Conservation Policies and Environmental Criteria: Principles, Concepts and Protocols

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Biodiversity and Conservation are terms that have been incorporated into the vocabulary and concerns of a significant portion of humanity. Everyone understands what biodiversity is and knows how to recognize it, at least comparatively and in reference to their own experience. Yet, curiously, although there is a general intuitive perception, there is no consensual scientific definition of biodiversity. Furthermore, according to some authors (for example, Dreyfus et al., 1999), there is no single way of seeing biodiversity, and therefore, of defining it. For the purposes of conservation policies, for example, biodiversity can be defined based on a symbolic or an operational perspective. In the realm of science, nearly every theoretical article written about the issue implicitly or explicitly offers its own definition or variation, although the central focus is always variety.

Variety emerges from the existence of similarities and differences observed on various levels of the biological and molecular universe, ranging from the individual to the ecosystem and landscape. It thus forms a fractal system, in both space and time. Our own evolution is so immersed in this system that our aesthetic sense and value systems are inalienably linked to variety – the interesting counterpoise to the monotonous, the valuable to the common, repeated. We are always looking for the rare, the singular, the unique, that which is different. The price of a diamond ring, the international trade in rare animals or those threatened with extinction, pressures from real estate development, tourism on islands and within the few remnants of preserved forests, prove that everyone recognizes the value of variety and exclusivity and wants to enjoy them. This appreciation is independent of an individual's personal environmental philosophy, whether it be biocentric or anthropocentric. The biocentrist understands that nature should be preserved simply because it exists and should be left functioning as it is. Species are a product of a long continuous evolutionary history through ecological processes and also have the right to life [Alho, 2008]). The anthropocentrist, on the other hand, believes that nature should be preserved because it has value, that it provides "ecological services" for humans within the notions of patrimony and inheritance [ibid]). However, a good portion of our population has no phisosophy, including many of our business leaders.

In the field of conservation, to speak of preserving biodiversity is equivalent to speaking of preservation of variety at all levels of universality. This includes its causes and all manifestations and components, from the genetic variation among individuals to variation among ecosystems. Without intending to resolve the question of defining biodiversity, we can say, simply and operationally, that *conservation is aimed at preserving representative samples of biodiversity and its processes and patterns.* Even limiting our discussion to the ecological realm, there are different levels of biological diversity, of which we are interested in the most simple, purely qualitative levels. That is, species richness (diversity α) and the immediately superior level (diversity β), which include quantitative components such as relative species abundance (size of each population).

Another term that became part of our daily vocabulary, even before biodiversity, is ecology. This is frequently used equivocally and is confused with "ecofilia" (filo =friend, the one which is identified with; while logos = knowledge, study). Therefore, in its technical use, ecology is a branch of the biological sciences dedicated to describing biological units. At a hierarchical level above that of populations/species, the ecologist investigates how these elements, as well as the individuals within each population, interact with each other and their environments, producing what we know as ecosystems, biomas and the biosphere.

The discipline of ecology arose when naturalists realized that the natural systems surrounding us do not result from a simple sum of their elements, and have properties that emerge from the interactions among individuals of a population and among the populations themselves, along with environmental factors, usually variable in space and time. Qualitative or quantitative alterations in any of these elements can lead to a loss of biodiversity.

On the other hand, it is also not true that ecosystems are like clocks with perfectly adjusted gears, in which any disturbance can cause significant losses in terms of diversity. In fact, each ecosystem has its own degree of *resilience*, which is the ability to tolerate and adapt to changes, maintaining its structure and general patterns. This ability is essential to evolution itself (remembering that evolution = change, transformation, and not "progress" in the sense of improvement), given that we live in an environmentally variable world, characterized by continuous natural fluctuations, which may or may not be cyclical. These fluctuations create the force that generates diversity by means of processes of diversification, resulting from vicariance (the fragmentation of habitat, caused by the appearance of barriers – geographic, geological, climatic, ecological etc. – which leads over time to the subdivision of populations), dispersion, extinction, etc. Environmental stresses may constitute a factor that accelerates evolution through bottleneck effects which may lead to drastic decreases in the size of populations, a known factor in biological diversification. One of the factors of resilience is redundancy. In general, ecosystems do not function at minimum population size, except for a few found on islands and in caves which can function at the limit of their resilience.

