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Calling into the void? German *forest dieback 2.0* debate on Twitter. A case study to operationalize the analysis of discursive power in hybrid media systems

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ABSTRACT

Forest dieback 2.0 is the common term for describing climate change-related forest damages that sparked a nation-wide debate in Germany starting in 2018. Referring to the "first" *forest dieback* in the 1980s that inspired environmental movements and policy changes, raises questions concerning today's mobilization potential. Political communication has been profoundly transformed, mainly through the spread of digital media. To understand the current debate, it is thus crucial to consider the complex entanglements in hybrid media systems. We contribute to the operationalization of analyzing discursive power in hybrid media systems, through Twitter-actor-networks as well as tweet-hyperlink-networks, representing a communication space where older and newer media logics blend. Results suggest a scattered debate characterized by insulated communication networks of few central actors. Whereas forestry frames dominate *original tweets*, nature conservation frames are more likely to be *amplified* through retweets. Despite having largest number of followers, legacy media actors show low *centralities* in the Twitter-network. However, their influence must be seen in regard to the referred hyperlinks. Interactions between tweets and hyperlinks revealed different mechanisms for how frames are *introduced* and *amplified*. Besides mainly following the cleavage between forestry and nature conservationists, alternative frames instrumentalize forest damages to call for climate action or climate change skepticism. Despite these controversies and insulated communication, the *forest dieback 2.0* debate on Twitter does not appear to be *destructively* polarized. Nevertheless, further research needs to carefully examine the polarization potential. Due to the limited outreach, however, the Twitter debate largely seems like a calling into the void.

1. Introduction

Consecutive droughts and related bark beetle outbreaks have led to large scale forest damages in Germany since 2018 (BMEL, 2021). The situation, commonly framed as *forest dieback 2.0,* has sparked a nationwide controversy. This debate centers around the current state of German forests and their future management in the face of the effects of climate change. The urgency is highlighted as forests are not only depicted as victims of climate change, but also as an important factor in its mitigation.

While all actors in the media debate relate the recent damages to climate change, some also stress the impact of forest management practices having weakened the forest over the last decades. These different interpretations are especially reflected in discussions on solutions to the forest damage, and vary from actively adapting forests to climate change, to leaving the forests alone in order to recover from the stress of forest management. While a newspaper analysis indicates balanced reporting, it adheres to the dichotomy between active forest management and passive nature conservation frames (Mack et al., 2023).

Although research has highlighted the relevance of media and press releases in shaping this public debate (Mack et al., 2024, 2023), the increasing importance of social media in agenda setting (Gilardi et al., 2022) has been neglected so far. In order to address this research gap, we refer to the theoretical framework suggested by Jungherr et al. (2019, p. 412) to analyze "discursive power in contemporary media systems". The

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theoretical framework relies on the concept of the Hybrid Media System that describes contemporary media systems. Introduced by Andrew Chadwick (2017, 2013), the concept encompasses the complex dynamics and entanglements of old and new media logics, in which media actors, politics, as well as the public, interact in coevolving discourses. In this context, discursive power is defined as the actors' ability "to introduce, amplify and maintain topics, frames and speakers" (Jungherr et al., 2019, p. 409) within the limited attention space of today's political communication. In this context, digital media plays a crucial role, as it has transformed contemporary communication spaces into networks of publics, offering new possibilities to analyze linkages between different media forms (Bruns, 2023).

Despite the increase in social media research, to our knowledge, no forest-related studies have taken up the perspective of hybrid media systems. Forest-related research first and foremost analyzes the role of social media in the forestry sector's communication (Korhonen et al., 2016; Słupińska et al., 2022), forest-related debates (Caetano, 2021; Skill et al., 2021), risk communication (Mirza and Kusumasari, 2022; Unal Colak and Yllmaz, 2021), or how it is being used by activists to increase social mobilization (Calibeo and Hindmarsh, 2022; Gerosideris and Ferra, 2020; Karamichas, 2007). Furthermore, social media is also used as a methodological tool with regard to citizen science approaches for species monitoring (Daume, 2016; Daume et al., 2014; Daume and Galaz, 2016), as a communicative intervention to investigate deliberation in forest conflicts (Mäder et al., 2025), to explore visitor behavior and preferences (Ciesielski and Tkaczyk, 2023; Huertas Herrera et al., 2023; Lingua et al., 2022; Pellicer-Chenoll et al., 2023), and as human-nature relations (Breithut et al., 2021). Despite this increasing research attention towards social media, to our knowledge, only one study analyzes a social media debate on German forests with the very specific focus on the oak processionary moth (Daume and Füldner, 2016). The broader participation in public debates facilitated through digital media has remained hidden so far due to the lack of analyses. Based on the public relevance of the current debate on forests in Germany and its mobilization potential (Mack et al., 2023), taking the perspective of hybrid media systems appears crucial.

With our case study, we aim to contribute to the operationalization of analyzing discursive power in hybrid media systems in the case of controversies surrounding German forests. Our approach combines quantitative and qualitative methods to adhere to the contextual specifications and the network logics of contemporary communication. Due to the lack of existing research, an exploratory approach was necessary to make a first step towards the understanding of how forests are being discussed in hybrid media systems. We did so by conducting a network analysis of Twitter data with the referenced hyperlinks, which represents one potential blend between old and new media systems (cf. Chadwick, 2017; De Maeyer, 2013; Elgesem, 2019). By focusing on one critical discursive event (cf. van Eck and Feindt, 2022), namely the forest summit organized by the Ministry of Agriculture in September, 2019, we aim to respond the following research questions:

- How is discursive power of actors reflected through their *standing* and *centrality* in the Twitter network?
- How is discursive power reflected by the *introduction* and *amplification* of frames in the tweet-hyperlink-network of the debate on German forests?
- Which forms of interactions shape the hybrid communication of the tweet-hyperlink-network?
- What role do referenced hyperlinks play in informing the Twitter debate?

To understand the current controversies surrounding German forests and climate change, we first briefly introduce past developments to situate the current debate in its socio-historical context. In the second part, we present the tenets of discursive power in hybrid media systems as a theoretical framework to analyze the current controversies in the increasingly complex domain of political communication. After detailing our approach to analyze discursive power in contemporary media systems, we present our main findings. At the end, we discuss our findings with regard to the ongoing debate in different forms of political communication.

2. Background: Controversies around German forests

2.1. The current debate in its historical context

The German forestry system is traditionally described as integrative and multifunctional. Despite the holistic and integrative characteristics of forest management in Germany, its responsibility traditionally lies solely in the hands of the forestry sector (Borrass et al., 2017). According to the forestry sector's conviction, ecological and social functions of forests are provided in the wake of the economically oriented forest management for wood production (Borrass et al., 2017; Hölzl, 2010; Pistorius et al., 2012; von Detten, 2011). This understanding is institutionalized in the abstract, non-binding and contested concept of proper forest management in the German forest law (Winkel et al., 2011; Winkel and Volz, 2003). The ideal of harmonizing the different functions in the same area received early critiques for obscuring potential conflicts arising from the different objectives (Glück and Pleschberger, 1982). Instead of actively managing forests for wood production, nature conservationists have called for a more ecologically oriented approach to forest management via minimum regulatory standards (Sotirov and Winkel, 2016; Winkel et al., 2011).

These fault lines between forestry and nature conservation actors were interrupted through the debate on the first *forest dieback* in the 1980s. Actors from different sectors, as well as the wider public, worried about the general state of German forests, adhering to the dominant narrative of the *forest dieback* being caused by acid rain related to industrial emissions (Metzger and Wagner, 2014; Schäfer, 2012; von Detten, 2013). The nation-wide scope and intensity of the media debate was facilitated by the visibility of forest damages that provoked profound personal experiences with forests, amongst other factors (Metzger, 2015). Critiques arose only later, arguing that the debate was constructed and dramatized by media (Holzberger, 1995). However, these critiques never reached the same impact as the dominant narratives of dying forests and were countered by the evidence of the yearly forest reports (Metzger and Schmit, 2015; Metzger and Wagner, 2014). Until recently (cf. BMEL, 2021), these reports showed an improvement in the state of forests, being mainly explained by the introduction of filters and catalytic converters to reduce harmful emissions, but also through an increased emphasis on forest conversion towards mixed stands (Metzger and Schmit, 2015). Due to its societal and political consequences, which profoundly shaped the environmental movements and policies, the *forest dieback* is still considered a decisive moment in German environmental history (Radkau, 2015). Therefore, it is crucial to embed analyses of the current debate in their historical context and draw parallels, not least because the situation is commonly framed as *forest dieback 2.0*.

