Ecological modelling in public policies of urban areas of the Atlantic Forest

A modelagem ecológica nas políticas públicas das áreas urbanas da Mata Atlântica

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ABSTRACT

In this paper possible applications of ecological modelling on the municipal level and beyond are investigated. The use of models and scenarios can help in the valuation of ecosystem services, that is, the benefits humans derive from nature for their well-being. Based on those scenarios, public policies can take better informed decisions on how to improve the provision of those services e.g. through conservation areas. To this end the concepts of ecosystem services, modelling and scenarios are explored to contextualize them in the urban setting of the setting of the Atlantic Rainforest.
In this paper, it is argued that the lack of applied ecological modelling in the Atlantic Forest biome poses a threat to the provision of ecosystem services for the populations in Brazil's most populous urban areas that are situated in this biome.

Keywords: ecological modelling, public policies, ecosystem services, urban planning, scenarios.

RESUMO

Neste trabalho são investigadas as possíveis aplicações da modelagem ecológica no nível municipal e além dele. O uso de modelos e cenários pode ajudar na valoração de serviços ecossistêmicos, ou seja, dos benefícios provenientes da natureza para o bem-estar humano. A base destes cenários politicas públicas podem tomar decisões melhor informadas sobre como aprimorar a provisão destes serviços por exemplo por meio de áreas de conservação. Para este fim são explorados os conceitos de serviço ecossistêmico, modelagem e cenário que depois são contextualizados no âmbito urbano do bioma Mata Atlântica no Brasil.
Esta pesquisa discorre sobre o risco que a falta de modelagem ecológica aplicada no bioma Mata Atlântica implica na provisão de serviços ecossistêmicos para a população nas áreas urbanas mais povoadas do Brasil que são inseridos nesse bioma.

Palavras Chave: ecological modelling, public policies, ecosystem services, plano diretor, cenários.

INTRODUCTION

The global rate of urbanization and the rapid change of land use is unprecedented in human history, while at the same time, loss of biodiversity as well as the demand for goods and services from nature, especially in urban areas, is on the rise (MCKINNEY, 2002; PUPPIM et al., 2014). According to Guo, Zhang and Li (2010) globally economic growth has made humans more dependent on ecosystem services and biodiversity, which is prevalent especially in countries with biodiversity hotspots, such as Brazil.

The valuation of Ecosystem Services (ES) can provide strong arguments for conservation in various disciplines, that add to ethical and scientific findings (FISHER et al., 2008). Gómez-Baggethun et al. (2009) hold that the concept of Ecosystem Services is already firmly establishment on the global policy agenda. However, there are many scholars who point to the existing lack of actual local application of the concept in policy making (ELMQVIST, 2008; DAILY et al., 2009; PUPPIM et al., 2014; FERRIER et al., 2016).

In Brazil, a country with several of the world's biodiversity hotspots, there is little scientific study that makes the complex interplay between human and ecological systems easily understandable for decision makers. The Atlantic Forest is the most urbanized biome in the country, and urbanization rates continue to grow (OJIMA; MARTINE, 2012). Heavy urbanization can have particularly negative impacts on ecosystems and ecosystem services in peri-urban areas. According to McKinney's (2008) review on 105 studies on the effects of urbanization on species-richness of mammals, amphibians, invertebrates, reptiles and plants, extreme urbanizations (found in urban core areas) almost always reduces species-richness. Also the Atlantic Forest is suffering from severe deforestation rates. Currently it consist of small isolated patches and its capability to support species is decreasing by degradation of this biome (RIBEIRO et al., 2009).

Studies that apply modelling were identified, but a great discrepancy in terms of the actual considerations of ES in public policies in the Atlantic Forest biome was found, especially on the sub-national and local scale. Ecological modelling can support effective policy making by providing plausible future projection on establishing environmental policy options in the Atlantic Forest for management of ecosystems and ecosystem services (MOKANY et al., 2016).

For this reason it was chosen to point out existing opportunities for the use of scientific, and here especially ecological modelling techniques to inform local policy making. Since municipalities are the smallest territorial unit in Brazil they are therefore important as the unit of analysis for the local scale. The legally established Master Plan for Brazilian municipalities is the most important instrument for urban planning (BRASIL, 1988) and therefore modelling on the local scale can be crucial for effective management of ecosystems and ecosystem services that urban areas are dependent upon. It is crucial to carry out those studies in a comprehensive framework that makes them understandable to decision makers.

This paper aims to cover the basic concepts of Ecosystem Services, modelling and scenarios. It explores urbanization process as drivers for change and contextualizes them in the urban setting context Brazilian Atlantic Rainforest and opportunities and limitations of a urban planning instrument - the Master Plan. It is argued that the lack of applied ecological modelling in this extremely pressured biome poses a threat to the provision of ecosystem services for its populations.

