PLOS SUSTAINABILITY AND TRANSFORMATION

OPINION

Science journalism and a multi-directional science-policy-society dialogue are needed to foster public awareness for biodiversity and its conservation

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Abstract

Biodiversity is the manifestation of life on our planet and provides manifold benefits for humans. Yet we destroy ecosystems and drive species to extinction. We submit that anthropogenic biodiversity loss does not yet receive sufficient public attention, although biodiversity conservation and its sustainable use are key to mitigate global crises. Effective communication of biodiversity-related knowledge with diverse audiences is therefore crucial and should contribute to ensuring that evidence guides environmental decision-making. In this context, it is essential to stimulate multi-directional dialogues between science, policy, and society. Here, we suggest Dos and Don'ts that can guide science communication for scientists working in biodiversity research and beyond. Moreover, we emphasize the role of science journalism and other institutions specialized in science communication in critically mediating the complexity of scientific knowledge.

Introduction

Science communication provides a link between scientific and non-scientific actors. It is often understood and practiced as a one-way knowledge transfer, which however should not be. Instead, we should understand science communication as complex interactions between science, media, policy and the public, as well as their respective and heterogenous institutions with multi-directional communications.

Political decision-making heavily relies on scientific expertise and communication skills. Scientists are therefore expected to communicate and discuss their research findings in a fully comprehensive and understandable way. Not only politicians and media but also the wider public should be able to understand how scientists come to their assessments and conclusions. Based on those, scientists are increasingly expected to provide evidence-based knowledge and develop policy options to pressing societal problems. Especially in times of 'fake news', conspiracy theories, and the rise of generative artificial intelligence, scientists play a major role in helping to ensure policy discussions are informed by science and facts [1–3]. At the same time, scientists are increasingly being forced to speak powerful [4], and to do so at times conceal uncertainties rather than using those as starting point for discussing how to deal with them [5,6].

In climate change, science communication is often based on comparatively simple parameters such as temperature or CO_2 levels, which can explain almost the whole plot. Science communication in the context of biodiversity, conversely, faces the particular challenge that biodiversity itself is a highly multifaceted and complex field of study. Biodiversity is the diversity within species, between species and of ecosystems [7] and therefore cannot be reduced to a single number [8]. Biodiversity-related science communication is similarly complex, however the importance of biodiversity for society is often framed in over-simplified or unrealistic narratives. For example, the extinction of bees would not lead to completely empty supermarket shelves, as not all crop species are completely dependent on pollinating insects [9] and many insects other than bees pollinate crops [10]. Pictures of hand pollination in China may reflect reality in certain regions, but we know of no original peer-reviewed study showing that this is only related to pesticide use (the shortcut storyline in media: pesticide spraying, dying bees, and hand pollinating humans). Also, there is no evidence supporting the often-used quote "If the bee disappears from the surface of the Earth, man would have no more than four years left to live." Notwithstanding such exaggerations, imminent threats to biodiversity exist and scientists must not fail to convey both the complexity of biodiversity and its importance for planetary health and human wellbeing.

Compared to climate change, biodiversity has been neglected in media discourses about global environmental crises since 1992 [11]. The IPBES Global Assessment from 2019 set a milestone in outreach and media coverage to the biodiversity crisis [12]. On Twitter/X, for example, the biodiversity-related term "conservation" increased by 61% in 2020 compared to 2019 [13]. Also the COVID-19 pandemic and the subsequent IPBES Pandemics Report led to increased publicity of biodiversity and its links with other environmental crises [12]. This is because COVID-19 likely originates from a transmission from a wild animal species to humans, and the IPBES Pandemics Report points to such scientific connections between COVID-19, biodiversity and human activities [14]. The report's media uptake in connection with COVID-19 reporting led to increased publicity about the links between biodiversity loss and zoonoses, and thereby also about biodiversity itself. Lately, it is our impression that the negotiations related to the Kunming-Montreal Global Biodiversity Framework in late 2022 have temporarily increased attention to biodiversity.

