EDITORIAL

Journal of Vegetation Science IAVS

Towards more reproducibility in vegetation research

1 | REPRODUCIBILITY OF VEGETATION RESEARCH

1.1 | Sharing data and code: The key to research reproducibility

Computational reproducibility is the ability to obtain consistent results using the same input data, computational steps, methods, and code from a previous study (Goodman et al., 2016; Ziemann et al., 2023). It plays an important role in science because it: (1) ensures the credibility of scientific results; (2) improves the understanding of complex analytical workflows; (3) promotes knowledge sharing; and (4) allows the saving of research funds (Alston & Rick, 2021). In vegetation science, as in other natural sciences, standards for the computational reproducibility of analyses (hereafter referred to as "reproducibility") have increased recently, driven in part by the widespread digitization of data and literature. The open sharing of data and code (the full source computer code used to generate research results) through repositories is a crucial step in promoting reproducibility, collaboration and scientific progress. In practice, however, reproducibility can be a challenge for researchers because it involves ensuring the permanent accessibility of data and code in repositories, creating sufficient descriptive metadata, providing unambiguous identifiers (e.g., Digital Object Identifiers, DOIs) and a versioning system (Sandve et al., 2013; Powers & Hampton, 2019; Jenkins et al., 2023). Another important aspect is that code needs to be thoroughly commented, documented and generalizable so that it can not only be reproduced but also extended to other contexts such as different study areas or groups of organisms.

The International Association for Vegetation Science (IAVS) strives to improve the reproducibility and transparency of its publications. In 2019, a "Data Availability Statement" was introduced as a mandatory section in the *Journal of Vegetation Science* (JVS) and *Applied Vegetation Science* (AVS). The new policy follows Wiley's "Mandates Data Sharing" line, which states that "it is required, as a condition for publication, that the data supporting the results in the paper will be securely archived in a public repository with DOI or in electronic Supplementary Information related to the paper. Whenever possible, the program source code, scripts and other artefacts used to generate the analyses presented in the paper should also be publicly archived" (quoted from the JVS and AVS Author Guidelines in November 2023). Here, we examine how data and code are shared in JVS and AVS and whether there is an increasing trend over time.

1.2 | Methods

We looked at articles published in JVS and AVS to assess the level of data and code availability achieved. Specifically, we scanned all issues of the two journals published in the last 10 years (from January 2013 to October 2023), which resulted in a total of 1,902 articles (1,184 from JVS and 718 from AVS). Commentaries and obituaries were excluded from the analysis. For each article, we evaluated, separately for data and code, whether these were:

1. Available: authors stated that data/code were made available and provided a link, either to the supplementary material or to an external repository
2. Accessible: the link worked, and the data/code could be downloaded and opened.

For data/code that was available but not accessible, we recorded whether this was because of a broken link, a private repository or other reasons.

Our working definition of data was limited to the numerical or categorical information necessary to reproduce at least the main analyses (and results) presented in the article, and thus included either raw data or derived data used as a starting point of the respective analysis. The latter category has limitations in terms of reproducibility, but in practice, it has proved difficult to separate raw data from derived data because there is a continuum between them.

1.3 | Patterns in the availability of data and code

The percentage of articles (standardized by the total number of articles published per year) with available data ranged from 1.5% in 2014 (AVS) to 82.3% in 2022 (JVS). The percentage of articles with available code ranged from 0% in 2013 (AVS) to 26.3% in 2023 (JVS). Both journals showed a steep increase in data availability from 2019 onwards. In comparison, the percentage of code available has increased only moderately since 2019. The differences between the journals showed that JVS had a slightly higher

proportion of articles with available data than AVS in all years except 2015–2017 (Figure 1). Similarly, the proportion of articles with available code was slightly higher in JVS than in AVS in almost all years (Figure 1). The data for 2023 (to mid-October) revealed an overall drop in the availability of code and data (except for code in JVS).

Overall, accessibility was quite high (Table 1), with 26.5% of the available data also being accessible (25.8% for JVS and 27.6 for AVS) and 8.5% of the available code also being accessible (9.6% for JVS and 6.5 for AVS). For articles with available but inaccessible data, this was mostly due to the link to the data being broken (52.9% of cases), although the use of private repositories was also a common cause (35.3% of cases). For code, the most frequent reason for inaccessible code was a broken link (69.2%), whereas the use of private repositories was much less common (7.7%).

