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***Article***

# Science-based Stakeholder Dialogue for Environmental Policy Implementation

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## Abstract

Science-based stakeholder dialogue is a strategy to bring science closer to decision-making with increasing importance for the design of environmental policies. The need for such an approximation has been stressed, but documented implementations are rare. We present our experience of developing a science-based dialogue for the Brazilian Forest Code implementation and share the lessons learned. We departed from a mix of participatory methods to conduct six meetings with stakeholders. During the process, we were able to reduce the gap between science and practice, meeting stakeholders' expectations and increasing the accessibility of scientific information. Avoiding falling back to top-down science and keeping stakeholders' participation constancy were challenges faced. Despite the project achievements, important scientific outcomes were disregarded by higher instances of decision-making. Thus, although we were able to start the dialogue successfully, we also come across the fact that external political factors impaired its reach. By reporting our experience, we expect to help to establish science-based dialogues applied to environmental policy implementation, narrowing the science-practice gap and contributing to more effective environmental policies.

**Keywords:** environmental policy, Brazil, decision-making, science-practice gap

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## INTRODUCTION

The current worldwide scenario of biodiversity losses and ecosystem degradation raises the need for evidence-based information to guide environmental policies (Sterner et al. 2019). However, segregation between science and policy in the decision-making process hinders effective environmental governance strategies and nature conservation efforts

(Battisti 2017). This detachment results from a two-way process among scientists and decision-makers or practitioners. Scientists are criticised for not producing socially relevant information (Battisti 2017), and decision-makers are frequently blamed for not making decisions based on scientific evidence (Abessa et al. 2019). Thus, there is a gap between science and practice, in which science is not easily accessible for decision-makers, and scientists often do not understand decision makers' information needs (Turnhout 2018).

Among several factors that explain the science-practice gap, three are particularly relevant for the context of this research. First, many researchers are focused on questions useless to decision making (Esler et al. 2010) or engaged in academic journeys that generate knowledge that has no social relevance (Aquino Neto 2005). Second, decision-makers frequently have no access to scientific data (Sunderland et al. 2009), or scientific information is presented in an unintelligible way for non-specialists (Azevedo-Santos et al. 2017). Last, the uncertainty and probabilistic outcomes inherent to scientific knowledge can lead to a low acceptance and a skeptical attitude from decision-makers that are more often forced to a yes-or-no answer (Bainbridge 2014).

Science-based stakeholder dialogues, also called co-operative inquires, cooperative research, or co-production, are promising procedures to overcome the science-practice gap (Welp et al. 2006; Lemos et al. 2018). Science-based stakeholder dialogues make room for a place where participants are not trying to enforce their viewpoints but, instead, establish an environment of trust, empathy, and respect where insights that would not be reached individually can be gained (Welp et al. 2006). This connection between scientists and non-academic stakeholders results in advantages to all parties. It leads to new relationships between stakeholders that are not used to talk to each other constructively, building social capital and knowledge (Reason 2002). Science gains access to multiples kinds of expertise from non-academic stakeholders and to information that, otherwise, would be very hard to access and formally include in the academic research (Welp et al. 2006). Non-academic stakeholders become empowered by these exchanges getting access to scientifically valuable data in an understandable way that can be safely applied to their agendas (Reason 2002). Finally, this process raises the chances of co-creation, generating socially relevant knowledge that will be genuinely used by practitioners and decision-makers, increasing the chances of successful environmental conservation strategies or policies (Lemos et al. 2018).

Fortunately, there is a current trend to involve non-academic stakeholders in the process of co-production with scientists (Lemos et al. 2018). This trend has been driven by scientists' perception about the need to go beyond the bounds of traditional academic methods and knowledge (Mielke et al. 2016), but also by demand from civil society and funding agencies for greater accountability and societal relevance in scientific researches (Lyall et al. 2013).

However, even if the importance of such interaction has been repeatedly stressed (Landry et al. 2001; Smits and Denis 2014), there is a general lack of knowledge of how to put it into practice (Ward et al. 2009; Lemos et al. 2018;), and such processes are rarely documented in the literature (Ward et al. 2009). Thus, studies reporting experiences of co-production can help to understand what works and what does not work within each application context, allowing us to avoid potential pitfalls or undesirable outcomes (Lemos et al. 2018).

Here, we present the lessons learned during establishing a science-based stakeholder dialogue applied to fill gaps between science and practice in implementing a specific environmental policy. We worked with the case of the Native Vegetation Protection Law, commonly known as the new Forest Code (FC), the primary Brazilian regulation for protecting native vegetation on private lands, which represents about 54% of the country's remaining native vegetation (Sparovek et al. 2015). More specifically, we focused on the following questions:

1) Does science-based stakeholder dialogue reduce the communication gap between science and practice?
2) Does the context of dialogues help to make scientific information more accessible for stakeholders?
3) Does science-based stakeholder dialogue help to minimise conflict among sectors?
4) Which are the challenges for the implementation of a science-based stakeholder dialogue?