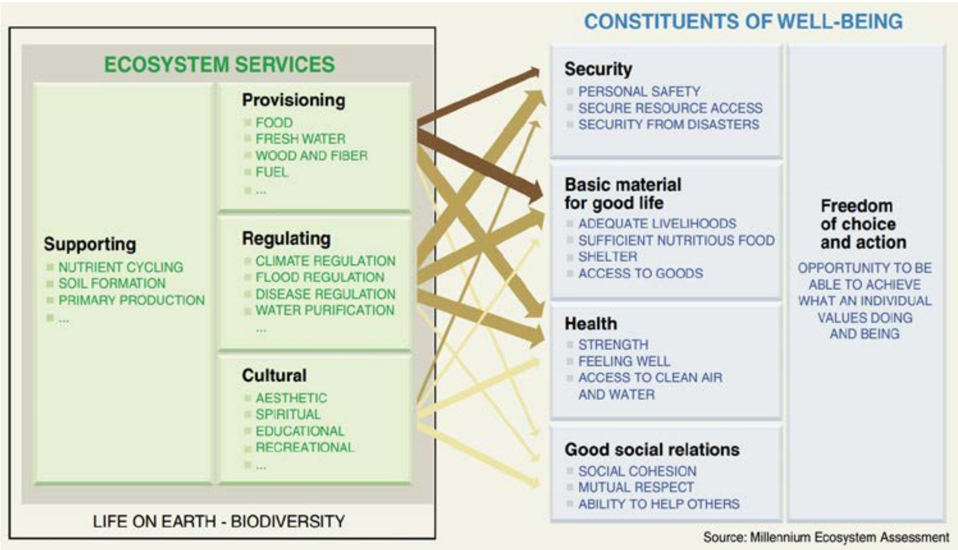
The research accompanies the IPBES Assessment of the Americas, within the Studio Cities and Biodiversity (UTFPR-Curitiba). The long-term objective of the project is to explore research on socio-environmental interactions, especially on the Atlantic Forest, considering one of the global hotspots, that can support decision making and public policy planning for conservation in urban and peri-urban areas (PUPPIM et al., 2014).

SOCIO-ENVIRONMENTAL RELATIONS: THE CONCEPT OF ECOSYSTEM SERVICES

To better understand the concept of human interactions with the environment, we work with the concept of ecosystem services. An exploration of the historical trajectory of ecosystem services in the literature helps to better understand the concept. The definitions and understandings of the concept are manifold, so it shall be acknowledged here, that the following categorization of ES is not absolute. As Ferrier et al. (2016) point out, biodiversity and ecosystem services is the concept used today in Western science, but similar concepts exist worldwide in indigenous and local knowledge systems with differing denominations.

The Millennium Ecosystem Assessment (MA) defines ecosystem services broadly as "the benefits humans derive from nature" (MA, 2005). We refer here to this most commonly used scientific categorization into 1) Provisioning, 2) Regulating, 3) Cultural and 4) Supporting Services as depicted in on the left in Figure 1.

Figure 1: Definition of ecosystem services and the connected constituents of well-being in the Millenium Ecosystem Assessment (2005)



The understanding of ES is based on the notion that ecosystems, that function by themselves, can provide certain benefits to human well-being. Supporting services like the nutrient cycle or soil formation are those functions "that are necessary for the production of all other ecosystem services" (MA, 2005). Provisioning and regulating services are the most easily studied ones, as they produce often very tangible and easily measurable benefits. Cultural services are a category that has long-term effects on humans, so their benefits are more difficult to measure. However, the use of those services is increasing globally, so human dependence grows along (MA, 2005). These services contribute to different extents to the constituents of human well-being in free societies. The services have an effect on aspects of security, material well-being, health and social relations.

It is for the complexity in those relations, that important development decisions need to be taken on the basis of a solid understanding of these relations, when planning processes involve

PUTTING A VALUE ON ECOSYSTEM SERVICES

With the publication of Garrett Hardin's "The tragedy of the commons" (1968), the 1970s can be marked as the starting point for the modern academic discussion on utilitarian definitions of the benefits of ecosystems for humans. In the 1990s this debate managed to attract a mainstream debate on the benefits of conservation and lay the basis for the current debate on ES as an intrinsically anthropocentric and utilitarian concept (GÓMEZ-BAGGETHUN et al., 2009).

Based on Ehrlich's work (1983) on the "societal value of nature's functions" and the work of Odum and Odum (1972) the conceptualization of ecosystem functions diffused from a strictly ecological concept to being used and studied by other sciences (EHRLICH, ANNETT and EHRLICH, 1981; GÓMEZ-BAGGETHUN et al., 2009). According to Gómez-Baggethun et al. (2009) the use of the concept of ecological, environmental, nature's or (as they are most commonly referred to today) ecosystem services, had at first mainly pedagogical purposes, to demonstrate human dependence on these interactions.

