Biota Neotropica 22(spe): e20211373, 2022
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)

Thematic Review

Science and environmental policy establishment: the case of the Forest Act in the State of São Paulo, Brazil

Kaline de Mello[1], Alice Brites[2], Clarice Borges-Matos[1], Paulo André Tavares[2], Jean Paul Metzger[1], Ricardo Ribeiro Rodrigues[3], Zenilda Ledo dos Santos[2], Carlos Alfredo Joly[4] & Gerd Sparovek[2]*

[1]Universidade de São Paulo, Instituto de Biociências, Departamento de Ecologia, Rua do Matão, 321, Trav. 14, 05508-090, São Paulo, SP, Brasil.
[2]Universidade de São Paulo, Escola Superior de Agricultura Luiz de Queiroz, Departamento de Ciências do Solo, Av. Padua Dias, 11, 13418-900, Piracicaba, SP, Brasil.
[3]Universidade de São Paulo, Escola Superior de Agricultura Luiz de Queiroz, Departamento de Ciências Biológicas, Av. Padua Dias, 11, 13418-260, Piracicaba, SP, Brasil.
[4]Universidade Estadual de Campinas, Instituto de Biologia, Departamento de Biologia Vegetal, Campinas, SP, Brasil.
**Corresponding author: kaline.mello@usp.br*

MELLO, K., BRITES, A., BORGES-MATOS, C., TAVARES, P.A., METZGER, J.P., RODRIGUES, R.R., SANTOS, Z.L., JOLY, C.A., SPAROVEK, G. **Science and environmental policy establishment: the case of the Forest Act in the State of São Paulo, Brazil**. Biota Neotropica 22(spe): e20221373. https://doi.org/10.1590/1676-0611-BN-2022-1373

Abstract: Natural ecosystems are under severe threat worldwide and environmental policies are essential to minimize present and future impacts on biodiversity, ecosystem services and climate change. The New Forest Act in Brazil is the main policy to protect native vegetation in private lands, which comprise 54% of the remaining Brazilian native vegetation. However, conflicts between environmental and agricultural concerns in its implementation demand for balanced solutions based on scientific evidence. To face the challenge of applying science in environmental policy establishment, we developed a scientific project funded by the São Paulo State Research Foundation (FAPESP) to support the implementation of the New Forest Act in São Paulo State, as part of the Biota/FAPESP Program. The project was conducted differently from a regular research project: the broad objective was to provide scientific support to the State's implementation of the New Forest Act, based on a participatory interaction among stakeholders to build specific objectives, methods, and discussion of results, within an interdisciplinary and intersectoral research team. Here, we present the lessons learned during and after the four years of the research project development to evaluate how scientific knowledge can be produced and adopted in the implementation of a specific environmental policy. We present the main outcomes and the challenges faced in trying to include scientific data in the decision-making process. We also present current and future challenges in the New Forest Act implementation that could be solved with scientific evidence. The lessons learned showed that even designing the project in order to meet the needs to support the implementation of the environmental policy, avoiding difficulties normally pointed out by similar projects, there was a great difficulty for scientific contributions to be adopted in the decision-making process. Most of the scientific information and advice, even after discussion and common understanding among a diverse stakeholder group, were ignored or over-ruled in the final decision-making phases.
Keywords: *Forest Code; policy design; forest conservation; forest restoration; scientific evidence; participatory method.*

Ciência e implementação de política ambiental: o caso do Código Florestal no Estado de São Paulo, Brasil

Resumo: Os ecossistemas naturais estão sob grave ameaça em todo o mundo e as políticas ambientais são essenciais para minimizar os impactos presentes e futuros na biodiversidade, nos serviços ecossistêmicos e nas mudanças climáticas. O Novo Código Florestal no Brasil é a principal política de proteção da vegetação nativa em terras privadas, que compreende 54% da vegetação nativa remanescente brasileira. No entanto, os conflitos entre as preocupações ambientais e agrícolas na sua implementação exigem soluções equilibradas e baseadas em evidências científicas. Para enfrentar o desafio de aplicar a ciência no estabelecimento de políticas ambientais, desenvolvemos um projeto científico financiado pela Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) para apoiar a implementação do Novo Código Florestal no Estado de São Paulo, como parte do Programa Biota/FAPESP. O projeto foi conduzido de forma diferente de um projeto de pesquisa regular: o objetivo amplo foi fornecer suporte científico para a implementação do Novo Código Florestal pelo Estado, a partir de uma interação participativa entre as partes interessadas para construir objetivos específicos, métodos e discussão de resultados, dentro de uma equipe de pesquisa interdisciplinar e intersetorial. Aqui, apresentamos as lições aprendidas durante e após os quatro anos de desenvolvimento do projeto de pesquisa para avaliar como o conhecimento científico pode ser produzido e adotado na implementação de uma política ambiental específica. Apresentamos os principais resultados e os desafios enfrentados na tentativa de incluir dados científicos no processo decisório. Apresentamos também desafios atuais e futuros na implementação do Novo Código Florestal que podem ser resolvidos com evidências científicas. As lições aprendidas mostraram que mesmo concebendo o projeto de forma a atender as necessidades de apoio à implementação da política ambiental, evitando dificuldades normalmente apontadas por projetos semelhantes, houve uma grande dificuldade para que contribuições científicas fossem adotadas no processo decisório. A maioria das informações e conselhos científicos, mesmo após discussão e entendimento comum entre um grupo diversificado de partes interessadas, foi ignorada nas fases finais de tomada de decisão.

Palavras-chave: *Lei de Proteção da Vegetação Nativa; design de políticas; conservação florestal; restauração florestal; evidência científica; método participatório.*

Introduction

Natural ecosystems are under severe threat worldwide mostly because of land use and climate changes, causing a decline in biodiversity and ecosystem services. Studies around the world point to the urgent need for the conservation of existing natural ecosystems, sustainable use of environmental resources, and the restoration of degraded ecosystems to avoid irreversible damage to human existence itself (McNicol et al. 2018, Grantham et al. 2020, Strassburg et al. 2020, Hoang & Kanemoto 2021). The most recent report by the Intergovernmental Panel on Climate Change (IPCC 2021) shows that the world will likely reach or exceed 1.5 °C of warming in the next two decades – sooner than in previous assessments. This signals the urgency of ambitious goals in cutting greenhouse gas emissions. Land-use change is one of the main causes of climate change, thus land-use policies are necessary to minimize present and future impacts on biodiversity and ecosystem services.

