ADJUSTMENTS OF THE ECO - TECHNOLOGY REVITEC® MODEL FOR THE RESTORATION OF DEGRADED AREAS

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INTRODUCTION

Since the agricutural and industrial revolution began, the rate of ecological destruction has far exceeded the rate of ecological repair (Cairns Jr., 1998). The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed is called Ecological Restoration (Society for Ecological Restoration International, 2004; Koehler, 2005). The goal is to return degraded biological communities to their original state (Jordan, Peter & Allen, 1988).

The choice of the restoration model is a process in frequent improvement and it must consider all the conditions of the region where it will be implanted (Leite, Martins & Haridasan, 1994), the application of soil management systems (Prober, Thiele, Lunt & Koen, 2005) and the re - establishment of species and communities (Palmer, Ambrose & Poff, 1997). The floristic base and dimensional structure analysis indicate if the area is being restored (Araujo, Bier & Maranho, 2008; Sávio & Maranho, 2008).

The model implanted and evaluated in the present work is based on the eco - technology developed by Kesel, Koehler & Associates (KEKO), called Revitec®. This has been applied by the quoted authors in other regions of the world, like Namibia (Koehler, Fischer & Radke, 2006) and Spain (Koehler, Kesel & Heyser, 2004; Koehler, Heyser & Kesel, 2006). Revitec® is described as pattern for the ecological recuperation of degraded areas, stabilization of areas exposed to erosion and the revitalization of adverse soil (Koehler, Kesel & Heyser, 2004; Koehler, 2005; Koehler, Fischer & Radke, 2006).

The basic model is like a disposable bag, in this case made of jute, filled with substrate specifically prepared with biotic and abiotic elements (Koehler, Kesel & Heyser, 2004). These bags protect the substrate and promote the initial control of the erosion and the superficial flow (Koehler, Fischer & Radke, 2006), until the moment the vegetation creates barriers against the erosion. This happens in a short time. An array of bags can be made linearly or on islands of fertilization that act also in the caption of water and particles, also in the dissemination of the parcel. It is expected that in a long time the successional processes propagate (Koehler, Kesel & Heyser, 2004).

OBJECTIVES

In this way, the present study had as objective the evaluation and implantation of the eco - technology Revitec®, making the adequacy to the restoration of the degraded area.

MATERIAL AND METHODS

The studied area is located in São José dos Pinhais, PR, Brazil, near the coordinates S 25º31'50" W 49º09'30". It is characterized as degraded and with erosive processes. The environment contains fractions of Atlantic Rainforest. The climate of the region is Cfb by the Köppen classification as: mesothermic, wet and super - humid (IAPAR, 1994). The experimental modules used the eco - technology Revitec®, where was established three sampling sub - areas: sub - area 1 (islands with vegetation implantation, called islands with vegetation); sub - area 2 (islands without vegetation implantation, called islands without vegetation) and sub - area 3 (control area).

For the preparation of the substrate it was used the tanned cattle manure in the fragments of the Atlantic Rainforest, located near the experimental area, in the proportion 1:1 (v/v). Next, it was added 20 kg of substrate in jute bags from which 10 kg were homogeneously deposited between the bags. Twelve islands of recuperation were implanted, being six with implantation of the vegetation and six without the vegetation. Each one of the islands was formed by six jute bags filled with substrate, within an area of approximately 4 m^2.

Each island with vegetation received a seedling of *Mimosa scabrella* Benth. and a seedling of *Sebastiania commersoniana* (Baill.) L.B. Sm. & Downs in their central jute bags, provided by the Instituto Ambiental do Paraná. Plants with pioneer ecophysiology characteristic were sown in these islands in the proper area of study: *Desmodium adscendens* (Sw.) DC. Fabaceae; *Vernonia nitidula* Less., *Aspilia montevidensis* (Spreng.) Kuntze and *Bellis* sp. Asteraceae; *Schizachyrium condensatum* (Kunth) Nees Poaceae. After two months of study a seedling of *Allophylus edulis* (A. St. - Hil., Cambess. & A. Juss.) Radlk. was still included in each vegetation island.