2.2. Forest controversies around climate change

With the upcoming debates on climate change and the diversification of societal demands, the foundations of forest management were increasingly challenged. While initially depicted as a help in mitigating climate change, forests were increasingly seen as its victims (Biller, 2011). Nevertheless, these debates were mostly restricted to specialized discourse arenas and regional contexts, without creating larger public awareness for controversies around forests (Sotirov and Winkel, 2016; Winkel et al., 2011). Societal interest in forests was rather reflected through the success of popular science books, mainly "The Hidden Life of Trees" by the forester Peter Wohlleben, which aimed to create fascination for forests by showing "discoveries from a secret world,"

including profound criticism of the forestry system (Wohlleben, 2017). This critique also provoked outrage and an internal debate within the offended forestry sector and science (Robinson et al., 2024; von Detten and Mikoleit, 2022).

A broader public debate on forests only emerged in 2018 (Mack et al., 2023), when consecutive summers of drought severely affected German forests (BMEL, 2021; Popkin, 2021; Senf and Seidl, 2021). These damages sparked a nation-wide debate on the so-called *forest dieback 2.0* and how to prevent forests from dying. In this situation, the underlying conflict between forestry and nature conservation sector came to light, with both parties instrumentalizing the climate change discourse to highlight the urgency of their proposed measures. On the one hand, forestry frames call for financial support to actively reforest the damaged areas by also including foreign, climate-adapted species. On the other hand, the nature conservationists' frames call for a more passive approach, relying on the self-regulation and adaptive capacities of the forest ecosystem (Mack et al., 2023). The latter argumentation has also been applied by more ecologically oriented foresters, most prominently by Peter Wohlleben (Mack et al., 2023; Popkin, 2021).

Besides being discussed in public arenas (Mack et al., 2024, 2023), the future of forests was also topic of debate in parliamentary sessions and during high-level political events. The event that raised most attention was the first forest summit organized by then Minister of Agriculture Julia Klöckner. At this two-day event in September 2019, the Ministry of Agriculture invited actors from different sectors to discuss future forest resilience by introducing climate resilient tree species, distribution of financial support, and the importance of wood use in pre-defined sessions based on a previously published discussion paper (BMEL, 2019a, 2019b). The agenda of the event provoked critique by several actors, mainly from the nature conservation sector who perceived its scope as being too narrow. Controversies culminated in a protest by the environmental NGO "Robin Wood" that was interrupted by the organizers (Ballenthien, 2019; BUND, DNR, NABU, Robin Wood, 2019). Due to the political relevance and the (social) media attention during the event (cf. chapter 4.1), the present work expands the analysis of traditional political communication by including Twitter communication during this event.

To do so, our work draws on the theoretical framework of discursive power in hybrid media systems that will be elaborated on in the next section.

3. Theoretical framework: Discursive power in hybrid media systems

3.1. Hybridity of political communication

According to Jungherr et al. (2019, p. 421), we understand political communication as the "political coverage in traditional or alternative media, communicative statements by professional actors, or personal discussions about politics on- or offline." This definition already implies the co-existence and interactions between older and newer forms of media that jointly co-evolve in hybrid media systems.

Instead of conceiving political communication in "'either/or' thinking" (Chadwick, 2017, p. 5) between older and newer media, the concept of the Hybrid Media System indicates a dynamic of "simultaneous integration and fragmentation" (Chadwick, 2013, p. 15) where traditional media like newspapers and television adapt to and accommodate new media logics, encompassing "technologies, genres, norms, behaviors, and organizational forms" (Chadwick, 2017, p. 4). The concept thus leads to new perspectives on analyzing power-related questions with regard to the hybridity of media systems. While this conception of the Hybrid Media System is quite new, all media systems, also past ones, exhibit hybrid features to varying degrees over periods of time. However, hybridity in today's media system is in particular characterized by the acceleration and amplification of distribution of materials reaching an unprecedented number of devices and users even in real time (Chadwick, 2017). In these dynamics, private and public communication spaces blend and dissolve into nested networks that range across different levels: from private to issue-related to broadly defined public spheres (Bruns, 2023). Citizens contribute to public debate by engaging and networking across devices and platforms and spending more time on media than ever before. This grassroots production of media content has transformed news-making processes, agenda-setting, and framing, including in traditional news media (Chadwick, 2017; De Benedictis et al., 2019; Delmastro and Splendore, 2021; Mattoni and Ceccobelli, 2018; Su and Borah, 2019).

While some scholars highlight the deliberative potential that digitally induced transformation of political communication spaces enables with regard to social movements (Berg et al., 2020; Bogen et al., 2021; Duvall and Heckemeyer, 2018; Ince et al., 2017; Lindqvist and Lindgren, 2023; Suk et al., 2024; Treen et al., 2022), others take a more pessimistic stance, highlighting the polarizing potential that is reinforced through the creation of *filter bubbles*, *echo chambers,* and a related reproduction of existing power relations (Boyd, 2023; Brüggemann et al., 2020; Elgesem and Brüggemann, 2023; Falkenberg et al., 2022; Heiberger et al., 2022; Kreiss and McGregor, 2024; Pearce et al., 2019). These dynamics are not only reinforced by user behavior, but also through user-targeted algorithms (Häussler, 2018; Ludwig et al., 2023; Treen et al., 2022). However, it is important to critically reflect and examine polarization, particularly with regard to simplified blame on social media and the question of when polarization actually becomes destructive or can still be considered a productive democratic process (Esau et al., 2024). For instance, the negative impact of the insufficiently defined techno-deterministic terms *echo chambers* and *filter bubbles* tends to be exaggerated, the terms being used as suggestive metaphors while their effects lack scientific evidence (Bruns, 2019; González-Bailón and Lelkes, 2023).

To summarize, the characteristics and emerging features of today's hybrid media systems have transformed political communication (Chadwick, 2017; Jungherr et al., 2019; Jungherr and Schroeder, 2022; Severin-Nielsen, 2023). The results are complex and messy hybrid environments prompting new methods of analysis able to capture and make sense of the situation (Bruns, 2023; Chadwick, 2017; Jungherr et al., 2019). The situation demands consideration in its broader social and technological context (Segerberg and Bennett, 2011).

3.2. Discursive power in hybrid media systems

Despite its detailed conceptual level, the concept of Hybrid Media System lacks an approach for systematic analysis. In response to this, Jungherr et al. (2019) suggest a theoretical framework to analyze and compare discursive power in contemporary media systems. In their understanding, discursive power captures the actors' "ability to introduce, amplify, and maintain topics, frames, and speakers" (p. 412). This ability has been deeply transformed through the dynamics of contemporary media systems. In this context, it is important to disentangle which actors *introduce* topics with their respective *framing* and which actors actually possess the discursive power to *amplify* and *maintain* them in the political communication system. This awareness helps to "reduce the risk of misattributing power" (p. 410), for example when analyzing whether a topic or frame is merely *introduced* by social media actors and later distributed via traditional media, or if the discursive power lies fully within the digital communication space. For a comprehensive understanding of discursive power, it is thus important to acknowledge three indicators along their different dimensions: the *topics* brought into the political communication space; how they are *framed*; and the *speakers* that *introduce*, *amplify* and *maintain* them (Jungherr et al., 2019).

However, according to the analytical framework proposed by Jungherr et al. (2019), actors' discursive power is embedded in structural determinants, which are expressed at *system*, *organizational*, and *individual* level. The *system level* encompasses the composition of the public

arena and power relations between its contributors. These refer to the regulatory environment of media systems as well as conditions of political parallelism between media and politics. The *organizational level* concerns the tendencies and ways in which actors increase resonance and consequently influence the public arena (Jungherr et al., 2019). Central characteristics that should be considered in this context are the direct reach, norms of communication, and business models of media actors. While these factors influence and determine structural components of discursive power, its actual effects manifest on the *individual level* that is highly context specific to the individual characteristics of national hybrid media systems (Jungherr et al., 2019).

