When planting, as in this example, 6% more seedlings, we will be showing some significant eco-inefficiencies, such as:

- we spend more seedlings than required and all inputs used to produce these seedlings;
- we will increase the working expenses of people and machines for the soil preparation and planting operations;
- we will increase the replanting requirements;
- we will spend more fertilizers, gel, irrigation water, etc.;
- we will impair the growth of the trees in terms of diameter, as this property is definitively ruled by spacing and the area allotted to each plant to grow.

Talking of **CAI** (Current Annual Increment) and **MAI** (Mean Annual Increment), our technicians can be always seen measuring them, presenting them and using them for planning decisions based on wood volume. There are sometimes those expressing them in tons of pulp/ha.year. In such a case, it is necessary to know very well how to make the calculation. If MAI is calculated at the end of the rotation by tree felling, volume measurement, and sampling of representative specimens for calculating the average wood basic density and the pulp conversion yield, there is nothing to question, admitting of course that representative samples are used, as well as a suitable number of repetitions in our testing for both forest field and laboratory measurements.

However, the forest inventory area at the companies is based on yearly volume measurements in the forest field, in semi-permanent experimental plots. We know that as the trees grow older, their cambiums learn to form higher density wood. The wood density affects its conversion into pulp, changing the pulp yield values during the aging process of the trees. For this reason, we will have volume measurements made by the forest inventory area which may impact in CAI results. On the other hand, we will have no basic density measurements for the wood grown from one year to the other (in the growth ring). Nor will we have the pulp conversion yield for this newly formed layer of wood.

The basic wood density is a value easy to be measured, whereas the pulp conversion yield is not so easy to calculate, as it depends on more complex testing. There are those obtaining it based on correlations with measurements made in the NIR (near infrared) spectroscopy.

Independently of how basic density and pulp yield are being measured, it is clear to all of us that the CAI and MAI curves expressed either in dry wood mass (obtained from the basic densities and volumes) or in tons of pulp are different from those expressed in volume. If the wood density increases correspondingly to the forest stand age, a CAI curve that may be declining from a certain age in terms of volume may present a different behavior when expressed in tons of dry wood or dry pulp. Then, this means that the forest rotations of maximum productivity may vary when calculated in wood volume, in wood mass, or in converted pulp stock.

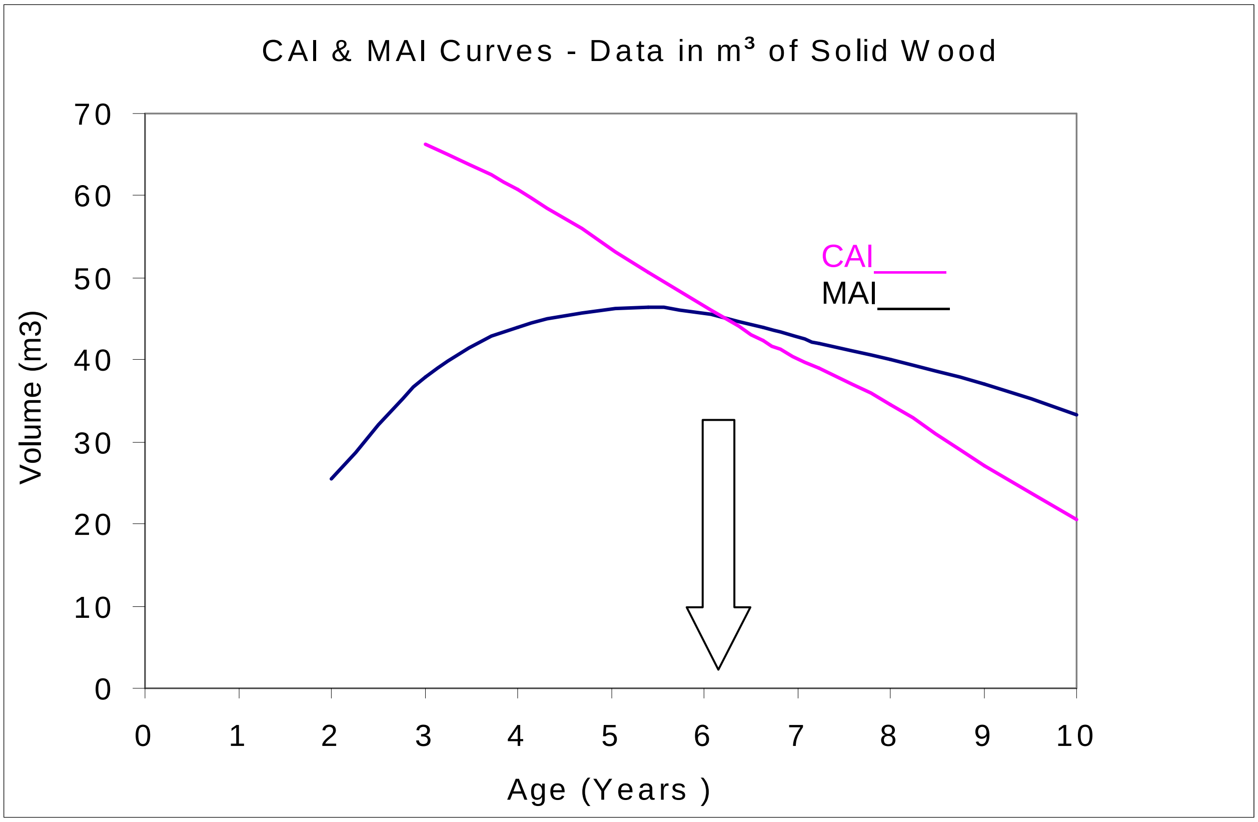
Definitively, the pulp manufacturing mills need tons of wood to manufacture tons of pulp or paper, while the sawmills need wood volume, not wood mass. Therefore, the analysis of current annual increments and mean annual increments should be different, according to the final use of the wood. According to our pre-established definition, we can calculate which is the forest rotation of best productivity, or by including economic values, the forest rotation of highest economic result. Based thereupon the planning area defines which is the best forest harvesting period.

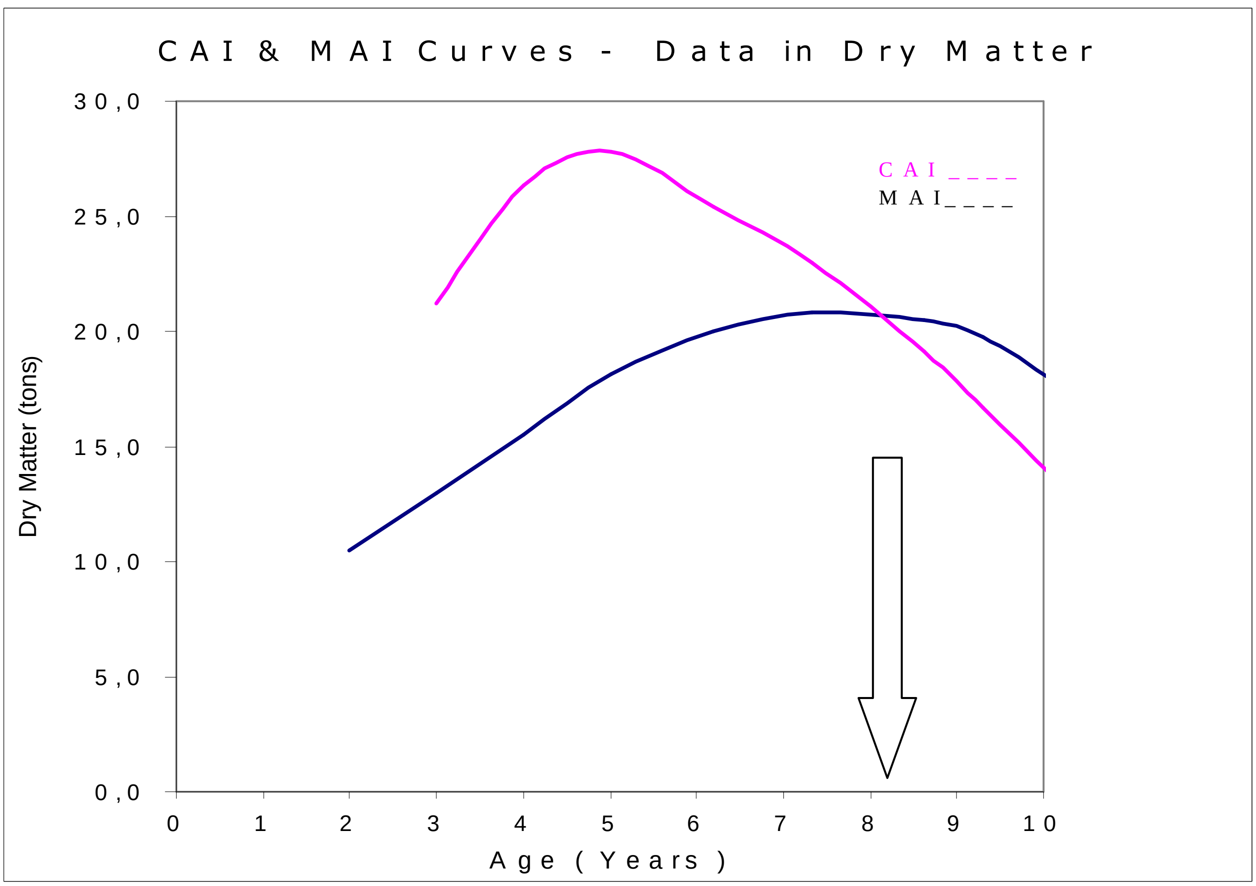
It should not be forgotten that all this is affected by the genetic material, the forest site quality, the forest operation quality, and the spacing adopted for planting.

As we change the spacing, we can also alter the forest harvesting moment.

Correct spacing definition is vital for higher eco-efficiency and higher productivity rates

Have a look at the following simulation, showing the relationships between CAI and MAI curves expressed on the basis of wood volume or dry wood mass for *Eucalyptus saligna* species. It is perfectly possible to observe that the forest harvesting age for maximum forest productivity varies as a function of expressing the values either in solid volume or in dry wood mass.


CAI & MAI Curves - Data in m³ of Solid Wood
Volume (m3)
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
Age (Years)
CAI
MAI


CAI & MAI Curves - Data in Dry Matter
Dry Matter (tons)
30,0
25,0
20,0
15,0
10,0
5,0
0,0
0
1
2
3
4
5
6
7
8
9
10
Age (Years)
CAI
MAI

Example 11: **Definition of the forest harvesting age or the forest rotation length**

I am very attached to the purpose of lengthening the *Eucalyptus* forest rotation, as you should already have noted. The environmental advantages are numerous for the soil, the biodiversity, and the forest productivity. I strongly suggest that our technicians evaluate more attentively this valuable opportunity we have at our disposal. I also suggest that you oppose more intensely and armed with good arguments, when one of the top managers of your company, interested in advancing incomes, start to consider harvesting the trees earlier than what is recommended.

I also ask you kindly to forget about the idea I can see germinating in some little eco-efficient minds, of planting *Eucalyptus* forests with close spacings, to harvest them at infantile ages, such as 3 to 4 years. When thinking of having biomass fuel or wood ethanol at such tender ages, we will be condemning our soils to a gradual fertility loss. These extremely short forest rotations will be one of the biggest environmental mistakes that the plantation forest sector may make. I hope that the foresters' good will and discernment, allied to the good scientific knowledge of our illuminated academic professors, will hinder this practice. Just imagine, I am proposing to lengthen the forest rotation by clear cutting to 8 or 9 years (based on better silvicultural, environmental and economic results) and I can hear people speaking of shortening it to 4 or 5 years! It seems that the economy and the environment are not speaking the same language for those who want it or think of doing it this way. We need to combat pedophile, even in the forest segment.