The lessons learned and reported here can help researchers, decision-makers, and other stakeholders implement and develop an efficient science-practice process to ensure the success of environmental policies worldwide.

## MATERIALS AND METHODS

### The Forest Code

The Forest Code (FC) is the primary Brazilian legislation to protect native vegetation in private lands (Brasil 2012). The FC 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.

The current FC replaced 1965's Brazilian Forest Code (Brasil 1965). Its revision and approval process were marked by an extreme polarisation between environmental and agricultural sectors, inquiries from the scientific community, and protests from civil society (Brancalion et al. 2016). At the core of the conflict was the debate about the amount of native vegetation to be protected or restored in private lands. The agribusiness sector argued that compliance with the previous Forest Code led to losses of productive farmlands, impacting Brazilian agricultural production and, consequently, the country's economy (Diniz and Ferreira Filho 2015). In contrast, scientists claimed that the changes would represent a significant environmental threat and proposed alternative strategies to council agriculture and nature conservation

(Metzger 2010). Although there were some public consultations during the process, the FC final version mainly disregards society and science claims (Brancalion et al. 2016).

Nowadays, nine years after the law's revision, the FC is still not fully implemented. At least three main factors that can explain this delay. First, there are still legal uncertainties about how to interpret some of its primary mechanisms. Second, the difficulty and delay in developing technical solutions for its implementation. Lastly, the dispute among sectors, especially about the amount and location of native vegetation to be protected or restored under Legal Reserves, keeps going on. The uncertainties and conflicts at the national level are mirrored in the State level, where a set of rules to guide and promote compliance with the FC, the "Environmental Regularisation Program" (Portuguese acronym, PRA), must be implemented.

## Case study

To reduce the gap between science and practice that happened in the policy design stage, we developed a scientific project to support the FC implementation in São Paulo State, Brazil. São Paulo State PRA was approved at the beginning of 2015 (São Paulo 2015) and suspended by the court one year later through an act of the State Public Prosecution. Overall, the suspension act claimed that São Paulo PRA's was unconstitutional because it was drawn up without public participation, and some of its articles represented significant setbacks for the national FC legislation. The PRA remained suspended for three years until its judgment in 2019 when most unconstitutionality claims were not accepted.

Four main characteristics made São Paulo State a good case study. First, the PRA suspension created the interval that allowed the start of a space for dialogue between stakeholders with opposing views that was inexistent in São Paulo. Second, the dispute among stakeholders was an opportunity to try the approximation and accommodation of conflicting interests through dialogue. Third, the State has strong institutions and organisations in all sectors involved with the FC debate at the state and national levels. Thus, the São Paulo debate may be seen as a smaller-scale sample of the national debate. Lastly, the State had a long history of past deforestation and agriculture expansion that had drastically reduced its original vegetation cover (Victor et al. 2005), raising the importance and impacts of the FC in the State.

## Transdisciplinary research team

The project was funded by the São Paulo State Research Foundation, which, together with the State secretariats of agriculture and environment, raised the demand for a research project to support the FC implementation. The research team was interdisciplinary and intersectoral, including researchers and experts in different fields from universities, non-governmental organisations (NGOs), the private sector, and the government (Table S1 supplementary information - SI). New actors were added to the research team during the project development, and partnerships with the private sector were done to obtain data that otherwise would not be available.

## The science-based stakeholder dialogue approach

Considering that policy implementation is a dynamic process and that the science-based stakeholder dialogue is a co-production approach, we did not fix a specific objective and a unique method for the whole project. We developed it based on the cycle of science-based dialogue proposed by Welp et al. (2006) — 1) identifying questions together with stakeholders to set specific objectives; 2) developing analysis and data processing to answer these questions; 3) presenting the results to the stakeholders; 4) reviewing models and setting new objectives based on the stakeholders' feedback; 5) presenting results again (Figure 1).

To establish the science-based stakeholder dialogue, we promoted large open meetings in the form of workshops between scientists and stakeholders. We used these meetings to select questions about the policy implementation that stakeholders believed scientists could solve. We also used the meetings to present results, discuss modeling changes and improvements, and identify new questions. We promoted small open meetings in parallel to solve specific issues that were not relevant for the large group of stakeholders.

To create an environment of trust in which people feel safe to share their viewpoints freely, we conducted the meetings based on three principles of the Stretch Collaboration Theory (Kahane 2017) — 1) embrace the existence of conflict among stakeholders; 2) explore multiple possibilities, instead of pursuing a consensus and 3) be open to change our beliefs rather than trying to change others. The Stretch Collaboration approach offers a strategy to enable dialogue and progress even when people have conflicting views (Kahane 2017).