This is the case of the Native Vegetation Protection Law in Brazil, Law 12.651 (Brasil 2012), known as the New Forest Act, the main Brazilian environmental policy to protect natural vegetation in private lands. This law governs approximately 54% of the remaining native vegetation in Brazil that occurs in private lands (Sparovek et al. 2015). It requires the establishment of Permanent Preservation Areas (protect environmentally fragile areas such as riparian zones and steep areas) and Legal Reserves. Legal Reserves protect the native vegetation in a fixed proportion of the rural property area (Sparovek et al. 2015). Few policies in the world establish an obligatory percentage to be conserved inside private property (GIBOP 2019), which highlights the New Forest Act as an advanced law in terms of conservation. However, the implementation of such a policy in agricultural landscapes can be especially challenging. Retaining and in some cases increasing natural vegetation cover is necessary for these landscapes to protect or recover species, ecosystems, and their associated essential ecosystem services, such as maintaining the quality of water supplies, crop pollination, and natural pest control (Boesing et al. 2017, Jenkins et al. 2010, Mello et al. 2018, Metzger et al. 2019, Saturni et al. 2016). However, the maintenance of natural vegetation reduces the area available for agriculture. There is little specific funding for the New Forest Act compliance, as payment for ecosystem services programs, so it ends up being a cost for the landowner. This leads to resistance from landowners and various stakeholders and to lobbies in Congress to postpone or change the law to reduce legal landowners' commitments. These conflicts represent a challenge for the design of effective and plausible environmental policy.

The conflicts between environmental and agricultural sectors continued even after the revision made in 2012 of the former Forest Act from 1965. Ten years after the New Forest Act publication, there is still plenty of uncertainty, especially regarding the specific requirements of Legal Reserves (Tavares et al. 2021, Mello et al. 2021a). To resolve these disputes between sectors and solve uncertainties regarding the law implementation, it is essential to find balanced solutions based on scientific evidence. Science can present paths that are interesting for both sectors (environmental and agricultural), in a win-win scenario, where both can make concessions, but also receive benefits (Brites et al. 2021). Furthermore, science presents accurate solutions, since they have been tested under standardized methods, that may be applied in legal mechanisms, minimizing uncertainties in law implementation. The current worldwide scenario of biodiversity losses and ecosystem degradation, added to the political, ideological, and socioeconomic conflicts, raises the critical need for evidence-based information to guide environmental policies implementation (Sterner et al. 2019).

However, there is a gap between science and practice (Bertuol-Garcia et al. 2018, Toomey 2016). Science frequently is not easily accessible for decision-makers and practitioners, and, on the other hand, scientists often are not aware of the information needed by these actors (Toomey 2016). Besides, not always is science welcome in policy structuring: political changes after elections, economic and ideological interests, government institutional instability, and the influence of high instances of power can dictate how far scientific evidence will be accepted in decision-making (Brites et al. 2021).

To face the challenge of applying science in environmental policy establishment, we developed a scientific project funded by the São Paulo State Research Foundation (FAPESP) to support the implementation of the New Forest Act in São Paulo State, Southeast Brazil (2016–2020), as part of the Biota/FAPESP Program. The project was conducted differently from a regular research project: it started from the broad objective of providing support to the State implementation of the New Forest Act, to move to a participatory technique to build specific objectives, methods, and discussion of results, within an interdisciplinary and intersectoral research team (Brites et al. 2021).

Here, we present the lessons learned during and after the four years of the research project execution to evaluate how scientific knowledge can be produced and adopted in the implementation of a specific environmental policy. We present the main outcomes and the challenges faced in trying to include scientific data in the decision-making process. We also present current and future challenges in the New Forest Act implementation that can be solved based on scientific evidence.

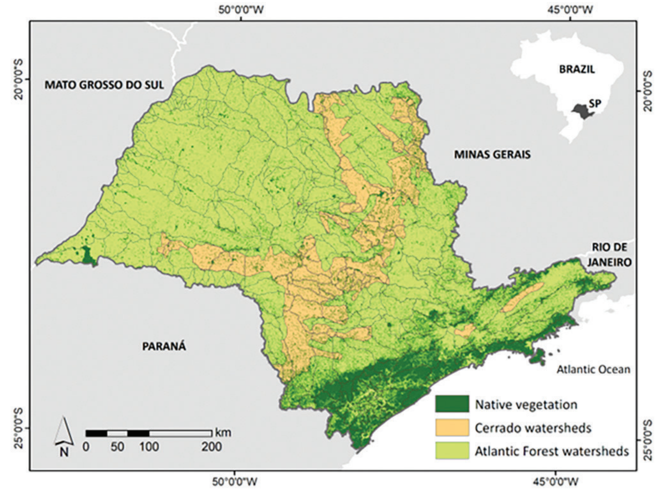

Figure 1. Native vegetation remaining and watersheds within the Cerrado and Atlantic Forest biomes in the State of São Paulo, Brazil.

Material and Methods

1. The New Forest Act

The New Forest Act (Native Vegetation Protection Law) is the main Brazilian policy to protect native vegetation in private lands (Brasil 2012). The law requires the establishment of Permanent Preservation Areas (mostly riparian vegetation) and Legal Reserves, a percentage of the rural property that must keep a native vegetation coverage. This percentage varies from 20% to 80%, depending on the biome. To comply with the law, landholders who do not meet these percentages can opt to restore or regenerate native vegetation inside their property, or to protect an existing vegetation in another land.

The law replaced the 1965's Brazilian Forest Code (Brasil 1965) and its process of revision and approval was marked by many conflicts. Although there were some public consultations, the final version of the law mainly disregards society and science claims (Brancalion et al. 2016). A major cause of disputes during this process was the amount of native vegetation to be protected or restore d in private lands (Diniz & Ferreira Filho 2015).