Example 12: **Definition of wood storage time prior to consumption**

As a function of difficulties to debark the *Eucalyptus* at the mills, there are companies harvesting the forest and keeping wood stocks at the forests for 4 to 6 months, waiting to be transported for consumption. They remain in intermediate stocks near to where the harvested trees were planted. The people adopting this procedure hope that by doing so the bark will release more easily and the wood and the bark will dry and become lighter for transportation. The drier bark will also release more calories at combustion, in case it is used as biomass fuel.

In principle, a decision like that seems to be somewhat eco-efficient, which is true, but it results in some significant losses, such as:

- loss of wood dry mass, which partially deteriorates in the forest field;
- loss of tree growth, which might have occurred in the forest during these 4 to 6 months;
- economic losses, due to increase in log handling, intermediate storages, etc.;

- financial loss, due to the long storage period. All financial resources spent for harvesting and stacking up the wood will be charged financially and the rates of interest in Brazil are among the highest ones all over the world. Considering an average rate of interest of 1% per month, for instance, a financial cost of 4.06% in case of 4 months of storage, or 6.15% when considering 6 months, will be added to the whole cost applied to the forest harvesting up to the moment of making the log stacks in the forest, which is not at all negligible, don't you agree?
- In case the wood is converted into chips and pulp, the drier wood consumes more energy in the chippers, generates more sawdust, and consumes more chemicals in the cooking process. In short, new losses and new eco-inefficiencies.

In this case it is better to evaluate the possibility of combining mill debarking with forest debarking, if there is biomass fuel in excess at the mill. We have already spoken about this previously, do you remember?

Harvested wood waiting for its turn to go to consumption

Example 13: **Release of the forest harvested area for planting**

The suitable forest operation planning is vital to avoid interference's of one area of activities in (an)other one(s). We must understand that there exists a logical sequence in the forest operations. These operations are often so intimately inter-connected that the delay in one operation, due to bad execution or bad planning, unchains a series of cumulative eco-inefficiencies. All this may result in losses in terms of results, as well as wastes of natural resources.

For example, if a certain forest harvesting operation is badly planned, so that it will take longer to remove the harvested log wood, it will also take longer to offer the land for the next forest stand reestablishment operation. Several losses will result from this series of delays, such as:

- Higher costs and herbicide consumption to eliminate the *Eucalyptus* stump sprouting and the weed competition;
- Production losses of the new forest, which might start growing earlier, as now it will be planted late. At present, considering the forest productivity rates reached in Brazil, at each month of delay in planting approx. 3.5 to 4 cubic meters of wood per hectare fail to be produced.
- Delay in planting the forest seedlings, which must be "forced" not to grow in the plastic tube containers. This seedling mistreating operation degrades the seedling root system and does not prevent them from growing in height. "Overripe seedlings" always result in problems concerning deformed or dead roots, have trees survival reduced, etc.
- Delay in supplying the harvested wood from the present plantation to the consumer company and delay in forest harvesting resulting from late plantation reestablishment;
- Etc., etc.


Large-dimension stump sproutings due to the delay in forest harvesting operations

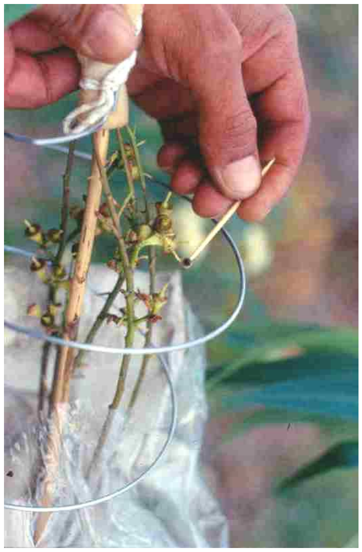

Overripe seedlings due to the delay in planting

Example 14: **Flow of vehicles for wood removal from the forest and its delivery to the mill**

Nowadays, with the modern communication technologies and IT, associated with the use of GPS - "Global Positioning System", it is possible to control and optimize very well the flows of the many vehicles involved in the forest activities. Just imagine that a pulp mill producing 2,500 daily tons of pulp receives on average approximately 200 to 300 trucks of wood every day, depending on the volume transported by each of them. If these flows are not based on a very good planning, there may be different waiting times during the process, resulting in worse eco-efficiency due to:

- Higher fuel consumption;
- Higher vehicle wear;
- Machine and worker idleness;
- Eventual lack of raw material at the mill;
- Wastes in related areas with log forwarding, unloading, etc.;
- Higher number of trucks required to be up to the process as a whole, as there will be idle vehicles, which will be waiting and therefore not being efficient and effective. Every 18 added waiting hours per day a new vehicle is required, an enormous waste that may be interesting for some people, but does not aggregate anything in terms of eco-efficiency to our operations;
- Etc., etc.

- **Genetic forest improvement**



Controlled pollination and hybrid production – 18-month-old *Eucalyptus* clone

The enormous Brazilian forest sector success is largely due to the genetic forest trees improvement and breeding. I have seen and been taken by surprise at the extraordinary efforts made for genetic improvement at *Eucalyptus* processing companies. It is common for the companies to speak of clone tests reaching some thousands in number. Any middle-sized company is proud of having already tested over 4 to 5 thousand clones and having these data in its clonal banks. From these evaluated clones, those effectively going to the planting front are only a very few. In general, the companies introduce just a few new clones per year in commercial plantations. The effort is too great and often the results are not proportional to such an effort.

Clones inadequately selected for commercial planting
(one with low wind resistance and the other one presenting a defect in the form of the trees)

I particularly have some restrictions to this torrent of tested material. I am quite sure that in many cases the suitable number of repetitions is not being applied or the sampling size is not sufficient for reaching safe decisions with regard to the clones. In such cases we are subject to make mistakes leading us to eco-ineffectiveness' and eco-inefficiencies.

When there are a few sampled trees for a certain genetic material, or when just a few repetitions are carried out for a certain characterization, or when a little representative sample is taken, mistakes can be made as to accept as good genetic materials that in fact are not.

Statistics teach us that there are two types of errors that can be made as a function of the level of significance which we decide to work with. We can choose this level of error we want to have. For example, 90% of significance means that we are willing to accept a certain margin of error in our selections. If we opt for 95% of significance, this will mean that we want a narrower margin of error.

The two main types of statistical errors which our analyses may lead us to are known as Errors Type I and Type II.

Error Type I: When we reject the null hypothesis, while we should not do such. In other words, there should not be any difference between a new and an old clone, while we accept that there is a difference. This means that we may be discarding or accepting a clone, when this should not be occurring. We end up accepting as very good a clone which is not, for instance. This is a rather dangerous type of error. The way of improving and minimizing this error is to increase the number of repetitions to analyze, in order to reduce of coefficient of variation.

Error Type II: We accept the null hypothesis, while in fact there are important and significant differences between the materials in question. We accept for instance that a better or worse clone is equal to those we already have. We may be discarding a good and better material because we believe that it is equal to the remaining ones we already have. If we make right with regard to other clones, this type of error is not so serious. To minimize this error we can change the level of significance and also increase the sample size.

The error type II is not so problematic, after all we may be failing to find a good genetic material, but we have already other good ones to make up for this loss. The error type I, on the contrary, is lethal. If we accept, for lack of suitable measurements or due to low sampling quality, a bad clone, thinking that it is good, the discovery may occur too late.

I prefer to work with less clones - to select and analyze very well each of them, increasing the sample size and the number of repetitions. I consider to be more suitable to do a better screening in the initial selection phases, so as to be able to work later more safely in terms of excellent samplings and credibility/reliability of the measured data.

Reflect on the following: when making a mistake of type I we are giving an eco-ineffectiveness certificate to our forest improvement program. For this reason I list in the following some questions for the forest breeders to reflect on:

- Who is working with preliminary testing to determine the optimum size of the sample to be collected as a function of the variability found for the characteristic in question to be optimized?
- Who is predetermining the error they are willing to have as maximum?
- Who is determining the variability of each test, in order to check whether the number of repetitions for the evaluations of wood basic density, pulp yield, etc., is suitable?
- Who is confirming whether the taken samples are actually representative?

In case you have good answers to these questions, keep moving, you are likely to be eco-effective in your genetic selections. But if you have not, rethink your breeding program, it may be just perfumery.

Number of repetitions, representativeness, and sample size are vital for the eco-effectiveness in forest improvement

* **Nurseries for excellent quality seedling / sapling production**

The good forest seedling quality is the foundation for a good planted forest, whichever species is involved. This situation becomes still more important when clonal plants are concerned, for which no typical root system exists, no well-defined axial pivoting root being present. Hence the attention to be paid to the seedlings in order to avoid tree development problems. We will discuss this later on a case example of seedling quality. There will be also a special chapter about forest nurseries in our **Eucalyptus Online Book** in the future. At present, the forest seedling production is based on excellent technologies and there are nurseries which are perfect seedling factories. In such cases, productions of 20 to 50 million seedlings per year are concerned, figures impossible to be reached by a nursery only some years ago.

There exist numerous opportunities to improve the eco-efficiency in forest nurseries. We will limit ourselves to just a few examples with brief comments, in order to avoid creating too extensive a text about this point, which is not the purpose at this moment.

One of the best opportunities for the forest nursery area is the reduction in the rate of losses with such plastic containers, which are planted, but do not result in viable seedlings. This proportion ranges from 5 to 30%, the higher values corresponding to clonal seedlings and the lower ones to seeded seedlings. It is absolutely incredible that a clonal nursery trying to produce 20 million seedlings useful for planting purposes has to plant initially about 28 millions. The whole work to fill up 8 million plastic tube containers with substrate is lost, as well as fertilizers, phytosanitary agrochemicals, mini-cuttings, etc., etc. An enormous waste deserving further studies to be solved. The cause of this loss is the lack of rooting ability of the clone cuttings, which shows low rooting capacity. Other causes are: inferior seedlings, non-uniform seedlings, seedlings presenting phytosanitary problems, incidence of frost, lack of irrigation, etc., etc.

All this represents an enormous operational eco-inefficiency, as the nursery will require:

- Larger amount of plastic containers to be filled up with substrate;
- Larger amount of cuttings;
- Larger physical area for all operations (clonal mini-garden, cutting preparation, greenhouse, shadow area, etc.);
- Larger amount of required human labor;
- Higher residue generation (broken plastic containers, discarded substrate, dead cuttings or seedlings that did not come to ripeness, etc.);
- Higher consumption of electric power, fertilizers, agrochemicals, phytosanitary products, water, etc.
- Larger intermediate stock areas to wait for operations that would not be necessary if these losses would not occur;
- Etc., etc.

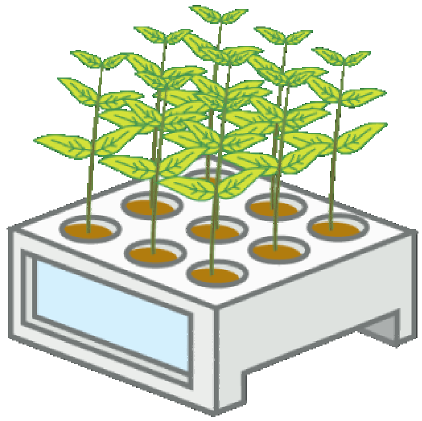
Up to this moment, all these additional costs resulting from lower eco-efficiency are paid by the seedlings that have survived and become appropriate, but this is too onerous. The search for technological solutions to increase the rooting ability should be carried out much more intensively than it is actually occurring. If we have a clone presenting 80% of rooting capacity this means that from every 100 cuttings, 80 will be rooted and 20 do not. Why did these 20 not develop roots? Which are the physiological reasons that prevented this from happening? Which are the forest companies producing millions of seedlings who have a vegetable physiologist in the R&D area, working on this problem?