The determinants of discursive power highlight that, on an analytical level, it is more convenient to refer to the plural of hybrid media systems instead of the conceptual singular. Further, the interplay between the above-mentioned determinants of discursive power influences the possibility of actors acting as gatekeepers, getting past them, or having the opportunity to shape debates in open communication spaces, mostly in the digital arena (Jungherr et al., 2019). While studies frequently compare old and new media, it is often the hybridity that matters as actors combine media outlets in order to put an issue and its respective frames on the agenda and convey their message effectively (Alyukov, 2021; Engesser et al., 2017; Langer and Gruber, 2021).

3.3. Grasping discursive power in hybrid media systems through tweet-hyperlink-networks

Despite its claim to contribute to systematized empiricism (Jungherr et al., 2019, p. 404), to our knowledge, the empirical analysis of discursive power in hybrid media systems has not yet been operationalized. Therefore, we present a case-study-specific attempt to do so by combining Twitter data and referenced hyperlinks to reveal discursive power in the blend of newer and older media logics. We understand tweet-hyperlink-networks as one possibility to do so. By expanding the Twitter network through its referenced hyperlinks, we can not only analyze discursive power within the Twitter debate, but also refer to the (media) actors that *introduce* specific frames and topics in the first place. In the network, hyperlinks, tweets, retweets, replies, and quotes equally represent nodes that are connected through their specific interaction dynamics. In the following, we will briefly explain the specific characteristics of the different data.

Despite profound transformations in the platform after being purchased by Elon Musk in 2022 and subsequently rebranded X, Twitter continues to be one of the most prominent micro-blogging platforms (Newman et al., 2023). The number of people using Twitter as source of information has remained stable globally (11 %) and on the German level (5 %) (Newman et al., 2023, p. 13 and 77). As a form of self-expression limited to 280 characters, it is mainly used by politicians, media, and civil society actors to inform, mobilize, and consequently influence political processes (Behre et al., 2023; Jungherr and Schroeder, 2022; Newman et al., 2023). Due to its political character, the analysis of Twitter seems more suitable to study debates in hybrid media systems compared to other, more widespread platforms (Jungherr and Schroeder, 2022; Newman et al., 2023; Pearce et al., 2019).

In this context, it is crucial to also consider hyperlinks as bridging devices between different contents of digital communication. Hyperlinks represent all kinds of online content, such as online sources of legacy media corporations, websites of associations and other political actors, as well as blogs and other social media platforms (De Maeyer, 2013). By using hyperlinks, Twitter users are able to expand their word count and include visual content, which attracts additional attention (Himelboim, 2017; Holton et al., 2014; Lovejoy et al., 2012). Actors also strategically include hyperlinks in their tweets to promote content created by themselves or others (Canter and Brookes, 2016; Harmer and Southern, 2020; Luzón, 2023; Moe and Larsson, 2013; Russell, 2019).

For our operationalization to analyze discursive power in hybrid media systems, we understand original tweets and referenced hyperlinks as the ability of actors to *introduce* frames into the tweet-hyperlink-network. In contrast, the resonance they trigger through hyperlinking, retweeting, replying, or quoting represents the ability of actors to *amplify* frames within the tweet-hyperlink-network. Although literature suggests that the *amplification* through hyperlinking and retweeting has mostly affirmative character (Adamic, 2008; De Maeyer, 2013; Elgesem, 2019), *amplification* can also scrutinize or even object to original tweets (Boyd et al., 2010; Lee et al., 2015; Majmundar et al., 2018; Marsili, 2021). While the position of actors towards the original tweet or hyperlink can be retrieved from the tweets, quotes, and replies, retweets do not contain further information beyond the original tweet. If retweeting is not meant as a form of endorsement, this is commonly disclosed in the user description. Nevertheless, it poses challenges to the interpretation regarding the exact meaning of retweeting (Molyneux, 2015).

To describe discursive power of actors, we refer to their *standing* as well as to their *centrality* in the network to adhere to the *introduction* and *amplification* of frames required by the theoretical framework (Jungherr et al., 2019). With regard to legacy media, *standing* refers to the quantitative appearance of actors that represents their ability to *introduce* topics to the debate and shape them through their framing (Kleinschmit and Sjöstedt, 2014). However, in the network logic of digital media, actors' interactions offer the opportunity to not only analyze their success in *introducing*, but also in *amplifying* and *maintaining* topics and frames (Bruns, 2023; Klinger and Svensson, 2015). As this study focusses on an issue-related network (Bruns, 2023), we consider the *topic* regarding the *forest dieback 2.0* debate as being set. Therefore, we focus on its framing and will reflect upon its general relevance in the discussion.

4. Operationalizing the analysis of discursive power in hybrid media systems: Methodological approach

Our operationalization of analyzing discursive power in hybrid media systems comprised four steps summarized in Fig. 1 and detailed in sections 4.1-4.4. The overall process comprised the identification and screening of tweets, leading to our final sampling. In the coding step, we first categorized the actors before conducting a framing analysis of the tweets and hyperlinks. Lastly, we conducted two network analyses to show the aggregated discursive power of actors in the debate as well as their ability to *introduce* and *amplify* frames in the tweet-hyperlink-network.

4.1. Identification, screening and sampling

Due to the lack of comparable studies focusing on twitter analyses, we opted for an open sampling approach referring to the keyword search that was applied for the analysis of newspaper articles on the current forest debate (Mack et al., 2023). We adapted the keywords iteratively to make them more applicable to the tweet search.

Using a twitter developer account, we retrieved the data via the Application Programming Interface (API) (Kwak et al., 2010) applying the R-package *academictwitteR* (Barrier, 2021) for the following keywords (*translated from German to English*): *"forest summit" OR "national forests summit" OR "forest report" OR "tree death" OR "damaged wood" OR "forest restructuring" OR "afforestation" OR "forest damages", "forest dieback" OR "dry AND forest" OR "drought AND forest" OR "bark beetle AND forest")*.

In line with Mack et al. (2023), the data retrieval focused on the time of highest media attention between 2018 and 2020. However, we had to reduce the number of tweets, as the 113,914 tweets found within the three years was not feasible to analyze with our theoretical and methodological approach.

We did so by focusing on a critical discursive moment (cf. van Eck and Feindt, 2022) that was central to the debate, namely the first national forest summit organized by the Federal Ministry for Agriculture

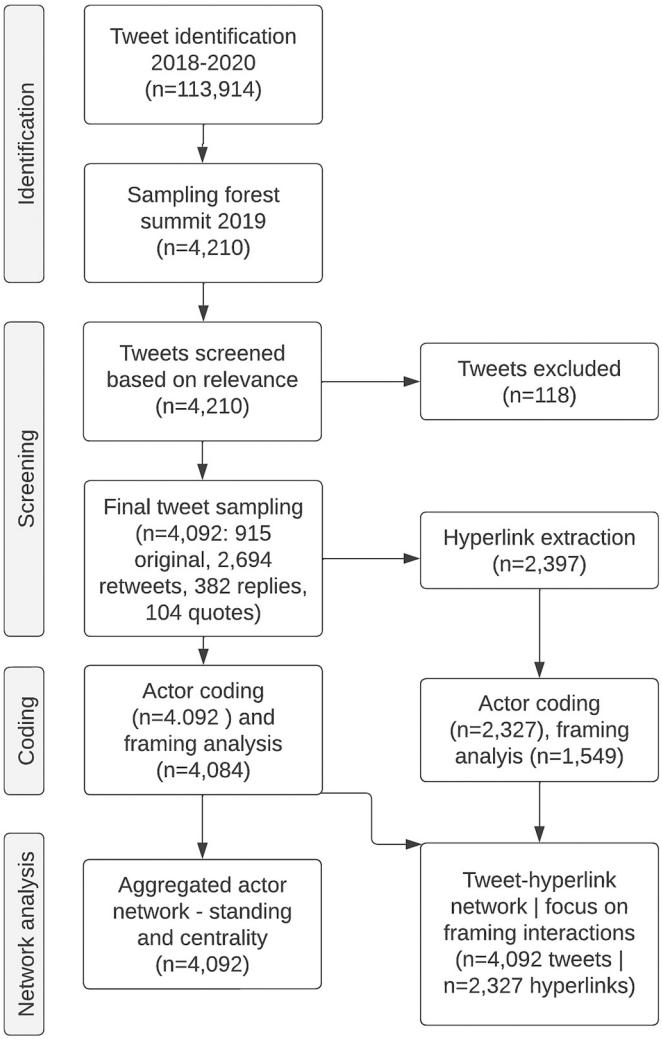

Fig. 1. Workflow.

on 25.09.2019. We chose this one-day event for several reasons: (i) the forest summit represents the first high-level political event to which actors of all sectors were invited to discuss the challenges of forest management and pathways to the future; (ii) it coincides with the peak in media reporting, publishing of press releases of forest actors, and twitter activity (Fig. 2); (iii) being the second consecutive drought summer in Germany, forest damages became physically and discursively visible to the public. This situation created a public awareness in which actors tried to position themselves in the political debate in order to convey their argumentation and influence decision-making processes. The relation between significant political events and Twitter activity is also highlighted in the scientific literature as a reason why media research often focuses on politically relevant events (Bennett and Segerberg, 2012; Jungherr, 2016; Segerberg and Bennett, 2011; van Eck and Feindt, 2022; Veltri and Atanasova, 2017).