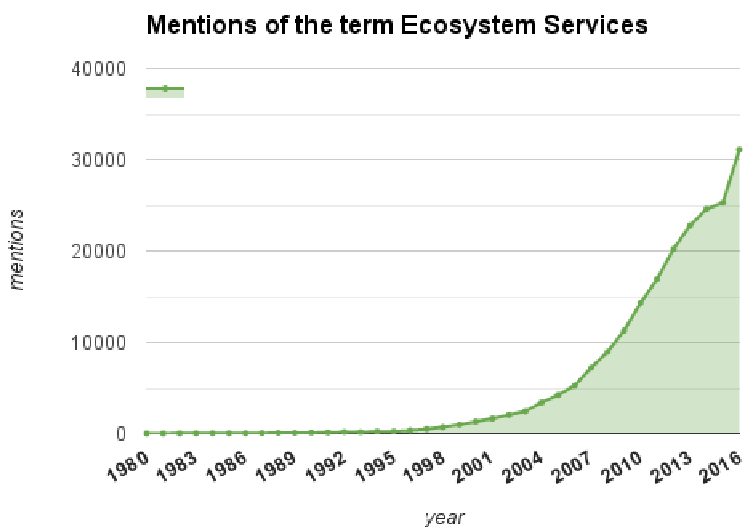
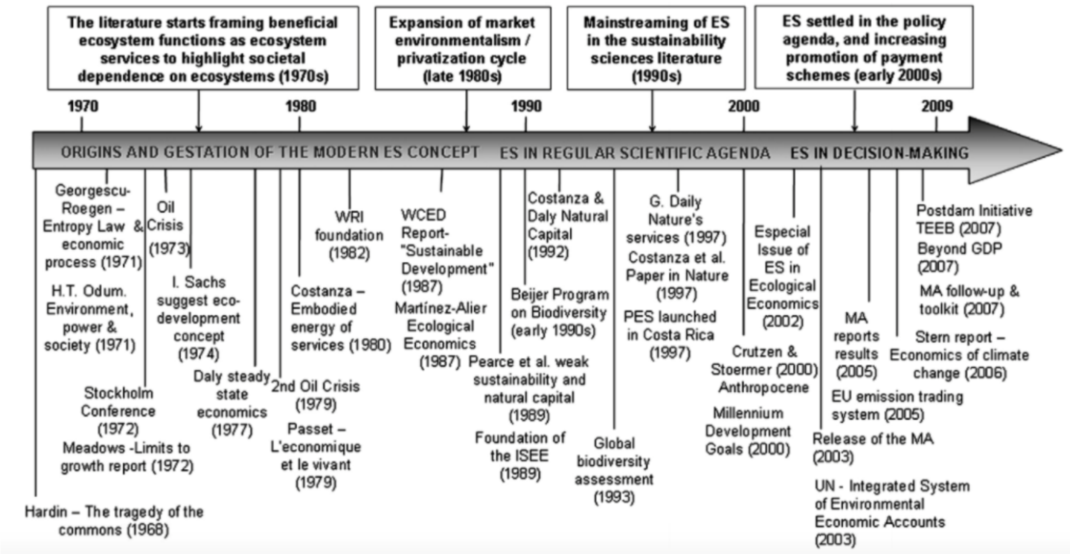


Figure 2: Number of publications that use the expression "ecosystem services" from 1980-2016, indexed in Google Scholar. (authors' visualization)

In their milestone paper published in *Nature* in 1997 Costanza et al. defined ecosystem services as "flows of materials, energy, and information from natural capital stocks which combine with manufactured and human capital services to produce human welfare." (COSTANZA et al., 1997). The impact of the monetary figures presented here was great in both science and policy. These responses led to a critical questioning of the valuation methods, but also to a sharp increase in studies replicating or further developing them (GÓMEZ-BAGGETHUN et al., 2009).

Following the adoption of the "ecosystem approach" in the UN Environmental Program and the Convention on Biological Diversity (CBD) as well as the Global Biodiversity Assessment and the subsequently starting Millennium Assessment process, the concept of ES made its way into the policy arena (GÓMEZ-BAGGETHUN et al., 2009). Following the assessment, scientific literature as well as projects working with the concept have multiplied (FISHER et al., 2008).

Figure 3 1: Stages in the modern history of ecosystem services. From Gómez-Baggethun et al., 2009.



ECOSYSTEM SERVICES ON THE INTERNATIONAL POLICY AGENDA

The Millennium Ecosystem Assessment has, since its publication in 2005, shed light on the importance of ecosystem services and their significance as a tool for informing decision-making. It assessed the "current state and trends, scenarios, policy responses" and laid the groundwork for a multi-scale assessment process (WILSON et al., 2014). Accompanying the report were special reports on topics like "biodiversity, desertification, opportunities and challenges for business and industry, wetlands and water, and health" (ibid.). The conceptual framework of the MA has been adapted to suit the needs of a number of sub-global assessments. Among the initiatives that are based on the conceptual framework is the TEEB project (The Economics of Ecosystems and Biodiversity) that today informs not only public policy, but also business decisions concerning ecosystem services (WILSON et al., 2014).

Following the findings and decisions that followed the MA, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012. IPBES's mission is to "strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development" (IPBES, 2016).

With the creation of the IPBES an important step has been made for tackling systematization and standardization of studies on ecosystem services (ES) (BROOKS, LAMOREUX & SOBERÓN, 2014; BORIE; PESCHE, 2016). IPBES hereby is trying to involve contributions not only of Western sciences, but as well those of local and indigenous knowledge that can give important support to political decisions on the subnational level (BORIE; PESCHE, 2016).

To understand the importance an ecosystem service has in a given context, there are several techniques and methods that help to codify those values and make scenarios for the policy process. The use of models and scenarios will be explored critically in the following chapter.

MODELS AND SCENARIOS IN POLICY MAKING

Models and scenarios in the IPBES process are used to contribute to policy and decision making by assessments, formal decision-support tools and informal processes (Figure 3) (FERRIÉR *et al.,* 2016). Scenarios enable considering the outcomes of different policy options, that models can transform into hypothetical consequences for nature, nature's benefits to people and quality of life (FERRIÉR *et al.,* 2016).