If we consider the valid sales price of each clonal seedling to be 0.15 US$, this eco-inefficiency would be built-in in such a value, do you agree? A nursery of 20 million useful seedlings, with 20% seedling losses, would have a yearly 3-million-dollar turnover. The economic loss value would be built-in in these 3 millions and would amount at least to 400 thousand dollars per year, since the inefficiency occurs rather in the initial phase of the seedling preparation process. If they would sell the 25 millions of possible seedlings for the same 0.15 US$, their turnover might amount to 3.75 million dollars. Or else, the sales price might be reduced to 0.12 US$/seedling, aggregating advantages for the customers. How much of this value would the company be willing to invest in plant physiology research, in order to find explanations and solutions for this low cutting rooting ability?

It should be considered that if the nursery manages to raise its historical value of 80% of successes to 95%, the nursery capacity would reach almost 24 million seedlings for the same physical area. Or else, for the same production of 20 million useful seedlings the investments in nurseries would be 17% lower.

Therefore, it is difficult to understand why the investments in research in this rooting physiology area are not so developed! What is the reason for a part of the cuttings not to develop roots? Should it be ascribed to the way they are collected? Would it be their state of juvenility? Would it be the possibly variable environment where they are planted? This is one more case to ask each individual dead cutting which did not develop root the reason "why it did not do it and ended up dying".

Healthy *Eucalyptus* forest seedlings



Another serious eco-inefficiency practiced in the nurseries producing seedlings from *Eucalyptus* seeds is to put 2 to 4 seeds per container, in the hope to guarantee several seed germination and to be able to choose the best one. The remaining ones will be sacrificed. Well, my friends, forest seeds have at present excellent germination rates. They can be even selected by size, index of germination, etc. It is also possible to improve the seed arrangement in the container.

A measure like the exemplified one presents low eco-efficiency, as it results in:

- Higher seed consumption;
- Larger amount of labor required;
- Larger nursery area required;
- Higher organic waste generation;
- Higher incidence of plant diseases due to the injuries caused to the removed plants;
- Higher consumption of phytosanitary agrochemicals;
- Etc., etc.

One more reflection for our nurserymen friends adopting this poor eco-effective practice.

Another forest nursery practice to be paid attention to is the combat against pests and diseases. The ideal procedure is to apply the phytosanitary agrochemicals when the monitoring indicates this becomes necessary. It is perfectly possible to have a technician exclusively monitoring the phytosanitary nursery condition, in order to recommend the application of fungicides, insecticides, etc. It is a very common practice to apply agrochemicals preventively, even if there is no incidence of any pest or disease at all. Thus, we are impacting more on the environment and consuming more natural resources. Under the illusion of killing what does not exist, the expenditures are higher, as well as the impact. It is absolutely certain that a technician specialized in pests and diseases monitoring the nursery pays for himself more than enough, besides aggregating eco-efficiency and environmental health to the seedling producing activity.

• Soil preparation with minimum impact (Minimum cultivation)

Soil preparation by the minimum cultivation technique

This operation varies considerably from company to company. It may have a strong environmental impact if it is badly executed. When it is well taken care of, it has reduced environmental effect and is considered to be one of the technological advantages of the modern *Eucalyptus* plantation forestry. Robust machines are used, furrowing the soil, or digging pits for the seedling planting operation.

When badly executed, these operations may damage the natural resources because they may:

- Favor soil degradation and particle losses (soil, sand, clay);
- Favor seedling losses caused by the torrent rainwater flows, as well as by seedling cover caused by the sediments brought by the same torrent water flows;
- Allow the loss of soil fertility (nutrients, organic carbon, etc.);
- Allow the loss of soil moisture;
- Allow the loss of humus of the superficial layers of the soil;
- Disintegrate the organic litter distribution over the soil surface (organic tree litter deposited on the soil surface and by the forest harvesting residues);
- Etc., etc.

It is very important to monitor the soil preparation in order to be sure of soil de-compaction where the new plant roots will grow. In case the soil is compacted and too moist, it may happen that the furrowing line ends up appearing on the soil just as a deepened streak, without causing a real soil disintegration, in order to allow a suitable planting to be carried out. The seedlings need the loosened soil structure for the roots to grow fast. Remember, the first and more vital new forest implantation phase is the root growth. After forming a suitable radicular mass, the new *Eucalyptus* plant will start stretching the stem and growing in height.

Each seedling must find moisture and nutrients from the fertilizer provided to it. We cannot prepare the soil and put hydrogel, water, and fertilizers in it, without providing the necessary conditions for the seedling to have its growth favored, both roots, stem and crown. It is for this reason that we prepare the soil, it is not as simple as just to dig a pit and to put the seedling into it. The *Eucalyptus* trees are rather rustic and brave, but they are not miraculous.

Seedling some 30 days after planting, ready for growth in height – root system and a good number of leaves are to help this

Other very important pre-planting activities are: chemical control of weeds, stumpage sprouts cleaning, hydrogel application, leaf-cutter ant poison application, fertilizer application, industrial residue application (biomass boiler ashes, lime sludge, organic composts, etc.). In all these activities it is fundamental to create eco-efficiency and "housekeeping" indicators. The operations should be clean, safe, and efficient, with minimum wastes and with minimum environmental impacts.

As far as herbicides are concerned, I beg the enthusiastic forest technicians to minimize their use, just applying such quantities as required for an effective combat against weed competition. The goal is not to eradicate the underbrush, it is just to prevent it from disturbing the initial growth of the trees. Thus, the seed banks and the soil micro-life will be respected. Fortunately, herbicide application evolved much in the last years, having largely improved the environmental aspects of this operational practice.

Research programs are what we definitively need soon to privilege the initial growth of the recently planted *Eucalyptus* seedlings. It is unacceptable that so expensive and so patiently developed seedlings as the *Eucalyptus* ones may lose the competition to a weed of whatever kind, that came to grow without fertilization, without irrigation, and without soil preparation. Then, one more question in the dialogue with the young *Eucalyptus* plants: "what do they need to grow faster in height and to win the competition with the weeds in the initial stage of their development?".

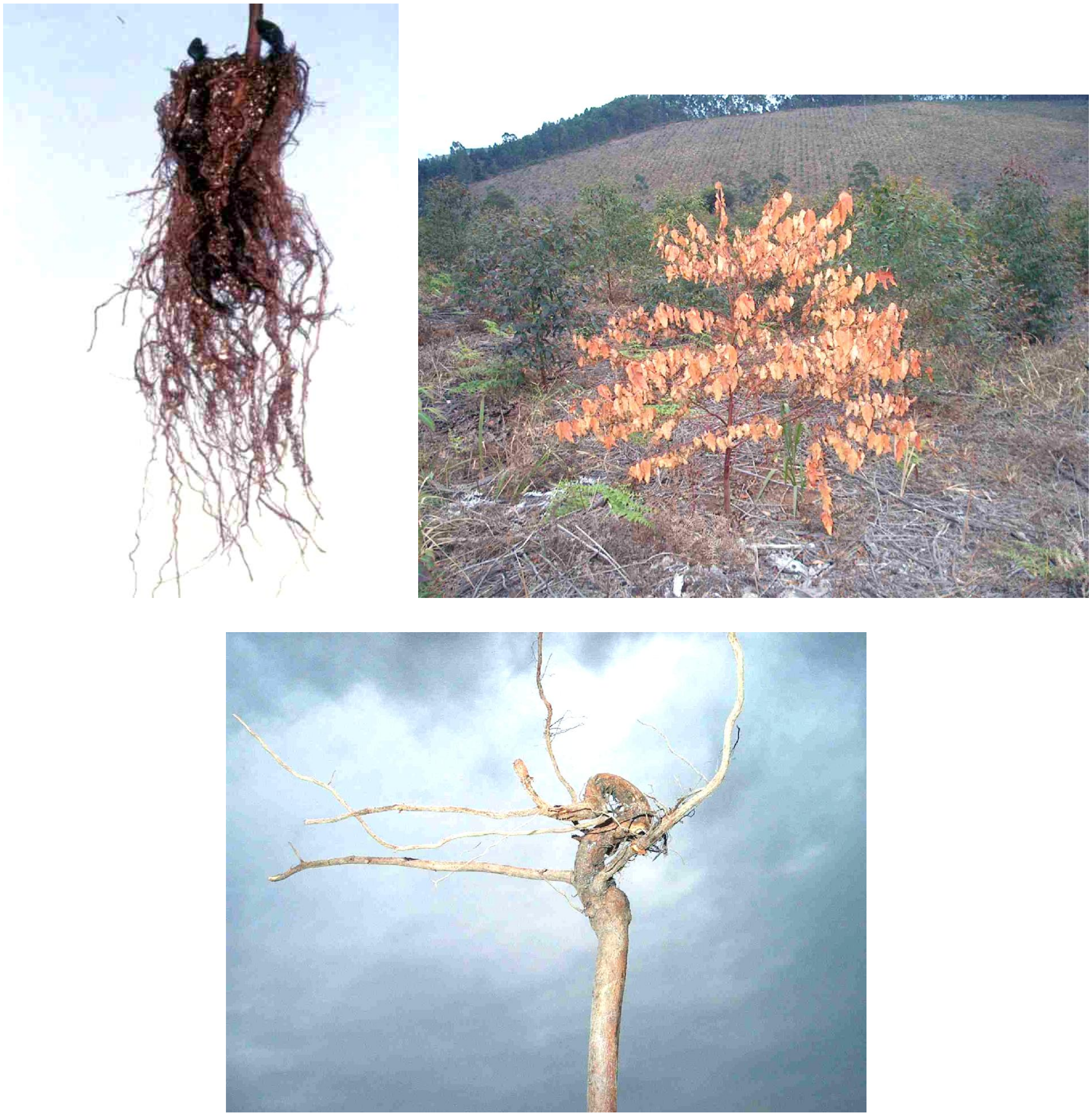
Young *Eucalyptus* plant competing with the surrounding weeds

- **Forest stand planting**

The planting process must be carried out with quality. It is not acceptable to lose such seedlings which do not like their new home and come to die for this reason. Therefore, much attention should be paid to the seedlings, as well as constant attention to the quality of the prepared soil.

It is very common for the planted seedlings not to present the quality they had when leaving the nurseries. There exist several reasons for this phenomenon, the most usual ones being those related to the waiting time they were subjected to prior to planting. When leaving the nurseries, to be directed to their new living place, the seedlings are most certainly within the specifications required by the forest planter. These specifications concern rusticity, seedling stem basis thickness, height, the presence of active and living roots, etc. However, between the moment at which they leave the nursery and the actual planting time, there are many things that may happen. Some of these inconveniences aggregate much stress to the seedlings. One of these problems are the so-called "waiting nurseries" in the forest field. These nurseries may retain the seedlings for one to two weeks (sometimes longer) under very inadequate conditions. This occurs for lack of planting conditions, which is justified by the most different reasons. Many of these seedlings change "status", stop being healthy and vigorous seedlings and become stressed, with "mummified" or dead roots, often without any chances of overcoming the post-planting difficulties. For this reason, survival is often poor, and so is the eco-efficiency.

The need for seedlings on the planting site should be very well matched up with their release by the nursery at the required specifications. To plant defective and low quality seedlings is to condemn them to a possible death still in the initial and juvenile forest stand phase, between the planting moment and the second year of age. Besides, even if many of them survive, they have all conditions to become dominated plants in the forest stand.