Currently, ten years after the law's publication, the Native Vegetation Protection Law is still not fully implemented. Some of the factors that contribute to this delay are remaining legal uncertainties about points of the law, the persistence of conflicts among sectors, and the challenge of finding technical solutions for implementing some mechanisms of the law. These factors of delay are present in all Brazilian States, and each State must implement a set of rules to guide and promote compliance with the law, the "Environmental Regularization Program" (Portuguese acronym, PRA).

2. Case study

The State of São Paulo (Figure 1) is a large and heterogeneous area, containing broad agricultural areas, but also important remnants of the Atlantic Forest and the Brazilian savannas (Cerrado) both considered as biodiversity hotspots (Mittermeier et al. 2011; Miyaki et al. 2022). The native vegetation of those biomes covers 24% and 17% respectively of their original coverage in the State (SMA 2017, IF 2020).

São Paulo State's PRA was approved at the beginning of 2015 (São Paulo 2015) and legally suspended one year later through an act of the State Public Prosecution. Overall, the suspension act claimed that São Paulo's PRA was unconstitutional because it was drawn up without public participation, and some of its articles represented significant setbacks for the national law. The PRA remained suspended for three years until its judgment in 2019, when most of the unconstitutionality claims were not accepted. Finally, in 2020 the state government published some regulations for the PRA implementation in the state, the same year that this project was finished.

3. The research project structure, team, and process

The project did not start with fixed objectives and methods. Instead, they were established during cycles of science-based dialogues (Welp et al. 2006). To establish this dialogue, we promoted open meetings between scientists and stakeholders. During these meetings, we raised the questions or the information about the New Forest Act that stakeholders needed in which the science could help. Further, during these encounters, we presented research outcomes, discussed changes in the adopted methodologies, and raised new questions (Brites et al. 2021).

The research team was composed of a multidisciplinary and multisectoral group, leading to a comprehensive way to tackle the objectives. Further, the research team formed alliances with actors from the private sector, which allowed us to obtain data that otherwise would not be available. These characteristics allowed the project to develop the most accurate spatial models and to follow the speed of need for information of decision-makers (Brites et al. 2021).

During the project, we also conducted three surveys to access stakeholders' perceptions and evaluations about the project (Brites et al. 2021).

4. Native vegetation deficit and surplus modeling

The native vegetation deficits and surplus modeling was based on information on land tenure, land use and land cover, riparian zones, municipalities and legal requirements (Tavares et al. 2019). Rural properties boundaries were extracted from a land tenure model that treated the geometries and overlaps among self-declared properties from the Rural Environmental Registry (CAR in Portuguese acronym) collected in December 2019 and other layers of private lands, public properties and non-processing areas. We used 18 different tenure bases to compose a model of land tenure at the national level in raster format, and a more detailed scale for the state level in shapefile format (Freitas et al. 2018a, Freitas et al. 2018b, Sparovek et al. 2019, Tavares et al. 2021). We integrated the modeled properties with land use information from the Brazilian Foundation for Sustainable Development (FBDS), combined with other land use information, producing a 5 m-resolution map. A river network from FBDS was also used to evaluate native vegetation inside and outside APPs (riparian zones) (FBDS 2013). We used information on fiscal modules (i.e. size of rural properties) for each municipality to model the Forest Act requirements in the rural properties (requirements depend on the size of rural properties). The estimated native vegetation deficit in the properties was calculated based on the requirements of the New Forest Act, as specified in Articles 12, 13, 15, and 67 (Tavares et al. 2021). We also modeled article 68, which was one of the greatest challenges in this project and is specificized below. This was the only model of the Forest Act that used vector information, not raster, which brings more accurate data at the rural-properties level. We considered as native vegetation surplus the amount of native vegetation higher than the minimum legally required.

5. *Past native vegetation cover to estimate Legal Reserve deficit considering art. 68*

This was one of the biggest challenges of modeling during the execution of the FAPESP project and the most requested topic in the participatory meetings. No other project in Brazil has modeled the article 68 at the property level.

The Article 68 of the New Forest Act states that if the native vegetation was converted without violating the legislation in force at the time of the conversion, the landholder should be waived from the obligation of restoring or compensating their Legal Reserves to the extent required by the New Forest Act. However, Brazilian native vegetation protection laws have been in place since 1812 (Andrada e Silva 1821), and each of these laws used different terms to refer to vegetation (e.g. forest, native vegetation, wood, bushes) and set different amounts of vegetation protection inside rural properties. Further, there is another problem in applying this Legal Reserve reduction mechanism: the lack of accurate and spatialized data to assess land cover information when the vegetation was cleared before 1965 (Tavares et al. 2019).

We provided a quantitative evaluation of the effects for native vegetation protection using different initial benchmarks (i.e. 1934 and 1965) in applying the Legal Reserve reduction mechanism. For this, we developed a methodology to assess the past native vegetation cover in 1934 (when no aero-photogrammetric data was available) through a probabilistic approach (Tavares et al. 2021).

6. *Modeling Legal Reserve compensation with ecological equivalence*

In 2019, the Supreme Federal Court decided that trades under the Legal Reserve compensation protocol should require "ecological equivalence" (Brasil 2018). This demand for like-for-like trades was criticized by the actors involved in this issue. A common criticism was that the level of equivalence to be achieved in trades remained undefined in the legislation, which could make room for an undesirable flexibility or even non-compliance by landowners with respect to the environmental benefits compensation should deliver. The agricultural sector also argued that the Court's decision would increase costs for landowners.

To address the need of balancing environmental gains and economic costs, we developed a dynamic tool (Mello et al. 2021b) that allows users to objectively analyze results from multiple scenarios of Legal Reserve compensation. Those scenarios can combine different levels of abiotic and biotic equivalence requirements (considering separately the biome present in the State, once Native Vegetation Protection Law requires compensation to be made in the same biome of the deficit) with different costs for compensation, which vary according to the compensation site and strategy adopted (protecting existing vegetation or restoring vegetation – for example, in areas with pasture of low productivity). The scenarios also include the possibility of trading up, *i.e.* compensate by protecting existing natural vegetation considered as priority areas for conservation that are not yet protected (BBOP, 2012, Bull et al. 2016) (see details in Mello et al. 2021b). The proposed approach aims to help stakeholders in finding the best solution for their specific situation of Legal Reserve deficit by balancing the legal requirements for ecological equivalence with land availability combining the available strategies for compensation trades.