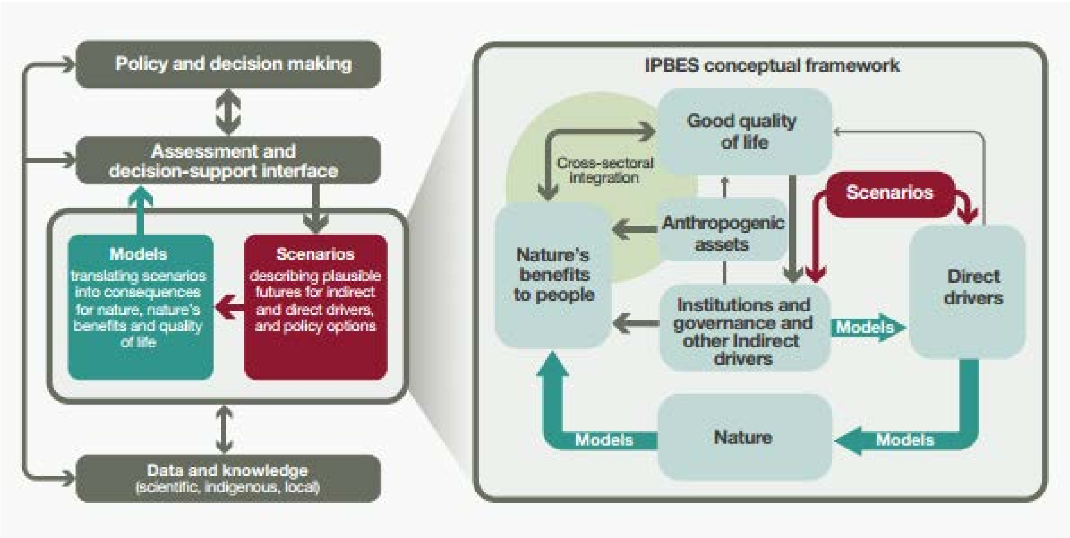
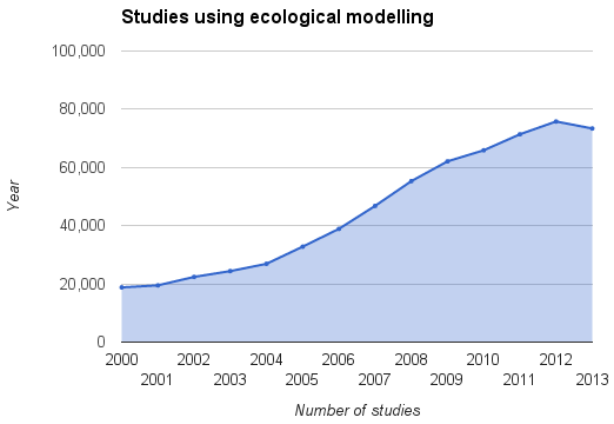


Figure 3: The IPBES conceptual framework. (Ferrier et al., 2016)

Models are defined here as "qualitative or quantitative descriptions of key components of a system and of relationships between those components" (FERRIÉR *et al.,* 2016). The importance of ecological modelling in research and policy making has been recognized in recent years' research (Figure 4), which has caused an immense increase in and a wide variety of modelling approaches (EVANS, 2012). Modelling ecosystem services can be used to provide information of possible events to ecosystems and human society pre-hand with minimal data (ANTLE & VALDIVIA, 2006; MOKANY *et al.,* 2016). It can be used also to study the optimal use, conservation and management of ecosystems (MOKANY *et al.,* 2016).

Figure 4: Studies using the term "ecological modelling" from 2000-2013, indexed in Google Scholar. (authors' visualization)



Models provide projections of the possible causal patterns and future estimates of current patterns considering recent trends of the effects of certain factors, such as forestry and agriculture, to ecosystems and ecosystem services, such as fish stock (WIEGAND *et al.,* 2003). Models are powerful tools to combine existing empirical data with fundamental theory to extend the understanding of an ecosystem (BRECKLING *et al.* 2011). Integrated models can highlight priorities for collecting new empirical data, identify gaps in existing theories of how ecosystem work and help develop new concepts for how species and ecosystem functions interact (MOKANY *et al.* 2016). However, available methods and tools need to be matched carefully to the specific assessments and decision-support activity, taking into account the uncertainties and unpredictability of model-based projections (FERRIÉR *et al.,* 2016). Modelling consists of scenarios, direct and indirect drivers of change in nature, indicators of change, modelling tools and variables concerning a specific issue or phenomenon in an area.

Scenarios are "representations of possible futures for one or more components of a system, often for drivers of change in nature and nature's benefits, including alternative policy or management options" (FERRIÉR *et al.,* 2016). Scenarios are hypothesized situations, that enable researching a process or situation without actual data across the whole study subject. For example, data from forest fires in a few areas can be used to construct a model and scenarios, that can predict possible outcomes of forest fires elsewhere without actually gathering data from all areas where forest fire could occur. These projections have uncertainties and they do not take into account unique features of each area, but they provide data that could not be otherwise gathered (FERRIÉR et al., 2016). Therefore, scenarios are usually not absolute or completely realistic depiction of a certain cascade of events or a process, but more of a synthesis of likely events on any area with certain variables and factors present.