The plants respond to our eco-inefficiencies (mummified roots - the plant dying at an early stage due to the extremely poor development of its root system)

Seedlings are not planted to be replaced after some time in the replanting operation. The higher the mortality rate, the higher our eco-inefficiency, as we waste fertilizers, herbicides, hydrogel, irrigation water, labor, fuel, etc., etc. - economic and environmental resources that are being destroyed. Those foresters who are happy with 5% mortality rate are behaving very eco-inefficiently. The target should be as close to 100% survival as possible. There is once more a need to understand the reasons for the deaths that may occur. We will present later on a case study into this theme.

When the forest stand start growing in height, we want to see it uniform and faultless. Any failure, any death should be understood as the loss of a dear one. The causes must be clarified. For this purpose, please do not only count the failures, but interpret them as well.

If the leaf-cutter ants are the major causes of the failures, they should be thrown into focus. This is another one among the many issues requiring research, the solution of which is being postponed so much. For many years one hears a saying such as “either Brazil puts an end to the leaf-cutting ants, or the ants will put an end to Brazil”. However, it seems that the problem has not yet any solution in the short-term. On the contrary, the legal impositions of agrochemicals of extremely low toxicity may even aggravate the problem caused by the ants.

Leaf-cutter ants attacking young *Eucalyptus* leaves

• Forest productivity throughout the forest rotation (Forest stand growth)

After having been very carefully followed by the foresters during the first 18 months of age, our *Eucalyptus* forests will go on growing almost by themselves. To be able to do this, they will rely upon their genetic potential, the environment offered to them, the forest protection they will be given, and the nutrient cycling. If they are given good feeding conditions and water and they have a good quality genotype, the productivity rate will be suitable and the planter will be happy.

There is always a potential productivity for each genotype in each forest site. Let's understand by potential productivity the maximum carbon fixation that a certain genotype manages to fix in the xylem in a certain cycle of growth. This potential value of maximum growth is not obtained, as there are always shortages and restrictions of some vital input, such as water, nutrients, light, etc. Besides, there is competition among plants, there may occur some attack of pests or some disease, even if it is not lethal, etc. All this contributes to a loss of productivity and xylem formation. In other words, it contributes to a loss of eco-efficiency of our planted *Eucalyptus* forest. When the forest stand grows well and healthily, it will present us with good productivity rates, guaranteed by its genetic potential. As a result of it, we gain eco-efficiency, as the planted forest will have taken good advantage of the inputs we gave it when applying fertilizer, hydrogel, irrigation water, etc. When the productivity is low, as a result of a reduction caused by some environmental factor, we will have a lower eco-efficiency. We waste fertilizers, work, fuel, machinery hours, etc. In general, all these wastes are not valued at the companies. They are just accounted as global production costs in US$ per hectare. We need to watch better our eco-ineffectivenesses and the eco-inefficiencies at our forests. We are always tempted to make the wheater or the genetic material responsible for our incompetence in doing the suitable management of the natural resources sustaining the forest productivity.

We should know and understand our limitations, our barriers, the forces acting negatively on our goodwill to win and to yield good results in our potentially performing planted forests.

Sometimes na *Eucalyptus* clone yields wonderful results in a certain place and not so good ones in another one. Explanations are quickly looked for based on the well-known theory of the interaction genotype – environment. Sometimes these explanations appear without being based on a visit to the area, just based on the data spreadsheets. Once more I affirm: <u>it is necessary to talk to the forest, as the causes may be different</u>. They may be in the preparation of a differentiated soil, in the higher mortality due to an attack of beetles, in seedlings planted after a long waiting period in those terrible waiting nurseries in the farm, etc., etc.

I would like to remind you of the words of our esteemed *Eucalyptus* friend, Dr. Jose Luiz Stape: "The more productive the forest, the fairer the chance that it becomes more eco-efficient, by using more efficiently the water, the nutrients, and the sun-light". Therefore, to develop forests with high productivity rates is a way of being more eco-efficient.

In the following I present you a little example of increase in forest productivity and its relationship with the eco-efficiency.

<u>Example 15</u>: **Number of trees per cubic meter of produced wood**

In the '70s, 10 to 13 trees were required to make up a solid cubic meter of debarked wood in a 7-year-old *Eucalyptus* forest. At present, just 3 to 3.5 are required in a forest with an under-bark increment of 45 m^3/ha.year. Just imagine the lower environmental impact of this increase in productivity. It means less land area to be planted, less ground to furrow, less trees to grow, less vehicles to consume fuel; in conclusion, fantastic gains. To plant forests to produce more means to impact less. The higher our capacity to offer more wood to Society, spending less natural resources, the quicker we will be advancing to guarantee the desired Sustainability.

We must start demanding this from ourselves. If we have technical potential to obtain 45 m^3/ha.year of MAI - Mean Annual Increment - in our plantations and achieve only 40, we have to question ourselves, as we lose twice, is it not so? We lose in the smaller amount of wood produced and we lose in the higher consumption of seedlings, fertilizers, herbicides, etc., per cubic meter of wood produced by the forest. It is a double inefficiency. We have already seen it, but it is always good to repeat it for concept consolidation purposes.

- **Forest protection (pests, diseases, fires)**

The good *Eucalyptus* rusticity, allied to the efficient prevention of pests, diseases, and forest fires, has been one of the key factors of success of plantation forestry competitiveness in Brazil. The leaf-cutter ants continue to be its main insect pest, but there are also possibilities of attacks of beetles and defoliating caterpillars. Among the diseases, some were very dangerous and threatening, as *Eucalyptus* canker and rust, all of them well-controlled by the development of genetic material resistant to them. The main control technologies use to be biological control, resistant clone development, and prevention.

The *Eucalyptus* enemies are capable of causing significant losses of productivity, yields, and results, as well as dismay to the forest planters, because they are enemies attacking without warning, no matter how attentive one is. Attacks of pests and diseases are capable of causing irreversible damages, and so are the forest fires. Sometimes, the only economically and environmentally viable solution is the forest stand reestablishment. In other cases, one chooses to coexist with defective or deformed trees and lower production yields. A wood that would be destined for furniture production ends up being directed to be burnt as biomass fuel.

Perverse attack of the yellow beetle *Costalimaita ferruginea* on young *Eucalypti*

Attack of *Eucalyptus* rust on a very sensitive *E.grandis* young tree

Result of a forest fire occurred at a *Eucalyptus globulus* plantation in Uruguay

The forest protection must be understood as one of the main eco-efficiency vectors. Although we understand the purposes of the pests and disease causing organisms, which also want to occupy their space in Nature, if we want to have good forest plantations we must be pitiless with them. An elegant and environmentally friendly way of combating these enemies is by biological control, the preferred way to deal with insects. Our universities and some private laboratories are capable of quickly meeting the sector requirements by means of selected populations of natural enemies of the pests. For the diseases, the selection of clones and resistant species has been one of the foundations of the most modern genetic tree breeding.

Finally, monitoring is a considerably eco-efficient way of facing these threats. Constant attention should be paid to the plantations, not only to our ones, but also to those of the neighborhood and of the whole sector. Any pest appearing in a region has potential to move to other ones. For this reason, attention and monitoring must be considered to be priorities.

• Wood multiple purpose utilization - plantation management with thinning

For many decades, the *Eucalyptus* plantation forestry had its management done by coppicing and clear cutting for industrial wood production for fibers, firewood and panels. However, in the past 15 years, the management for nobler wood production for furniture, houses, veneers, etc., experienced a significant growth. The multiple purpose tree management with thinnings has been considerably popular.

The eco-efficiency must be present in this case as well. The main way of acting eco-efficiently in this segment is by constantly following the plantation growth, in order not to miss the correct occasion of doing the thinning work. Likewise, the tree pruning must be very well planned, in order not to cause damages to the tree growth. Science has developed much in order to help take these management actions.

One of the greatest dangers of meeting with low eco-efficiency in this type of management would be the unsuitable destination of the thinning operation products. There are many people who are satisfied with selling the removed material as biomass fuel. Other ones do not even remove the thinner twigs from the place. On the other hand, there are also those who developed a special market for such materials. Thus, they ensure a better use for this wood and anticipate economic results from the forests.

Eco-efficiency must be striven for by:

- Avoiding the loss of valuable woody products grown by the forest;

- Developing special markets for the woods from each thinning operation;
- Designing the planting spacing between the trees so as to allow carrying out the thinning operations and removing the thinned material without causing any damages to the remaining trees;
- Promoting the use of the forest understorey of thinned areas for agroforestry or pasture for cattle growing. I have already seen passion fruit, papaya, and cacao plantations in this kind of situation. To associate the multiple purpose tree management with thinnnings with agroforestry and agro-ecology is a considerably ecological procedure, which aggregates environmental value and quality to the *Eucalyptus* forests.

Thinned wood logs removal

- **Plantation forest harvesting**

In this **Eucalyptus Online Book** of ours I have written a whole chapter about the wood losses occurring in the forest harvesting operations, as already mentioned earlier:

Eco-efficient management of woody forest residues from the *Eucalyptus* plantation forestry. Eucalyptus Online Book. Chapter 07. 48 pp. (2007)
Available at: http://www.eucalyptus.com.br/capitulos/ENG07.pdf

Apart from avoiding wood losses, there exist other ways of being eco-efficient at the forest harvesting operation, such as:

- Avoiding soil and erosion losses;
- Avoiding soil compaction;
- Avoiding soil moisture loss and the consequent effects on the soil micro-life;
- Avoiding organic carbon loss from the superficial layers of the soil;
- Avoiding the "luxury consumption" of fuels by means of a suitable harvesting and transporting vehicle operation planning;
- Avoiding the loss of economic resources resulting from excessive storage of harvested material in intermediate stocks;
- Studying all kinds of rework, redistribution's, and losses of time, in order to improve the operational efficiency;
- Avoiding to impact on other areas as a result of badly executed forest harvesting operations in terms of quality and times.

It is the forest technicians' and foresters' function to quantify and value these losses, even those considered to be difficult to quantify. However difficult it may be, it is very necessary. This quantification should be technical, environmental, economic, and social, do you remember this?

- How much is worth for the company and Nature a loss of 50 cubic meters of sediments entrained by rainwater and winds per hectare throughout the forest cycle, from planting to harvesting?
- How much is worth the loss of 2% of the organic carbon content from horizon A of the forest soil as a function of the unsuitable soil denudation during forest harvesting?
- How much is worth the full permanence of the forest harvesting residues (leaves, branches, barks) on the forest soil, reducing the organic carbon loss, the soil compaction, the moisture loss, and the export of nutrients valuable for the soil fertility?

To protect and recover degraded soils: vital for our forest-based activity

- **Leaving the land area after the period of forest plantation with *Eucalyptus* trees**

I have always advocated that it is very important to have a suitable crop rotation for the forest plantation land areas. To keep the same area with the same forest species for decades or centuries may have a higher level of impact than that resulting from a planned crop rotation for those soils. For this reason, when planning a land crop rotation it is important for the forester to understand the concept, as well as what is behind it. We are always suggesting to do the forest rotation by using forest cultures of Leguminosae (either exotic or native). We have excellent exotic species, such as *Acacia mearnsii* and *Acacia mangium*. Among the native Leguminosae there is for instance the bracatinga (*Mimosa scabrella*). There are still many others, like ironwood, *angico*, etc.

The Leguminosae are the main and most economical way of reestablishing the nitrogen reserves of any soil. This nutrient does not come from rock weathering. What exists in terms of nitrogen in the soils was either introduced into them by man through fertilizing, or proceeds from the decomposition of Leguminosae that have lived there in the past.