We need to keep up this momentum for biodiversity by highlighting how biodiversity research and its communication can contribute to ongoing sustainable development discourses. Science journalism, institutions specialized in science communication (e.g., science media centers), as well as public relations and outreach departments of research institutions can play a key role in critically mediating the complexity of scientific knowledge and in supporting scientists in their communication.

Here, drawing upon our experiences as biodiversity researchers and science communicators (i.e., experts in the biodiversity science-policy-society interface, experienced participants

in radio and television interviews, round tables or talk shows, youth communicators, and science journalists; see S1 Text for author biographies) we identify challenges researchers can face in science communication. Further, we present "Dos and Don'ts" that can guide scientists working in biodiversity research and deciding to engage in science communication to do so. We use original data to assess their worldwide applicability and to help shape the Dos and Don'ts' discussion as a roadmap for biodiversity-related science communication. For the purpose of this paper, we define science communication as the communication and exchange of scientific ideas, research, findings, and knowledge in a way that is accessible, understandable, or useful to and with non-expert audiences (see S2 Text for a glossary of terminologies used in this paper).

Challenges in biodiversity-related science communication

Biodiversity has a range of special challenges with regard to science communication. First, for example, biodiversity conservation has a long history of colonialism, exacerbated by having little money for nature conservation in the Global South [15]. This should be kept in mind, and researchers from the Global South should be especially supported in science communication. Second, the naming of species is often socially or politically motivated [16], calling for special attention in science communication. For example, a horse fly is named after the American artist Beyoncé (i.e., *Scaptia beyonceae*) and a parasitic wasp received the name of a German politician (i.e., *Aphanogmus kretschmanni*). Such naming of species is generated to gain media attention and to foster science-policy-society dialogues. Even more, scientists can use this to engage with the public to learn about biodiversity and value it, and to objectify debates, inform about challenges in biodiversity research and show opportunities of scientific developments [17–19]. The question remains if such forms of science communication are socially fair [16,20,21]. Third, and as a challenge not limited to biodiversity-related science communication, the public "doesn't speak data" [22]. Just as researchers are experts in their field of studies, politicians and people from the public are experts in their domains and are used to the language of those. The language needed for communication with the public therefore is plain, inclusive, and accessible to a diversity of people [23] with different cultural backgrounds and different scientific and media literacy [24].

Similar to this multitude of backgrounds that needs to be considered for effective science communication, there is a huge diversity of communication channels to interact with society. Online media channels are at the front of mass media [25,26]. In particular, scientists increasingly discover the functionalities and options social media offers [27]. However, many researchers do not know their opportunities [28] or do not have the capacity to comprehensively handle multiple social media channels [27]. Some might not even know about the wealth of social media channels available, about the target audience they might reach with different social media channels, or about how they are used successfully. This, however, is particularly important, because for biodiversity-related science communication, different social media channels are used to different degrees around the world (Fig 1).

Irrespective of the communication channel selected for outreach, the key to a wide and attentive audience is story telling [23]. The public is interested in topics that connect to their lives, to individual interests (e.g., prominent people), or because of public discourses. For the latter, different topics work differently well [11] and remain in discourse only as long as they are of concern (e.g., sensations or disasters).

The role of science journalism in biodiversity-related communication

Most scientists across the globe are not specifically trained to communicate [24,29] but to conduct research in their specific scientific discipline and to publish their findings in the scientific

