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ECOLOGICAL RESTORATION IN THE STATE OF SAO PAULO, BRAZIL: GUIDANCES, GUIDELINES AND CRITERIA

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Abstract: Brazil, specifically the state of São Paulo, is at the forefront in legislating on ecological restoration. Since the first resolution, published in 2001, by the Secretary of the Environment of the State of São Paulo with the objective of providing guidances and guidelines for Heterogeneous Reforestation with native species, others were published in which the knowledge acquired was incorporated as they put it. techniques for planting and recovering degraded areas are put into practice. However, previous resolutions (from Resolution SMA 21/2001 to Resolution of SMA 08/2008) focused on techniques to be used in planting seedlings in the total area to be restored without leaving room for other methods – sometimes more appropriate and access to certain areas – a fact that has led to criticism from professionals and scientists linked to the field of ecological restoration. The current São Paulo state legislation, Resolution SMA 32/2014 and its complement, Ordinance CBRN 01/2015, replaced the term Heterogeneous Reforestation with Ecological Restoration, expanding the objective of the forest restoration process and also changing the previous focus on the method used and emphasizing the result to be obtained; in other words, the establishment of a self-sustaining ecosystem.
Keywords: Ecological Restoration, Forest Restoration, Environmental Legislation, SMA Resolution 32/2014, SARE.

INTRODUCTON

The Society of Ecological Restoration – S.E.R. defines ecological restoration as a human-induced process of alteration of a habitat to establish a defined, natural and historical local ecosystem, that is, as a process of aiding the restoration of a local ecosystem that has been degraded, damaged or destroyed, whose objective is to imitate the structure, function, diversity and dynamics of the original ecosystem (S.E.R., 2004). The purpose of this process is, therefore, to obtain a self-sustaining native ecological system.

This article aims to present and discuss the legal requirements, criteria, guidelines and objectives for ecological restoration projects in the state of São Paulo in accordance with the legislation established by its Secretary of the Environment - SMA. Thus, this work was developed based on consultation with legal documents on ecological restoration in the state of São Paulo, especially Resolution SMA number 32, of April 3, 2014, which establishes guidances, guidelines and criteria on the subject, and its complement; Ordinance: CBRN 01/2015 (published in the Official Gazette of January 17, 2015, section I, pages: 45–46), as well as the specialized literature.

BRIEF HISTORY OF ECOLOGICAL RESTORATION IN THE STATE OF SÃO PAULO

The first official publication on an ecological restoration process in the state of São Paulo was carried out by the Instituto Florestal through its Technical Bulletin Number: 24, in 1977, with the title Heterogeneous Reforestation with Indigenous Essences. It was a project to restore a riparian forest carried out from 1955 to 1960 in the municipality of Cosmópolis, where 71 tree species, both native and exotic, were used (Nogueira, 1977). About 60 years after the beginning of this restoration process, the result is the presence of a well-developed riparian forest where several other native species were, during this period, introduced into the system through natural dispersion. However, this good result was achieved through great efforts in terms of planting, replanting and maintenance actions; therefore, its good performance was due to a high cost (Rodrigues et al. 2008).

Due to the importance of riparian forests in maintaining water quality and protecting the aquatic environment, as well as their importance and functionality in acting as ecological corridors for terrestrial fauna and flora, and also motivated by the high degree of destruction of native forests, especially In the Southeast region of Brazil (the state of São Paulo in particular), from the beginning of the 1980s, studies aimed at restoring destroyed or degraded riparian forests began in Brazil at various universities, research centers, etc. In the middle of that decade, Federal Law Number: 7,511, of July 7, 1986, expanded the Permanent Preservation Area strips – APP established in Federal Law Number: 4,771, of September 15, 1965. In view of this, in April In 1989, the event called "Symposium on Riparian Forest" took place in the city of São Paulo, organized by the Institute of Botany of the State of São Paulo. On the occasion, several professionals participated who exposed their experiences both in research and in forest restoration practices in Brazil. As a result of this event, exchanges of knowledge between professionals in this field of research and action intensified. Today, the 1989 Symposium on Ciliary Forest is recognized as having been the first symposium on ecological restoration, in a series of similar events also organized by the Institute of Botany that followed in subsequent years and that currently take place every two years.