Combined *Eucalyptus* and black wattle plantation in the State of Rio Grande do Sul, Brazil

Another important situation when leaving an area is the suitable management of stubs and stumps remaining from the harvested trees. The harvesting of the trees at the bottom, leaving the stub top as close to the soil surface as possible, is the minimum expected. Thus, there will be a clear area on its surface. In the course of the years, roots and stumps will decompose and will aggregate nutrients and carbon to the soil.

To leave high stubs for the future generations is a practice lacking on sustainability. The stub reduction on height is an expensive, little eco-efficient option, but necessary when a bad quality forest logging is carried out. It should be born in mind that one eco-inefficiency brings about another one. If the forest harvesting is badly done, afterwards the stubs must be reduced on height. Energy is spent, wood is lost, a disaster. Just imagine that an operation of stub reduction on height is rather brutal, requiring powerful machines. The cost is also brutal: from 150 to 250 dollars per hectare, consuming machines, fuels, and damaging the soil.

Operation of *Eucalyptus* stub/stump reduction on height (Photos: CENIBRA, 2008)

- **Management and bureaucracy affecting the eco-efficiency**

The forest sector has always had some type of eco-efficiency loss due to bureaucratic and legal formalities and procedures. In spite of the greatest respect that Brazilian companies have for the pertinent laws, in spite of the forest certification that has been already obtained by almost all forest companies, in spite of constant striving for sustainability, the Brazilian forest sector has always suffered from bureaucratic delays, as well as from those of legal nature. These losses may be expressed in financial losses, due to planting delays as a function of off-timing on forest licenses on the part of the authorities. In other cases, they concern legalization of acquired land, or they are due to land and forest invasions by social movements organized by activists, etc., etc. To these problems, which we will call bureaucratic and legal, we will add those resulting from mismanagement by plantation owners. For all these reasons, the resulting eco-inefficiency is a big one.

Every delay in the forest operations aggregates economic losses, but it also generates losses of natural resources. For example: seedling losses, the need to prepare the soil once again, or to combat once more against weed competition, or the need to keep employees, in order not to dismiss them, who are however unmotivated because they are not doing what they like to do, etc., etc.

Some causes for these hindrances are described in the following:

- Lack of a suitable program of communication and information from the planted forest sector to Society. For many years this sector has adopted a low-profile attitude and faces now difficulties to change this behavior.
- Non-acceptance of the plantation forestry economic activity as important and environmentally safe by a part of Society;
- Lack of a common language along the wood productive chain;
- Resistance from some Non Governmental Organizations, media, and judicial sector;
- Lack of a clear position on the part of the Government with regard to the planted forest sector;
- Bureaucratic difficulties for forest and environmental licensing;
- Bureaucratic difficulties for forest harvesting legalization;
- Bureaucratic difficulties for land legalization in the country geographic borderlands (country limits);
- Unacquaintance with environmentally more correct technologies on the part of many rural farmers, who want to plant forests, but do not know how to do it well;
- Problems connected with invasions of land, whether planted or not, by social movements organized by activists;
- Etc., etc.

In conclusion, my friends, you can see now how many opportunities there exist to optimize the eco-effectiveness and the eco-efficiency in our forest-based sector, even in the aspects involving bureaucracy. Who could imagine that a lawyer or an authority, when dealing uninterestedly with a planting land licensing process would be causing heavy eco-efficiency losses? It would be very good to send him a report on the losses of raw materials, inputs, energy, etc., caused by his tardiness. As to the lawyers who did well their homework and had quick success, they might also receive the applause from the technical area, for the conquered eco-efficiency gains.

It is Society and Nature who gain from eco-efficiency. It is all within that proposed by Sustainability, so much dreamt of.

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CASE STUDIES FOR NEW OPPORTUNITIES IN TERMS OF ECO-EFFICIENCY AND CLEANER PRODUCTION IN PLANTATION FORESTRY

In order to consolidate the concepts of eco-effectiveness, eco-efficacy, eco-efficiency, and cleaner production, when applied to the *Eucalyptus* plantation forestry sector, we will demonstrate them in the following in the context of three case studies of our daily forest life. These evaluations should be understood as just indicative of the way of applying the tools, since the used values are general estimations by way of exemplification. Everyone of you, motivated to use these concepts in your forest unit should look for the best values for the quantification's in your databases. In other cases, methodologies will have to be developed to obtain data when not available. Thus, your evaluations will be much more precise as to the economic, environmental, and social aspects.

- **Case study 01: The high tree mortality occurrence throughout the forest life cycle**

Dead tree in a forest stand (18 months old)

The tree mortality rate occurrence throughout the *Eucalyptus* forest growth can be considered to be a result of eco-inefficiencies. Besides losing the efforts to plant the trees, the forest producer also loses production and will have new challenges to be able to coppice his tree population to a new forest rotation by the stump management. When the tree mortality occurs very intensely, the sole solution offered to him will be the forest stand plantation reestablishment after forest harvesting. A forest stand that eventually might be coppiced during two or three forest rotations ends up generating only one. It is undoubtedly an environmental, social, and economic loss.

With the implementation of the most recent forest technologies in Brazil and with clonal planting instead of seed-origin seedlings, the tree mortality problem has decreased considerably, because the competition among trees began to occur among individuals of same genotype. Thus, genotypes overlapping each other in the phenotypic expression were minimized. Dominated trees still exist, but to a considerably lower extent than in plantations originating from seeds.

The high mortality process can be either expressed by random or maintaining a systematic tendency of occurring in all forest stands. When the incidence of a higher number of dead (or defective) trees is randomic, it is necessary to look for the specific causes of these particular situations. It may have been an intense attack of ants, the occurrence of a severe drought, or frost, or a disease or insect pest, etc. On the other hand, if mortality occurs in all forest stands, most probably a systematic cause connected with some operational deficiency in the use of some technology is concerned. This may be for instance: poor fertilizer application, inappropriate seedling quality, unsuitable soil preparation, inappropriate way of planting the seedlings, etc., etc. For this reason, when studying the problem, we must not only quantify the percentage of dead trees, but also ask them why they have died. Were the dead trees concentrated in groups? Were they randomly scattered? Was there a higher tendency towards deaths and failures in one planting line? Who planted that specific tree line or how was it planted? Etc., etc.

The first step to understand the problem is to quantify the loss of trees and the possible production loss in our forest. It is also possible to make benchmarks (comparisons) with other *Eucalyptus* forest planting companies in that region.

Let's suppose in our case study that we are evaluating the failures in a clonal planting of *Eucalyptus grandis*, originally planted on the basis of a 3x2 m spacing. At 7 years of age, a number of failures was quantified which corresponded to 20% of the effectively planted trees. When 1667 trees per hectare have been originally planted, only 1334 trees were found in that hectare at forest logging. After harvesting the remaining trees, the debarked wood production of the forest stand amounted to 280 solid cubic meters, which allows concluding that each tree had an average volume of 0.21 m³ of wood. It is not the forest stand the leading companies in Brazil dream about, in spite of a reasonable production of 280 m³. Partly this is due to the original 3x2 m spacing, foreseeing a larger number of trees than the normal one for an *E.grandis* clone. Many trees died, but even so 1334 were left. The competition was certainly fierce and may have been one of the causes of late deaths of trees. Nevertheless, abandoning preconceived or biased ideas, we have to understand very well the possible causes of the death of 20% of the planted trees.

In our example, our foresters' evaluation showed that:

- The failures and death of the trees was randomic, there were no concentrations of dead trees;
- The trend towards a 15 to 25% mortality rate occurred in practically all plantations of the species and clones in that specific one, as well as in other forest farms of the company. Even for other species and clones the percentages of failures were detected as being as high as this one we are measuring.
- In the places of the failures no dead tree remains could be noted, which means that they died still very young, still as babies. They had no time to show as tree corpses, they endured a decomposition of their small bodies and disappeared.

For the specific case study, the production loss estimated for this 20% tree mortality was considered to be 10%, because, as the failures were randomic, the remaining trees could find and occupy a larger space to grow. In spite of trees being more non-uniform in volume, the loss did not amount to 20%, which would have been much worse. If there were more concentrated failures, this production loss would have been worse, since the remaining trees would not manage to make up for this part of the production loss with a higher individual increment.

In this hypothetical example of ours, the production could have amounted to 311 m³, but it ended up being 280. Then it meant a loss of 31 m³/hectare of solid wood.

A first suspicion that might come would be the clone inadequacy for the local conditions. It is very common for the technicians to try to make a certain clone responsible for the greatest successes or misfortunes in terms of productivity. This should only occur after a judicious and discerning evaluation of the causes for the productivity loss. In the case in question, our worthy forest technicians discovered that the percentages of 15 to 25% of failures also occurred for other clones, even for the much more flexible *E.urograndis*. As a result of it, they discarded the possibility that the cause of the failures was the clone inadequacy to the region or to the environment where the forest stand was installed.

It is also very important that the foresters discover how the forest stand failures express themselves:

- Is there a failure without plant material in the place where a tree should be present?
- Is there a dominated dead tree, small in diameter, which it was decided to count as failure or mortality?

If nothing is found in the place where there should be a tree, this means a very premature death of the plant, perhaps during its first year of life after the seedling was planted. It may have even died in the seedling phase, shortly after being planted. At the moment of evaluation for replanting it was still alive, but died soon after that.

If a dominated dead tree of inferior volume, but still upright, is found, the cause of its death may have been its incapacity to compete for water, light, and nutrients with the neighboring trees. But why did it lose that competition, if after all it was a clone, having exactly the same genotype of its neighbors? What led it to lose the competition and to be subdued to such an extent that it caused its death?

When there are high incidences of failures in forest stands, it is of interest to do a separate quantification of living trees, dead trees, and failures without plant material residues. This will lead us to monitoring operations to be performed by the forest inventory area, which will be able to inform us these types of age percentages in its evaluations, such as:

- From 0 to 3 months (survival and mortality in the planting operation);
- From 6 to 12 months;
- From 12 to 18 months;
- From 18 to 24 months;
- Forest rotation end.

According to the results found for mortality and its type, it will be possible to have better clues of the major causes of deaths.

If in the first 6 months of forest stand age high mortality rates are already recorded, the causes may be:

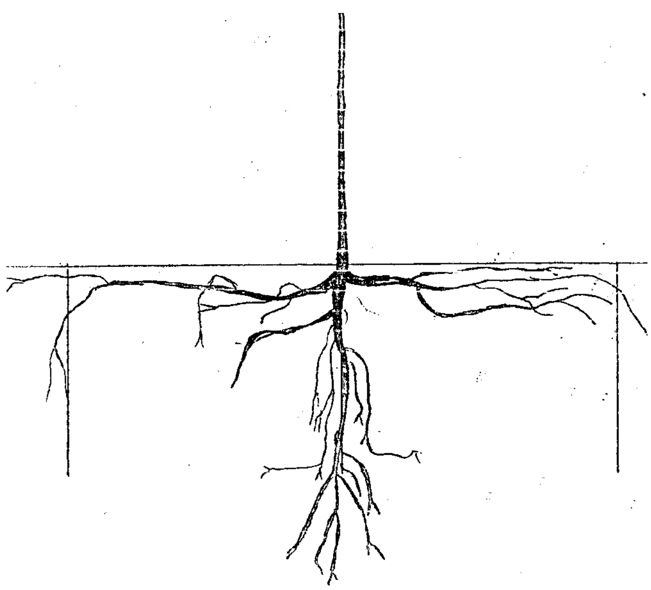
- Water deficit;
- Plants burnt by badly applied fertilizer;
- Attack of ants or other insects (termites, beetles, caterpillars, etc.)
- Mechanical damages caused by animals (invasions of animals);
- Mechanical damages caused by persons (invasions of persons);
- Inadequate forest seedling quality;
- Seedlings not planted by the tree planter (planting failures);
- Seedling stem basis presenting an injury;
- Unsuitable planting (buried seedling, seedling planted with its root system turned upwards, etc.)
- Etc., etc.