By limiting the timeframe to the week of the national forest summit (22.09.2019–28.09.2019), we were able to reduce our sampling to 4210 tweets that were retrieved on 20.07.2022. After cleaning the sample of non-German tweets and tweets unrelated to damages to German forests or related actors, our final sample consisted of 4092 tweets. In our analysis, we refer to the user name, user description, and their follower counts. Concerning the tweets, we included both the tweet-text itself and the type of tweet (original tweet, retweet, reply, quote), as well as the retweet count and the tweet-likes. Additionally, we used the tweet, author, and conversation-IDs to construct the Twitter-networks.

Based on this sample, we manually extracted 2372 hyperlinks from the tweets. For the analysis of the referenced media content, we focused on the headline and lead paragraph, as they convey the main message of the article (Carvalho, 2000; Ruiu, 2021). This approach guaranteed comparability to the analysis of tweets.

4.2. Actor categorization

In the coding process, we followed the aggregated actor categories provided in the literature published on forest debates in Germany (Sotirov and Winkel, 2016; Winkel et al., 2011). We added the category of *individual* Twitter users without affiliation. As a sub-group of these *individuals*, we coded users depicting themselves as activists. Further actors expected to appear in social media, such as celebrities or bloggers, were not identified during the coding process. We also checked for bots using the platform Botometer (Yang et al., 2022, 2020), manually verified suspicious cases according to proposed criteria (Lopez-Joya et al., 2023), and found no clear evidence for the influence of bots in our dataset. In line with Mack et al. (2023), we categorized the single actors in the coding process according to their self-description derived from their user description, user name, and user status (Table 1). If information was missing, we complemented the coding by online research. This way, we ensured to code the actors according to how they present

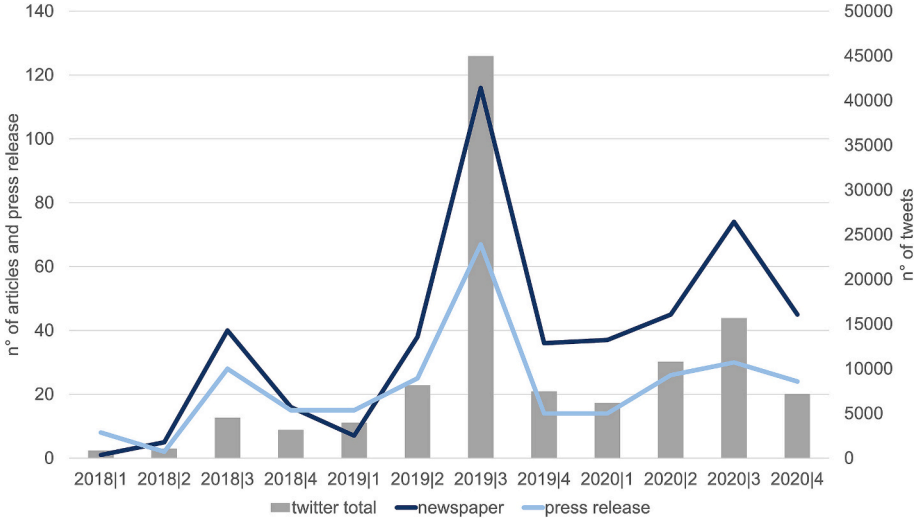

Fig. 2. Timeline of the forest dieback 2.0 debate Germany (Twitter n = 113,914; newspaper articles n = 460; press release n = 268) (cf. Mack et al., 2024, 2023).

Table 1
Actor categorization.

Actor categories	Actors (exemplified)
Politicians	political parties, politicians, representatives of ministries
Forestry	foresters, private forest owners, forestry associations, public forestry administration
Nature Conservation	nature conservation associations, individual actors positioning themselves clearly as nature conservationists
Media	journalists, media companies (press, broadcasting), online news channels, other social media platforms
Others	mostly other collaborative actors such as climate initiatives, tree-planting organizations and companies
Individuals	*individual* Twitter accounts without further affiliation. Activists coded as a sub-category.

themselves and are most likely to be perceived in the broader public, rather than how they have been categorized in previously published scientific literature.

To exemplify our approach, we depict the case of Peter Wohlleben, who is often described by media as "the chief forester of the nation" (Uhlenbruch, 2017), "so popular that he hardly needs to be introduced" (Simmank, 2020). In his Twitter user description, he described himself as follows: "I'm a forester, and if that would [*sic*] not be my job, it would be my hobby". Thus, despite being seen as a political opponent and nature conservationist by the forestry sector due to his criticism (von Detten and Mikoleit, 2022), we assigned him to the forestry sector.

According to the prevalence of the media category that published hyperlinks, we further differentiated the category into broadcasting, press, online news, and social media (cf. Vowe, 2021). Following ethical considerations in Twitter research, if retraceable, we only depict actors and their respective tweets from organizations and public figures in our results. *Individuals* are anonymized (Williams et al., 2017).

4.3. Framing analysis

We adopted commonly applied schemes of interpretations in an iterative deductive-inductive framing analysis. For this purpose, we based our analysis on the core framing tasks of diagnostic and prognostic framing proposed by Benford and Snow (2000). While the diagnostic framing refers to identifying causes and causers of a situation, the prognostic framing depicts solutions, as well as pathways and actors legitimized to solve the identified problems. Within these two core framing tasks, existing literature on German forest debates served as a deductive orientation to make the analysis of the Twitter debate comparable to previous analyses. These structure the debate along two main conflict lines between forestry and nature conservation (Mack et al., 2024, 2023; Sotirov and Winkel, 2016; Winkel et al., 2011). The categories presented in Table 2 and supplementary material 1 were adapted in an inductive coding process that included several iterations between the authors (König, 2023; Pfistner, 2022; Zwickel, 2024).

First, it was necessary to adapt our coding process to the limitation of tweets to 280 characters. Through this limitation, users are likely to simplify and highlight the most salient aspects in their frames (Bogen et al., 2022). Thus, tweets often lack the context they are embedded in and mostly remain superficial (Pearce et al., 2019; Talbot et al., 2023). Through iterative coding, we adhered to intersubjectivity and comparability between our coding. Second, to display the frames in the tweet-hyperlink-network, it was necessary to apply an exclusive coding approach, meaning that only one category was assigned to each tweet. For this purpose, the coding was conducted in the Excel-Sheet provided through the API to link the actor categories and frames directly to the respective tweets. Third, the inductive coding revealed frames beyond the main axes of conflict between nature conservation and forestry (Mack et al., 2024, cf. 2023). These include criticism on climate policy

Table 2
Coding scheme (see supplementary material 1 for details).