During the process, we used the "generative listening" from Theory U, i.e., listening to what emerges from the dialogue group without judging it and focusing on an emerging future or solution, rather than revisiting past conditions and conflicts (Scharmer 2009). This approach helps to gain a broader view of the problem and a greater awareness of individuals' points of view (Scharmer 2009).

To provide anonymity and promote openness and information sharing, meetings were set under the "Chatham House" rule. The rule states that participants can use the information received during the meetings but cannot reveal the speaker's identity or institution (Chatham House 2017). The FC implementation in Brazil is a very contentious topic, involving many conflicts among stakeholders with opposing stances. The space created by the project was the first to bring them all together and engage them in a constructive talk. In this context, the Chatham House Rule was used to help create this space where stakeholders felt safe to talk freely and express their views.

We promoted six open meetings over two years of the project. The first three open meetings were conducted by a researcher from the team with the help of an impartial

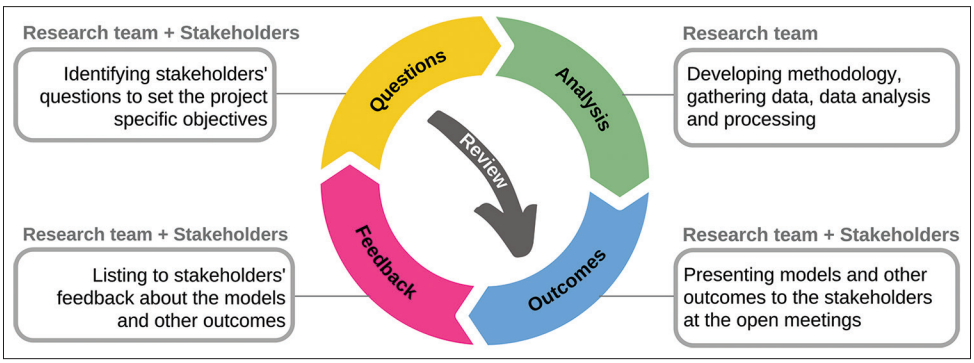


**Figure 1**
*Science-based stakeholder dialogue approach applied*

professional facilitator. They were held in a politically neutral environment to safeguard stakeholders' attendance and trust.

## Stakeholders invitation and project divulgation

To create an initial stakeholders' contact list, we asked experts from agriculture and environment secretariats, public prosecution, university, public and private research institutions, NGOs, and landholders' representatives, for suggestions about stakeholders engaged in the discussion about São Paulo State FC implementation. We used this initial list to invitestakeholders for the first open meeting. Following a snowball approach (Goodman 1961), we asked the initial stakeholders to name other people, who then provided other names, and so forth. We also requested their help to disseminate the project and invite other actors to contribute to the dialogue. These new actors were then added to our initial contact list and invited to the next open meeting. Although we had this contact list to send invites and project information, we always emphasised that meetings were open to anyone interested in participating.

We created an e-mail and a website for stakeholders' communication, data sharing, and project reporting. Reports from each open meeting were sent to our contact list, even for those who did not attend a specific meeting. Besides scientific papers, we also wrote technical notes, a material more practical and objective for supporting decision-makers.

## Project evaluation

To evaluate stakeholders' participation during the project, we registered the number of participants and represented institutions in each meeting. Further, after each meeting, we classified the represented institutions in six sectors: 1) research, comprising public or private universities, governmental or private research institutions, and non-environmental organisations (NGOs); 2) government, such as agriculture and environment secretariats, excluding research institutions; 3) São Paulo State public prosecution; 4) NGOs focused on advocacy; 5) private, comprising landholders, landholders representants', producers' associations and lawyers engaged in the compliance of the FC; and 6) independent, people without a connection with a specific sector. The classification was made using the sector self-reported by participants in the presence list of each meeting.

Two researchers from the project team conduct Participant Observation (Newing et al. 2010) to gather qualitative information about stakeholders' dynamics. The Participant Observation approach provides the opportunity to witness unscheduled events and build hypotheses through inductive reasoning (Newing et al. 2010). They were also responsible for the meeting registry, noting the subjects discussed, participants' and stakeholders' questions and suggestions.

To evaluate communication gap reduction and increased accessibility of information, we consider whether there was a consensus on the topics discussed based on information presented during the dialogues. We also evaluated the time gap between the scientific data presented in the dialogues and the same data published in a scientific journal.