If the plants survived this period, dying later, between 12 and 24 months of age, a strong suspicion falls on the root system of the plants. As a function of radicular deficiencies, many plants do not manage, with their deformed roots, to cope with the demands of the crowns and die.

Other suspicions, as always, would be the probable attacks of diseases or pests (caterpillars, beetles, leaf-cutter ants, rust, etc.).

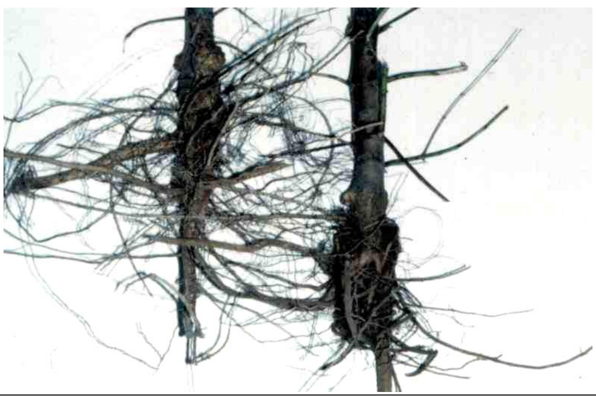
To illustrate these types of situations, there is in the following a selection of photos showing these recently mentioned situations.

Forest *Eucalyptus* seedlings with living and active roots



Well-formed root system, desired for an *Eucalyptus* plant in the forest

Root system defects due to bad seedling/sapling quality or unsuitable planting - (a "horror movie" that must be avoided)



Although plant losses between planting and forest logging is a common phenomenon in any activity depending on climate and environment conditions, if these losses are heavy and chronic, their causes must be identified and worked on. They cannot and must not be accepted as normal and inherent in the forest activity. The foresters must question them and talk to the dead plants, as well as to the failures, to understand what happened and to solve the problem. When we do this, we can understand many of the major causes leading to the death of plants. Even if several of these causes are secondary and less relevant, we can improve our operations and reduce their incidence in the new planting operations.

When we do the autopsies of the dead plants between planting and 24 months of post-planting, we can analyze their parts, such as: stem basis, roots, leaves, branches, bark, etc.

The good autopsy gives us indications of the "causa mortis" of the plant. The major and more frequent causes for plant mortality are as follows:

- Folded root system (planting defect);
- Compressed root system (planting defect);
- Root system winding (unsuitable seedling quality);
- Deficient root system (unsuitable seedling quality);
- Seedling covered by soil (planting or soil preparation deficiency);
- Attack of leaf-cutter ants;
- Attack of crickets (the crickets gnaw the little seedling bark in the stem basis region);
- Attack of beetles, caterpillars, etc.;
- Attack of *Eucalyptus* rust (serious disease);
- Soil erosion (pulled out or soil covered seedling);
- Burning by fertilizers;
- Seedling break by mechanical action (wind, rain, animals, man treading on them, etc.)
- Old or overripe seedling (with many leaves, tall, and having a root system which is insufficient to meet the requirements of the aerial portion);
- "Too tender" a seedling, unsuitable to resist the climate variations, as well as those of the environment where it is planted;
- High weed competition;
- Incidence of frost;
- Etc., etc.

In general, most causes of mortality at this young age are related to the poor seedling/sapling quality and/or the way the planting was carried out. The attacks of pests are also frequent. The mechanical damages are more common when the planted area is left abandoned or used (even without authorization) for pasturing of animals (cattle - bovine and ovine).

Having identified the main causes, we must now select them by relevancy, trying to rank them in the form of a Pareto's graph, in order to classify the most vital ones. Thus the main causes (just a few vital) and the many secondary causes can be found.

In this specific example of ours, we can suppose that the main causes were:

- Seedling quality;
- Unsuitable planting procedures;
- Attack of leaf-cutter ants and other insects;
- Damages caused by soil erosion, due to planting in a “downhill” prepared soil;
- Mechanical damages caused by cattle brought to the recently planted area by invaders;
- Frost.

Frost in a young *Eucalyptus* forest (Photo: Edson Martini, 2007)

The practical actions that can be taken by the operational team are as follows:

- Adequacy in forest seedling quality;
- Change the seedling substrate composition;
- Planting operator training;
- Utilization of planting depth limiter;
- Miscellaneous planting system adaptations;
- Soil preparation in contour level line;

- Attention to the fertilizing procedure (way of application and types of fertilizers);
- Alteration in the system of seedlings packaging, loading, transportation, and delivery for the planting operation, with minimum waiting time in the forest field prior to planting step;
- Better weed competition monitoring and application of chemical and mechanical control at the required times;
- Definition of sites more propitious to frost for planting species or clones more tolerant to cold weather;
- Definition of sites and clones for planting according to the land topography, incidence of sunlight (North or South face), etc.;
- More frequent monitoring of attacks of ants, insects, diseases;
- Creation of controls to avoid the presence of cattle on the forest area during the initial forest stand phase (in general, the animals are brought in an unauthorized way by third parties);
- Establishment of controls to avoid invasion of forest areas by wood robbers;
- Etc., etc.

<u>Evaluation of the Economic Impacts for this Case Study 01</u>:

The first great impact is the <u>production loss</u>: **31 m³/hectare.**

Considering the value of the debarked wood at the standing forest tree to be 20 US$/m³, it will result:

$$31 \text{ m}^3/\text{ha} \times 20 \text{ US\$/m}^3 = \mathbf{620\ US\$}$$

The second and very significant impact corresponds to the <u>losses resulting from planting and managing this present forest rotation</u> (waste of seedlings, herbicides, etc.). The value applied to these operations in Brazil corresponds to about 2,000 US$/hectare. Then, each seedling planted in the spacing in question would cost 1.2 US$/plant. This cost involves fertilizing, soil preparation, phytosanitary treatments, chemical combat against weed competition, etc., etc. A part of these spent values ends up being directed to the rest of the forest stand, even with the death of some seedlings. It is the case of the fertilizers, which will end up being used by the surviving plants. The ants must be combated by any means, etc. Therefore, we will consider that the lost value per plant in this example of ours would correspond to 60% of 1.2 US$ i.e. 0.7 US$/failed plant.

Then the result will be:

333 failed plants per hectare x 0.7 US$/failure = **233 US$/ha**

The third and very significant loss would be the management of the following forest rotation. As seedlings have been lost, in several cases we will have to leave two sprouts per stump, while in other cases we will have to intercalate new seedlings to reestablish the original forest population. We will suppose that this will correspond to the requirement of digging 120 pits per hectare, plus the use of seedlings and inputs to plant these 120 pits.

120 seedlings at 0.15 US$/seedling = **18 US$/ha**

120 pits at 0.45 US$/pit = **54 US$/ha**

120 planted seedlings at 0.3 US$/plant = **36 US$/ha**

Total economic losses = 620 + 233 + 18 + 54 + 36 US$/hectare

Total economic losses = **961 US$/hectare**

An enormous economic loss, do you agree?

Evaluation of the Environmental Impacts for this Case Study 01:

In this case, we would have to quantify all inputs wasted in the seedling preparation, in the failed plant soil preparation, in the combat against weed competition, etc., etc.

All these inputs, as substrates, fuels, agrochemicals, electric power, etc., are natural resources that have been used without any return whatsoever to both Society and undertaker. Besides the economic loss, we had also significant impacts for the exhaustion of limited and finite resources of the planet. Moreover, a larger planted forest area will be required to make up for the production loss occurred as a function of the death of trees. All these data can be quantified and listed by our team concerned about the eco-efficiency of the problem being evaluated.

Evaluation of the Social Impacts for this Case Study 01:

The additional requirements in terms of human resources for these tasks that resulted in losses must be quantified at this evaluation stage: which are the eventual impacts on more labor accidents? Which are the higher incidences of occupational diseases, etc., etc. In general, the economic and environmental losses always end up demanding further human labor, exactly to manage and deal with these losses and wastes.

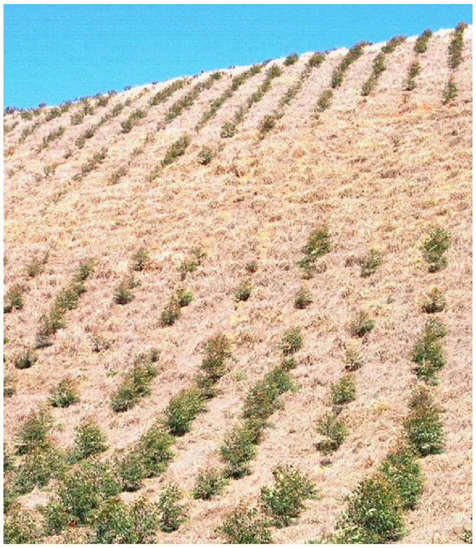
This social evaluation also includes the additional requirements in terms of higher technician and operator qualification, so as to enable them to carry out their tasks in a more eco-efficient way and involving lower wastes.

My friends, with this very simple and partial example I believe that we could demonstrate with reasonable didactics and clarity how we should proceed to quantify our eco-ineffectiveness and eco-inefficiency. It is very important to quantify all this, as these evaluations help us meet the continuous improvement target.

Observe the following: which is the forest manager who will not worry about environmental, economic, and social losses that are so expressive and well-clarified in the form of being reported and quantified? Which is the manager who will refuse to approve investments with quick payback and with good explanations of how to solve the problem? Therefore, do not forget it: working out an objective and conclusive report, with quantification's, proposals, and economic, environmental, and social evaluations is essential.

Tree that died still at an early age and presentation of its deformed roots by the *Eucalyptus* friend Teotonio Francisco de Assis

- **Case study 02: The occurrence of losses in the second forest rotation due to non-sprouting of stumps**




Eucalyptus areas with irregular sproutings (Inadequate planting "downhill")

For practically one decade the Brazilian forest sector relying on *Eucalyptus* forests is replacing its past plantations obtained by seed-origin seedlings with new and more productive clonal plantings. The plantation area reestablishment's, even after a good production, have been justified by the higher productivity rates expected and by the higher technological quality and higher uniformity of the new clonal materials.

However, my friends, we should not neglect this gift that the *Eucalyptus* offers to us, which is its sprouting after forest harvesting and possibilities of obtaining a new forest from the remaining stumps that sprout. We are absolutely sure that this stage of enchantment with the new clones being planted and yielding wonderful new productivity rates will be soon fulfilled. Then, the sprouting management will be able to come back victoriously. This may be happening soon. After all, this management provides planting gains, input savings, lower investments to make, etc.

Therefore, the sprouting management for a new forest production is rather eco-efficient, as:

- it does not require new seedlings;
- it does not require soil preparation for the stumps to sprout;
- it requires neither irrigation nor hydrogel consumption;
- there is no need to use herbicides to kill the sproutings, in order to allow reestablishing the plantation area;

- the weed competition is more easily dominated;
- the sediment losses due to soil erosion are considerably lower;
- the soil is better covered and protected by the forest harvesting residues;
- complex operations, such as stub reduction on height, are not required;
- etc., etc.

In spite of fertilizer requirements, as well as an additionally required step, which would be the selective sprout removal from the excess twigs, the costs to obtain a new forest are considerably lower. What matters is to do all this very well, in order not to have production losses in the new forest rotation coppiced from the stump sprouts.