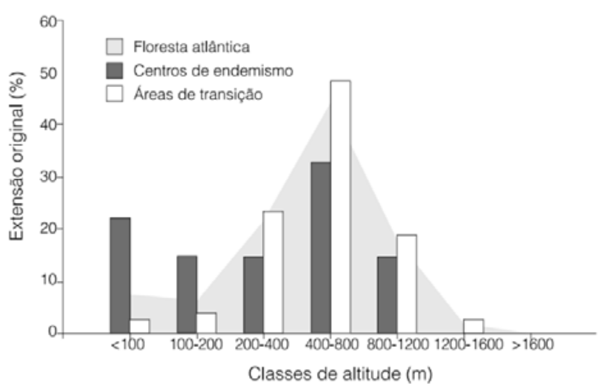
Synthesis of results from various models and scenarios from a wide variety of studies with different scales, drivers, processes and indicators can be very unreliable and vague. Modelling poses issues that are related to reliability and accuracy of the scenarios of reality, as "uncertainty associated with models is often poorly evaluated" in the policy process (FÉRRIER et al., 2016). In policy making the decisions are usually made with fast pace to be applied over years on a variety of different ecosystems providing different ecosystem services. Therefore models, even though providing the closest possible assessment of effects of a certain policy in the future, may have errors or be missing variables that change the outcome entirely from the result in reality. The spatial and temporal data of changes in biodiversity, ecosystems and ecosystem services is uneven, so there are large gaps in data availability, which creates barriers to construct and test scenarios and models (FÉRRIER *et al.* 2016). Effective application and uptake of models and scenarios therefore requires involving policymakers, practitioners and other relevant stakeholders, including local and indigenous knowledge throughout the process, where appropriate, to level out these errors (FÉRRIER *et al.* 2016).

MODELLING AND SCENARIO BUILDING WITH ECOSYSTEMS AND THEIR BENEFITS

The application of models and scenarios also involves several issues of scale. Studies operating with a large scale (such as a 100 km x 100 km resolution) often have robust data which might not be applicable in policy making on a smaller region or when results are summarized for other spatial units (Radeloff *et al.,* 2011). Information value of fine scale models on the other hand may be restricted to a very specific area and situation, in which case applying them for policy over large areas may be unreliable (ibid.). The Atlantic Forest biome covers a large area with a wide variety of different ecosystems, some having a more crucial role in the web of interactions than others. For example, small areas of wetlands may be much more important for maintaining biodiversity than large areas of dry grassland.

Therefore, identifying and mapping key ecosystems in areas under pressure of urbanization is particularly important in order to prevent sudden degradation of biodiversity. For example, in Atlantic Forest areas, mangroves and sandbanks (*restinga*) are small ecosystems under heavy pressure, but they provide unique habitat for species specialized to them. In addition, identifying key species and their ecology in an ecosystem is important, because losing these species may result in significant loss of other species that depend on them. Also the location of the biome can affect the pressure and effects of anthropogenic and natural drivers on it. For example, in the Atlantic Rainforest, certain ecosystems at higher altitude are better preserved, because they are under less pressure from urbanization or agriculture, as they are not fit for those uses (Fig 5) (TABARELLI *et al.,* 2012). Therefore, local scale modelling is often the most reliable and it is necessary for effective support for local policy making on the municipal or metropolitan scale.

Figure 5. Distribution of original vegetation cover [light grey] and biogeographical regions (endemic centers [dark grey] and transition areas [white]) of the Atlantic Forest by altitude. From Tabarelli et al., 2012.