To assess if the dialogues met stakeholders' expectations, helped minimise disputes among them, and make scientific information more accessible, we used the stakeholder's perception of the project. For that, we conducted three surveys, two in the middle of the process and another in the end. Stakeholders were invited to evaluate the data presented, methodology transparency, impartiality, dialogue quality, and report critics or suggestions. We also used answers to assess if there was a reduction in the communication gap and improvement of information accessibility under the stakeholder's perspective. The surveys consisted of open and closed questions (SI) sent by e-mail, to be anonymously answered by participants. Quantitative data from survey closed questions were analysed using descriptive statistics; qualitative data from open questions were analysed using Content Analysis (Krippendorff 2018).

We observed challenges and barriers to implementing a science-based stakeholders' dialogue in implementing the environmental policy. For that, we evaluated difficulties from the research team to develop the participatory dialogues, conflicts that were not solved, and whether decisions made by the rulers during or right after the participatory process followed the meetings' recommendations.

## RESULTS

### Open meetings

We conducted a total of six open meetings. In the first meeting, we presented the science-based stakeholder dialogue concepts and accessed the primary stakeholders' questions about the FC implementation (Table 1). At this meeting, stakeholders raised the Legal Reserve regularisation, especially regarding a solution for Article 68 from the FC, as the main issue. Article 68 releases landholders who removed native vegetation from having to conform to the new percentages under the FC as long it was performed following the ratios established by law at the time of such removal. The main questions about the rule were how to prove the farm's native vegetation, which dataset could be used to access this information, which legal benchmarks should be considered, and how this new rule would affect the Legal Reserve deficit. Therefore, the research team decided to work on a scientific proposal to answer such questions.

In the second meeting, we presented four possible scenarios for Article 68 application. These scenarios combined different datasets, legal benchmarks, and law interpretations (Table S2 from SI). A primary outcome presented in this meeting was that the first dataset with the necessary accuracy to develop a spatially explicit proposal for this rule was from the 1960s. Thus, the four scenarios had the 1965 Brazilian Forest Act as its initial legal benchmark. Stakeholders from distinct sectors presented a clear preference for one scenario or another since the rules and legal benchmarks applied to them were more or less conservative in terms of the type of vegetation protection and the starting date for such protection. However, the group decided that, at this point, it was better to model all four possibilities instead of opting for a specific scenario.

In the third meeting, we presented partial results from scenarios' development and advances in modeling methods. Stakeholders dialogued about the advantages and disadvantages of each scenario.

In the fourth meeting, we presented scenarios' outcomes. At this meeting, some stakeholders detected that the way we had calculated Article 68 effects was not consistent with governmental institutions' legal interpretation. Thus, the model codes were modified. It was also at this meeting that the disputes about which scenario was the best started to weaken. This happened after the acknowledgment that the numbers and geography of Legal Reserve areas were not so different from one scenario to another,

In the meantime, there was an important decision from the Supreme Court about the FC requiring that Legal Reserve must be compensated in ecologically equivalent areas. The research group started working on a proposal for an ecological equivalence model to follow this political event. In the fifth meeting, we presented an early version of this model and asked stakeholders about modifications and improvements. During this meeting, the research team was criticised by part of the stakeholders for bringing up a subject that the dialogue group had not previously agreed upon. At this meeting, we also presented Article 68 scenarios revised numbers. We observed that there was no longer a dispute among stakeholders about it, and they reached a consensus about adopting one of the scenarios. Thus, the research team prepared and submitted a scientific paper about Article 68 effects published 15 months after this meeting (Tavares et al. 2019).

After the fifth meeting, the State PRA was reestablished by the court with the decision of including the 1934 Forest Act as the initial benchmark for Article 68 application. This decision was made regarding the evidence brought by the project outcomes about the need for considering the 1965 Forest Act as the starting point since there was no accurate data for native vegetation distribution before this benchmark. This outcome was vastly reported by the research team in the project site and meetings, by stakeholders in their respective institutions, and through a scientific paper (Tavares et al. 2019). However, since it was a final and official decision, in the sixth meeting, we presented a new scenario (Figure S1 SI) considering the 1934 Forest Act as a starting point. To model this scenario, we made a probabilistic map of native vegetation cover in 1934. Even though the model can contribute to an overview of São Paulo State land use for this period, we explained the restrictions for its use as a decision-making tool since it relies on a probabilistic distribution of native vegetation.