According to the percentage of stumps which do not sprout, an inter-planting operation is sometimes required i.e. it is necessary to plant some new seedlings to replace some of the plants that did not sprout. However, this inter-planting operation is only recommended in case of an excessive percentage of stumps that did not sprout, especially if this happens in a region with higher incidence of this type of failure. When the stumps that do not sprout are just a few and scattered throughout the area, it is possible to selectively remove extra sprouts, leaving two good quality sprouts arranged face to face in living stumps near the failed ones. Thus, one tries to reestablish the plant population of the original forest stand. If it was a clonal forest stand with 3x3 meter spacing (1,111 trees/hectare) and there are 200 trees among failures due to mortality throughout the cycle and dead stumps which did not sprout, we will have to manage about 200 stumps, for each of them to have 2 sprouts. The remaining ones will be selectively treated to remove extra sprouts from, so as to keep only one vigorous sprout each. Thus, a population of 1,111 twigs will be reached in the forest stand, which will be restoring the population striven for in the management of this second forest rotation.

Stumps sproutings: a gift from the *Eucalypti* to the forest sector

Science and quality are required for a suitable sprouting management

We will now consider this new case study of ours, to see how the required quantification's could be carried out. It is again a hypothetical example, the data of which should be considered just as those of an illustrative example.

Then, if we had 1,111 initial trees and found 200 "sprouting failures" among them, initially it is necessary to identify how many were due to tree mortality during the planting process and how many corresponded to stumps originating from harvested trees which did not sprout. Let's suppose the mortality losses throughout the preceding forest rotation have amounted to 60 trees and 140 were the stumps which did not sprout.

In the same way as in the previous case study, it is necessary to identify how these stumps were distributed. Was it in a randomic manner? Were they systematically located in groups? Would that dead stump group area have been a wood deposit area? Would it have been an operators camp? Would it have been a machine parking area? Etc., etc...

Next, we must identify case by case the reasons why the stumps did not sprout. Once more, we will have to go there and talk to them for this identification.

The main causes for stumps failing to sprout are as follows:

- Choking by bark and forest harvesting residues;
- Mechanical damages to the stumps by the forest harvesting machines and vehicles;
- Tree cutting height out-of-specification (either too high or too low a cutting);
- Genetic material (some clones sprout badly, other ones very well);
- Trampling by animals which were grazing in the area;
- Attack of ants or other insects (caterpillars, crickets, etc.);
- Attack of diseases (rust, leaf wilt, canker, etc.);
- Frost;
- Winds throwing the sprouting twigs down;
- Heat and stump over-exsiccation;
- Hydrological deficit;
- Damages caused by late removal of the wood harvested by the log forwarding and transporting team;
- Unsuitable sprout position at the stump;
- Stump excessively large in diameter;
- Forest age (the older the forest and the longer the forest rotation, the worse is sprouting; the more forest rotations are coppiced, the worse is the sprouting);
- Death by chemical drifting when applying herbicides;
- Accidental forest fire;
- Insensitivity and disrespect to the sprouted twigs on the part of forest operators;
- Low soil fertility;
- Weed competition choking the stumps;
- Stump shadowing;
- Soil compaction caused by forest logging machines;
- Harvested forest heterogeneity;
- Stump live-bark displacement and loosening as a function of tree harvesting;
- Period of the year (the more intense the direct sunlight and the longer the rainless period, the worse is the sprouting);
- Excess of sprouts competing at the same stump;
- Stump covered by earth, mud, etc.;
- Solar position of the area;
- Etc., etc.

Sprouts dying due to excess of temperature and water deficit

This large number of causes brings inconveniences resulting not only in stump non-sprouting, but also in an irregular and bad quality sprouting. Even having 100% of stumps sprouting, if they do it in very different times and also with distinct vigor, the forest stand will be very heterogeneous in its tender age, because there will be stumps sprouting within up to 30 days after forest harvesting, other ones from 30 to 60, or from 60 to 90 days, and still other ones requiring over 90 days. This variability is also uninteresting. Then, we have to understand not only the causes of non-sprouting, but also those of the variation in sprouting speed and quality.

While these causes are identified, they must be also classified as primary or secondary causes. Also, in this respect we can already work out measures to minimize these impacts through new procedures and operational controls.

Among the actions to minimize the problem, following can be highlighted:

- Forest harvesting operator training;
- Creation of technical forest harvesting specifications;
- Development of procedures for the forest harvesting resulting in minimum impact on the stumps;
- Correct tree cutting height specification and a very good control of it;
- Strict supervision of the area;
- To prevent stumps from being choked by branches, bark, etc.;

- To monitor phytosanitary aspects, as well as those connected with attacks of insects and diseases;
- To avoid the presence of animals grazing in the area during this stump sprouting phase;
- To introduce the variable stump sprouting into the forest breeding programs as an important clone and new forest genotype selecting factor;
- To combat weed competition earlier or by frequent monitoring, to prevent sproutings from being choked by the underbrush;
- To avoid forests to be managed by sprouting coppicing in periods of excessive drought or intense heat due sunlight;
- To harvest forests in mosaic, to avoid the incidence of strong winds on the recently developed sproutings;
- Etc., etc.

It is fundamental to classify the causes, as this will indicate us which will be the preventive or curative measures to solve the problem. The purposes will be to increase the sprouting rate and to equalize the growth speed and the vigor of these twigs as much as possible. Each lost stump is an economic and environmental loss. If we lose many stumps which will not sprout, the forest stand most probably will have to be reestablished, or else, it will be only able to be coppiced for one more forest rotation and nothing else.

A stump choked by forest logging residues and a clean stump, susceptible for good sprouting

Then, the following phase must comprise an evaluation and a quantification, to indicate the real value of the economic, environmental and social losses.

Evaluation of the Economic Impacts for this Case Study 02:

⇒ Seedlings and relevant forest operations lost as a function of 140 stumps which did not sprout, valued in 50% of the original value, as they have produced in the first forest rotation:

0.5 x (1.2 US$/plant) x 140 = **84 US$/hectare**

⇒ Possible wood production loss, even having recourse to the procedure of leaving 2 twigs per stump, in order to try to make up for the problem of the 140 stumps that did not sprout

20 m^3 lost/hectare x 20 US$/$m^3$ = **400 US$/hectare**

⇒ Potential loss if the forest stand will have to be reestablished after the second forest rotation, in case the stump mortality problem after the forest logging of the second rotation fails to be solved.

An economic estimation is left out, as it is just a supposition.

Total economic losses = 84 + 400 US$/hectare

Total economic losses = **484 US$/hectare**

Evaluation of the Environmental Impacts for this Case Study 02:

- A larger forest area is required to obtain the amount of wood that failed to be produced;
- All inputs additionally required;
- All inputs already applied and lost due to the death of the stumps.

Evaluation of the Social Impacts for this Case Study 02:

- It is necessary to better qualify the operators and to sensitize and commit them more to the forest harvesting quality;
- Additional people required to monitor and control these operations.

- **<u>Case study 03</u>: Forest rotation age increased to 8 years instead of 6 years (calculating the forest rotation age of maximum technical forest productivity on the basis of wood dry mass produced, instead of wood volume)**

For this case study, we will use the values shown on pages 42 to 45 of the present chapter. We have presented therein the differences found for CAI and MAI curves, when expressed on wood volume basis and dry wood mass basis for the same *E.saligna* forest stand. I believe that I made it clear when I showed you that as the forest is growing older, within the usual ages practiced by silviculture in Brazil, its wood becomes gradually denser. For this reason, its current annual increment in terms of dry wood mass may go on increasing, even if its current annual increment expressed in volume is decreasing.

Independently of how we will evaluate this example, what does matter is that the expenses to implant the forest are the same, whether it is harvested at 6 or at 8 years of age. We will also equalize the value of the wood, calculating it in terms of dry mass as the one which would be paid at 6 years of age for the wood purchased by volume, basing the price on the equivalent dry mass.

When the forest stand is planted for short forest rotations adopting clear cutting and coppicing management, it will be basically destined for pulp of fiberboard. It may also serve as biomass fuel to feed power boilers burning organic biomass. For these cases, the wood production as dry mass is the most logical way of quantifying the forest production. It will be the dry wood mass that will determine the raw material feeding, which will result in production at the mill or in the boiler. A pulp mill, using a lower density wood will most probably result in larger wood volumes required for the same production in tons of pulp, in comparison to a denser wood of the same forest species.

For this specific example we will consider that the economic valuation will be based on the dry wood mass. For comparative calculation purposes, we will consider 6 or 8 years of age as forest harvesting ages. As it is just an example, we will consider for cash flow simplification that the forest will be reestablished and not coppiced after forest logging, either at 6 or at 8 years of age.

The values taken as reference in both cases will be as follows:

- Sales price of the dry ton of wood at the standing forest trees = 40 US$/ton.

- Costs of forest stand implantation (all operations in the planting phase) = 1,750 US$/hectare
- Costs involved in the post-planting period up to the first year of forest age (fertilizing, combat against weed competition, etc.) = 350 US$/hectare
- Yearly maintenance costs between the second year and the forest harvesting period = 50 US$/hectare
- Land rental cost = 120 US$/hectare.year

- Wood production at 6 years of age (volume) = 258 m^3/ha
- Wood production at 6 years of age (mass) = 123 dry tons/ha

- Wood production at 8 years of age (volume) = 315 m^3/ha
- Wood production at 8 years of age (mass) = 164.8 dry tons/ha

In the following we will work out two extremely simple cash flows, in order to check the economic feasibility of both proposed management systems, one for forest harvesting at 6 years and another one at 8 years of age. As the forest rotation periods are distinct, the most favorable economic option will that offering the best Internal Rate of Return (IRR). It is important to observe that we are valuing the land, attributing a rental to it for its use. Afterwards, it will remain to check the environmental and social comparisons of both options.

Situation for forest harvesting at 6 years of age : in US$

Investment year

0	(-)1750	= (-) 1,750
1	(-) 350 (-) 120	= (-) 470
2	(-) 120 (-) 50	= (-) 170
3	(-) 120 (-) 50	= (-) 170
4	(-) 120 (-) 50	= (-) 170
5	(-) 120 (-) 50	= (-) 170
6	(-) 120 (-) 50 (+) 4920	= (+) 4,750

IRR = 10.1 %

Situation for forest harvesting at 8 years of age : in US$

Investment year

0	(-)1750	= (-) 1,750
1	(-) 350 (-) 120	= (-) 470
2	(-) 120 (-) 50	= (-) 170
3	(-) 120 (-) 50	= (-) 170
4	(-) 120 (-) 50	= (-) 170
5	(-) 120 (-) 50	= (-) 170
6	(-) 120 (-) 50	= (-) 170
7	(-) 120 (-) 50	= (-) 170
8	(-) 120 (-) 50 (+) 6592	= (+) 6,422

IRR = 10.8 %

In economic terms, changing the harvesting age from 6 to 8 years did not result in an impressive difference. The internal rate of return for the later forest logging was only a slightly better one. It should be remembered that cash flows are very sensitive to revenue anticipations, especially when applied to so short forest rotations as those evaluated. Anyway, the forest logging at 8 years of age based on dry wood mass production showed to be more efficient in both technical and economic terms, which is interesting for the business.