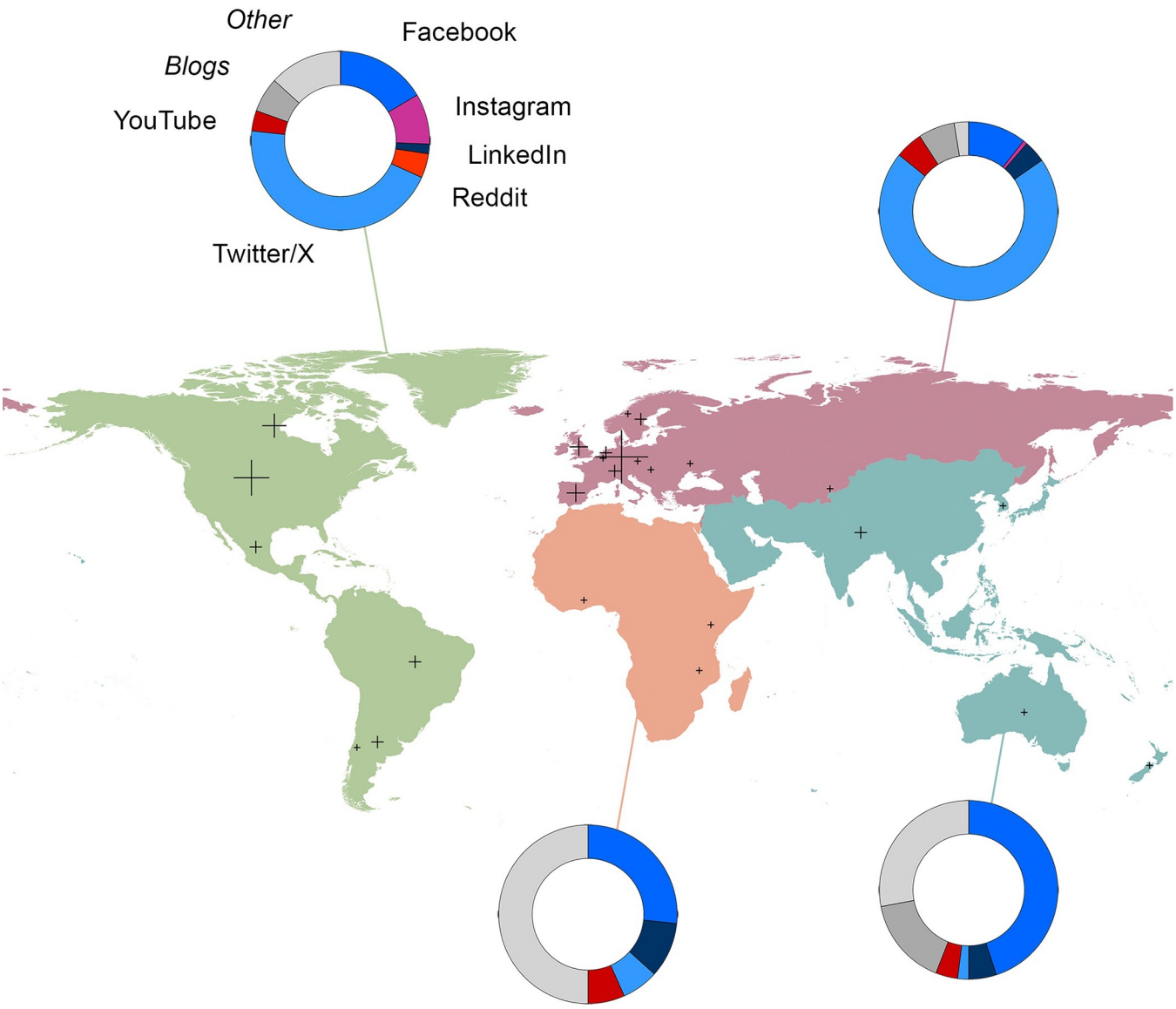

Fig 1. World map with donut charts of perceived patterns in social media use as reported by IPBES authors that responded to a survey on biodiversity-related science communication. Illustrated per IPBES region: the Americas (top left), Europe and Central Asia (top right), Africa (bottom left), Asia and the Pacific (bottom right). Social media channels in the donut charts from the top center to right: Facebook, Instagram, LinkedIn, Reddit, Twitter/X, YouTube, Blogs and Other (i.e. ResearchGate, email, WhatsApp, Telegram, KakaoTalk). The cross size in the world map indicates the number of responses per country, given by scientists engaged in IPBES; n = 17 (the Americas) / 27 (Europe and Central Asia) / 3 (Africa) / 5 (Asia and the Pacific). The IPBES region map layer is openly available from the IPBES Technical Support Unit on Knowledge and Data [43].

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literature. They are not experts in public communication and do not necessarily speak a widely accessible language, in which they would need to be trained [18,24]. However, we argue that scientists, working on questions related to biodiversity or not, should not be pressured into becoming communication experts but should be allowed to focus on conducting and explaining their research and to pass on the communication to colleagues or journalists.