### Stakeholders' participation

The two first open meetings presented the lowest number of participants and institutions. From the third meeting onwards, we reached a higher number of participants and represented institutions. This number remained high until the last event, even with a gap of almost one year between the fifth and the sixth meeting (Table 1). We can also note a high percentage of participation from the private and NGO sectors (Figure 2). Although the number of sectors represented in each meeting remained constant, the individual's participation constancy was

*Table 1*
*Open meetings' subjects, participants, and institutions*

| Meeting/Date | Main subject | *n*° participants | *n*° institutions |
|---|---|---|---|
| 1st 03/2017 | Dialogue start; set out the group functioning; stakeholders' demands | 38 | 20 |
| 2nd 05/2017 | Multiple scenarios for Article 68 | 29 | 16 |
| 3rd 08/2017 | Methodological progress; partial results | 77 | 48 |
| 4th 11/2017 | Scenarios' outcomes | 64 | 38 |
| 5th 04/2018 | Ecological equivalence, revised model outcomes | 78 | 48 |
| 6th 02/2019 | New scenario including a probabilistic map for 1934 | 89 | 45 |

low: 55% joined only one open meeting while 2% participated in all meetings.

## Stakeholders perceptions and evaluations about the project

The surveys applied to access stakeholders' evaluation of the project showed that, in general, the project was well evaluated in terms of the five considered aspects (Figure 3). Considering the mean score between the first and second surveys, the elements that had the highest evaluations were providing scientific information to support decision-making ($\bar{X}$=4.52), creating a safe environment for dialogue ($\bar{X}$=4.37), and being transparent about data and methods used ($\bar{X}$=4.22). However, all the other aspects received a mean score higher than 3.98, showing that evaluations were closer to a positive assessment ("agree" or "totally agree") than to a neutral or negative one ("disagree" or "totally disagree"). The score of the five considered aspects had increased from the first to the second survey, being the project impartiality the element with the highest increase.

On average, all the meetings' subjects were classified as being important for the dialogue about the FC implementation in São Paulo State (Figure 4), i.e., were classified as being "important" or "very important" by 80% or more respondents. Among them, creating multiple scenarios for Article 68 implementation and presenting these scenarios' outcomes were considered important by all respondents. Content analysis from open survey questions reinforced the project importance for building a dialogue space where stakeholders with frequently distinct stances (e.g., agribusiness and environmentalists), and who were not used to talk constructively to each other, could collaborate in the pursuit of the same objective, i.e., to implement the FC in São Paulo State (Table 2).

Presenting an ecological equivalence model received the highest rate of "unimportant" or "low importance" responses. Indeed, results from surveys' content analysis (Table 2) showed that presenting a subject that was not a demand from the group (the ecological equivalence model) was not well received by some of the stakeholders, who claimed that we were deviating from the participatory approach and the project scope. However, this subject was still considered important by 82% of respondents, and it was not mentioned in the second open survey questions.

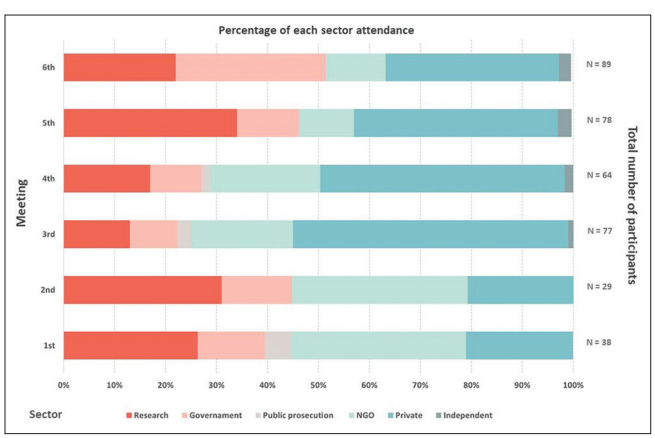


**Figure 2**
***Sectors' percentage of attendance per open meeting***

# DISCUSSION

## Reducing the communication gap between science and practice

This project was the first dialogue arena established in São Paulo State to assist in the FC implementation, a policy marked by disputes over decades (Sparovek et al. 2016), and was the first space for debate to bring together representatives from six different sectors, including the environmental and agricultural ones. The meetings had an average of 60 participants and always had representatives from all sectors. During this process, we were able to meet up stakeholders' demands and provided scientific data to support decision-making in São Paulo State FC implementation. The most urgent request from stakeholders, was addressed and the proposals presented were well accepted by the majority. Additional demands presented during the project process were also achieved. We believe that three main characteristics from the project design may have contributed to this outcome: a flexible research agenda, an intersectoral and multidisciplinary research team, and multiple interactions during a long period.