The great challenge is, therefore, to detect the resilience limits of an ecosystem, based on the understanding of the factors involved in the evolution and functioning of each ecosystem. If limits are exceeded, it will lead to an irreversible loss of biodiversity. Ideally, we should allow the loss of only that which is redundant, but to ensure this our current economic development model must be completely changed. It is the role of the natural sciences to provide the scientific bases needed to determine degrees of fragility (proximity to the limits of resilience) and disturbance. Any decision violating the basic principles of conservation is a political one, allowing the loss of important portions of biodiversity.

In the absence of conclusive scientific data, the option is to use logic, always based on the *principle of precaution/prevention*, which should be the guide for all and any conservation policy. The Precaution principle, which is also a legal principle (*in dubio, pro reu*), dictates that whenever there is good evidence that an ecosystem is fragile or threatened, the most unfavorable scenario should be assumed. Therefore, action should be taken guaranteeing protection in this scenario. For example, if there is doubt about whether a given species is truly threatened, evidence indicating that it *may be* (which may include a restricted distribution of threatened ecosystems, low population levels, apparent decline, etc.) justifies actions to guaranteeing its protection and that of its habitat. In the same way, it is reasonable to suppose and assume, for the purposes of conservation policies, that ecosystems which lose a large percentage of their area of distribution should have integral protection. This is the classic case of the Atlantic Forest (which has lost more than 80% of its area) and more recently the Cerrado, which is shrinking before the naked eye. Therefore, development projects with irreversible impacts should be exceptions that are very well politically justified.

In this regard, it is also necessary to clearly demonstrate the difference between fragility and disturbance. The concept of *fragility* refers to the potential for loss of diversity, depending on the degree of resilience of a system and on the type and intensity of potential disturbances. It is, therefore, a relative concept. Meanwhile, degree of *disturbance* is an absolute concept, due to the fact that the disturbance has already occurred and is detected afterwards. The lists of threatened species, presented in documents such as Red Books that are made official by state and federal environmental agencies, such as the Brazilian Ministry of the Environment (MMA), are examples of the latter. Reduced area and presence of endemic species, and/or those with restricted distribution and reduced area, are indicators of high fragility. This is independent of the existence of real risks, to the degree that evidence of species loss and decreased size and density of populations maintained over time (not considering, however, natural cyclical fluctuations) indicate a real and current threat. In this sense, vertebrae such as amphibians are particularly informative (see the article by Verdade et al. in this dossier), as well as large predators and macroinvertebrae, especially arachnids such as spiders (predators) and opiliones which are especially vulnerable to environmental changes. A decline in numbers of some of these animals is indicative of disturbances, even in their initial stages.

One of the many fallacies that permeate our myopic and poorly effective environmental policy is the mistaken notion that small development projects do not present important threats to biodiversity. This totally disregards the *accumulative effects* of the multitude of individually small interventions. The principle is simple and obvious: for each event of destruction or disturbance of natural systems, the importance of those remaining systems, regardless of their singularity, increases exponentially. Thus, their importance as representative samples of biodiversity, including processes and standards, significantly increases.

Small developments (sugar cane plantations, real estate developments and various others) are licensed one after another by environmental agencies, with the justification that they will not have significant impact. Nevertheless, the absence of global analysis of the combined effects, within the current poorly organized and badly articulated policy, can cause even greater losses than those caused by a few large developments, where the control of protective measures is greater. For example, one measure taken is based on a prevision for corridors for fauna within the areas of these developments, among other mitigative measures and monitoring programs.

The notions and concepts cited are essential to understanding that multiple facets must be considered in legislation. The current approach is extremely simplistic and has a weak logical and conceptual basis. If it is maintained, we risk losing the ability to act effectively.

Conservation Policies

Two principal tools for conservation policies have been recognized by Brazilian environmental agencies: the identification of priority areas for conservation and lists of threatened species. In daily licensing activities, however, only the latter are effectively used, although only partially as we shall see.