7. *Results communication*

The project presented several results over eight meetings between 2017 and 2020, which were presented during the seven face-to-face meetings and the last online meeting. The results were also presented in scientific conferences and published in scientific articles. To reach the local audience (decision-makers, technicians, landowners, public prosecutor's office, NGOs, etc), the results were also published as technical notes and the data were available on the project website (https://codigoflorestal.wixsite.com/tematico).

Results

1. *Project process*

We conducted a total of eight open meetings between March 2017 and February 2019. The number of participants in face-to-face meetings ranged from 29 to 89 persons, while the number of represented institutions ranged from 16 to 48. 55% of the participants joined only one meeting, while only 2% took part in all meetings.

The main dispute that emerged from the process was related to which should be the legal benchmarks used for Article 68 modeling. However, during later meetings and after the presentation of the research results about each possibility and their limitations/flaws, the participants agreed that the initial benchmark should be the 1965's Forest Act, due to the lack of official spatially explicit data from dates before 1965 that allows the construction of an accurate modeling solution for art. 68 (Tavares et al. 2019), as shown below.

On average, participants agreed that the project was able to create a safe space for an open dialogue between actors that, frequently, have opposing stances, and to provide useful scientific information to support decision-making. During the process, we were able to reduce the gap between science and practice, meeting stakeholders' expectations and increasing the accessibility of scientific information (Brites et al. 2021).

Avoiding falling back to top-down science and keeping stakeholders' participation constancy were challenges faced. Despite the project achievements and consensus between stakeholders during the open meetings, important scientific outcomes were disregarded by higher instances of decision-making during and after the FAPESP project execution, as shown below.

2. *Native vegetation deficit and surplus*

There is an estimated APP deficit (the minimum amount of riparian area to be restored when it was deforested in the past – article 61-A of Law 12,651/2012) of 768,580 ha in the State of São Paulo (111,785 ha in the Cerrado and 656,795 ha in the Atlantic Forest) and 367,403 ha of Legal Reserve deficit (54,890 ha in the Cerrado and 312,513 ha in the Atlantic Forest) (Figure 2), totaling 1.14 Mha of native vegetation deficit to be restored and/or compensated (the second option only applies to Legal Reserves). From the total APP deficit, only 16% are related to small farms (rural properties up to 4 fiscal modules), and 48% are concentrated in large farms (greater than 15 fiscal modules). Farms with up to 1 fiscal module represent 45% of the rural properties in SP, however, they present only 3% of the APP deficit in the state. Regarding the Legal Reserve deficit, 65% is concentrated in large farms and the rest in medium farms (between 4 and 15 fiscal modules). Most of the native vegetation deficit is in properties where the major land use is sugarcane (39%) followed by pasture (36%).

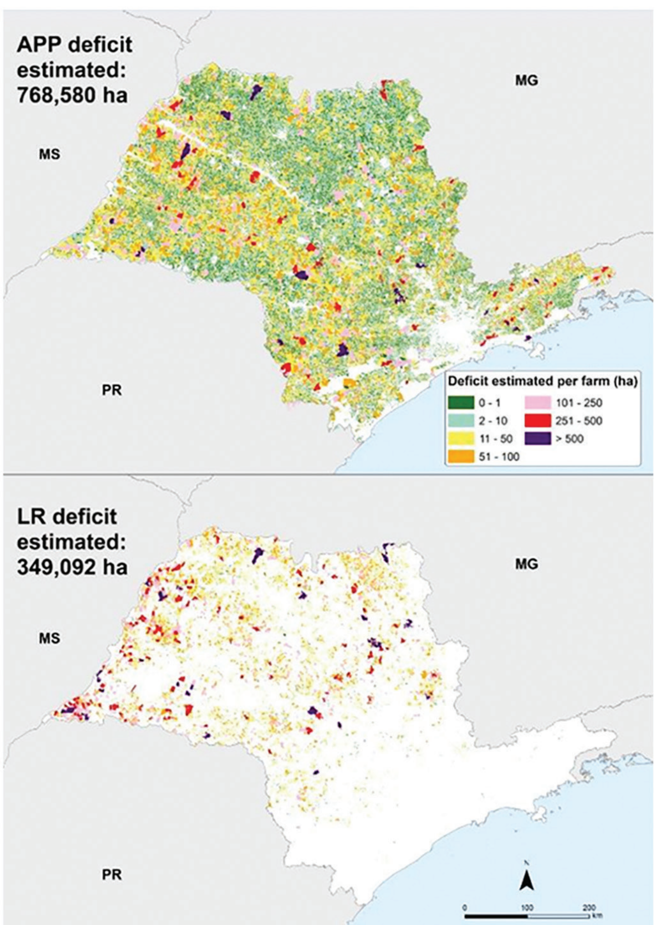

Figure 2. Estimated native vegetation deficit of Permanent Preservation Areas (APP) and Legal Reserves (LR) in the State of São Paulo.

It is important to note that the municipalities have different realities regarding the distribution of APP deficits in relation to the size of the rural property. There are municipalities such as Marília and Araçatuba, where 72% and 60% of the APP deficit, respectively, is concentrated in large properties (greater than 15 fiscal modules). Other municipalities, such as Socorro, present a large part of the deficit in properties up to four fiscal modules. Municipalities where there are many small properties benefit from article 61-A, which exempts landowners from restoring native vegetation, decreasing the APP deficit. This is the case of Piracicaba, leading the deficit to be concentrated in large properties (54% in properties larger than 15 fiscal modules). Thus, it is observed that the municipalities have different APP deficits distribution and different strategies for the Forest Act implementation can be adopted according to these realities.