Policy-making is a dynamic process in which decision-makers step back and forward following social, economic,

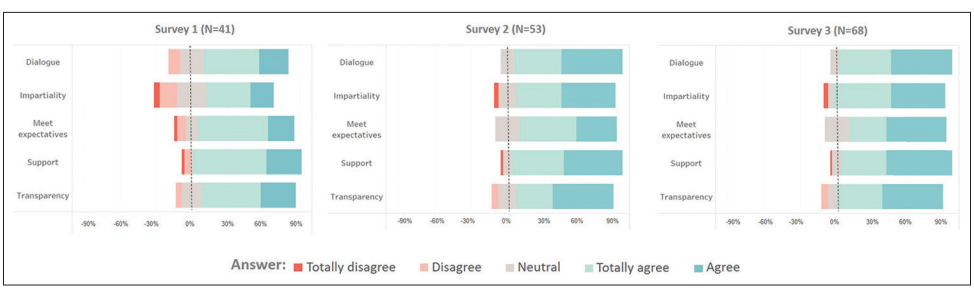


**Figure 3**
***Percent and the average score for survey questions about the project's aspects. Answers were provided using a Likert Scale ranging from "totally disagree" to "totally agree," following scores: "totally disagree" = 1; "disagree" = 2; "neutral" = 3; "agree" = 4 and "totally agree" = 5***

*Table 2*
*Results from the content analysis made on first (n=13), second (n=14), and third (n=22) surveys.*

| Category | Description | Example | Survey 1 % | Survey 2 % | Survey 3 % |
|---|---|---|---|---|---|
| Dialogue space | Responses mentioning the opportunity of communication and information exchange enabled by meetings | "The meetings have been highly positive in search of common ground among actors that, frequently, for the lack of dialogue spaces, ending up with radical antagonisms. The free dialogue space is fundamental for finding possible solutions". | 59 | 71 | 75 |
| Researchers' top-down attitude | Responses pointing out that researchers missed out in some moment the participatory approach | "As I understand, at no time, the group had the objective of discussing the ecological equivalence subject. With this discussion, the project is deviating from its participative scope". | 31 | 0 | 0 |
| Support decision-making | Responses giving examples about ways the project outcomes helped in decision-making or just mentioning that they can be useful for this end | "It is a great Project. It helps a lot with decision-making." | 5 | 7 | 15 |
| Project expansion | Responses mentioning that it was important to give the project outcomes a broader dissemination | "I believe that the project outcomes should be disseminated on a larger scale." | 0 | 21 | 20 |

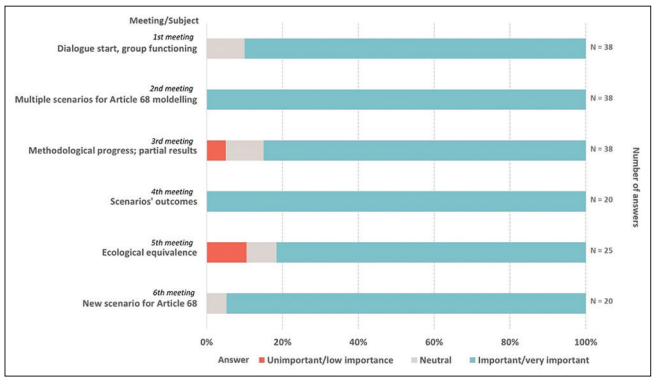


**Figure 4**
*Stakeholders' evaluation of meetings subjects' importance*

and political shifts (Tyler 2013). The back and forward moves are even more intense for developing and implementing environmental policies due to the complexity of natural systems and anthropic activities (Maier et al. 2008). Thus, a research project with fixed objectives and schedules cannot correctly meet decision-makers demands for scientific information in the context of environmental policy design and implementation. In this project, although our general goal was to support the FC implementation in São Paulo State by developing a science-based stakeholder dialogue group, the specific research objectives were not set *a priori*. Instead, they emerged from the group demands and political events that happened along the process. This flexibility and adaptability in research objectives allowed us to follow the shifts in the political process of São Paulo State FC implementation and to better meet stakeholders' demands.

Traditional academic research does not provide the agility and flexibility required to build an effective collaboration between science and decision-makers in the process of policy-making. An approach that is not only interdisciplinary but that also involves multiple sectors, welcoming different types of knowledge and viewpoints, is essential for a co-production process (Lyall et al. 2013).

Throughout the open meetings, we had constant feedback from stakeholders about the proposed scenarios and modeling methods. Performing these multiple iterations of demand-feedback cycles contributed to fine-tuning researchers and stakeholder relationships and producing more decision-making-oriented information. Besides building a shared understanding of the demands, the iterations also allowed stakeholders to adjust their expectations and better understand the project potentials and limitations. Indeed, other initiatives of science-based dialogues pointed that constant interactions with stakeholders over long periods favor establishing a shared understanding and an environment of confidence and open dialogue (Welp et al. 2006).

Through this dialogue space, scientific information could be presented to both sides of the conflict simultaneously, allowing them to argue and reach a consensus. Also, presenting scientific data in open meetings is a strategy to increase the information outreach since data published in a scientific journal is not accessible for all stakeholders (Varner 2014).