At the beginning of this century, based on the knowledge accumulated until then, the Secretary of the Environment of the State of São Paulo - SMA published Resolution SMA number 21, of November 21, 2001, which guided the heterogeneous reforestation of degraded areas, determining the criteria for forest restoration in the state based on the planting of seedlings of native tree species in the total area and taking into account the principle of favoring secondary ecological succession, providing guidelines for heterogeneous reforestation with native species in the areas to be restored, having been the first specific legislation for the activity of ecological restoration in the state of São Paulo. Other resolutions followed, which were: Resolution of SMA 47/2003, Resolution of SMA 58/2006, Resolution of SMA 08/2007 and Resolution of SMA 08/2008. However, the planting of seedlings in the total area is maintained as a methodological basis.

However, this emphasis given to the restoration method through strict measures adopted in the legislation led them to become the target of criticism by professionals and scientists working in the area (Durigan et al. 2010). In addition to not allowing the adoption of alternative techniques for ecological restoration that are cheaper and more suitable for certain local environments (such as, for example, the adoption of stimulating natural regeneration in areas with little degradation). This emphasis on the planting method, to the detriment of the results obtained in the projects, also ended up causing the failure of many of them, since one of the consequences was that some people responsible for the projects ended up not paying due attention to the maintenance actions of the plantings and thus the plantations succumbed to the so-called factors of environmental degradation (fire, erosion, predation by animals, etc.), resulting in a great waste of the applied resources. Therefore, after several studies involving several of these professionals and scientists, on April 3, 2014, the SMA published Resolution SMA number 32.

SMA RESOLUTION: 32/2014

Resolution SMA number 32, of April 3, 2014, establishes the current guidences and guidelines for the elaboration, execution and monitoring of Ecological Restoration Projects in the State of São Paulo, in addition

to criteria and parameters to evaluate their results and certify their conclusion. The current resolution brought an advance in the guidelines by replacing the term Heterogeneous Reforestation with Ecological Restoration, so that the processes admitted for the purpose of restoration now include any other methods in addition to the widely used planting of seedlings in the total area. These other methods include, among others, conducting natural regeneration, nucleation techniques (systems that promote regeneration from diffusion nuclei), direct sowing (with or without green manure), mixed methods (conjugation of more than one method), etc. Furthermore, this resolution not only deals with forest restoration, as in previous resolutions, but also with the restoration of non-forest ecosystems such as the mangroves, savannah, stricto sensu (typical savannah) among others.

Another breakthrough achieved with Resolution of SMA 32/2014 focuses on the results obtained in the restoration processes, as opposed to previous resolutions, whose focus was on the method used for planting and which had been the subject of controversy, as already reported. For this reason, parameters were determined to support the monitoring of areas under restoration, the objective of which is to indicate whether or not the purpose of the restoration project will be achieved; in other words, they are parameters that will indicate whether the procedures adopted in the process would lead to the restoration of the ecosystem in the area in question, or if, on the other hand, they would result in failure. Thus, if, when monitoring the area under restoration, it is observed that the parameters adopted in the Resolution were achieved within the specified period, its adequacy level is classified as "adequate", indicating that the probability of success of the restoration is high. project, that is, that the ecosystem under restoration becomes self-sustaining; otherwise, if the level reached is considered as "minimum", this would indicate the existence of flaws in the project and therefore, that there would be a need to adopt corrective actions and a new subsequent assessment; and finally, if the level reached is considered "critical", then there would be a need to elaborate a new project, since the probability of success of the original project would be very low (Table 1, below).

	Ombrophylous and Seasonal Forests / Restinga Florestal / Riparian Forest in savannah region									
	Indicator	Coverage with native vegetation (%)			Density of regenerating native individuals (ind./ha)			Number of regenerating native species (spp.)		
	Level of suitability	Critical	Minimum	Adequate	Critical	Minimum	Adequate	Critical	Minimum	Adequate
Intermediate reference values	3 years	0 to 15	15 to 80	80	–	0 to 200	200	–	0 to 3	3
	5 years	0 to 30	30 to 80	80	0 to 200	200 to 1000	1000	0 to 3	3 to 10	10
	10 years	0 to 50	50 to 80	80	0 to 1000	1000 to 2000	2000	0 to 10	10 to 20	20
	15 years	0 to 70	70 to 80	80	0 to 2000	2000 to 2500	2500	0 to 20	20 to 25	25
Values used to attest recomposition	20 years	0 to 80	–	80	0 to 3000	–	3000	0 to 30	–	30

Levels of adequacy expected after certain periods of time elapsed since the implementation of the project for each type of vegetation: forests, forest restingas and riparian forest in the savannah region. (From Annex I of Resolution of SMA 32/2014 with modifications.)