The literature is very rich in documents about conservation strategies and guidelines, recommendations and proposals for areas to be protected. It is not our objective here to bring together and analyze all of this material. Yet the principal message is: something must be done, and urgently. In practice, it should be recognized that the message has not reached the most important level, which is that of government decision-making. Such decisions are supported by environmental studies that are full of errors and fundamentally ineffective (see below). These decisions hide behind a smoke screen of mitigative measures (see article by Mechi & Sanches in this dossier), and practically all requests for environmental licenses are approved. That is, the documents mentioned, which are the result of tremendous effort by the scientific community and technicians at environmental agencies, are in practice, ineffective in the face of the powerful economic interests of a few businesses and politicians. We must review the strategies to raise awareness and sensibility of governments and the political forces that sustain it. The very philosophy of the Federal Growth Acceleration Program (PAC) in Brazil must be reviewed.

We will now focus on some of the most objective documents relating to proposals for priority areas. Published on May 27, 2004, Guideline n.126 of the Ministry of the Environment made official the recognition of "Priority Areas for Conservation, the Sustainable Use and Sharing of Benefits of Brazilian Biodiversity or Priority Areas of Conservation for the purpose of formulation and implementation of public policies..." (art. 1º). This was issued in conjunction with a map of the realm of the Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (Probio). The project lasted more than 24 months and combined information prepared by more than a thousand scientists, technicians from public agencies and leaders of social movements. It is thus an unquestionably robust technical document with a solid scientific base, recognized by representative sectors of society. At the same time, as one of the products of the BIOTA-FAPESP program, a document was produced in the form of a book, also offering proposals for priority conservation areas, which are based on scientific study as well.

These areas, however, have not been considered in the analysis of environmental licensing requests to use natural resources. This compromises the objectives of Portaria MMa n.126, art. 1º which include:

I – Conservation *in situ* of biodiversity;

II – Sustainable use of components of biodiversity;

III – Sharing of the benefits derived from access to genetic resources and of associated traditional knowledge;

IV – Research and inventories about biodiversity;

V – Recuperation of damaged areas and of species that are over-exploited or threatened with extinction;

VI – Establishing the economic value of biodiversity.

Examples of the lack of commitment to the national conservation guidelines, that are made official in current norms, are the various non-sustainable projects recently approved by government agencies in São Paulo. These are located in high, very high and extremely high priority areas, such as the Serra do Mar and the São Paulo state coast, where real estate speculation and port developments, among other ventures, exercise strong pressure to change environmental legislation (see the article by Varjabedian in this dossier).

Throughout Brazil, mining developments overlap with priority areas for biodiversity, and in the event of legislation creating impediments, it had been changed. Among the most alarming cases involve caves, which contain fragile and highly important environments in terms of biodiversity. Caves were protected by decree n.99.556, Oct. 1, 1990, which determined that "the natural underground cavities within national territory constitute part of the Brazilian cultural heritage" (art. 1º) and that "the use of natural subterranean cavities and of their area of influence should be in keeping with specific legislation, and only conducted within conditions that assure their physical integrity and the respective maintenance of the ecological balance" (Art. 2º). The existence of such caves in regions with iron represent an additional problem for large companies interested in mining iron and limestone and in constructing hydroelectric plants to supply these industries (see the case of Tijuco Alto, located in a priority area of the Karst region of the Upper Ribeira River in São Paulo State, which is still pending). The conflict of interest sparked a new decree, n.6.640, which allowed destruction of caves if their maximum importance could not be proven (we will return to this subject later).

The tools effectively used in decision-making related to licensing of projects in general (in the fields of energy generation, mining, agriculture, tourism, real estate, etc.), which in practice constitute the central threat to biodiversity, are the *Official Lists of Species Threatened with Extinction*. Although they are useful in some cases, they are very weak and poorly effective in global terms, given that they often have serious conceptual and operational problems.

The first and largest problem is the very definition and delimination of the taxon "species," which is a very complex issue and for which there is no consensus among scientists. In practice, the definition of species in the taxonomy of each group is determined by specialists, who look for sets of characteristics that can distinguish different units (diagnostic categories. They are then given specific official names, or binomials, within the convention established more than 250 years ago by Linnaeus. This is where the difficulties begin. Discontinuities that can be used to distinguish species are not always found, and there is frequently a certain overlapping in the variation of characteristics analyzed in different sets of individuals. Considering the gradual nature of evolution in most known cases, it is expected that we would encounter populations in processes of differentiation, but which are still not totally separated (see example for fishes in caves in Reis et al. (2006)).