The scientific model adjustment due to the government secretariat's information also shows a communication gap reduction during the meetings. If this correction was made after the publication of a scientific paper, it could take years. The article was published only 15 months after the data was presented in the meetings, showing the great time gap between scientific knowledge production and its publication. Publication in scientific journals frequently entails a long cycle which slows down the outcome's dissemination (Powell 2016). Presenting data to a vast array of actors and allowing feedback to fine-tune or correct mistakes through iterative, open meetings and dialogue can be drastically shortened by publication time and information dissemination. This is especially important for the environmental conservation field since scientific information can help support policies (Sterner et al. 2019), but where a delay in decision-making can lead to adverse outcomes (Meffe 2002).

Also, the dialogues allowed us to access data that, otherwise, would not be available. Aliances with actors from

the private sector allowed us to obtain the most accurate spatial data on native vegetation cover and, consequently, to produce a precise model for the effects of Article 68 over Legal Reserve deficits. Besides, academic experts can lack the openness and the systemic way of approaching a problem that may be the key to develop successful environmental policies (Battisti 2017).

## Conflict attenuation

We had started the project from a conflict context about the legal benchmarks included in Article 68 analysis and stakeholders. However, in the fourth meeting, this conflict started to weaken until its complete pacification over the following meetings. At least four factors may have contributed to stakeholders' perception that it was not a battle that worth fighting. First, embracing distinct viewpoints and departing from multiple scenarios instead of opting for one or another since the project beginning. Second, developing and adjusting scenarios and modeling methodologies accordingly to stakeholders' feedback. Third, adopting spatially explicit models based on the most precise data available and decision-making-oriented information. And lastly, providing clear explanations about the used methodologies and being transparent about the models' data was also crucial to tame the dispute. The explanation that one of the models used a more precise and actual database to estimate native vegetation cover, and the perception that the omission of one of the legal benchmarks already set by the FC for Article 68 application (Law 7.803/89) could lead to legal insecurities, helped to reduce the dispute, even if scenarios outcomes lead to differences in the Legal Reserve deficits.

Even if we were able to tame the conflict present in our context, science-based dialogue projects might face significant challenges to obtaining the same outcome. The maintenance of disputes to favor specific sectors, influence policies, or keep public attention to a subject is commonplace among stakeholders involved with environmental problems (Sparovek et al. 2016). Thus, the ongoing and persistent disputes can impair the capacity of a participatory approach in conflict attenuation. Indeed, in our case, it was the existence of conflict itself that led us to create distinct scenarios and, consequently, to have a more productive analysis of the possibilities for the effects of Article 68 over Legal Reserve areas. Further, the use of models obtained through a social and participatory approach, as the science-based dialogue, rather than through scientists alone in purely academic research, seems to be a promising path to produce data that are trusted and used by decision-makers and practitioners (de la Vega-Leinert et al. 2008). However, we need to keep in mind that science does not always lessen disputes around policy decisions. On the contrary, in some contexts, as in situations where policy options already attract a political consensus, it can make the conflict even worse (Sarewitz 2004).

## Challenges for a science-based stakeholder dialogue development

During the process of establishing this dialogue space we faced four main challenges.

First, even with the established dialogue and the engagement of stakeholders throughout the meetings, in our first attempt to model Article 68 scenarios we used a method of calculating its effects that were not following the legal interpretation made by governmental institutions. This fact shows how it can be difficult for researchers to bridge the gap between science and practice and understand all the aspects of policy-making, including law interpretation. Indeed, there is a need not only to foster the use of science by decision-makers but also to educate scientists in the policy-making field (Tyler 2013).

However, the fact that stakeholders could detect our mistake and that we have had the chance to review our models shows the science-based dialogues' ability to perform a reality check and bring science closer to practice (Welp et al. 2006). Besides allowing model adjustments and researchers' learning, this characteristic also allowed stakeholders to create a sense of ownership over the research once it brings them closer to the research process. Also, it may contribute to stakeholder's commitment to participation and the actual use of the generated data in decision-making (de la Vega-Leinert et al. 2008).

Second, the decision to present a subject that was not previously discussed with the dialogue group was not well received. This was an example where we, unintentionally, deviated from our proposal of dialogue and ended up taking a top-down attitude from classical science (Stokes 2005). We acknowledge that breaking up with the behavior of working on a subject of researchers' investigative interest without previous consultation about its social relevance is challenging. Thus, even when working with the build-up of science-based stakeholder dialogue and aware of the importance of participation, scientists still need to make an extra effort to change their deeply rotted patterns of acting and doing science.