Biodiversity researchers work on complex questions and matters of concern. The answers they find and which they are expected to give are similarly complex. Often, a highly simplified way of wording an answer would simply be wrong or might not be able to cover the whole scientific meaning of the answer. Hence, in a best-practice case, a scientist works closely together

with a trained communicator, likely a journalist, to simplify the language used while being clear about the complexity of biodiversity research and the interpretation of research findings.

Science journalists can support scientists and evoke emotions, as they are press and public relation specialists with a unique perspective on hot topics, experience of when and how an issue can be positioned in the media, and knowledge of the challenges scientists can face with effective science communication [24,30]. At the same time, science journalism (if not politically suppressed or censored itself) can protect scientists from societal, political, and medial pressure by offering joint-communication events or writing in which scientists explain their research and the journalists provide the interpretation for potential implementation. It is not a one-way broadcast service that science can or should use to be heard but it responds to scientific needs and can assist in identifying what–and especially how–the public wants to know. It is important that scientists are aware of when, where, and why their topic is socially relevant and what language the target audience expects from scientists. Here, science journalists can build the bridge by taking into account essential communication criteria, such as competence, integrity, and public welfare orientation [31].

An important difference to make is between science-public relations and outreach departments of research institutions and science journalists working for independent media. The latter can select their topics of interest, whereas science-public relation communicators typically promote research findings and increase media coverage of their institution. While some institutions use journalism by press release–and a high-quality press release surely has its value–other institutions have science journalists doing investigation and interpretive work. We therefore need to acknowledge that there is much variation in the veracity, independence, and bias of media outlets.

Nevertheless, in general, science journalism has the function of reporting independently, credibly, and competently on scientific content, transforming research findings into well readable stories, and integrating science-related topics into socially relevant discourses [32]. Vice versa, it also expresses the public's expectations towards science. So, for the science communication of biodiversity researchers, science journalists trained to communicate biodiversity research always should be one of the first instances to approach for transferring research findings having implications for policy or society.

Suggesting Dos and Don'ts for biodiversity-related science communication

To give biodiversity and its complexity a stronger voice, we, the authors of this article, first compiled a collection of Dos and Don'ts for biodiversity-related science communication (Box 1), complementing available recommendations [see, e.g., 19,23,33–38].

Box 1. Non-exhaustive list of potential Dos and Don'ts for biodiversity-related science communication.

Their applicability may vary throughout the different world regions (see main text).

Do . . .

1. **Do create a fact-based story:** People do not remember plain-spoken biodiversity research findings but a fact-based story. Before you talk to your audience, make sure you know what narrative you are going to tell, but try focusing on science and facts. For outreach to the wider public, consider collaborating with science

journalists to shape a compelling story. The most important elements here are the portrayal of conflict(s) and protagonist(s). Which are they in your case? It can be about the hardship of getting data, the personal fight for an endangered species, or the unlikely heroism of a community that protects an ecosystem against all odds. Try different narratives and ways of communication and evaluate what works best for you and your story.

2. **Do use target audience language:** Carefully study the audience you want to reach and adopt your language accordingly. Most audiences do not care about the nitty-gritty of your biodiversity research, and most communication formats do not allow for details; only sometimes a quick glimpse on genuine science and details on methods may still be helpful. Aim to link your research findings to your audience's lived experience to make it real for them.
3. **Do put key findings first:** Similar to the abstract of a paper, an audience wants to hear/see/read the biodiversity-related headline straight away, so they can decide whether to continue with the details or not. Details of research methods and caveats should come later. For effective, memorable communication, hit them with the top line. You can also repeat this later, once you've explained how you got there. If possible, use examples of your own research to illustrate your key messages.
4. **Do prepare take-home messages:** Clear, easy to understand and consistent take-home message(s) help a lot to convey your scientific information. Practice saying them. Learn them or have them in front of you, to help you get them clearly across.
5. **Do clarify your expertise and limits of knowledge:** Specify your expertise and indicate when you are leaving your core area of biodiversity research. Address uncertainties and the limits of your biodiversity-related knowledge. Also, in the broader sense, you can point out the limits of understanding–stating what science does not know might just be as important as what it does, especially in the field of biodiversity where there are still huge gaps in our understanding of the natural world.
6. **Do listen to your audience and enter into a dialogue:** Take your audience seriously, explaining why you think some of their biodiversity conservation concerns are justified or not. Communicate in a dialogue with your audience, actively listening and responding to your core target audience. Manage emerging discussions with individuals so that you do not spend too much time discussing individual opinions.
7. **Do find new audiences:** Communicate with new audiences and proactively approach new target groups interested or not yet interested in biodiversity, especially those with a high potential to act as multipliers. Although it is much harder to convey knowledge on a topic to a less informed and not already convinced audience, which needs additional preparation and specific approaches, too, this is especially rewarding.
8. **Do be yourself:** You can speak as a scientist and as someone personally affected by biodiversity loss at the same time as your audience is also interested in your personality. But it is important to clearly indicate what role you are in at any given