The second problem is the following: since the currently rigid environmental bureaucracy has only been accepting the inclusion of nominal species (those which are formally described and referred to by a binomial *gender species*) on the official lists, geographic variations remain unprotected. They should also be the object of conservation measures ("preserve representative samples of biodiversity, their processes and standards"), as well as those species still not described. A country with recognized megadiversity, such as Brazil, is particularly affected by the so-called *Taxonomic Impediment*, which is the lack of competent and qualified specialists to describe all of the country's diversity, and name taxons with both biological and operational significance. A conceptual change is needed in the approach to how these lists are prepared, so that they can effectively include the diversity of processes and standards that generate this wealth.

The Logic of Relevance *Versus* Non-Relevance: Research Protocols

In general, the establishment of criteria to create conditions for the preservation of species, habitats or ecosystems are based on the presence of certain factors. It is the norm for populations appartenant to nominal species to be included on official lists of species threatened with extinction. This occurs once and again among the large majority of cases and the list is utilized in an extremely simplistic and inefficient approach to the problem of the conservation of Brazilian biodiversity. Providing a slightly better level of protection, and offering a wider scope of criteria, is legislation referring to caves, such as in the previously mentioned decree n.6.640, which is regulated by Ministry of the Environment Instructional Norm, n.2, of August 2, 2009. According to these legal norms, cavities that have at least one of the following attributes are of maximum importance and should suffer no interference or disturbance:

I – unique or rare genesis;

II – unique morphology;

III – notable dimensions of size, area or volume;

IV – unique speleothems;

V – geographic isolation;

VI – provide shelter essential for the preservation of genetically viable species of animals that are threatened with extinction, and are found on the official lists;

VII – essential habitat for preservation of genetically viable populations of species of endemic or relic troglobites;

VIII – habitat of rare troglobites;

IX – unique ecological interactions;

X – representative cavity; or

XI – have outstanding cultural, historic or religious importance.

The important issue here is that, logically, the existence of an attribute can be proven but not its absence. That is, the absence of evidence is not evidence of absence. This is the basis of science itself, based on the logical principles proposed by Popper. In the language of hypotheses testing, the initial hypothesis (Ho) previously held was that all caves had maximum importance (cf. decreto n.99.556), thus should not be destroyed. With decree n.6.640, only caves of maximum relevance, i.e., possessing at least one of those 11 attributes, are fully protected. Thus, Ho switched to: a cave is not relevant (therefore, it may be destroyed) until one proves the existence of at least one of the mentioned attributes.However, it is not possible to demonstrate, absolutely and definitely, the falsity of Ho because an attribute could be detected at any time, unless, of course, the habitat is conveniently destroyed. In other words, it is logically impossible to classify any cave, or any other habitat, as not being of maximum importance. In the same way, it cannot be affirmed that in a given area populations of threatened species do not exist. Only the opposite is true.

We have here a logical dilemma, whose solution resides in the method. What does science do with its initial hypotheses? It looks for collaboration by means of a large quantity of data that make the initial hypothesis highly probable, even if impossible to be demonstrated (a situation in which it would be possible to justify the impacts of any intervention). I will briefly present some methods to collaborate an initial hypothesis within biology, largely because biological systems are, without a shadow of a doubt, the most complex and the most vulnerable because of their time scale.

The principal question relates to how well represented the sample is. The answer of this question is sought to detect the four principal factors of relevance (for ecosystems in general, including subterranean ones): taxonomic scope, sample frequency, spatial coverage/distribution, and time distribution/coverage.

Taxonomic Scope

The great majority of environmental studies that support requests for licensing of projects are restricted to the survey of vertebrates, with a large emphasis on mammals and birds. These are not necessarily the best indicators of priority for conservation and of degree of previous impact. Honorable exceptions include environmental studies of caves, which traditionally include all fauna. In fact,

> *Although arthropods encompass a major part of tropical biodiversity, dominate terrestrial animal biomass, play important ecological roles in tropical forests as parasites, decomposers, herbivores, predators and pollinators* [...] *and are better predictors of the conservation value of tropical forest areas than vertebrates* [...], *most information was gathered on vertebrates and plants... (Bragagnolo et al., 2007).*

An effective policy would thus require environmental studies to include vertebrates, with an emphasis on predators (for example arachnids) and groups that are indicators of environmental changes (for example, forms of young insects from lotic environments, butterflies and opiliones) (Brown Junior, 1997; Bragagnolo et al., 2007).