However, on the second project evaluation survey, this subject was not mentioned by respondents as a problem anymore. This outcome points out that the relationship of trust and collaboration established by a science-based stakeholder dialogue can get through eventual conflicts. The strong connections created by participatory ways of doing science are critical to approaching sensitive and complex issues like environmental policies (Mitchell and Leach 2019). Further, presenting the ecological equivalence only as one possible model and being open to suggestions to modify it, instead of imposing it as a final and unquestionable model, could also have contributed to stakeholders overcome their discontentment.

Another challenge of participatory approaches is to ensure stakeholders' representativeness and balance (Alonso-Yanez et al. 2016). Although we had succeeded in keeping a high

participation rate, the constancy of people attending was low. This low constancy may result from two different reasons: competing commitments within individuals' schedules or constant changes in institutions' staff, especially the governmental ones. The lack of stakeholders' constancy can be a problem for the group cohesion in participatory approaches because, even if the represented institutions remain the same, different individuals may have different opinions and stances and, consequently, the relationship of trust and respect accomplished through the iterative process of meetings can be lost.

Thus, this can be a barrier to the successful establishment of science-based stakeholder dialogue in countries with a similar political background or institution instability history. Maybe it would be possible to develop some incentive to stimulate the same person's participation or, at least, the same group of people of each institution. Also, a strategy to deal with this problem could be to guarantee that all sectors or institutions are well represented, even if not by the same person, and make a clear distinction between personal opinions and sector stances.

Finally, even with the dissemination and comprehensive communication that the initial legal benchmark for the application of Article 68 rule should be the 1965 Brazilian Forest Act due to the lack of accurate spatial data of native vegetation distribution for previous dates, São Paulo State Court decided to use the 1934 Forest Act as the initial point. The fact that even the scientific knowledge co-produced by the process of science-based stakeholder dialogue can be overlooked by decision-makers shows that there are limits for the success of the participatory process in the approximation of science and practice.

We believe that we had gone as far as possible in the process of co-production within the actual Brazilian political and social context (Escobar 2019). Other countries where governments are unsympathetic to science generally or, more specifically, environmental subjects can come across with the same barrier. Thus, even if the science-based stakeholder dialogue process is acknowledged as an efficient way of bridging the science-practice gap (Welp et al. 2006) we still need to ensure that science is not silenced by political arguments and find ways to overcome the fact that, frequently, political interests speak louder than scientific facts (Ripple et al. 2019).

## CONCLUSION

The project was the first dialogue space established in São Paulo State to assist with the FC implementation, a contentious theme with stakeholders with conflicting stances. We were able to reduce the gap between science and practice, meeting stakeholders' expectations and increasing the accessibility of scientific information.

Our experience showed that a science-based stakeholder dialogue could help to minimise disputes among sectors. The embracement of multiple research possibilities, keeping a flexible research agenda, and being transparent about methodologies and data used in the research process are some points that can enhance the chances of a successful science-based dialogue

We also come across challenges that can limit the reach of participatory processes in general and, more specifically, a science-based stakeholder dialogue process in designing and implementing environmental policies. Political changes, institutional instability, and the influence of higher instances of power are some external factors that can dictate how far the outcomes of a science-based dialogue can go. Further, without the engagement of higher decision-making instances, or if strong political interests influence them, the use of the knowledge produced through the science-based dialogue process may be doubtful in the final legal decisions.

Lastly, researchers need to make an extra effort to avoid falling into the traditional ways of doing science and learning about the process of policy-making. Frequently, scientists are not trained in the policy field, and working on this interface may present a real challenge for those who venture on this path.

Our findings can also help future science-based stakeholder dialogue projects on the process of knowledge co-production and pave the way for its conversion in policy actions.

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### Author contribution statement

ADB: conception or design of the work: data collection, data analysis, drafting of manuscript; critical revision of manuscript, final approval of the version to be published

KM: conception or design of the work, data collection, data analysis; critical revision of manuscript, final approval of the version to be published.

PAT: conception or design of the work, final approval of the version to be published.

JPM: conception or design of the work, critical revision of manuscript, final approval of the version to be published.

RRR: conception or design of the work; critical revision of manuscript, final approval of the version to be published.

PGM: critical revision of manuscript, final approval of the version to be published.

LFGP: critical revision of manuscript, final approval of the version to be published.

CAJ: Critical revision of manuscript, final approval of the version to be published

JFAF: critical revision of manuscript, final approval of the version to be published.

FSM: critical revision of manuscript, final approval of the version to be published.

ET: critical revision of manuscript, final approval of the version to be published.

GS: conception or design of the work; critical revision of manuscript, final approval of the version to be published.

## Declaration of competing/conflicting interests

The authors declare no competing interests in the conduct of this research.

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## Data availability

Details about methods and additional data are available in the Supplementary Information.

Link to supplementary material: https://bit.ly/3uAxpoZ

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