Table 1. Reference values for monitoring ecological restoration projects.

ORDINANCE CBRN 01/2015

On January 17, 2015, the Coordination of Biodiversity and Natural Resources – CBRN, published Ordinance CBRN 01/2015. It is a specific complement to Resolution of SMA 32/2014 establishing the Monitoring Protocol for Ecological Restoration Projects. It defines the data collection methods for measuring the indicators shown in table 1, as follows:

(1) land cover with native vegetation;
(2) density of regenerating native individuals; and
(3) number of regenerating native species.

It also establishes the shape, size and number of sample plots, and the method by which monitoring of areas undergoing restoration must be conducted.

MONITORING INDICATORS AND HOW TO CARRY OUT THE SURVEY

They are obtained through sample plots, which represent the entire area subject to restoration. Examples:

A) POLYGONS AND SAMPLE PLOTS

Polygons represent the areas under restoration and Parts, the areas to be surveyed within the polygons.

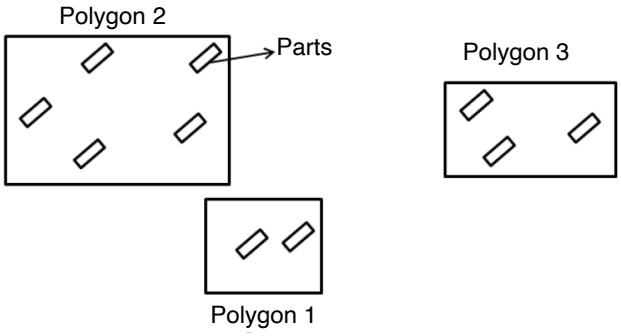

Figure 1. The plots must be randomly positioned and their locations can be fixed (permanent) or variable (temporary), according to the decision of the project executor.

The number of plots is determined according to the total area (in hectares) of the project, as shown in table 2 below:

A = Project area in hectares (ha)	N = number of sample plots
A ≤ 1 (one ha)	5 (five)
A 1 (one ha)	Number of hectares + 4 (four)*

*Limited to a maximum number of 50 installments and a minimum of five. Note: As long as the polygons have the same type of vegetation, the number of sample plots for a discontinuous area can be calculated in the total area as if it were a single monitoring unit.

Table 2. Calculation of the number (N) of installments per project.

B) SURVEY WITHIN A SAMPLE PLOT

Figure 2.

C) CALCULATION OF SOIL COVERAGE INDEX AND DENSITY IN THE PLOT

Only native species are considered!

Native plant cover of the soil: each stretch is measured in meters (m); the coverage of each plot and the native vegetation cover indicator in the polygons, in percentage (%):

Coverage in each installment (%)	=	([snippet 1 + snippet 2 + … + snippet n]× 100) ÷ 25
coverage indicator (%)	=	(installment coverage 1 + partial coverage 2 + … + partial coverage N) ÷ N

Density of individuals in the plot and in the polygons: number of individuals per hectare (ind./ha).

Proportion of plot per hectare (formula): 100 m2 ÷ 10,000 m2 = 0.01.

Density in the plot (ind./ha)	=	(number of individuals found in the plot) ÷ 0,01
Density indicator (ind./ha)	=	(partial density 1 + partial density 2 + ... + partial density - N) ÷ N