Note that an acceptable taxonomic scope, which would allow for drawing valid inferences about biodiversity, would require the application of different complementary methods (see article by Silveira et al. in this dossier). If the objective is to characterize the biodiversity of a region, less selective methods are better in terms of results and of making best use of the effort (of both labor and funds). Unfortunately, most technicians working in environmental agencies are against the use of these non-selective methods, contributing even more to delays in the development of knowledge of our biodiversity, and consequently, to the inefficiency of Brazilian environmental policy.

Sufficient Sampling

Concerning the spatial scope of the study, it is clear that the minimal sample area should include at least the entire project and its area of influence. The latter is the most problematic factor, since the area of influence depends on a set of factors, which in no way is fixed. For example, for a project of the same type and size, the downstream impacts in a hydric system will affect a much larger area than those upstream. The areas of influence for projects in locations with migratory species, or of species with broad habitats, will certainly be large, and so on. In light of this, the legislation should be adapted to each particular case.

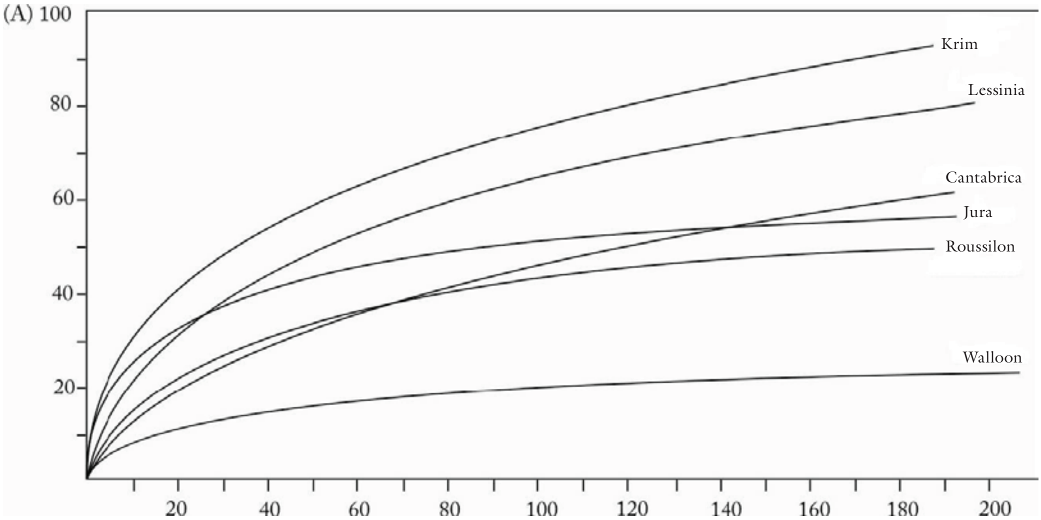
The issue of area of influence is particularly important in the case of caves, of which only a portion is accessible by humans. The remainder includes a much more extensive habitat, which is the underground environment. Thus, the great majority of underground species would occupy an area larger than that directly studied.

In addition, due to their dependence on nutrients imported from the surface, the area of influence of subterranean ecosystems is generally very broad, encompassing the entire watershed upstream of the cavity and the living area of species responsible for bringing food into caves, such as bats. Here resides one of the most serious technical problems: both decree n.6.640 and its predecessor, decree n.99.556, explicitly refer to caves and not to the biological units of habitat, which are subterranean systems. For example, the presence of attribute VII art. 1º, paragraph 4º of decree n.6.640 – "habitat essential for the preservation of genetically viable populations of species of endemic or relic troglobites" – can only be verified based on an analysis of the entire system, including the epigean (superficial) environment.

A polemical factor is the scope of time. This not for lack of scientific foundation (to the contrary), but simply because business interests, anxious for fast and easy profit, are not willing to spend a sufficient amount of time on a project. The seasonal functioning of subterranean systems is a widely known fact. Biological studies that cover consecutive years frequently point to important differences between years. Chronobiology, which studies biological rhythms, has already established that in order to define cyclical patterns studies are needed which cover at least three times the period of the cycle that is to be defined. That is, at least three years of study are needed to define seasonal standards. In practice, ecological studies, as well as those on biodiversity, show that even these three years are frequently not sufficient, indicating that four or five years are the minimal amount of time needed for a well-grounded understanding of the operation of a particular ecosystem.