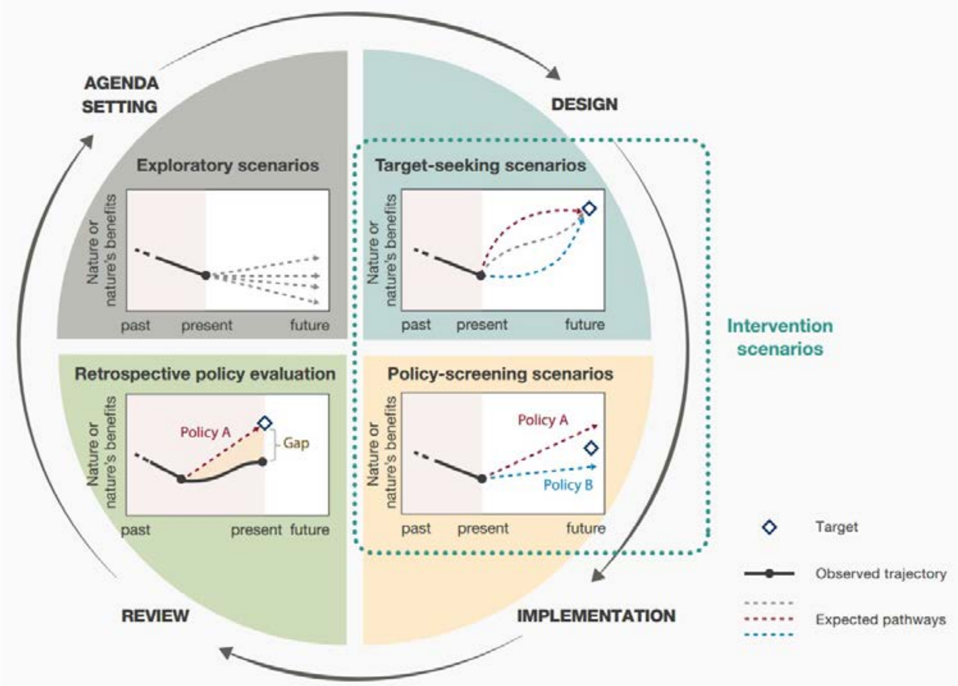


Modelling has an important role in research and optimization of landscape management, but modelling can also be used to prepare for example to extreme natural events beforehand. This is strategic application of ecological models, which provides assessments of possible outcomes of policy or management interventions and helps finding the most effective policies in order to reach a goal of maintaining certain ecosystem services, biodiversity or a structure in a certain area (CBD 2010). In a study by Arkema et al. (2013) it was modelled how intact reefs and coastal vegetation can reduce damages on people and property caused by extreme weather, degraded coastal ecosystems and sea-level rise around the coastline of the continental USA. This was modelled by a using coastal vulnerability model in the InVEST-modelling tool. Five sea-level-rise scenarios were constructed: 1) Current, observed levels of sea-level rise, 2) Trend, projection of observed sea-level rise until 2100, 3) B1, based on Special Report on Emissions Scenarios, 4) A1, based on Special Report on Emissions Scenarios, and 5) High, incorporates glacier and ice-sheet contributions. In addition, two habitat scenarios were constructed: 1) With habitat, including nine habitats in the hazard index and 2) without habitat, assuming those habitats do not provide protection. The study was performed with 1 km^2 resolution scale, which means that relative exposure in 2100 and today with or without habitat was calculated for 1 km^2 areas of US coastline. The indicators used were human vulnerability to hazards and property losses. Variables included were number of people, income, age groups and total values of residential properties exposed to hazards. The results showed that if existing coastal habitats remain fully intact, damages are halved.

Scenario building should play an important part in informing the policy process, as is suggest

ed by IPBES (FÉRRIER *et al.* 2016). The top left figure 6 shows how an issue, in our case the provision of a certain ES can be put on a policy agenda, by exploring possible scenarios with open outcomes. After the issue is placed on the agenda, a target should be defined and scenarios should be explored on how this target can be reached (figure 6 top right). In this phase and in the implementation of measures, we argue, scenarios can enrich the planning process in municipalities, by offering more effective evaluation of alternative policy options, and identifying ways to reach the defined targets (bottom right, figure 6). After implementation, models should be used to review the effects of the policy (figure 6, bottom left). The next chapter will give insight on how this could work in Brazilian municipalities.

Figure 6:The roles played by different types of scenarios corresponding to the major phases of the policy cycle. From Ferriér et al., 2016.



BRAZILIAN MUNICIPAL URBAN PLANNING

As pointed out by Andrade (apud REZENDE & ULTRAMARI, 2007) planning is one of the classical functions of the scientific administration. The Master Plan (*Plano Diretor*), as established by the Federal Law nº 10.257 (BRASIL, 2001) - also known as the Estatuto da Cidade (*City Statute*) - is the basic instrument for urban development and expansion politics and the most important planning tool in municipalities. According to Braga (2001) the Master Plan is also the most important instrument for urban environmental management, since there is no tradition for environmental policies on the municipal level.

The Master Plan is mandatory for municipalities within at least one of the following categories: a) more than 20.000 inhabitants; b) integrated in metropolitan regions; c) public authorities intent to apply instruments to induce a certain land use; d) part of a special touristic interest area; e) inside the influence area of some undertaking or activity of significant regional or national impact; f) included in the national base of municipalities susceptible to landslides, flash floods or similar geological and hydrological processes (BRASIL, 2001).

In some cases the Master Plan has become mandatory even for those municipalities that are not framed in those categories[5] (REZENDE & ULTRAMARI, 2007). It is also regulates that the Master Plan must be reviewed at least every ten years (BRASIL, 2001). Even if these municipalities are obliged to have a Master Plan, there can be a lack of technical capacity in small municipalities for planning and data collection (REZENDE & ULTRAMARI, 2007).

[5] As an example in Paraná State all financing arrangements to benefit the municipalities request a Master Plan. (REZENDE & ULTRAMARI, 2007)

The Master Plan starts off acknowledging the state of the city, to register what is existent, and must address urban, social, economical and environmental aspects. It must have few and clear principals and show a strategy for immediate interventions (Estatuto da Cidade: guia para implementação pelos municípios e cidadãos). It is also expected to have at least instructions and objetives for a environmental zoning (TORRES, 2007).

One important aspect is that it applies for the whole territory of the municipality. Another aspect is that it defines the urban area and establishes different goals for urban an rural areas. For legal reasons the distinction between rural and urban is important, but the criterias are not standardized for all municipalities (SPAROVEK, LEONELLI & BARRETTO, 2004). However most of environmental issues demand the use of scales that go beyond the administrative boundaries (ex. water management and biological corridors) and most of the important ecosystem services on which cities depend are provided by rural areas (SANTORO, COSTA & PINHEIRO, 2004). The Estatuto da Cidade actually emphasize that urban and rural must be seen as integrated and complementary as they are interdependent and impact each other (BRASIL, 2001).

WHY THERE IS A NEED FOR COMPREHENSIVE MODELLING STUDIES IN THE ATLANTIC FOREST BIOME

According to Elmqvist (2008) there is a great lack of research that can serve as a base for decision making in urban planning processes, even though studies of ecological patterns and processes in urban areas has grown substantially, there continue to be significant research gaps than limit the general understanding of the effects of urbanization processes. The majority of the studies that have been published to date have been of short duration, and have been carried out in cities in the global north and do not show experimental approaches (ELMQVIST, 2008).

The degree of importance of the generation of those ES is often bigger than the planning scale, as seen e.g. in the reduction of atmospheric pollutants or provision of clean drinking water. In most cases these services tend to be neglected by urban planners and decision makers, even though the potential for generating and improving these ecosystem services can be substantial (ELMQVIST, 2008; BERGHÖFER et al., 2016).

So far, many assessment and valuation studies have not been able to meet the goals Berghöfer et al. (2016) point out: 1) the studies do not provide neutral and objective information, 2) studies always favor conservation, while they can also give support unsustainable practices, 3) the studies are not noticed by decision makers or do not get the necessary repercussions, or 4) they are unnecessary, inappropriate or even counter productive.