The evaluation of the survival rate and biometric index was done monthly. They are used respectively to evaluate the survival and to measure the height and perimeter from the height of 15 cm of the seedling's soil of *M. scabrella*, *S. commersoniana* and *A. edulis*. The floristic and phytosociological surveys were conducted in June and October 2008. The material was collected and herborized according to the usual technics (Fidalgo e Bononi, 1989). For species identification, besides the specific literature, comparisons with the collections of the herbarium of the Museu Botânico Municipal de Curitiba (MBM) were done. To evaluate the performance of the succession process a survey of the vegetation structure was done, estimated by the horizontal coverage of individuals of each species.

For the determination of the species average degree of coverage was used the scale proposed by Braun - Blanquet (1979). The phytosociological parameters were estimated: absolute frequency, relative frequency, the species coverage, value of the species coverage in the plot and amount of species coverage. The phytosociological study was accomplished according to Braun - Blanquet and proved to be efficient and essential in the evaluation, since it allows to estimate the relative coverage, without however allowing the high expression of dominant species, as mentioned by Pilar, Boldrini & Lange (2002). It is also recommended the use of this survey to combine several advantages found in other methods, as stated by Moore *et al.*, (1970).

The species diversity was evaluated by the Shannon index (H') (Magurran, 1989). To analyse the significance of the change over both surveys it was used the t test for diversity, significance level of 0.05. The Jaccard similarity index was used to estimate the similarity between the sub - areas.

RESULTS AND DISCUSSION

The more index of the survival was from *S. commersoniana* (100%), followed by *A. edulis* (83.34%) e *M. scabrella* (16.67%). The best height registered (75 cm) as well as the largest perimeter (2.40 cm) occurred in the seventh month of the experiment, to the species *M. scabrella* and *A. edulis* which had reached an average height of 29.20 cm and 1.06 cm average perimeter, while *S. commersoniana* had reached an average height of 40.0 cm and average perimeter of 1.12 cm in the same period. From June to August of 2008, mainly, the three implanted seedlings have suffered growth reduction. Right after the implantation and in the months of September and October the growth was higher. The variations of survival and growth along the present study have probably occurred due to the climatic conditions and the deciduous and semi - deciduous characteristics of the species. The species used are indicated for the recuperation of degraded areas with original coverage of the Atlantic Forest, especially in places with moist soil, as observed by Lorenzi (1998).

Even during the most intense rains, the islands remained stable and have supported the maintenance of the vegetation. The jute bags, the soil incorporated of forest fragments, the tanned cattle manure and the revegetation were essential factors for the soil stabilization and the erosion control, providing the re - establishment of the pioneer species and consequently the acceleration of the ecological succession. Other experiments with the utilization of the Revitec® model highlight the importance of theses aspects in the restoration context (Koehler, Kesel & Heyser, 2004; Jacomel & Maranho, 2005; Koehler, 2005; Koehler, Fischer & Radke, 2006; Koehler, Heyser & Kesel, 2006; Araujo, Bier & Maranho; 2008).

The easy applicability of this eco - technology and adaptability to each characteristic area and biome could be verified by the use of the soil and the seeds from the proper place and the jute bags, which were obtained at low cost. The disposal of the model in islands and the array of the bags in them proved to be suitable for the study area, although other authors (Koehler, Kesel & Heyser, 2004; Koehler, Heyser & Kesel, 2006) suggest that the bags could be placed in different ways, linear or circular. Reis, Três & Scariot (2007) stated that the arrangement in island allows the formation of diversity centers and the occurrence of natural regeneration in the rest of the area, following the characteristic successional stages.

In the three sub - areas were found 118 species throughout the study. In the first floristic survey, done in June of 2008, were found 65 species, 15 of which were not identified and the rest of them belonging to 42 genera, distributed in 16 families. The Asteraceae family has presented the biggest floristic representativeness, with 20 species, around 31% of the total, followed by the families Poaceae (8), Fabaceae (4) and Solanaceae (3). In the sub - area 1, the most representative specie was *Bulbostylis capillaris* (L.) C.B. Clarke, with a relative coverage equal to 22.86%. This species has also presented the biggest coverage in the sub - area 2 (23.53%). However, in the sub - area 3 the most representative species were *Saccharum angustifolius* Ness and Poaceae 1, with the relative coverage of 11.54%.