The total native vegetation surplus in the State of São Paulo is 645,905 ha (580,510 ha in the Atlantic Forest and 65.395 ha in the Cerrado). There is enough native vegetation surplus to easily compensate the Legal Reserve deficit in the Atlantic Forest, but the numbers for Cerrado are tighter, which means that for this Biome restoration may be necessary to achieve compliance (Mello et al. 2021b). In addition to native vegetation surplus, Legal Reserve of small farms (up to four fiscal modules) can be used in Legal Reserve compensation through the CRA mechanism. Considering this mechanism, the total area available for Legal Reserve compensation in São Paulo is 104,052 ha in the Cerrado and 836,404 ha in the Atlantic Forest.

3. *Past native vegetation cover to estimate Legal Reserve deficit considering art. 68*

The outcomes showed that the benchmark change (considering the different initial benchmarks – 34 and 65) does not significantly affect the total area of Legal Reserves protection, the number of farms potentially benefited by this mechanism, and the amount of native vegetation deficit (Tavares et al. 2021). However, the use of year 1934 as an initial date for considering protection of Legal Reserve can delay the implementation of the law due to a time-consuming farm-by-farm analysis, once the probabilistic map has an intrinsic limitation for an automatic process. Thus, the environmental gains with the adoption of 1934 as the initial date do not overcome the limitations of using a probabilistic map, suggesting that effective law enforcement depends on reliable and more recent baselines, allowing semi-automated analyses. Because of that, we advised the state government to adopt the 1965 Forest Act as the initial benchmark to apply the art. 68. We also suggested the use of the best land-use and native vegetation information to apply the art. 68 analysis (IBGE 1965, Radam 2015).

These results and scientific arguments were ignored by the decision-makers in the regulation of the New Forest Act in São Paulo, who published the Resolution SAA 55/20, contradicting all evidence-based suggestions for the application of art. 68. The IBGE map of biomes (2004) was adopted as reference of native vegetation formations, instead of the RADAM map from 70/80 decades (2015), the resolution adopted the 1934 Forest Act as the initial benchmark, and the interpretation to calculate the discounts of native vegetation deficit was different from the interpretation discussed during the open meetings of this project.

4. Modeling Legal Reserve compensation with ecological equivalence

The dynamic tool we developed enabled flexibility in balancing the environmental equivalence, mostly represented by abiotic factors, with economic costs and land availability (Mello et al. 2021b). Thus, the tool can create scenarios that better fit the stakeholder's needs. This tool was used to test Legal Reserve compensation scenarios for all Brazil, inside each of the country's biomes restricted to each state (Mello et al. 2021a). The scenarios showed that, when the similarity of abiotic factors is considered as ecological equivalence, it is possible to compensate all Legal Reserve deficit in the country using the compensation strategies (protect existing native vegetation, restore in areas of low suitability for agriculture and trading-up) in different extents (Mello et al. 2021b). For the State of São Paulo, other mechanisms besides the compensation in native vegetation surplus, such as compensating in Legal Reserves of small farms and restoration of areas of low agricultural suitability, are especially necessary for the Cerrado and the West of the State.

The dynamic tool developed by our research group was presented in the project's face-to-face meetings in intermediate and final levels of development. The intermediate-level tool raised preoccupation among many participants, especially those involved in the agricultural sector, because of the possible costs of compensating with equivalence. The tool in its final development was better received by the participants, mostly because of the flexibility in automatically combining environmental and cost conditions and the inclusion of trading-up as a compensation strategy. By the end of the project, the tool was largely disclosed among participants of our meetings and institutions of the State of São Paulo interested in Legal Reserve compensation.

However, we are not aware whether and how the dynamic tool has been used in the state or outside it. Neither the meeting participants nor institutions have contacted us to inform they were employing our tool in compensation schemes. Also, we did not provide a system that would register the tool use in a database, so that we could monitor and understand its use across time. Besides, despite our effort in developing, testing, and disclosing the tool that includes ecological equivalence in Legal Reserve compensation, equivalence has not yet been mentioned or included in the regulation of the New Forest Act in São Paulo.

5. Results communication

The results were published in six technical notes (avaialable in https://codigoflorestal.wixsite.com/tematico/publicacoes), eight scientific papers (Freitas et al. 2017, Sparovek et al. 2019, Tavares et al. 2019, Metzger et al. 2019, Mello et al. 2021a, Mello et al. 2021b, Brites et al. 2021, Tavares et al. 2021), two technical papers (Guidotti et al. 2017, Guidotti et al. 2021), and several other technical notes and papers under preparation or review. The research project also resulted in other media publications of wider reach, as in the Nexo Journal and Biota – FAPESP website. We also created a YouTube channel for scientific dissemination about environmental policies, focusing on the Forest Code – "Meio Ambiente Sem Mistério" – (https://www.youtube.com/channel/UCdbLgYpEnOcmUTTwTW4QHhw).

Discussion

The project was able to reduce the gap between science and practice, providing useful and accessible information for decision-makers to use in the process of implementing São Paulo State's Forest Act. However, the process also showed that science outreach is still being limited by political interests, and the use of knowledge produced through science-based dialogue may be disregarded in final legal decisions (Brites et al. 2021).

The results presented during the FAPESP project showed that the State of São Paulo has a great opportunity to reach the native vegetation protection and restoration target avoiding the conversion of agricultural productive lands (Mello et al. 2021a). Our results showed that the state has enough areas to restore or compensate the Legal Reserve deficit, and the APP deficit is small (less than 1 ha – Figure 2) in most of the rural properties, facilitating law enforcement. However, political, and economic interests of small and powerful groups can prevail over an efficient and socially fair implementation of the environmental policy (Rajão et al. 2022), and this happened in the State of São Paulo.

During the meetings, there was consensus on controversial issues of the New Forest Act implementation, such as art. 68 and the ecological equivalence in Legal Reserve compensation. We counted on the presence of technicians from state secretariats from both agricultural and environmental departments. Yet, the discussions and even the consensus were ignored in decision making, and the regulations published in 2020 ignored the scientific evidence we generated. This is a threat to the protection of native vegetation, which is the objective of this environmental policy, and it hinders transparency in decision-making (Sterner et al. 2019).