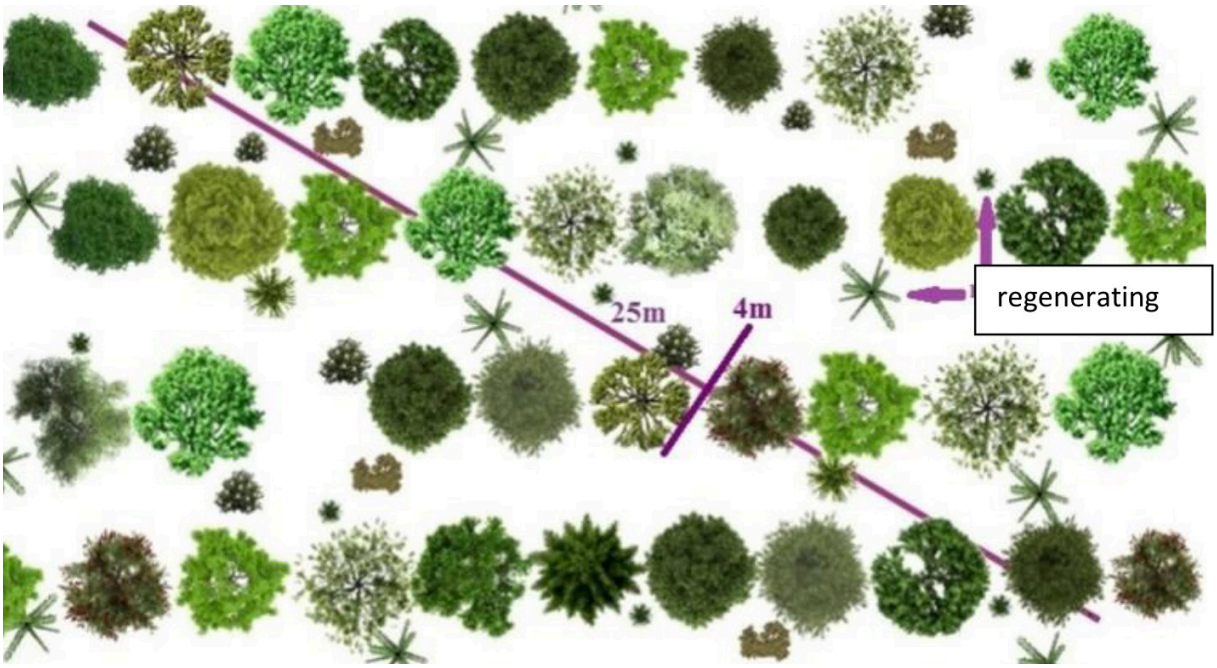

Figure 2. Top view of a sample plot of a restoration carried out by planting seedlings or sowing in rows. For the sample line (25 m) a measuring tape is stretched diagonally to the planting lines. Next, its width is fixed: 4 m (2 m for each side of the tape, therefore, an area of 100 m2 for each plot).

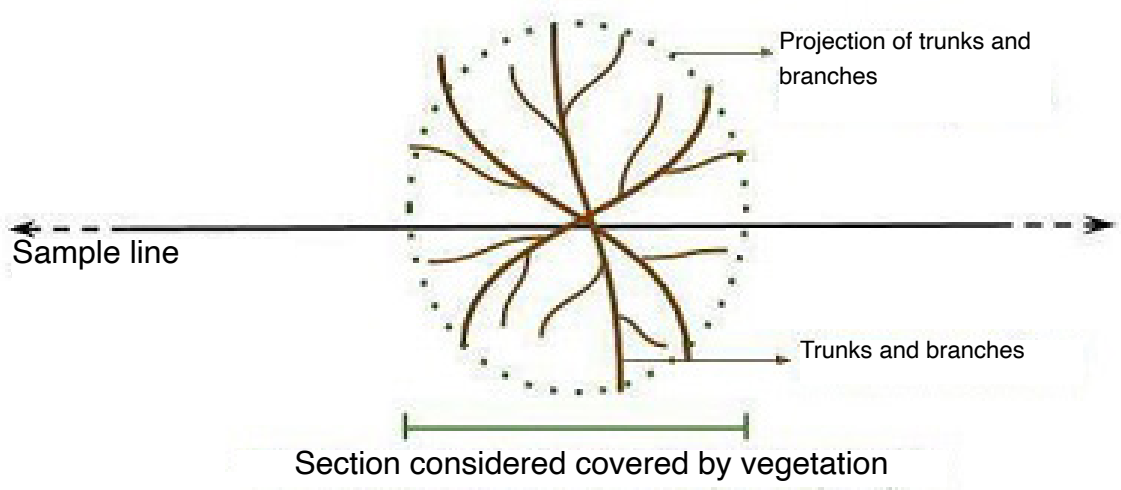

Figure 3. Deciduous species: projection of tree trunks and branches is used to measure coverage.