In the second survey, in October of 2008, there were 86 species, 13 of which not identified and the rest pertaining to 55 genera, distributed in 18 families. The major floristic representativeness was of the Asteraceae family, with 21 species, completing 24.42% of the total, followed by Poaceae (8), Fabaceae (7) and Rubiaceae (4). The most representative species were *Bulbostylis capillaris* (L.) C.B. Clarke e *Brachiaria decumbens* Stapf in the sub - area 1, with relative coverage of 26.19%. The highest coverage in the sub - area 2 (19.90%) was also from *Bulbostylis capillaris* (L.) C.B. Clarke. In the sub - area 3 *Saccharum angustifolius* Ness was the most representative species, with relative coverage of 57.89%.

The major floristic repetitiveness of the Asteraceae and Poaceae family was also observed in the studies with seed banks of fragments of the Atlantic Forest of São Paulo (Baider, Tabareli & Mantovani, 2001) and in the applicability of the Revitec® model (Jacomel & Maranho, 2005) in degraded areas by pasture in Paraná, Brazil. High germination of *B. capillaris* in the soil collected in the forest fragments was observed next to the study area. This species was identified in a floristic survey made in the urban area of Curitiba, Brazil, reported as from the Atlantic Forest (Biondi & Pedrosa - Macedo, 2007).

The seed bank allows recolonization with seeds and other propagules of pioneer plant species (Baider, Tabareli & Mantovani, 2007; Reis, Três & Scariot, 2007). In the bank of seeds in the soil implemented as well as in the restoration of species collected around the experimental area, was observed the influence of forest remnants on the species diversity and acceleration of the ecologic succession. Baider, Tabarreli & Mantovani (2007) suggest that the bank of seeds is not enough for restoration. Seeds from other sources are necessary, because the soil bank often does not store medium and large seeds of shade - tolerant woody species. In this context, we find the importance of planting the seeds collected and seedlings of characteristic species of the surrounding forest fragments. In this study was observed higher species diversity in the areas where the model was implanted with vegetation.

The similarity index (Sij) between the sub - areas was 27.69% in June and 11.36% in October of 2008. The Shannon index (H') has revealed that the highest species diversity (1.66 nats/ind.) was found in the sub - area 2 in the first survey and in the sub - area 1 (1.76 nats/ind.) in the second survey.

In the control area H' has reached only 1.37 nats/ind. In the seventh month the diversity increase between the surveys was significant only where the model was implanted, as noted by t test for diversity, significance level of 0.05. The surveys were fundamental to the analysis of the species diversity in each sub - area and to assess the potential of the eco - technology used to accelerate the succession process. Many authors emphasize the importance of these surveys on projects of restoration of degraded areas (Moore *et al.*, 970; Wikum & Shanholtzer, 1978; Lamb, 1998).

The results of this work in relation to the growth of the diversity and acceleration of the successional process corroborate to other studies of the application of the Revitec® model in areas of original coverage of Atlantic Forest in Brazil (Jacomel & Maranho, 2005) and other countries and biomes in the world (Koehler, Kesel & Heys, 2004; Koehler, Heys & Kesel, 2006; Koehler, Fischer & Radke, 2006).

Thus, the model proved to be relevant to the restoration of degraded areas in a global view and within the context of the most diverse ecosystems that currently are degraded and fragmented.

CONCLUSION

The application of jute bags filled with substrate plentiful of organic material with a diverse bank of seeds has provided the contention of the erosive processes, the stabilization of the soil and the re - establishment of the Atlantic Rainforest's characteristic species. Through the analysis of the floristic base it was observed that the restoration is reaching its initial objective of simulating and accelerating the successional process, since the increase of the species diversity was significant for Revitec® sub - areas. It is expected that the area can be returned to a form close to its original state and that the vegetation islands can disseminate the successional process and restoration. The application of the Revitec® model is suggested in new restoration projects, since it was shown sustainable and efficient.

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