Framing tasks	Intention	Referred frame	Content
Diagnostic Framing	critique	of forestry practices	economic focus of traditional forestry practices, disregard of proper forest management, afforestation optimism, foreign tree species
		of forest policy	staged forest summit, deficient solutions, exclusion of actors, inappropriate financial support and distribution, general failures of forest policy
		of nature conservation practices	relying on forests' self-regulation, lack of openness towards active management approaches
		of climate change policy	political failure, wrong decisions, lack of political will
		of society	climate harming behavior, uninformed criticism
		of forest and climate hysteria	false alarmism concerning *forest dieback* and climate change, critique of climate activism, exaggerated restrictions and regulations
		of forest and climate skepticism	critique on irrational skepticism
	status description	of state of forest	forest damages, *forest dieback*, multiple crises
Prognostic	claims	related to forestry practices	financial support, active management including increased use of wood, active forest restructuring
		related to nature conservation practices	ecological management approaches, ecological paradigm shift in forestry, nature-based forest restructuring
		related to action on climate change	climate mitigation measures beyond forestry, afforestation for climate mitigation
		related to societal mobilization	societal mobilization
	solutions	based on forestry practices	active forest restructuring, forest conservation and restructuring through afforestation, financial support, traditional forest management through increased use of wood and hunting, compensation payments
		based on nature conservation practices	natural rejuvenation, nature-based forest restructuring, self-regulation of forests
		related to climate change	forests as CO_2-sink, emission trade, afforestation for climate mitigation
		based on cooperative instruments	constructive dialogue, cooperation between actors, scientifically informed decision-making, results of the forest summit
		related to *forest dieback* in the 1980s	Highlight success of regulatory instruments proposed against *forest dieback 1.0* in the 1980s

and skepticism towards climate inducement of the forest damage. A further differentiation that emerged from the inductive analysis concerns the intention of the framing. The diagnostic framing showed politicized critiques on the one hand, but also rather apolitical descriptions of the current forest situations on the other hand. Regarding the prognostic framing, we distinguished between directed and politicized claims and rather undirected, as well as less politicized solutions. We differentiate between these framing intentions, as they represent different degrees of political pressure and persuasion emphasized in the tweets.

The tweets used as quotations were all translated into English by the authors.

4.4. Network analysis

In addition to analyzing discursive power through quantitative appearance, the network structure of social media also facilitates the analysis of interactions and resulting *centralities* of actors. These determine discursive power more thoroughly, as not only their appearance, but also the *amplification* and resonance of their framing by other actors can be analyzed (Himelboim, 2017). Following our conceptual approach, we mainly refer to the *degree centrality* of actors within the network dynamic. In contrast to other centrality measures, the *degree centrality* describes the number of actors the author of one tweet influences directly or indirectly. Thus, it reveals amongst other things, which actors hold most information in the network (Arifi et al., 2023; Freeman, 1979) and the resonance that was created through their framing (Snow and Benford, 1988). More precisely, we applied directed *degree centrality* measures, as the interactions, such as retweeting, replying, and quoting, are always directed towards the user or tweet that has initiated the interaction. Therefore, a tweet or user that is often replied to, retweeted, or quoted has a high *in-degree*, while users that often retweet, reply, or quote holds a high *out-degree*. To analyze the *centrality* of actors, we thus refer to the *in-degree centrality* (Himelboim, 2017; Himelboim et al., 2017; Milani et al., 2020; Verweij, 2012). For particular dynamics within the network, it was, however, useful to consider the *betweenness-centrality* of actors. The *betweenness-centrality* indicates actors' ability to make connections between other actors. That is to say, their authority to build bridges amongst actors in a cluster (Arifi et al., 2023). Additionally, we added the *distribution count* to measure the absolute number of times a tweet or hyperlink was spread in the network.

The network graphs were created in *Gephi*, an open source software that is commonly used in network research and also facilitates the creation of large networks (Bastian et al., 2009; Jacomy et al., 2014). It was crucial to depict the complexity of the entire tweet-hyperlink-network without excluding peripheral actors through certain thresholds. While many studies focus on statistical correlations between the large amount of data that social media offers, we focus on the description and qualitative interpretation of discovered patterns. In combination with our deductive-inductive coding approach, we take note of the context-specificity of our case study.

With regard to our research questions, theoretical underpinnings, and coding process, we included two kinds of networks in our analysis: actor-networks and tweet-hyperlink-networks. First, we analyzed the actor-network of Twitter users involved in the debate. This network especially refers to research question one and detects the aggregated discursive power of actors in the Twitter network, also in relation to their potential outreach represented by their number of followers. For this purpose, all tweets, retweets, replies, and quotes of one actor were aggregated to one actor node to describe the actor's *centrality* within the debate. While this actor *centrality* is one way to measure discursive power, it does not provide information on the content and interaction of single tweets.

Second, we analyzed the tweet-hyperlink-network, depicting frames and interactions between the tweets and hyperlinks. This refers to the second, third, and fourth research questions. In this context, tweets, retweets, replies, quotes and hyperlinks build the nodes, whereas the type of interaction (retweeting, replying, quoting, hyperlinking) forms the edges in the network. In contrast to the aggregated *centrality* of actors, the tweet-hyperlink-network shows the *centrality* of frames *introduced* or *amplified* by the respective actor. For a comprehensive understanding of discursive power in hybrid media systems, we argue that it is crucial to combine both the actor-network and the tweet-hyperlink-network. Fig. 3 shows the generalized network structure, including information from Twitter and hyperlinks.

5. Results

5.1. Description of the dataset

We analyzed a final dataset of 4092 tweets (Table 3), which is composed of 915 original tweets, 2694 retweets, 382 replies, and 104 quotes. However, it should be noted that not all the respective tweets that caused a reaction are within the temporal scope of the sample. Whereas 2600 retweets are in reaction to the tweets in the sample, only 55 quotes and 106 replies refer to tweets within the original timeframe. Concerning the endorsing character of *amplification*, only for 20 retweets did users state that their retweets do not necessarily represent endorsement.

We identified 2372 hyperlinks originating from 646 original tweets, 1390 retweets, 56 replies, and 9 quotes. In total, the links refer to 470 online contents, originating from 212 different websites. Due to the temporal gap between the retrieval and analysis of the data, 100 of the links represented in 823 tweets were not accessible for content analysis. The same applies to 8 tweets that contained only a hyperlink (Table 4). However, the URL was sufficient for the actor coding of the hyperlinks, as it indicates the actors' names without having to access it.

Due to the importance of hashtags in Twitter communication to anchor messages to issue-specific communication spaces (Jungherr and Jürgens, 2014), it is remarkable that only 2024 tweets included hashtags. This supports our methodological approach to not rely on hashtags in our sampling strategy, especially considering the hashtags applied are very heterogeneous and the most frequent one, "#forestsummit", only appeared in around 999 tweets.

5.2. Discursive power: standing and centrality of actors

In this chapter, we present the dominance of different actors in the Twitter debate. We do so by first descriptively depicting the *standing*, understood as quantitative appearance, of actor categories. Second, we will present the actors' interconnections in the network structure, allowing us to also determine their *centrality*.

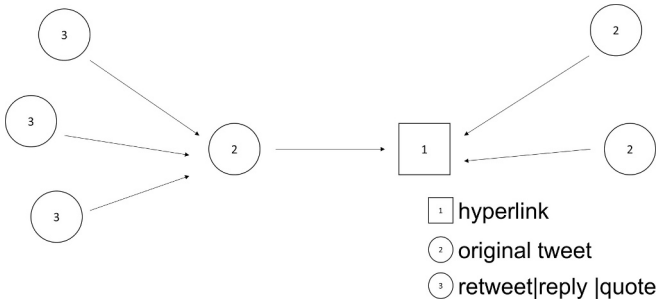

Fig. 3. Generalized tweet-hyperlink-network interactions; hyperlinks not included in the actor-network (adopted from Zwickel, 2024).

Table 3
Standing according to tweet type. As three tweets represent quotes and replies at the same time, the categorized tweets sum up to 4095. Numbers in the text partially refer to subcategories that were not included in the table.

	all tweets	original	retweet	reply	quote	hyperlinks
individuals	2741	342	2036	321	45	0
	67 %	37 %	76 %	84 %	43 %	0 %
forestry	103	42	57	4	0	11
	3 %	5 %	2 %	1 %	0 %	0 %
nature conservation	179	54	88	10	27	314
	4 %	6 %	3 %	3 %	26 %	13 %
politics	275	86	161	14	14	72
	7 %	9 %	6 %	4 %	13 %	3 %
media	462	308	124	18	12	1820
	11 %	34 %	5 %	5 %	12 %	77 %
science	80	13	54	11	2	47
	2 %	1 %	2 %	3 %	2 %	2 %
others	252	70	174	4	4	108
	6 %	8 %	6 %	1 %	4 %	5 %
SUM	**4092**	**915**	**2694**	**382**	**104**	**2372**
	100 %	100 %	100 %	100 %	100 %	100 %

5.2.1. Standing

The authors of most tweets (67 %) cannot be attributed to specific actor groups. We subsumed those under the category of *individual* actors engaging in the Twitter debate on forests (Table 3). However, as a subcategory of the *individual* actors, we coded 23 accounts that position themselves as activists. These posted 49 tweets. The second most active actor category is media actors (11 %), followed by political actors (7 %). Other actors add up to 6 %, while actors from nature conservation, science, and nature conservation are quantitatively underrepresented.