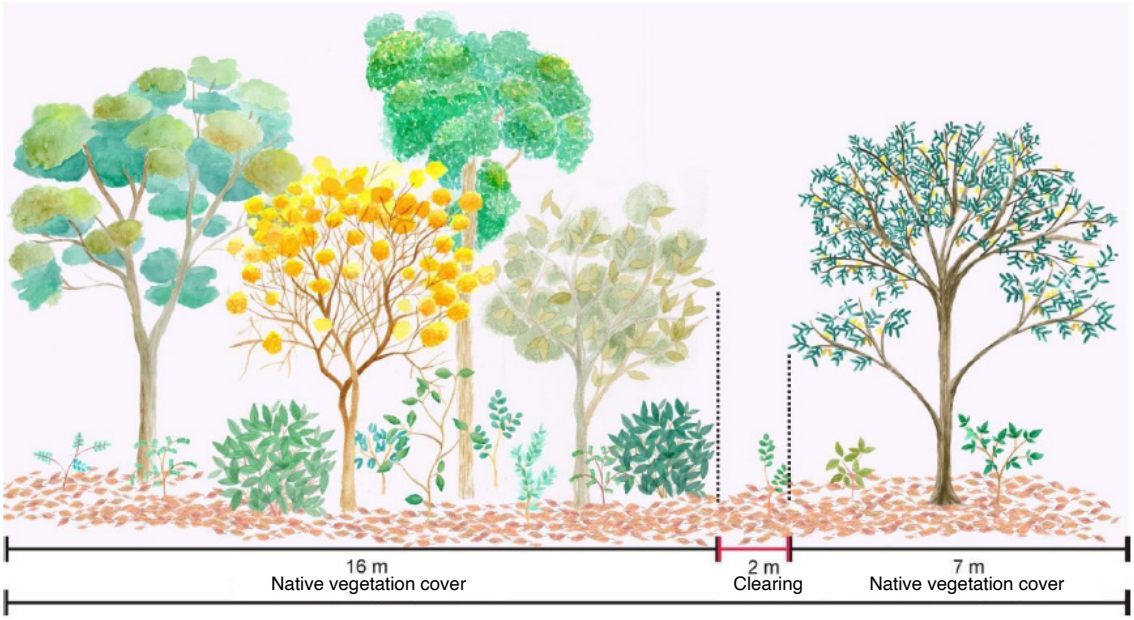

Figure 4. **"Soil cover with native vegetation"** forest is the area of the soil covered by the canopy of native species (only!). In this example, the 2 m clearing is excluded, therefore, the soil cover by native species in the plot is 23 m (covered) / 25 m (total), which results in 92% coverage: (23 ÷ 25 × 100 = 92%).

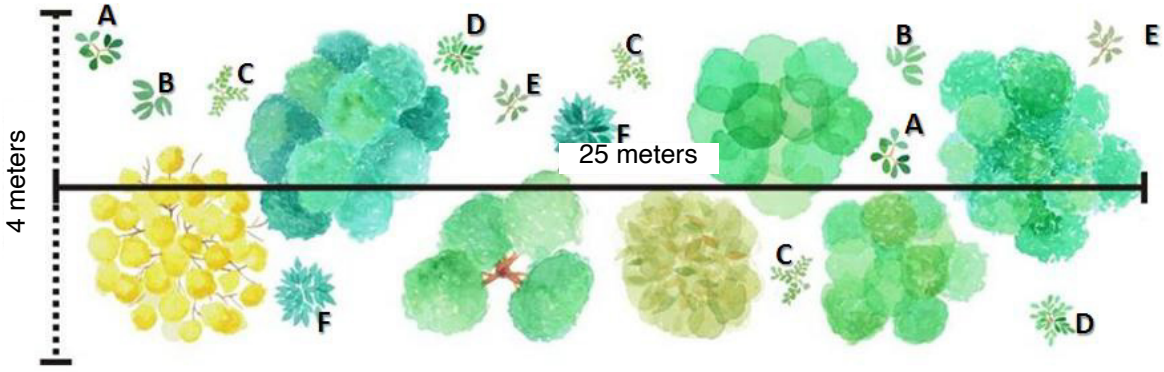

Figure 5. Representation of a monitoring plot with 13 (thirteen) regenerating native individuals of 6 (six) different native species (A, B, C, D, E, F). If other different species are not found in other plots, the total value for the indicator "Number of regenerating native species" in table 1 will be 6 (six).

D) NUMBER OF REGENERANT NATIVE SPECIES

Number of regenerating native species: only individuals with height (H) equal to or greater than 50 cm (ground base to its highest living part) and circumference at breast height (CAP) less than 15 cm at height of 1.30 m above the ground (H ≥ 50 cm and CAP 15 cm). Attention: the same species can only be counted once in the same monitoring unit, even if it occurs in several plots and there is no need to measure the exact height of each individual sampled, as shown in figure 5 (above).