Although we had presented a scientific methodological solution to estimate past native vegetation cover before the first spatial land-use data (1965) was available, it is a probabilistic map with its intrinsic uncertainties. Thus, the decision of the State of São Paulo to consider the 1934 Forest Act as the initial benchmark for the art. 68 can delay the law implementation, because it will require a case-by-case analysis for the rural properties' land regularization (Tavares et al. 2021). In the same way, ecological equivalence has not been included yet in São Paulo regulation of the New Forest Act, disregarding not only the efforts made in this project relative to the dynamic tool creation and divulgation, but also the Brazilian Supreme Court decision. Even though monitoring the use of the tool would help in its continuous improvement and dissemination, it would not do much if the state legislation still does not recognize ecological equivalence as a requirement for compensation trades. This represents a possible threat to Atlantic Forest and Cerrado remnants in São Paulo, which could keep on losing biodiversity in imbalanced trades, consequently losing important ecosystem services (Mello et al. 2021b). Also, the lack of regulation could impede small farmers from offering their Legal Reserves as environmental credit for compensation, through the Environmental Reserve Quotes (Portuguese acronym CRA), avoiding these landowners having economic gains from the compensation scheme.

Even with the scientific data being produced in a participatory way, including government departments, all evidence-based suggestions for the New Forest Act implementation in the State of São Paulo were ignored, showing that there is still a long way to go to solve the gap between science and practice, what we did was just to reduce it, but we were only able to advance to a certain degree. Bringing specialists from government sectors to the process of producing scientific knowledge will not solve it if higher instances of decision-makers are not aligned. Otherwise, decisions may continue to predominately attend to economic or short-term political interests. The lessons learned with this FAPESP project showed that there is still a great challenge to adopt scientific information in the decision-making process, especially during the current Brazilian government, which is not concerned about environmental conservation (Abessa et al. 2019). The state of São Paulo is considered a leader in economic and environmental aspects in Brazil, which should contaminate regulations in other states.

Science can still contribute to the implementation of the New Forest Act at the federal, state and municipal levels. Many states still need to regulate their PRAs (CPI, 2021) and the State of São Paulo needs to regulate some of its PRA instruments, such as Legal Reserve compensation. In addition to the regulation of the law, one of the biggest challenges for the implementation of the New Forest Act is the CAR validation (Brites & Mello, 2021). Brazil currently has 7.02 million rural properties registered, all of them need to go through a validation process, because CAR is self-declaring. The only solution for all properties to be validated will be the adoption of an automated system. Therefore, it is necessary to adopt prioritization strategies (where to start validating and regularizing) and targeting strategies (where to restore and to protect). It is also necessary to outline the best restoration strategies for each reality within the states and biomes, for different sizes of properties and different municipal scenarios. Science can help in all these issues, by indicating priority areas for the payment for environmental services with a focus on the recovery of riparian zones and Legal Reserves, by monitoring the law implementation. For example, the data produced by this FAPESP project have been used to find rural properties in the Piracicaba municipality which will receive payment for environmental services, once owners restore native vegetation in their lands focusing on water resources protection and improvement of landscape connectivity. This was carried out through the collaboration of NGOs, municipal government, private investors, and academia. A good example of how the joint work of these institutions can contribute to native vegetation protection in Brazil.

In conclusion, the lessons learned showed that even designing the project in order to meet the needs to support the implementation of the environmental policy, avoiding difficulties normally pointed out by similar projects, there was a great difficulty for scientific contributions to be adopted in the decision-making process. These initiatives won't always work and the knowledge we currently have of why it doesn't work was not enough to make it work. In other words, we need to better understand the relationship between science and politics, and only the study of empirical cases that did and did not work as this FAPESP project can expand this knowledge.

Acknowledgments

We thank the SOS Mata Atlântica, Imaflora, WWF, the Environmental and Infrastructure Secretary of São Paulo and FAPESP for financial and data support. We also thank the University of São Paulo and the University of Queensland for the institutional support. This work was supported by the São Paulo Research Foundation (FAPESP) [grants numbers 2016/17680-2, 2016/2431904, 2017/02755-0, 2017/04812-0, 2017/07942-2, 2017/24028-2, 2018/25147-8].

Associate Editor

Carlos Joly.

Conflicts of Interest

The authors declare that there is no conflict of interest.

Ethics

Not applicable.

References

ABESSA, D., FAMÁ, A.& BURUAEM, L. 2019. The systematic dismantling of Brazilian environmental laws risks losses on all fronts. Nature Ecology & Evolution, 3: 510–511. https://doi.org/10.1038/s41559-019-0855-9

ANDRADA E SILVA, J. 1821. Remembrances and Notes from the Provisional Government to the Deputies of the Province of São Paulo.

BERTUOL-GARCIA, D.B., MORSELLO, C., EL-HANI, C.N. & PARDINI, R. 2018. A conceptual framework for understanding the perspectives on the causes of the science-practice gap in ecology and conservation. Biol Rev Camb Philos Soc, 93: 1032–1055. https://doi.org/10.1111/brv.12385.

BBOP, 2012. BBOP Glossary. Forest Trends. Available at https://www.forest-trends.org/publications/bbop-glossary/ (accessed 4/12/2022).

BOESING, A.L., NICHOLS, E., & METZGER, J.P. 2017. Effects of landscape structure on avian-mediated insect pest control services: a review. Landscape Ecology, 32(5): 931–944. https://doi.org/10.1007/s10980-017-0503-1

BRANCALION, P.H.S., SCHWEIZER, D., GAUDARE, U., MANGUEIRA, J.R., LAMONATO, F., RARAH, F.T., NAVE, A.G. & RODRIGUES, R.R. 2016. Balancing economic costs and ecological outcomes of passive and active restoration in agricultural landscapes: the case of Brazil. Biotropica, 48: 856–867.

BRASIL. 1965, Lei n° 4.771, de 15 de setembro de 1965.

BRASIL. 2012. Lei n° 12.651, de 25 de maio de 2012.

BRASIL. 2018. Supremo Tribunal Federal. Ação Declaratória de Constitucionalidade 42 /DF – Distrito Federal. Relator: Ministro Luiz Fux. Pesquisa de Jurisprudência, Acórdãos, 28 Fevereiro de 2018. Available in: https://redir.stf.jus.br/paginadorpub/paginador.jsp?docTP=TP&docID=750504737. (accessed in 14/01/2019)

BRITES, A.D. & MELLO, K. 2021.Código Florestal: Avaliação 2017–2020. 1. ed. Observatório do Código Florestal. Rio de Janeiro, 80p.