Evaluation of environmental gains as a function of later forest harvesting

The environmental advantages are very important, as:

- All inputs used by the forest planter from planting to harvesting will be substantially reduced when expressed per dry ton of produced wood (specific input consumption's). This would also happen for the volumetric production, which went on increasing, although with MAI at lower annual values than CAI from 6 years onwards. The relationship between the dry mass based productions at 6 and 8 years of age was 75%. This means that there was a lower environmental impact as a function of using 25% less fertilizers, herbicides, seedlings, soil preparation, fuels, etc., etc., with regard to the unit of dry mass wood production.
- The 8-year-old trees will be heavier and more voluminous than the 6-year-old ones. Thus, the forest harvesting costs will be also lower, on

both harvested wood volume and dry mass basis. The impacts of harvesting will also be reduced.

- Less anthropic action in the area, due to forest rotation lengthening;
- There is greater nutrient cycling effectiveness for both soil and plants;
- There is less soil erosion and greater preservation of its micro-life, etc.;
- There are lower impacts occurring on the local biodiversity;
- Etc.; etc.

This is definitively the adoption of eco-efficiency in its clearest and more crystalline vision, each ton of the product offered by the plantation forest requiring much less natural resources to be produced.

Evaluation of social gains as a function of later forest harvesting

- Less exposure of the forest field workers to the use of agrochemicals;
- Higher productivity rates of the forest harvesting workers;
- Etc., etc.

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SOME REAL LIFE CASES EXEMPLIFYING EITHER ECO-EFFICIENT OR ECO-INEFFICIENT SITUATIONS

In this item I intend to show, in a simple way, some situations happened to me in real life, showing opportunities that may be worked on *Eucalyptus* forest plantations. In some of these situations the cause is in the machinery, in other ones in the procedure adopted, and still in other ones in the people's commitment. Opportunities and favorable examples of actions taken aiming at cleaner production and higher eco-efficiency are also provided.

I will present you eleven situations, showing photos and making some comments about. I hope you will appreciate them and amuse yourselves therewith. In case you identify similar situations in your activities, do not be surprised. Things use to be very similar among the different companies. It is perfectly possible to anticipate where wastes and eco-inefficiencies are occurring at any company. No matter how good is the company management, there will be always opportunities for incremental gains and improvements. "It is always in the same places under the carpet that the things left over are placed". It is enough to look at these places to find the inefficiencies.

Real Life Case 01: The eco-inefficient burning of a forest biomass

There are companies insisting on burning as biomass fuel all forest harvesting residues, such as leaves, thin branches, treetops, etc. As it is a very nutrient rich biomass, it should be rather used as organic soil fertilizer.

Moreover, when it is fragmented, energy is consumed and a very bulk fuel is generated, poor in terms of heat per transported volume unit or unit fed into the boilers. In terms of energy balances, it represents an enormous eco-inefficiency.

Luckily, this has already been duly proven by some of these companies.

Real Life Case 02: Increasing the log length increases the eco-efficiency

At each chain saw or harvester cutting blade pass, a slice of wood is removed, which remains in the forest field and will not be consumed by the mill. Likewise, if there is the possibility of transporting longer logs, it is also possible to gain in terms of fuel consumption, as well as vehicle use per weight unit of transported wood. For this reason, many farmers who previously cut the logs into short 1 m lengths ("one meter firewood"), do it now into lengths ranging from 2 to 2.4 meters.

The technologically most developed mills harvest the trees and divide them into 6 m long logs to transport them to the mill. Definitively they are saving natural resources by doing such.

Real Life Case 03: Dirty logs with branches, soli, etc., is a synonym of eco-inefficiency

Every contamination taken to some place where it will not be used turns into solid waste. I have seen this problem several times with the forest area of some companies, who forgot about the customer and did not care to send the cleanest possible log load to them.

At one of these companies, we opted to commit the employees, imposing them a little punishment. As they paid no heed to our request to endeavor to stack up the wood as clean from branches, leaves and soil as possible, we asked them to clean the logs before sending them to the mill. Right away there appeared good ideas to avoid log contamination and the problem was solved. Sometimes it is necessary to show a certain level of energy for the ideas to succeed, but commitment is also achieved by motivation, as well as good examples.

Real Life Case 04: To forget chemicals "innocently" in the forest, or to leave them uselessly in the deposits is an example of low operational and ecological efficiency

Cooperators and employees, both of our own and from third parties, committed not to waste inputs, represent one of the eco-efficiency foundations. Another frequent fact is the purchase of a large lot of certain product, as it is suspected that its price will increase. It often occurs that the company priorities change and the term of validity of the product goes so far as to expire in the company warehouses. In case it is an agrochemical, this represents a very serious problem, as there is no place where it might be discarded, except for a controlled and supervised landfill for hazardous products, at an enormous economic value to dispose of. This fact characterizes a low eco-efficiency situation, because a raw material was allowed to turn into a dangerous and harmful waste.

Real Life Case 05: Who does already know the "euca-fence", a great example of eco-efficiency?

My friends, only creativeness and imagination could lead to this type of living fence to separate the cattle in the pasturing activities. It serves, of course, other purposes too...

Real Life Case 06: The suitable sprouting management is a key factor for the success of the new forest rotation

Many people forget that the sprouting management begins at the forest harvesting preceding in such way the sprout/shoot development growth.

Semi-destroyed or too high stumps result in fragile or weak twigs, capable of being easily thrown to the ground before firming as new trees.

Real Life Case 07: To prepare the soil as aligned with the contour lines as possible

When establishing the practice of not preparing the soil "downhill", we will be contributing to avoid soil losses and seedlings covered with soil as a function of sediments being dragged along from the higher sectors of the planting area. It often occurs that the seedlings themselves are carried by the torrent rain water flow running along the furrows.

This point must be still intensively worked on at many companies. When they elect some easier and low-cost procedures at forest planting and harvesting they end up aggregating an enormous eco-inefficiency to the process as a whole.

Real Life Case 08: Implementing the irrigated planting throughout the year allows optimizing the use of natural resources

Irrigated planting allows better using the natural resources available to the company, as it excludes seasonality from the forestry operation. As a result of it, there are neither unnecessary waiting times nor are there losses of seedlings, dying due to water deficit - the need for replanting decreases, etc., etc.

The Brazilian silviculture gained much eco-efficiency as a function of having adopted the irrigated planting, by using hydrogel to retain and release water to the young seedlings.

Real Life Case 09: Not to combat weed competition in a suitable way results in many losses of natural resources. The situation will get still worse without adequate mineral fertilizing

In general, it is possible that some companies control weed competition badly or do not control it at all. The result is very perverse, as some kinds of competing weeds are very aggressive, impairing considerably the growth speed-up of the recently planted *Eucalyptus* seedlings.

If this deficiency is added to an incompetent mineral fertilizing, so as to lead the forest to have nutritional deficiencies as well, we will see *Eucalyptus* plantations in a regrettable condition.

My friends, the forest plantation activity requires technology, without which the results will be far from satisfactory.

Unfortunately, many rural farmers still believe that it is enough to plant the *Eucalyptus* seedling the soil, to have a vigorous forest developed therefrom. They end up getting acquainted with an unexpected truth instead.

Extremely poor forest growth are due to nutritional deficiencies and weed competition

Real Life Case 10: Helping rural farmers with technologies and genetic material is a way of enhancing the eco-efficiency of the planet's plantation forests

There are many fantastic examples of forest fostering in Brazil, stimulating the rural farm producers to separate a part of their lands more appropriate to plant trees to be used for *Eucalyptus* plantations. I have an interesting example concerning Nobrecel, which I have already mentioned to you. Its forest partnership program has been made so as to guarantee a good forest quality and so that the farmer can have a yearly income from a mosaic of planted forests of distinct ages.

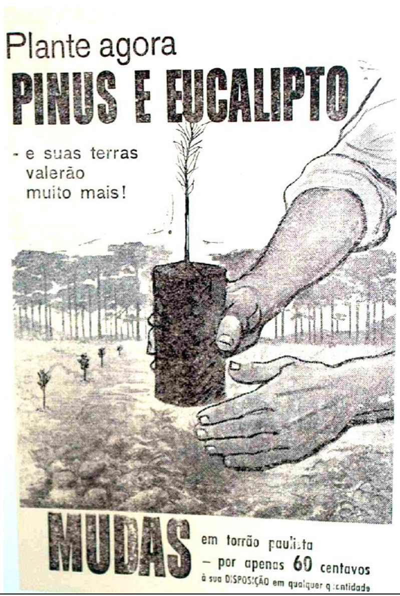
Real Life Case 11: The "old silviculture" in Brazil. A past time that served as foundation for the present and much more eco-efficient and sustainable activity.

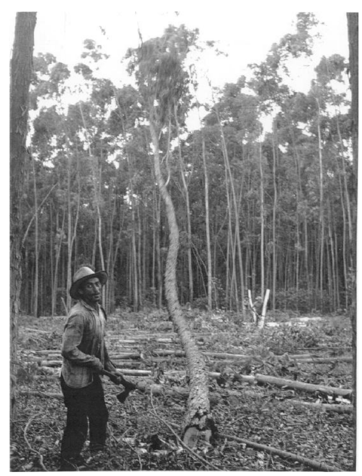
My friends, it cannot be denied that the present, when compared to 50 or even more years ago, is rather different. There is now a modern plantation forest activity of extremely high technological level in Brazil.

Nevertheless, things change and science and economy keep offering us new opportunities. Sometimes threats as well...

I just question myself about how our forest activity will be within 50 years ahead. I wonder whether the new generations will be competent enough to maintain the course of sustainability and eco-efficiency. I hope very much so and that what we are presenting to you in this chapter may contribute in some way and to some extent to a better silviculture and a better world.

I would like to thank my dear friend Manoel de Freitas for providing some of these images of the "old" Brazilian silviculture (early and mid 1900's).


Plante agora
PINUS E EUCALIPTO
- e suas terras valerão muito mais!
MUDAS
em torrão paulista
– por apenas 60 centavos
à sua DISPOSIÇÃO em qualquer quantidade



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FINAL REMARKS

Definitively, there are fantastic opportunities for eco-efficiency and cleaner production in the forest business. They may help the sector to move quicker towards the necessary and dreamt of Sustainability. As this way is long and difficult, it is necessary to know how to tread and step in this direction. And it is for this very reason that I stimulate and make all efforts, having set myself a target of causing the people working and deciding in the forest sector to start seeing our wonderful forest world with the focus on eco-efficiency. By observing from the perspective of eco-effectiveness, eco-efficiency and cleaner production, we will be able to acquire or reinforce our capacity to perceive the problems concerning not so suitable and not so efficient uses of the natural resources. By means of their constant application to our daily lives in the planted *Eucalyptus* forests we will be able to make more eco-effective, less impacting, and better decisions, as far as Sustainability is concerned. Through them, we will be able to develop the respect for the natural resources, promoting a more conscious consumption of the goods offered to us by Nature. If there is a sector that can help us reaching a suitable level of sustainability in using renewable natural resources, this one is the plantation forest based sector. Therefore, let's set to work, with our minds illuminated by the light of both environmental and social respect.

We can help the little seedling of eco-efficiency to grow more and more. Just let's do it.

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LITERATURE REFERENCES AND SUGGESTIONS FOR READING

Dear friends, unfortunately the technical literature about eco-efficiency, eco-effectiveness, eco-efficacy and cleaner production is scarce when we are referring to plantation forestry. Although there are so many references on other technologies and businesses, it seems to me that these tools are still germinating in forestry. Well, it does not matter, we are also planting some seeds, aren't we?

I'm bringing to you several texts that in some extent are very much related to the topics I have presented to you along this specific chapter. Most of them may be reached through the web, visiting the suggested URLs. Unfortunately, the great majority of the references are in the Portuguese idiom. But you also suggested to visit, because you may find abstracts in English, and in some cases, fantastic pictures, images and figures.

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