moment, what biodiversity research institution you are representing and what messages are based on your personal perspective. Explain how potential conflicts of interest affect your biodiversity research, teaching or policy interactions.

9. **Do prepare for criticism and to fight arguments of denialists:** It is easier to deal with criticism if you anticipate denial or criticism on your biodiversity-related topic beforehand and develop a strategy for dealing with it. Also, when you understand the thinking of denialists, you have a better chance make them rethinking.
10. **Do provide content-related links to other areas of concern:** Biodiversity cannot be separated from other planetary boundaries such as climate change, land use changes and pollution. Try to link your field of research to other fields of expertise and societal areas of concern.

Don't. . .

1. **Don't communicate when you are not keen on doing it:** Biodiversity-related science communication needs concentration, preparations, and enthusiasm. If you are not in the mood to communicate, think carefully about whether you do it yourself or whether you can pass it on to a colleague.
2. **Don't wait to answer if you are keen on doing it:** Media requests for interviews or talk invitations about biodiversity research are usually time-bound, so the window of opportunity to reach a new and/or large audience may close quickly.
3. **Don't take every opportunity:** Only select opportunities if they suit to convey your biodiversity-related messages (e.g. regarding nature conservation), and pass others to your colleagues. It is important for the public to know different experts for different aspects. Therefore, recommend colleagues if you think they have more time or expertise for the specific request.
4. **Don't leave your area of knowledge:** Do not communicate if you are not prepared or sure, or if e.g. journalists try to get a biodiversity research message that is not yours. Focus on your evidence-based information and stop or withdraw quotes of yours if you feel uncomfortable with the situation or outcome.
5. **Don't make statements you cannot prove:** Avoid political or private statements that are not backed up by scientific evidence. When addressing societal or political relevant issues, but the evidence is inconclusive, make sure you clearly state that it is your private opinion, for example by saying "when you ask me as a private person. . .". Be extra careful with communicating new scientific findings that are not (yet) well supported by evidence, especially if they contradict with accepted knowledge, in order not to distort the agreed knowledge base.
6. **Don't always use technical terms:** Avoid technical terms and abbreviations related to biodiversity for a general audience, and only use them if they are key terms in your research area. For example, "biodiversity" is fine for an audience that is used to listening to scientists but a brief explanation when first mentioning the term still helps. "Number of species" is a term that everyone understands but make sure you refer to species only and not to other biodiversity aspects (genes and ecosystems).

7. **Don't overload with details:** Of course, the scientific findings and general notion have to be right but if that is the case, do not spam your audience with too many details. Biodiversity research is complex, but only select the most important information and have courage for some simplification of your message. You can also look for specific formats allowing for more insights if you want to bring them to an audience. Remember that you are not talking to your colleagues but an audience in which some might have never heard of your field of research.
8. **Don't forget to have fun:** When you communicate with a broader audience, remember that it is not just to share some biodiversity data. It is about telling a fact-based story, infecting others with your passion and making them understand your messages. Do not be afraid to talk about passion, pain, fun, and devotion–with genuine emotions, information will stick much longer.
9. **Don't blame others for miscommunication:** Media builds its–and not necessarily your–biodiversity-related stories around your quotes. In case of an interview, before doing it, ask if it will be possible to review the final product before publication to check your quotes (this is not always possible). If a quote other than yours is published, take it as it is or express your opinion, for example, in your social media account(s) or on your university website.