BRITES, A.D., MELLO, K., TAVARES, P.A., METZGER, J.P., RODRIGUES, R.R., MOLIN, P.G., PINTO, L.F.G., JOLY, C.A., FERNANDES, J.F.A., MACHADO, F.S., TRANI, E. & SPAROVEK, G. 2021. Science-based Stakeholder Dialogue for Environmental Policy Implementation. Conservation & Society, 19: 216.

BULL, J.W., GORDON, A., WATSON, J.E.M. & MARON, M. 2016. Seeking convergence on the key concepts in 'no net loss' policy. Journal of Applied Ecology, 53:1686–1693. https://doi.org/10.1111/1365-2664.12726

DINIZ, T.& FILHO, J.B.F. 2015. Impactos Econômicos do Código Florestal Brasileiro: uma discussão à luz de um modelo computável de equilíbrio geral. Revista de Economia e Sociologia Rural, 53(2): 229–250.

FBDS – Fundação Brasileira para o Desenvolvimento Sustentável. 2013. Available in: http://geo.fbds.org.br/. (accessed in 12/07/2017)

FREITAS, F.L.M. DE, ENGLUND, O., SPAROVEK, G., BERNDES, G., GUIDOTTI, V., PINTO, L.F.G. & MÖRTBERG, U. 2018a. Who owns the Brazilian carbon? Global Change Biology, 24: 2129–2142.

FREITAS, F.L.M. DE, SPAROVEK, G., BERNDES, G., PERSSON, U.M., ENGLUND, O., BARRETTO, A. & MÖRTBERG, U. 2018b. Potential increase of legal deforestation in Brazilian Amazon after Forest Act revision. Nature Sustainability, 1: 665–670.

FREITAS, F.L.M. DE, SPAROVEK, G., MÖRTBERG, U., SILVEIRA, S., KLUG, I. & BERNDES, G., 2017. Offsetting legal deficits of native vegetation among Brazilian landholders: Effects on nature protection and socioeconomic development. Land Use Policy, 68: 189–199.

GIBOP, 2019. Global Inventory of Biodiversity Offset Policies (GIBOP). International Union for Conservation of Nature, The Biodiversity Consultancy, Durrel Institute of Conservation & Ecology. Available in https://portals.iucn.org/offsetpolicy/ (accessed in 13/1/2022).

GRANTHAM, H.S., DUNCAN, A., EVANS, T.D., JONES, K.R., BEYER, H.L., SCHUSTER, R., ... & WATSON, J. E.M. 2020. Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. Nature communications, 11(1):1–10.

GUIDOTTI, V, FREITAS, F.L.M., SPAROVEK, G., GUEDES-PINTO, L.F. 2017. Números Detalhados do Novo Código Florestal e suas implicações para o PRAs: Principais resultados e considerações. Sustentabilidade em Debate, Imaflora, Piracicaba, 1, p. 1–10. doi:10.13140/RG.2.2.23229.87526.

GUIDOTTI, V, MELLO, K., PINTO, L.F.G., BRITES, A.D., TAVARES, P.A., FERNANDES, R.B., CHAMMA, A.L.S., FRANSOZI, A.A., DEL GIUDICE, R., ROSA, M. & SPAROVEK, G. 2021. O Código Florestal na Mata Atlântica. Sustentabilidade em Debate, Imaflora, Piracicaba, 11: p. 1–44. ISBN : 978-65-86902-06-8

HOANG, N.T. & KANEMOTO, K. 2021. Mapping the deforestation footprint of nations reveals growing threat to tropical forests. Nature Ecology & Evolution, 5(6): 845–853.

IBGE – Instituto Brasileiro de Geografia e Estatística. 1965. Cartas Topográficas 1:50.000. Available in https://www.ibge.gov.br/geociencias/downloads-geociencias.html (accessed in 10/07/2017)

IBGE – Instituto Brasileiro de Geografia e Estatística. 2004. Mapa de Biomas do Brasil 1:5 000 000. Available in https://www.ibge.gov.br/geociencias/downloads-geociencias.html (accessed in 10/07/2017)

IF – Instituto Florestal, Secretaria e Infraestrutura do Meio Ambiente. 2020. Inventário Florestal do Estado de São Paulo: Mapeamento da cobertura vegetal nativa. Instituto Florestal, São Paulo.

IPCC – Intergovernmental Panel on Climate Change. 2021. Climate Change 2021: The physical science basis. Switzerland: IPCC. Available in www.ipcc.ch (accessed in 28/10/2021)

JENKINS, W.A., MURRAY, B.C., KRAMER, R.A. & FAULKNER, S.P. 2010. Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley. Ecol. Econ., 69:1051–1061. https://doi.org/10.1016/j.ecolecon.2009.11.022.

MCNICOL, I.M., RYAN, C.M. & MITCHARD, E.T.A. 2018. Carbon losses from deforestation and widespread degradation offset by extensive growth in African woodlands. Nature communications, 9 (1): 1–11.

MELLO, K., FENDRICH, A.N., SPAROVEK, G., SIMMONDS, J.S., MARON, M., TAVARES, P.A., BRITES, A.D, JOLY, C.A. & METZGER, J.P. 2021a. Achieving private conservation targets in Brazil through restoration and compensation schemes without impairing productive lands. Environmental Science and Policy, 120: 1–10. https://doi.org/10.1016/j.envsci.2021.02.014

MELLO, K., FENDRICH, A.N., MATOS, C.B., BRITES, A.D., TAVARES, P.A., DA ROCHA, G.C., MATSUMOTO, M., RODRIGUES, R.R., JOLY, C.A., SPAROVEK, G. & METZGER, J.P. 2021b. Integrating ecological equivalence for native vegetation compensation: A methodological approach. Land use Policy, 108: 105568. https://doi.org/10.1016/j.landusepol.2021.105568