It is crucial to consider the tweeting behavior of these actor groups. While *individuals* represent by far the most prominent actor group, they do not stand out regarding their published original tweets, implying that their *standing* mainly originates from retweets. Concerning the published tweets, media actors published far more tweets than political, nature conservation, and forestry actors. Least active in publishing their own original tweets were scientists.

However, when considering whose input was considered in the Twitter debate, it is also relevant to look at the external input by hyperlinks. The majority of links included in tweets originate from media sources (77 %). Whereas content from legacy media such as press and broadcasting (65 %) represents the predominant media source, links to social media including blogs (2 %) are underrepresented. The remaining 13 % of the hyperlinks from media sources refer to exclusively online news channels. Besides references to media, links stem from nature conservation organizations (13 %), political actors (3 %), scientists (2 %), and other collaborative actors (5 %). Only eleven tweets (0.5 %) include links to content from the forestry sector.

5.2.2. Centrality and potential outreach of actors

The actor-network on Twitter (Fig. 4, supplementary material 2) reflects the importance of considering actors' *centrality* in the Twitter debate, beyond their *standing*. It shows few *central* actors, Peter Wohlleben (*weighted in-degree:* 407; *betweenness centrality:* 5241) being the most *central* one, and many unconnected actors at the margins of the network. Further *central* actors are from the nature conservation sector like Greenpeace (*weighted in-degree:* 172; *betweenness centrality:* 8913) or

Table 4
Distribution of framing. Numbers in the text partly refer to aggregations.

Framing tasks	Framing	all tweets	original tweets	retweets	replies	quotes	hyperlinks
DIAGNOSTIC FRAMING	critique of forestry practices	795	51	703	32	10	264
		19 %	6 %	26 %	8 %	10 %	11 %
	critique of forest policy	335	73	210	32	21	91
		8 %	8 %	8 %	8 %	20 %	4 %
	critique of nature conservation practices	12	7	2	3	0	0
		0 %	1 %	0 %	1 %	0 %	0 %
	critique of climate change policy	259	32	178	44	5	10
		6 %	3 %	7 %	12 %	5 %	0 %
	critique of society	86	10	58	16	2	2
		2 %	1 %	2 %	4 %	2 %	0 %
	critique of forest and climate hysteria	137	17	44	71	6	4
		3 %	2 %	2 %	19 %	6 %	0 %
	critique of forest and climate skepticism	27	2	3	22	0	1
		1 %	0 %	0 %	6 %	0 %	0 %
	status description of state of forest	673	203	430	30	10	220
		16 %	22 %	16 %	8 %	10 %	9 %
PROGNOSTIC FRAMING	claims related to forestry practices	119	55	56	6	2	31
		3 %	6 %	2 %	2 %	2 %	1 %
	claims related to nature conservation practices	257	52	189	9	7	215
		6 %	6 %	7 %	2 %	7 %	9 %
	claims related to action on climate change	94	15	71	6	2	5
		2 %	2 %	3 %	2 %	2 %	0 %
	claims related to general mobilization	51	13	34	2	2	5
		1 %	1 %	1 %	1 %	2 %	0 %
	solutions based on forestry practices	378	142	201	25	10	394
		9 %	16 %	7 %	7 %	10 %	17 %
	solutions based on nature conservation practices	220	35	167	11	7	60
		5 %	4 %	6 %	3 %	7 %	3 %
	solutions related to climate change	177	29	107	33	8	38
		4 %	3 %	4 %	9 %	8 %	2 %
	solutions based on cooperative instruments	439	175	237	15	12	209
		11 %	19 %	9 %	4 %	12 %	9 %
	solutions related to *forest dieback* in the 1980s	25	0	2	23	0	0
		1 %	0 %	0 %	6 %	0 %	0 %
	NA	8	4	2	2	0	823
		0 %	0 %	0 %	1 %	0 %	35 %
	SUM	**4092**	**915**	**2694**	**382**	**104**	**2372**
		100 %	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

Uwe Ness (*weighted in-degree*: 147; *betweenness centrality:* 121), an environmental and peace activist employed at the German parliament in a scientific position. Despite a low *degree centrality*, Julia Klöckner (*weighted in-degree*: 17; *betweenness centrality:* 6604), then Minister of Agriculture and responsible for forests, is still relevant to the presented network. This relates to the relatively high *betweenness centrality,* reflecting the ability to connect actors. Notably, the network relations within an actor category are almost exclusive to political actors, mostly, as in the case of Julia Klöckner, referring to their respective ministry or political party.

In contrast, media actors are not *central* in the network, despite their potential outreach indicated by the high number of followers. While Peter Wohlleben, as the most *central* actor in the network, has 22,059 followers, accounts from legacy media exceed this number by far, e.g.: tagesschau (3,693,402 followers; *weighted in-degree*: 31), zeitonline (2,534,899 followers; *weighted in-degree*: 26), ZDF (1,400,996 followers; *weighted in-degree*: 3).

To conclude, when reflecting on the central actors in the debate, we want to underscore that the *degree-centrality* measures their direct or indirect outreach to actors within the network. However, it does not reflect the ability of actors to reach out to the whole network. Therefore, even the most central actors and their interaction networks seem insulated regarding the whole network structure. Further, one must also consider the multiple accounts of the same media corporation, as well as their influence via hyperlinks (see section 5.4, Fig. 5).

5.3. Discursive power: introduction and amplification of framing

In line with our theoretical framework, we distinguish between the *introduction* of frames through original tweets and hyperlinks as well as their *amplification* through retweeting, hyperlinking, quoting, and replying. However, it is important to recall that this *amplification* does not necessarily represent a form of endorsement. The results show that there is a slight tendency towards prognostic framing in the 911 analyzed original tweets (57 %) and 1549 accessible hyperlinks (62 %). This pattern reverses when also considering retweets, replies, and quotes (Table 4). When considering all tweets, 57 % refer to the diagnostic framing. While these numbers show that diagnostic framing is more likely to be *amplified*, we will argue that this relates especially to the high quantity of retweeted critique. In the following, we first describe the general patterns of *introduction* and *amplification* before explaining the frames more thoroughly based on their content and sub-categories (supplementary material 1).

5.3.1. Diagnostic framing

When focusing on the diagnostic framing, data reveals that the original tweets are balanced between general descriptions of the current state of forests (51 %) and a more politicized critique directed towards different actors or measures (49 %). When also considering their *amplification* by including the retweets, replies, and quotes, critique increases especially towards the forestry sector (49 %), whereas the general depiction of the situation only adds up to around 29 %. The diagnostic framing amongst the hyperlinks is even more dominated by critique towards the forestry sector (60 %), as well as the general