We then wanted to have this collection of Dos and Don'ts evaluated by IPBES authors, assuming that they are aware of the importance of effective biodiversity-related science communication and that they have relevant experience. As both the IPBES Secretariat and the IPBES assessments' Technical Support Units were not able to provide mailing lists due to data security reasons, we took the author lists from openly available IPBES assessment documents to compile an overview of who contributed to which IPBES assessment. Starting with those authors that contributed to at least two IPBES assessments, we manually searched for their email addresses on the internet. In the end, we compiled an email list of 447 IPBES authors, from which 129 email addresses did not work anymore. Thus, the final outreach size for the survey was 318 IPBES authors. The survey was open for participation for a two-week period, after which one reminder email with an additional extension period of one week was sent. To expand the range of views we had already received, we asked the IPBES authors to share the survey with colleagues and friends with experience on biodiversity-related science communication. In the end, 130 people participated in the survey, with a total of 108 completed survey forms (response rate of 34%), of which 35 said they are not actively doing biodiversity-related science communication. The evaluation results are therefore based on the statements of 73 responses. It is important to note that the findings of the survey therefore may not be representative of the broader biodiversity science community. Further details on the methods and results of the evaluation survey are provided in S3 Text.

As predominantly being IPBES authors (60 of the 73), the survey respondents come from all around the world (see S1 Fig, S1 Table and S2 Table), representing diversity and giving an impression of how the Dos and Don'ts could be perceived outside of our Western European group of authors. Further, they have proven expertise in different fields of biodiversity research and are also addressees of our Dos and Don'ts. As only a few representatives for each country are selected for an engagement in an IPBES assessment, all IPBES authors likely have multiple experiences with science communication of different formats. In regard of concrete

communication expertise, as the evaluation survey was filled out anonymously, we can just state that we, the authors of this article, have some to substantial experiences in giving interviews in a variety of formats, ranging from blog entries and newsletter articles to TV talk shows, and some of us are active by using multiple social media formats. We assumed the use of different social media channels might differ between cultures and therefore across countries.

From the survey respondents, around 70% had strong experience (at least five years) in biodiversity-related science communication (see S2 Fig). While their evaluation may not represent the overall biodiversity-related science community, their science communication habits could still serve as a model for others.

The variation of the respondents' agreement with our Dos and Don'ts throughout the different world regions (see S3 Fig) offers a first impression of the complexity of biodiversity-related science communication and indicates that a use of the Dos and Don'ts as guidance remains highly context specific. A follow-up communication study to examine the global applicability of the Dos and Don'ts and a possible revision of them could be conducted. Therefore, the Dos and Don'ts are not exhaustive but meant to stimulate awareness and further discussion around robust science communication:

Presenting scientific findings with a good narrative and providing your audience with an emotional and enthralling story based on scientific evidence can be a game changer. Strong metaphors [39] or outlining personally relevant benefits [33] may help, too. Use your audience's (main) language. If you have different audiences, adopt your language to each of them. Do not use agitative and persuasive language but convince with scientific evidence and clear explanation of these facts, their context of research and their implications. As outlined above, science journalists can play a gatekeeping role [36] and critically help you in effectively and credibly addressing different audiences.

Carefully select your position on the gradient from a "researcher who informs" to a "science communicator who persuades" [34]. Communicate the level of existing evidence and missing knowledge and choose a level of presentation detail suitable for your audience–in particular if you decide to position yourself as an "honest broker" [34]. While a certain level of simplification may help convey your message, you may also want to focus on a specific detail [e.g., a specific species' loss projection, 33]. Whatever level of detail you choose, stay with the reality of science. For example, misleading narratives like the one from Bastin et al. [40] that restoring the entire land area of the world with trees would save us from climate change may create political and public awareness in the short-term, but their long-term communicative impact on policy and the implementation of biodiversity-friendly restoration is difficult to predict. Several scientific flaws have been brought up in regard of their analysis (see, e.g., box 3.1–1 in [41]), and it has to be acknowledged that Bastin et al. responded to address those [42]. Scholarly discussions and corrective assessments of the factual situation such as this one should be widely transferred to the media, and it should be highlighted to the public that scientific knowledge can advance over time.