THE IMPORTANCE OF THE BIOME MATA ATLÂNTICA

The neotropical Atlantic Forest, *Mata Atlântica*, is one of the largest rainforests in America's coastal zone of around 150 million hectares and covers highly heterogeneous ecosystems extending to tropical and subtropical regions (Figure 7) (RIBEIRO et al., 2009). The Atlantic Forest has one the highest degrees of species richness and rates of endemism on the planet, its flora and fauna potentially including 1-8% of the world's total species (SILVA et al., 2003). Over 500 endemic species of various taxa living in the Atlantic Forest have been identified as highly vulnerable to go extinct (GALINDO-LEAL and CÂMARA, 2003). However, the Atlantic Forest is highly fragmented, most of the existing patches are <100 há in size and have long distances between them (RANTA et al., 1998). Recently, the biome has been assessed to be potentially on the verge of ecological collapse by several researchers (ALARCON et al., 2015).

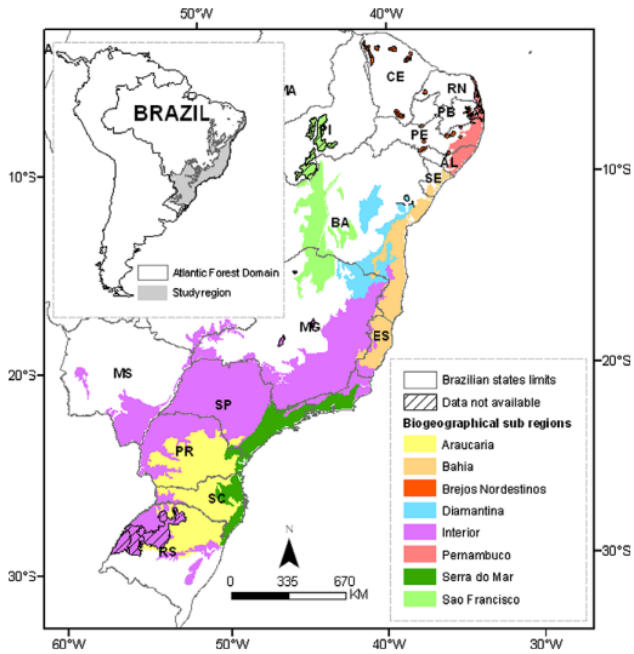


Figure 7. Atlantic forest area and biogeographical regions. From Ribeiro *et al.* 2009.

The Atlantic Forest is assessed as one the most threatened tropical biomes (TEIXEIRA et al., 2009). Almost 60% of the Brazilian population live in the Atlantic Forest biome (IBGE 2010) and mostly in coastal regions as seen in Figure 8. Furthermore, 38 of the 50 biggest Brazilian cities and 8 of the 10 biggest metropolitan regions are in the biome (IBGE, 2016). The region is under pressures from urbanization and urban sprawl and the expansion of Eucalyptus plantations have been related to deforestation in the area (DEAN 1997). Forest is in an extremely degraded state, according to a quantification study by Ribeiro et al. *(*2016) "more than 80% of the fragments are <50 ha, almost half the remaining forest is <100 m from its edges, the average distance between fragments is large (1440 m), and nature reserves protect only 9% of the remaining" and 1% of the original forest; the authors recommend urgent conservation and restoration actions with careful planning and clear targets.

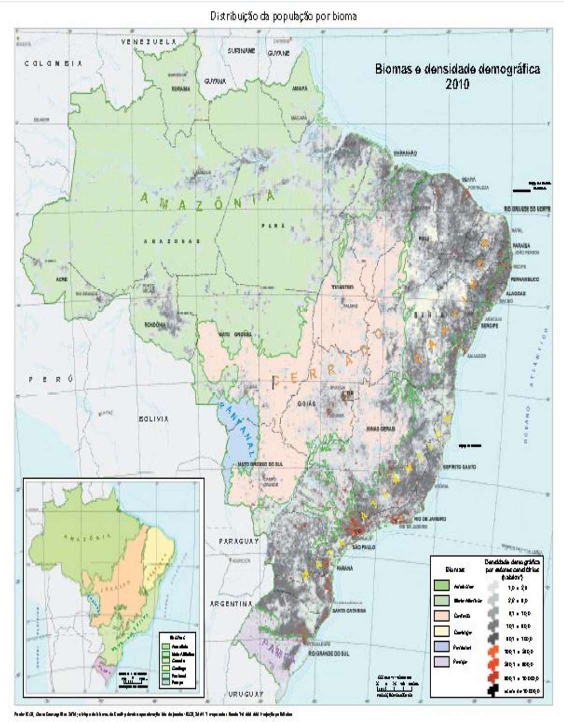


Figure 8: Population x biomes. From IBGE, 2013.

This is especially important in areas, that are under strong pressure of anthropogenic drivers of change, such as agriculture, roads, land use change and urbanization (FREITAS, HAWBAKER & METZGER, 2010). Especially conservation of areas that have remained in their natural state, is of very high importance because of their vulnerability to change from anthropogenic activities. Deforestation in the Atlantic Forest occurs mostly in remote rural areas with more cattle, less occupation of people, lower human development index and more wood use (NEVES, 2006).