MELLO, K., VALENTE, R.A., RANDHIR, T.O., DOS SANTOS, A.C.A. & VETTORAZZI, C.A. 2018. Effects of land use and land cover on water quality of low-order streams in Southeastern Brazil: Watershed versus riparian zone. Catena, 167: 130–138. https://doi.org/10.1016/j.catena.2018.04.027

METZGER, J.P., BUSTAMANTE, M.M.C., FERREIRA, J., FERNANDES, G.W., LIBRÁN-EMBID, F., PILLAR, V.D., PRIST, P.R., RODRIGUES, R.R., VIEIRA, I.C.G. & OVERBECK, G.E. 2019. Why Brazil needs its Legal Reserves. Perspectives in Ecology and Conservation, 17: 91, https://doi.org/10.1016/j.pecon.2019.07.002

MIYAKI, C., CRUZ JUNIOR, F., HICKERSON, M., MICHELANGELI, F., ROCHA, R.P., THOMAS, W. & CARNAVAL, A.C. 2022. A multidisciplinary framework for biodiversity prediction in the Brazilian Atlantic Forest hotspot. Biota Neotrop. 22: e20221339. https://doi.org/10.1590/1676-0611-BN-2022-1339

MITTERMEIER, R.A., TURNER, W.R., LARSEN, F.W., BROOKS, T.M., & GASCON, C. 2011. Global biodiversity conservation: the critical role of hotspots. In Biodiversity hotspots. Springer, Berlin, Heidelberg. pp. 3–22. https://doi.org/10.1007/978-3-642-20992-5_1

RADAM – Projeto Radar na Amazônia. 2015. Available in: https://dados.gov.br/dataset/cren_vegetacao_radambrasil. (accessed in 13/07/2017)

RAJÃO, R., NOBRE, A.D., CUNHA, E.L.T.P., DUARTE, T.R., MARCOLINO, C., SOARES-FILHO, B., SPAROVEK, G., RODRIGUES, R.R., VALERA, C., BUSTAMANTE, M., NOBRE, C. & LIMA, L.S. 2022. The risk of fake controversies for Brazilian environmental policies, Biological Conservation, 266: 109447. https://doi.org/10.1016/j.biocon.2021.109447

SATURNI, F.T., JAFFE, R. & METZGER, J.P. 2016. Landscape structure influences bee community and coffee pollination at different spatial scales. Agriculture, Ecosystems & Environment, 235: 1–12.

SMA, Secretaria de Estado do Meio Ambiente. Resolução nº 146, de 08 de Novembro de 2017. Institui o Mapa de Biomas do Estado de São Paulo, e dá outras providências. São Paulo. 08 de Novembro de 2017. Available in: https://smastr16.blob.core.windows.net/legislacao/2017/11/resolucao-sma-146-2017.pdf.(accessed in 07/02/2019)

SPAROVEK, G., BARRETTO, A.G.O.P., MATSUMOTO, M. & BERNDES, G. 2015. Effects of Governance on Availability of Land for Agriculture and Conservation in Brazil. Environmental Science & Technology, 49: 10285–10293. https://doi.org/10.1021/acs.est.5b01300

SPAROVEK, G., REYDON, B.P., PINTO, L.F.G., GUIDOTTI, V., FREITAS, F.L.M. DE, AZEVEDO-RAMOS, C., GARDNER, T., HAMAMURA, C., RAJÃO, R., CERIGNONI, F., SIQUEIRA, G.P., CARVALHO, T., ALENCAR, A. & RIBEIRO, V. 2019. Who owns Brazilian lands?. Land use policy, 87: 104062.

STERNER, T., BARBIER, E.B., BATEMAN, I., VAN DEN BIJGAART, I., CRÉPIN, A.S., EDENHOFER, O., FISCHER, C., HABLA, W., HASSLER, J., JOHANSSON-STENMAN, O., LANGE, A., POLASKY, S., ROCKSTRÖM, J., SMITH, H.G., STEFFEN, W., WAGNER, G., WILEN, J.E., ALPÍZAR, F., AZAR, C., CARLESS, D., CHÁVEZ, C., CORIA, J., ENGSTRÖM, G., JAGERS, S.C., KÖHLIN, G., LÖFGREN, Å., PLEIJEL, H. & ROBINSON, A., 2019. Policy design for the Anthropocene. Nat. Sustain. 2:14–21. https://doi.org/10.1038/s41893-018-0194-x.

STRASSBURG, B.B., IRIBARREM, A., BEYER, H.L., CORDEIRO, C.L., CROUZEILLES, R., JAKOVAC, C.C., & VISCONTI, P. 2020. Global priority areas for ecosystem restoration. Nature, 586(7831): 724-729.

TAVARES, P.A., BRITES, A.D., SPAROVEK, G., GUIDOTTI, V., CERIGNONI, F., AGUIAR, D., METZGER, J.P., RODRIGUES, R.R., PINTO, L.F.G., MELLO, K. & MOLIN, P.G. 2019. Unfolding additional massive cutback effects of the Native Vegetation Protection Law on Legal Reserves, Brazil. Biota Neotropica, 19(4): e20180658. http://dx.doi.org/10.1590/1676-0611-bn-2018-0658.

TAVARES, P.A., BRITES, A.D., GUIDOTTI, V., MOLIN, P.G., MELLO, K., SANTOS, Z.L., PINTO, L.F.G., METZGER, J.P., RODRIGUES, R.R., JOLY, C.A. & SPAROVEK, G. 2021. Testing temporal benchmarks effects on the implementation of the new Brazilian Forest Act. Environmental Science and Policy, 126: 213–222. https://doi.org/10.1016/j.envsci.2021.09.024

TOOMEY, A.H. 2016. What happens at the gap between knowledge and practice? Spaces of encounter and misencounter between environmental scientists and local people. Ecology and Society 21(2):28. https://doi.org/10.5751/ES-08409-210228

WELP, M., DE LA VEGA-LEINERT, A., STOLL-KLEEMANN, S. & JAEGER, C.C. 2006. Science-based stakeholder dialogues: Theories and tools. Global Environmental Change 16(2): 170–181.

Received: 10/06/2022
Accepted: 18/07/2022
Published online: 15/08/2022