To effectively transfer your message, be convinced of it yourself. Being enthusiastic and creating a positive notion makes your audience believe in you and your message. If you do not want to communicate or have no time, pass the opportunity on to a colleague. Last but not least, if someone fully intends to misrepresent what you have said, seek to correct such misrepresentations on a content-related and not on a personal level [33,38].

During the evaluation of the Dos and Don'ts, we also asked about the respondents' use of social media channels (see Fig 1). Twitter/X is the most used channel in Europe and Central Asia and in the Americas, while Facebook is most used in Asia and the Pacific and in Africa. Instagram is most used in the Americas. Based on our survey, Reddit is solely used in the

Americas. YouTube is globally used in an equal manner. Other channels frequently used are ResearchGate, emails and messaging services such as WhatsApp, Telegram, and KakaoTalk.

This indicates scientists should carefully decide which channel(s) to choose for promoting their topics throughout the different world regions, provided that the various channels are freely available and uncensored in their world region and country. The same applies for TikTok, which is also used for science communication by some but was not yet a well-known social media channel when we conducted our survey. It reaffirms, though: Scientists need to become flexible and audience-oriented in their communication. As we assume this will distract them more and more from their research, digital content creation and social media coordination are additional capacity needs of future science labs.

Science journalism and a multi-directional science-policy-society dialogue are needed to foster public awareness for biodiversity and its conservation

To strengthen the role of biodiversity in public discourses and political decision-making, biodiversity scientists need to build trust with their audiences. Scientists should carefully listen how non-scientific actors communicate their biodiversity-related ideas and knowledge, entering an appreciating dialogue. Joint efforts, such as interviews, panel discussions, and (interactive) social media campaigns including various experts from different fields of study, and, where applicable, actors from civil society, can create and empower a new form of environmental journalism. Scientists should be empowered to focus on the communication of their research field's facts and findings; science journalists should be available to broaden the readership, present scientific knowledge in an accessible way and strengthen the outreach impact. Strong cooperation between scientists from different disciplines and well-trained science journalists is crucial to discuss and perform science communication.

Research ethics

The figures presented are the result of a survey involving human subjects. There was no local research ethics committee that could have approved the proposed survey. Nevertheless, we worked hard to ensure that the rights of participants were respected during the survey participation and whole analysis process. The survey, which is provided as part of the supplementary information, was accompanied by a short introductory text outlining the survey cause and stating that there is no personal data collected. We did offer the submission of email addresses to receive the published survey results, this was however done through an external survey so that we could not link the addresses to any of the anyhow anonymous survey responses. Accordingly, as i. the participation was fully voluntary, ii. no personal data was collected, and iii. the separately collected email addresses could not be linked to responses, it did not appear necessary to seek an extra consent in writing. The participation in the survey was accepted as consent.

In response to the survey, we received messages entering a discussion about our proposed Dos and Don'ts in biodiversity-related science communication, which was and is the one of the aims of the paper.

Supporting information

S1 Text. Author biographies.
(PDF)

S2 Text. Glossary of terminologies.
(PDF)

S3 Text. Survey details, including the survey, software, data and code, and results.
(PDF)

S1 Table. Number of responses per country.
(PDF)

S2 Table. Number of responses per IPBES region.
(PDF)

S3 Table. Proportionate use of social media channels per IPBES region.
(PDF)

S1 Fig. Global response distribution per country and IPBES region.
(PDF)

S2 Fig. Number of responses (from a total of 73) doing biodiversity-related science communication in social media for less than a year, 1 to 5 years, 6 to 7 years or longar than 10 years.
(PDF)

S3 Fig. Rating of Dos and Don'ts for biodiversity-related science communication, with perspective from a) the Americas (n = 25), b) Central and Western Europe (n = 36), c) Africa (n = 6), d) Asia and the Pacific (n = 6), and e) globally, i.e. the IPBES regions altogether (n = 73).
(PDF)

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