There are many studies about the *minimal sampling frequency* in biological surveys and there is a consensus about the use of the curves of accumulation or rarefication (the collector's curve is a particular case). These are graphs on which are plotted the occasions of collected data against the cumulative number of species of all groups (see, for example, Gotelli & Colwell, 2001). A given area would only be considered well understood in terms of its fauna and flora when the curves of these graphs reach the asymptote.

Graph 1 shows an example demonstrating the need for much larger sampling efforts than those practiced in Brazil. In each one of the six European Karst regions plotted on the graph, 187- 206 samples were taken. The authors of the study show that, with only 10 samples, the conclusions about the relative diversity in these areas would have been wrong (Culver & Pipan, 2009). Our experience in Brazilian caves shows that at least 10 occasions of collection in different years are needed to begin defining all of the characteristics of the subterranean ecosystems, and that troglobite species can still appear even after 20 collections.



Graph 1 – Accumulation curves of troglobitic species (exclusively subterranean species) in six Karst regions in Europe (from Culver & Pipan, 2009).

The methods cited, and others with equivalent objectives and robustness, can be applied in any environmental study. Alleging that they are not feasible is incorrect. In addition, it is a clear conflict of interest to have developers be responsible for contracting environmental studies and this should not be permitted, at least for ethical reasons. In other countries, such as Australia, government environmental agencies are responsible for selecting and supervising the teams that conduct these studies, although those with direct interest, or the builders, pay for the services. This should be the case in Brazil.

The fact is that Brazilian environmental agencies in general have been incapable of establishing and applying protocols with basic criteria for environmental studies such as those discussed here. This is very convenient for business interests, given that the studies are analyzed on a case-by-case basis, in *ad hoc* reports that are not integrated or coherent with the environmental legislation. This facilitates political pressure to manipulate technical decisions. Once again, the legislation concerning caves appears to be an exception, given that Article 16 of Instructional norm no. 2 of 2009 includes a series of minimum requirements for speleological studies, seeking classification of the degree to which the cavities are relevant. Although they still have many problems (for example, only two samples distributed in a single annual cycle are required and there is no call for the use of accumulation of species curves), this legislation is an advance in relation to the broader laws for epigeous ecosystems.

Environmental studies should be conducted responsibly, especially when the very survival of entire ecosystems is at stake. This proposed rigor is not nit-picking, but simply the minimal requirement for conducting approximate analyses of the consequences of disturbances on complex systems. The Rapid Assessment Protocols (RAP) conveniently adopted in many cases, were not created with the objectives of environmental studies in areas considered for development, and therefore should not be accepted as a single source of data.

In conclusion, the philosophical, theoretical and practical foundations of Brazilian environmental policy should be broadly reviewed, separating it from economic interests and establishing scientifically solid and valid methods. This would allow these policies to achieve their legitimate objective to preserve representative samples of Brazilian biodiversity. In their current state, these policies and related actions rank far below the minimum required to guarantee survival, in the medium and long terms, of what remains of Brazil's magnificent original diversity.

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ABSTRACT – Biological concepts basic to environmental policies are discussed, such as biodiversity (based on the notion of variety), conservation, ecosystem resilience, fragility and disturbance, accumulative effects and the cautionary principle. We analyze two main tools for conservation decisions, i.e., priority areas for conservation of biodiversity and lists of threatened species (which have been, in the practice of licensing, the only criterion taken into account). We also detail minimum criteria in protocols for environmental studies: taxonomic (all groups should be sampled), spatial (including the project area and those affected by it) and temporal (at least three annual cycles) coverage, whose suffciency should be tested through accumulation curves. Legislation concerning caves is used as an example.

KEYWORDS: Biodiversity, Conservation, Environmental Policies, Caves.

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Received on 2.26.2010 and accepted on 3.5.2010.

Translated by Jeffrey Hoff. The original in Portuguese is available at http://www.scielo.br/scielo.php?script=sci_issuetoc&pid=0103-401420100001&lng=pt&nrm=iso.