Our analysis shows a remarkable increase in the availability of data and a much slower increase in code availability since 2019. The trend was particularly strong for data sharing, which experienced a much steeper increase (JVS: from an average of 8 articles with available data in the period 2015–2018 to 67.5 in the period 2020–2023; AVS: 6.5 to 46 articles) than code (JVS: from an average of 6.75 articles with available code in the period 2015–2018 to 16.8 in the period 2020–2023; AVS: 1.25 to 9.5 articles). The slower increase in code availability could be because: (1) data analysis is often not code-based, but rather relies on the use of point-and-click software; (2) less-strict rules of the journals, which make data sharing mandatory, but encourage code sharing only "whenever possible"; (3) authors

being more familiar with data-sharing than code-sharing practices; and (4) data sharing being less time-consuming than code sharing, which typically requires time to clean up, annotate and organize scripts. In addition, there may be other barriers to archiving code, such as uncertainty about how to prepare code for sharing, complexity of workflow, fear that revealing the details of data management and analysis might cause others to spot inaccuracies or errors, or embarrassment due to perceived lack of style in code writing, for which Gomes et al. (2022) discuss possible solutions.

1.4 | A way forward

The steep increase in data archiving that we have highlighted in our analysis represents a commendable effort towards improving reproducibility. Yet, this should not stop us from striving for further improvements, especially in terms of code sharing. One way to achieve this is to provide more information and training on data- and code-sharing practices. There are convenient options for making data and code repositories permanent, accessible and unambiguously identifiable (through DOI), and several of these options are free.

Advocating the open sharing of scientific data and code via repositories is a pragmatic choice. It facilitates research efficiency by encouraging collaboration among researchers. The commitment to transparency is a practical step towards more reproducibility in the future. However, there are also issues of governance, protection
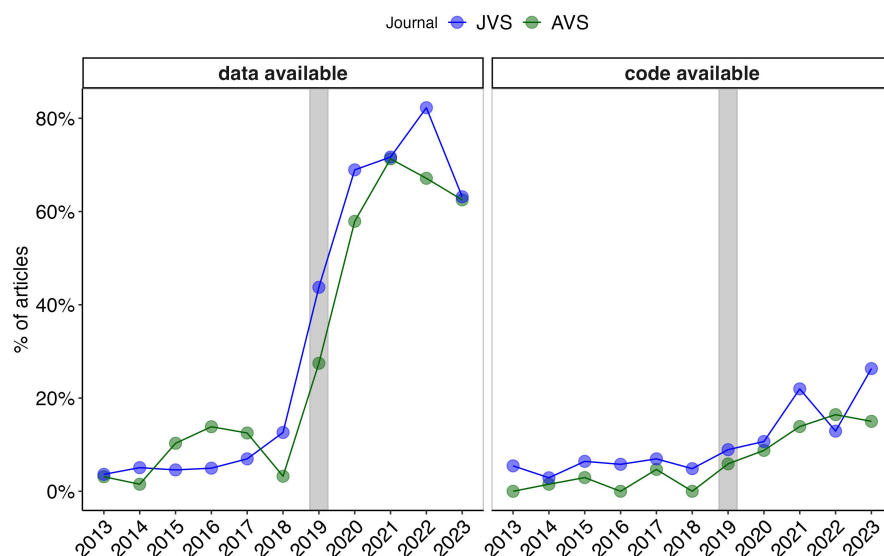

FIGURE 1 Temporal trend in the percentage of articles published in the *Journal of Vegetation Science* (JVS) and *Applied Vegetation Science* (AVS) with data (left) or code (right) made available by the authors. The gray band highlights 2019, the year in which a mandatory Data Availability Statement was introduced.

TABLE 1 Availability and accessibility of data and code for the two journals (across all considered years).

	Total no. of articles examined	Articles with data available (%)	Articles with data available and accessible (%)	Articles with code available (%)	Articles with code available and accessible (%)
JVS	1,184	30.6	25.8	9.6	8.9
AVS	718	31.6	27.6	6.5	6.0

of local community knowledge and restrictions on third-party data sharing, as well as equity in data use that should be considered and respected by authors and editors (Lima et al., 2022).