The focus of the restoration is on the results obtained relative to the expected parameters for each of the stages, defined in periods of time elapsed since the beginning of the project implementation (table 1). The objective is greater probability of success with consequent reduction of costs. Resolution: SMA 32/2014 also provides that exotic species (herbaceous, shrubs or trees) are potentially invasive, measures for the maintenance and control of these species (duly registered in the Computerized System of Support for Ecological Restoration – SARE) must be taken with a view to their eradication from the location. Except for exceptions provided for in the legislation, the control of these exotic species in areas undergoing restoration does not require the issuance of authorization by the competent environmental agency.

SARE AND SICAR

The Computerized System to Support Ecological Restoration – SARE (instituted by Resolution SMA 32/2014) is an online platform for the electronic registration and monitoring of all ecological restoration projects in the state of São Paulo. It is a tool for the mandatory registration of projects linked to environmental licensing requirements and/or repair of environmental damage, and projects financed with public resources or carried out on rural properties within the Environmental Regularization Program - PRA (State Law Number: 15,684, of January 14, 2015). Registration in the SARE is mandatory and free, but for rural properties, prior registration in SiCAR is mandatory so that the restoration project can be registered in the SARE. SiCAR allows the registration of rural properties in São Paulo in the CAR – Rural Environmental Registry, which was instituted by Federal Law Number: 12,651/2012 and regulated by MMA Normative Instruction Number: 02, of May 5, 2014. At the national level, CAR is a mandatory electronic public record for all rural properties, whose purpose is the integration of environmental information of rural properties and possessions concerning: APPs, Restricted Use Areas, Legal Reserves – RLs, remnants of forests and other forms of native vegetation; as well as existing consolidated areas in the properties. The objective of the C.A.R. is to obtain a database for control, monitoring, environmental and economic planning and combating deforestation.

Enrollment in the C.A.R. is the first step towards obtaining the environmental regularity of the rural property. Small properties and rural possessions (defined in Federal Law number 12.651/2012) have support from the public authorities to register

ANALYSIS AND DISCUSSION OF THE CURRENT LEGISLATION

The new resolution and its respective ordinance present several changes in relation to the previous ones; However, some of the existing guidelines were maintained, for example there was no major change with regard to the recomposition of native vegetation by planting seedlings in the total area for regions where vegetation formations such as: dense rainforest occur, seasonal semi-deciduous forest and forested savannah. The Resolution of SMA 08/2008 (previous),

established that planting in a total area must be carried out with at least 80 (eighty) native forest species of regional occurrence, a minimum of 5% of native species of regional vegetation, falling into one of the categories of threat (vulnerable, endangered, critically endangered or presumably extinct), the chosen species must contemplate the two ecological groups: pioneers (pioneers and early secondary) and non-pioneers (late secondary and climax), considering the minimum limit of 40% for any of the groups, except for forested savannah. At Resolution of SMA 32/2014, with few modifications, these same recommendations were included, however as a guide (not mandatory) and also allows the adoption of different methods for the restoration of native vegetation, provided they are duly justified in the project.

Accepted alternative methods of ecological restoration include: (1) favoring natural regeneration in cases where there is the presence of native forests relatively rich in species in the vicinity of the area to be recovered; (2) direct seeding in the field; (3) nucleation; (4) other existing methods or those to be developed. However, the parameters or reference values already set out regarding the recomposed vegetation (native vegetation cover, density of individuals, etc.) are now required as the final objective of the project, thus, the competent environmental agency will mainly supervise the final result of the restoration project based on reference values that will indicate whether or not the objective is being achieved. It will be observed, for example, the self-sustainability of the vegetation recomposed by native species of regional occurrence. In any case, one of the three evaluation parameters is soil cover by vegetation, which will be considered adequate when the coverage percentage is greater than 80%.

As for the maintenance and monitoring of the Project, the terms of 3 (three), 5 (five), 10 (ten), 15 (fifteen) and 20 (twenty) years (table 1), or any other period of time are foreseen necessary until recomposition has been achieved; duly attested by the competent environmental agency or entity. If the values measured as a reference for recomposition have not been reached, the "Ecological Restoration Project" will be considered not fulfilled, resulting in the persistence of the recomposition obligation, regardless of applicable administrative sanctions.

With this, it is expected that the monitoring and control capacity on the part of the environmental agencies over the areas in recomposition will be reinforced with SiCAR and SARE, which will also serve as auxiliary tools in the preservation of native forest fragments in the state of São Paulo.