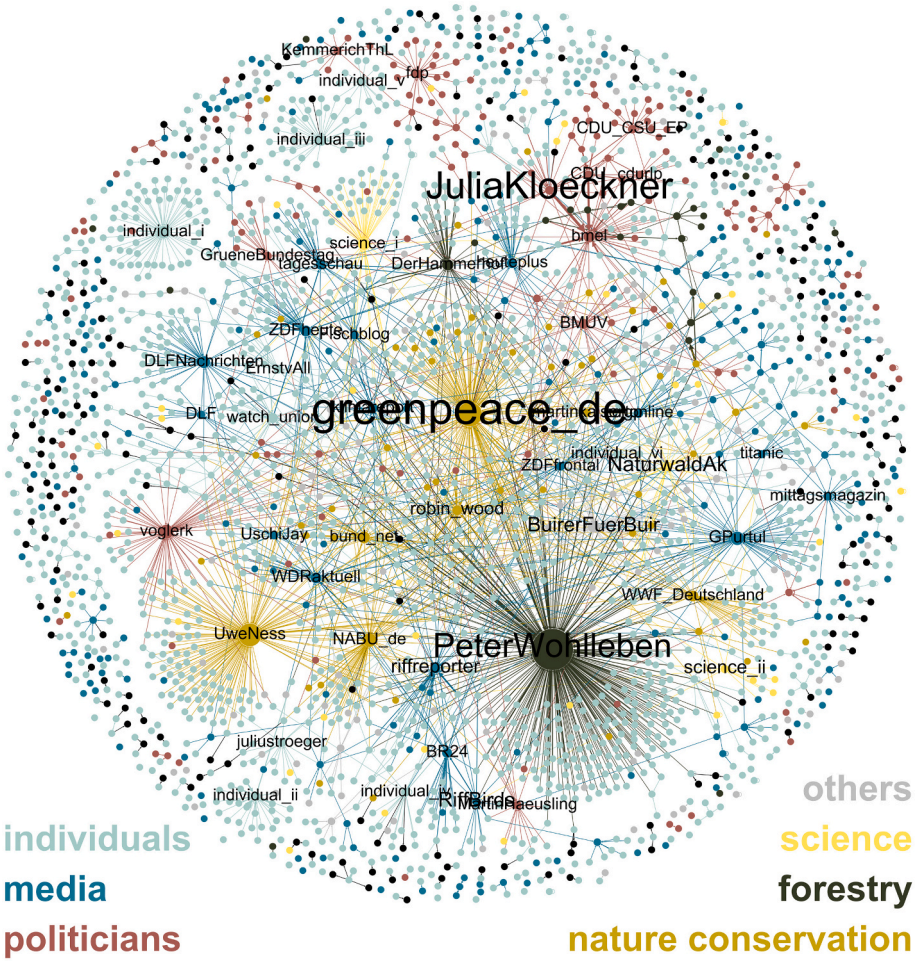

Fig. 4. Twitter actor-network. Colors: actor category, node-size: in-degree centrality, font-size: betweenness-centrality. Only 50 most central actors labelled.

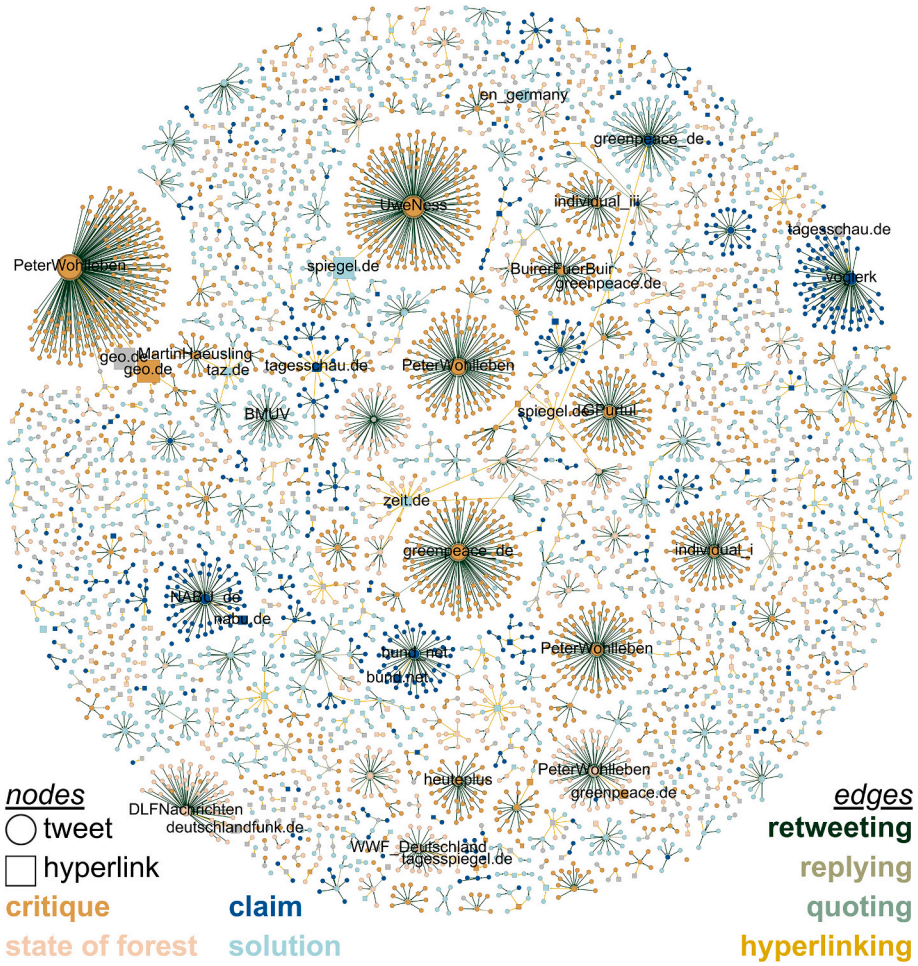

Fig. 5. Tweet-hyperlink-network. Nodes represent hyperlinks, tweets, retweets, replies, and quotes. Edges represent the form of interaction. Node-color: framing devices, node-size: distribution count (only 30 most distributed tweets were labelled), node-label: tweet/hyperlink author, edge-color: type of interaction.

description of the state of forests (37 %). This reflects the *introduction* of forestry critique via hyperlinks, as well as the resonance of more politicized tweets critiquing the forestry sector. Further, we were also able to observe an increase in skepticism, from 4 % of the diagnostic framing considering the original tweets, to 6 % including all tweets, through the *amplification* dynamics within the network.

The general description of the damage is presented in a rather apolitical way, highlighting the extent of the damages, such as "*[a]ccording to the Ministry of Agriculture, million trees are affected by severe damages. Besides drought and heatwaves, a beetle species is worsening the situation*" (*FAZ_Politik*).

The largest share of critique is directed towards the forestry sector (31 % of the original and 68 % of all diagnostic tweets), which we further divided into forestry practices and forest policy (Table 4). Critique of forestry practices refers predominantly to the economic focus of traditional forestry, but also to disregarding the tenets of proper forest management by referring to established monocultures or clear cuts as well as the ad hoc afforestation activism and the associated optimism displayed by forestry actors. The following tweet by a parliamentarian from the Green Party exemplifies this critique by also referring to the introduction of foreign tree species: *"Let's protect our #forest from panic-induced rapid reforestation campaigns with miracle-tree-species that don't even exist! #forestsummit #germanparliament @JuliaKloeckner @bmel @GrueneBudestag" (Ebner_sha)*. In contrast, critique of forest policy focusses mainly on the forest summit for being staged without producing substantial results: "*After the laughing stock at the #windsummit with @peteraltmaier, today comes the next big coup. The #forestsummit with @JuliaKloeckner."* (anonymized *individual*).

Critique of measures combatting climate change accounts for around 8 % of original diagnostic tweets (11 % of all diagnostic tweets): "*At least now at the forest summit! Discussing climate and 'intergenerational contracts' without thinking about Germany's biggest CO_2 sink is an art! But why help 2 million forest owners when you can also support a state-owned company in its efforts to come late [referring to German train service]?" (Brandenburg-Wald)*. The reference to the climate change debate and a general societal critique (3 % for original and 4 % for all tweets) reflects the embeddedness of the forest debate in overarching discourses. This is also true for the accusation of a climate and forest hysteria that is present in 4 % of the original diagnostic tweets (6 % of all diagnostic tweets). This frame represents skepticism towards the role of climate change and a downplaying of the current situation. On the one hand, it relates to past environmental debates that have never materialized: *"There is a #forestsummit because the #forestdieback of the 80s is supposed to be back. What comes next? The big #ozonehole-revival?"* (anonymized *individual*). On the other hand, it questions climate change: *"Who says that climate change will hit us hard? The intellectual glass ball owners who once warned us about the coming ice age… and the dying forests… and other things that never came. We should take care of real problems."* (anonymized *individual*). In contrast, only two tweets respond to and critique these skeptical tweets. These tweets were shared twice and replied to 22 times. The low critique towards nature conservation measures (2 % for original and 0.5 % for all diagnostic tweets) can be seen as a consequence of the fact that these are only suggestions within the current debate without effective implementation in the past, as these have been reserved for the forestry sector.