2 | EDITORS' AWARD

The Editors' Award for the year 2023 goes to Gabriel Massaine Moulatlet for the article "Global patterns of phylogenetic beta-diversity components in angiosperms" (Moulatlet et al., 2023). This article does not deal with plant communities in the strict sense but provides a macroecological analysis of a large number of plant species, a topic that is also within the scope of the *Journal of Vegetation Science*, as shown in the recent Special Issue Macroecology of Vegetation (Pärtel et al., 2022). Moulatlet and co-authors compiled distribution range maps for 207,146 species of angiosperms and conducted the first global assessment of phylogenetic beta-diversity (PBD) patterns for this group. They decomposed PBD into turnover and nestedness components and found that in most areas, lineage replacement was more important than lineage loss. However, the importance of lineage loss (nestedness) increased at higher latitudes, at higher elevations and on islands and peninsulas. They also compared taxonomic beta-diversity with PBD and showed that species exchanges were more important overall than lineage exchanges and that the importance of species exchanges relative to lineage exchanges even increased toward higher latitudes and low-temperature areas. This study demonstrates that global PBD patterns in angiosperms are related to geographic and environmental gradients and reflect evolutionary and biogeographic history.

Other notable articles considered as Award candidates by the Chief Editors or Associate Editors were Delalandre et al. (2023) and Alessi et al. (2023). Léo Delalandre and his co-authors compared the change in plant traits in response to management intensification between two groups of plants with different life histories: annuals and perennials occurring in the same plant community of Mediterranean rangeland. They found that each of these groups responded differently to the management intensification gradient for some plant traits. These results suggest that plant groups with different life histories should not be blindly grouped in studies of trait–environment relationships; otherwise, we might neglect important information about differential responses in different components of a plant community.

Nicola Alessi and colleagues addressed a recurring methodological issue in vegetation science: the effects of probabilistic vs preferential sampling on analytical results. They compared two large data sets of forest vegetation plots sampled across Italy, one probabilistically and the other preferentially. They found that the analyses of the probabilistic data set were better in estimating species richness and diversity of plant communities, whereas the preferential approach was better suited to detect forest-specialist species and hotspots of plant diversity. The authors conclude that both approaches should be combined to achieve the best results.

3 | JOURNAL NEWS

New Associate Editors have joined the *Journal of Vegetation Science* in 2023: Arshad Ali (CN), Eric Lamb (CA), Luis Daniel Llambí (VE), Josep Padullés Cubino (ES), Sergey Rosbakh (DK), Julian Schrader (AU), Guilherme Seger (BR), Ole R. Vetaas (NO), Amanda Taylor (DE), Kerstin Wiegand (DE) and Sa Xiao (CN). We welcome these colleagues and thank the outgoing Associate Editors, Sándor Bartha (HU) and Alessandra Fidelis (BR), for their valuable contributions to the journal. We also express gratitude to the referees who dedicated their time to the journal in the past year (Appendix A).

AUTHOR CONTRIBUTIONS
Section 1 was prepared by the members of the Steering Committee of the IAVS Ecoinformatics Working Group (MGS, MBa, GML, SS and RAFdL) and MBo, who considered the comments of the JVS Chief Editors (VP, JP, VW and MC). The text of this section represents the opinion of the JVS Chief Editors. Sections 2 and 3 were written by the JVS Chief Editors.

DATA AVAILABILITY STATEMENT
Data and R code to reproduce the main stats and the plot in Figure 1 are available at https://doi.org/10.5281/zenodo.10305789.

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APPENDIX A

LIST OF REFEREES

We thank the referees who served the *Journal of Vegetation Science* from 1 December 2022 to 30 November 2023. Those who reviewed more than twice are indicated by asterisks.

Juan Alberti	Hans Beeckman	Richard Busing*
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Batbaatar Amgaa	Dana Blumenthal	Cesar Carvajal Hernández
Fabien Anthelme	Stephen Bonser	Lohengrin Cavieres
Joseph Antos	Kauane Bordin	Eduardo Chacon
Francisca Araújo	Gudrun Bornette	Stefano Chelli
Antonio Arroyo Martínez	Tanay Bose	Chengjin Chu
Giovanni Bacaro	Zoltán Botta-Dukát	Marcin Churski
Santiago Baeza	Hannah Brazeau	Kryštof Chytrý
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Andres Baselga	Julia Burton	Miquel De Cáceres

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Jürgen Dengler

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Mario Fariñas

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Hannes Feilhauer

Marcos Fernández-Martínez

Arianna Ferrara

Pavel Fibich

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Pieter Vangansbeke

Thomas Vanneste

Tony Verboom

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Jonathan von Oppen*

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BIng Wang

Xuyang Wang

Sophie Weides

William Weinberg

Pat Werner

Benjamin Wigley

Jan Wild

Scott Wilson

Sonja Wipf

Florian Wittmann

Thomas Wohlgemuth

Kerry Woods

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Sa Xiao

Jingyi Yang

Yin-Sun Yao

Alyssa Young

Truman Young

Hui Zhang

Zhigang Zhao

Shilu Zheng

Huakun Zhou

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