According to our literature research, despite the high species richness and vulnerability of the Atlantic Forest, rainforest loss and recovery have not been as extensively studied, as they have e.g. in the Brazilian Amazon. For a heterogeneous and highly diverse ecosystem such as the Atlantic Forest, biodiversity inventories are complex, time-consuming and expensive to perform (GARDNER et al., 2008). This, combined with unstandardized inventory methods have lead to uneven data with large gaps (RIBEIRO et al., 2009). Local studies on specific subjects are available for several areas, but they support only local conservation planning and applying their implications on larger areas is unreliable and difficult (RIBEIRO et al., 2009).

APPLYING MODELLING IN URBAN PLANNING IN BRAZILIAN MUNICIPALITIES

Models can provide information on how landscape management practices and political decisions can maintain biodiversity and ecosystems in the Atlantic Forest. Models of landscape dynamics have been used to study the drivers and patterns of deforestation in tropical forests (LAMBIN, GEIST & LEPERS, 2003). It can be used to make cost-effective, realistic decisions on anthropogenic activities and conservation that meet the challenges and conflicts caused by e.g. increasing land use change and population growth in the Atlantic Forest's urban areas. For example, in a study by ZANELLA et al. (2012) a model was constructed to explore the effects of landscape management strategy scenarios, incorporation of secondary forests and reforested permanent protected areas, based on the indicators forest cover, connectivity, number of forest patches and a large patch index. The modelling tool used was FRAGSTAT Spatial Analysis. The results were that natural vegetation in the study area, Carmo de Minas, was highly fragmented and that this compromises the conservation of biodiversity. Small patches of remnant vegetation were found to be important for reducing the isolation between vegetation units. Therefore, the authors could conclude a recommendation that maintenance of secondary forest areas and their restoration can improve the integrity of that landscape.

To apply modelling effectively to the process of developing the Master Plans in Brazilian cities, models can be used to study local, specific political options on a certain area. In Atlantic Forest conservation, current changes in forest legislation have given rise to a debate on policy impacts of land-use and consequences for ecosystem services provision and biodiversity conservation (ALARCON et al., 2015). In a study by Manuschevich and Beier (2016), a Dyna-CLUE modelling framework and four complex scenarios were constructed (basic, negotiated, industry forestry coalition and forest conservation coalition) aiming to understand the possible impacts of the Native Forest Law's (NFL) on achieving the goals to protect, recover and improve the native forests in Araucania, Chile. Drivers were the policies of the NFL and policy configurations by the forest industry. Indicators were land use restrictions and forest loss. They found that different policy configurations of the NFL only resulted in minor differences in native forest conservation. The study also highlighted the importance of considering both political dynamics and economic processes in modelling the outcomes of land use policy. The results of the study pointed out that measures of the NFL were inadequate to accomplish the stated objectives of the legislation entirely. Also, they found that timber farms are actually a very stable land use in comparison to land use change to agriculture, pasture and open shrubs, native forest and dense shrubs or urban/industrial areas.

2Based on the searches in scientific databases, we identified 118,491 studies in total that make use of the term “Mata Atlântica” and “Atlantic Forest”, 170,884 for term “Cerrado” in English and 607,351 in Portuguese. For the term “Amazon” the total result was 1,240,976 and for the term “Amazônia” it was 378,396.

CONCLUSIONS

Scientific studies that make use of ES modelling and valuation techniques in local environmental contexts are important for informing the creation and execution of public policies (COSTANZA et al., 1997). For the Atlantic Forest there are very few ES valuation and modelling studies, compared to Brazil's other two big biomes, the Amazon and the Cerrado.

Further development of local research is needed, that is accessible and relevant to decision makers as it could lead to better informed decision-making about the importance of healthy ecosystems for human well-being in cities (in this case in the Atlantic Forest biome). The internalization of this topic on local agendas will depend on the growth of scientific production that consider ES in urban environments in the different biomes.

Modelling studies can be used to support of political process, if applied carefully and uncertainties taken into consideration. Especially conservation planning in large, diverse and scattered biomes such as the Atlantic Forest with large difficulties to gain enough field data, modelling may be most powerful tool to assess effective actions on preserving vital ecosystem services that human societies in Brazil depend on (RIBEIRO et al., 2009). Modelling studies however, are necessary to translate into policy making, so it is important for studies to find equilibrium between necessary scientific rigour while maintaining the text understandable and message clear for decision makers (FISHER 2008). However, development of scientific research requires independence, objectivity and critical debate on the current issues in the scientific community, so scientific publications need to be summarized, evaluated and translated for the use of policy processes. This is why IPBES, an international platform that combines modelling and scenario building from ecological studies around the world, is providing information for straight use of the decision makers.

Applying the potential of modelling studies is likely to have a crucial role in future conservation planning on large, highly valuable areas such as Atlantic Forest, from negative impacts of human activities. At the same time, applying models can prepare human societies for potential ecological collapses and massive losses of ecosystem services if they are used carefully in conservation agenda setting, planning, implementation and review phases of policy cycle. Scientific studies that make use of ES modelling and valuation techniques in local environmental contexts are important for informing the creation and execution of public policies (COSTANZA et al., 1997). For the Atlantic Forest there are very few ES valuation and modelling studies, compared to Brazil's other two big biomes, the Amazon and the Cerrado.

This study identified some opportunities in applying modelling studies to support the Master Plans, such as: a) the Master Plan concept as an instrument for integrated management and the need for diverse scientific information; b) the Master Plan's local focus makes it feasible to work with local environmental specificities. Also, some limitations were pointed out, as: a) the focus on urban areas and restriction to municipal boundaries; b) the absence of Master Plans or lack of quality of the Master Plans specially in small municipalities.

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