CONCLUSIONS

Brazil is, according to available information, a pioneer among nations in the initiative to legislate on ecological restoration techniques (Durigan, et al. 2010), and at the national level, the state of São Paulo is at the forefront and at the over the past two decades, considerable progress has been made in guiding state legislation on ecological restoration. However, only time will show whether Resolution SMA 32/2014 has been successful in achieving what it sets out to do it, that is, that from now on the ecological restoration actions carried out in the state of São Paulo will show a much greater degree of success. than those done so far.

REFERENCES

1. BARBOSA, L. M. (Coord.) **SIMPÓSIO SOBRE MATA CILIAR**, 1989, Campinas-SP. Anais... Campinas: Fundação Cargill, 1989.

2. CAR – **Cadastro Ambiental Rural**. Sistema Nacional de Cadastro Ambiental Rural – SiCAR. Disponível em: http://www.car.gov.br/. Acesso em: 7 dez. 2022.

3. CBRN – Coordenadoria de Biodiversidade e Recursos Naturais. Secretaria do Meio Ambiente do Estado de São Paulo – SMA. **Portaria 01/2015. Estabelece o protocolo de monitoramento de projetos de restauração Ecológica**. Estabelece o Protocolo de Monitoramento de Projetos de Restauração Ecológica, considerando o disposto no § 2º do artigo 16 da Resolução SMA 32, de 3 de abril de 2014. Disponível em: http://arquivos.ambiente.sp.gov.br/legislacao/2016/12/2015_1_15_Procotolo_monitoramento_restauracao_vfinal.pdf . Acesso em: 7 dez. 2022.

4. DURIGAN, G., ENGEL, V. L., TOREZAN, J. M., MELO GALVÃO, A. C. G., MARQUES, M. C. M. M., MARTINS, S. V., REIS, A. e SCARANO, F. R. **Normas jurídicas para a restauração ecológica: uma barreira a mais a dificultar o êxito das iniciativas?** Revista Árvore, v. 34, number 3, p. 471–485, Viçosa-MG, 2010.

5. NOGUEIRA, J.C. **Reflorestamento heterogêneo com essências indígenas**. Boletim Técnico – Instituto Florestal number 24. São Paulo, 1977.

6. RODRIGUES, R.R., LIMA, R.A.F., GANDOLFI, S., NAVE, A.G. **On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest**. Biological Conservation 142:1242–1251, 2009.

7. SER – Sociedade Internacional para Restauração Ecológica. **Princípios da SER International sobre a restauração ecológica**. Grupo de Trabalho em Ciência & Política (versão 2), outubro de 2004. Disponível em: https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/SER_Primer/ser-primer-portuguese.pdf. Acesso em: 7 dez. 2022.

8. SER – Society for Ecological Restoration. **What is Ecological Restoration?** Disponível em: https://www.ser-rrc.org/what-is-ecological-restoration/. Acesso em: 7 dez. 2022.

9. SIMA – Secretaria de Infraestrutura e Meio Ambiente do Estado de São Paulo. **Manual de Orientações do SARE: Análise, celebração de termos e monitoramentos**. Disponível em: https://smastr16.blob.core.windows.net/sare/2019/01/2019-01-25_manual-sare-analise_termos_monitoramento.pdf. Acesso em: 7 dez. 2022.

10. SIMA – Secretaria de Infraestrutura e Meio Ambiente do Estado de São Paulo. **Resolução number 32, de 03 de abril de 2014. Estabelece as orientações, diretrizes e critérios sobre restauração ecológica no Estado de São Paulo, e dá providências correlatas**. Disponível em: http://arquivos.ambiente.sp.gov.br/legislacao/2016/12/Resolução-SMA-032-2014-a.pdf . Acesso em: 7 dez. 2022.

11. SIMA – Secretaria de Infraestrutura e Meio Ambiente do Estado de São Paulo. **SARE (Sistema Informatizado de Apoio à Restauração Ecológica)**. Disponível em: https://www.infraestruturameioambiente.sp.gov.br/sare/. Acesso em: 7 dez. 2022

12. SIMA – Secretaria de Infraestrutura e Meio Ambiente do Estado de São Paulo. **Sistema de Cadastro Ambiental Rural – SiCAR**. Sistema Ambiental Paulista – Governo de SP. Disponível em: https://www.infraestruturameioambiente.sp.gov.br/sicar/. Acesso em: 7 dez. 2022.