5.3.2. Prognostic framing

When only considering the original tweets that *introduce* prognostic framings, it becomes clear they are dominated by solutions (74 %) rather than political claims (26 %). Hyperlinks also reflect this pattern, with claims accounting for 24 %. In contrast, when considering all tweets, the share of claims rises to 30 %. Similarly, the share of nature conservation (from 17 % to 27 %) and climate-change-related (from 9 % to 15 %) tweets amongst the prognostic framing increases when also considering their *amplification*. As for the diagnostic framing, it suggests that more politicized tweets, as well as nature conservation and climate framing, are more likely to be *amplified*. But still, forestry-related solutions and claims dominate the prognostic framing (38 % for original and 28 % for all prognostic tweets), also amongst the hyperlinks (44 %).

Forestry-related prognostic framing refers predominantly to active afforestation and forest restructuring towards mixed and climate-resilient forest stands. Cooperative instruments are suggested in 34 % of the prognostic tweets that refer to facilitating a constructive dialogue and collaboration amongst different actors. While most tweets referring to cooperative instruments mention the forest summit more or less superficially (80 %), fewer highlight the necessity and also the chance for constructive dialogue: *"The situation of the forest is severe. Foresters and nature conservationists are unsettled. This offers opportunities for a new culture of debate."* (*tazKlima*). 17 % of the prognostic tweets included prognostic framing that focusses on nature conservation practices demanding an ecological paradigm shift in forestry exemplified by more passive management approaches that rely on the self-regulating power of nature. Nine percent refer to climate mitigation beyond the role of forests. These tweets mention the importance of reducing the emission of greenhouse gases and the role of afforestation.

5.4. Discursive power: interaction between actors and framing

Having depicted the quantitative distribution of actors and framing, in this chapter, we aim to demonstrate the links between them. First, we show descriptively which frames were applied by certain actors. Second, we depict some dynamics of how the different media logics blend. For instance, media actors adapted to new technologies and the genre of Twitter, while depending on multipliers to introduce, amplify, and lastly commercialize their content.

5.4.1. Framing applied by actors

Table 5 shows the distribution of framing according to the actor category including all tweet categories. Concerning the diagnostic framing, nature conservation actors focus mostly on forestry critique, while suggesting nature-conservation-oriented solutions. These framings seem to resonate with the large number of *individuals* in the Twitter debate. In contrast, politics and the forestry sector focus more on solutions, especially with regard to forestry practices. Media actors apply less critique, but highlight the state of the forest in the diagnostic framing and focus on forestry measures in the diagnostic framing. The small number of scientists engaging in the debate show a tendency towards critique of the forestry sector and proposing more ecologically oriented solutions.

5.4.2. Ways of introducing and amplifying framing in the tweet-hyperlink-network

This section focuses on the interactional dynamics of Twitter communication in relation to its included hyperlinks. Fig. 5 shows the tweet-hyperlink-network that consists of 4828 nodes and 3908 edges.

Table 5
Framing applied by actors for all tweets $n = 4092$ (original tweets, retweets, replies and quotes).

Framing	individuals	forestry	nature conservation	politics	media	science	others
critique of forestry practices	659	2	39	9	27	14	45
	24 %	2 %	22 %	3 %	6 %	18 %	18 %
critique of forest policy	242	3	26	12	26	7	19
	9 %	3 %	15 %	4 %	6 %	9 %	8 %
critique of nature conservation practices	4	0	0	1	5	1	1
	0 %	0 %	0 %	0 %	1 %	1 %	0 %
critique of climate change policy	212	3	6	5	17	4	12
	8 %	3 %	3 %	2 %	4 %	5 %	5 %
critique of society	65	2	3	0	8	1	7
	2 %	2 %	2 %	0 %	2 %	1 %	3 %
critique of forest and climate hysteria	129	0	0	1	5	1	1
	5 %	0 %	0 %	0 %	1 %	1 %	0 %
critique of forest and climate skepticisms	27	0	0	0	0	0	0
	1 %	0 %	0 %	0 %	0 %	0 %	0 %
status description of forests	446	16	6	33	121	17	34
	16 %	16 %	3 %	12 %	26 %	21 %	13 %
claims related to forestry practices	43	3	0	38	26	0	9
	2 %	3 %	0 %	14 %	6 %	0 %	4 %
claims related to nature conservation practices	159	2	36	10	21	7	22
	6 %	2 %	20 %	4 %	5 %	9 %	9 %
claims related to action on climate change	73	0	3	7	4	1	6
	3 %	0 %	2 %	3 %	1 %	1 %	2 %
claims related to societal mobilization	32	2	3	2	4	2	6
	1 %	2 %	2 %	1 %	1 %	3 %	2 %
solutions based on forestry practices	168	34	11	51	85	4	25
	6 %	33 %	6 %	19 %	18 %	5 %	10 %
solutions based on nature conservation practices	125	1	29	14	15	8	28
	5 %	1 %	16 %	15 %	3 %	10 %	11 %
solutions related to climate change	96	2	1	51	9	5	13
	4 %	2 %	1 %	19 %	2 %	6 %	5 %
solutions based on cooperative instruments	232	31	15	41	88	8	24
	8 %	30 %	8 %	15 %	19 %	10 %	10 %
lessons learned from forest dieback	25	0	0	0	0	0	0
	1 %	0 %	0 %	0 %	0 %	0 %	0 %
NA	4	2	1	0	1	0	0
	0 %	2 %	1 %	0 %	0 %	0 %	0 %
SUM	**2741**	**103**	**179**	**275**	**462**	**80**	**252**
	100 %	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

Whereas the nodes represent tweets, retweets, replies, quotes, and hyperlinks, the edges represent the interaction amongst them.

Of the 915 original tweets, 776 (85 %) showed some kind of interaction. However, only 470 (51 %) received a like, 348 (38 %) were retweeted, 123 (13 %) were quoted, 45 (5 %) were replied to, and 646 (71 %) contain hyperlinks. Further, the number of retweets per original tweet is quite low, as only 14 % of the tweets are retweeted more than three times, and merely 52 tweets were retweeted 10 times or more. Also, the most *central* tweet only has 193 retweets (supplementary material 3). While 71 % of the original tweets contain hyperlinks, 70 % of these tweets are not further distributed in the Twitter network. In contrast, 49 % of all original tweets without hyperlinks are retweeted at least once.

The tweet-hyperlink-network thus reinforces the impression of insulated communication spaces whose interaction is almost exclusively based on retweets, representing a monodirectional distribution of the same content. Connections between original tweets being bridged through replies or quotes that provoke interaction beyond the mere distribution only occur sporadically. Therefore, they do not play an important role in the overall network structure. Furthermore, the tweet-hyperlink-network reflects that the actors' *centrality* (see 5.2) relates to only a few tweets being published within the analyzed time frame.

Considering these general structures of the network, we focus on the interaction dynamics of some *central* tweets that reveal different forms of interaction between legacy and social media. While on a general level, actors use the hyperlinks to expand their message, which facilitates a short and concise tweet referring to a more detailed source, we found some more specific interactions on how actors specifically adapt to the logic of hybrid media systems:

5.4.2.1. Amplification through multipliers. The first example refers to the tweet with highest *degree centrality* (*weighted in-degree*: 179; *distribution count*: 193) in the network. It is posted by *Peter Wohlleben* and contains a link to an article in the magazine *GEO*. In the tweet, he simply posted the link and title of the article *"What our forests look like – and what they should actually look like - https://t.co/j1bM1pfPM5"*. Hence, a very short message that was backed up by the hyperlink to the main article. The article then explains his claim in more detail that only *"forest plantations"* modified through forestry are facing severe problems. In contrast, "*real forests,*" mainly consisting of beech trees, would not have such problems. When considering the *centrality* of that tweet, hyperlinking the article represents a very efficient strategy to underscore his call for a more ecologically oriented management of forests. Despite having its own Twitter account, *GEO* did not share the link itself, but instead gained a *central* position (*weighted in-degree*: 9; *distribution count:* 193) in the network by being linked by Peter Wohlleben. He thus functions as an important multiplier for the magazine in the tweet-hyperlink-network. This interaction becomes even more particular as *Peter Wohlleben* also authored the referenced article, therefore promoting his own article in the digital communication space. Besides this tweet, his *centrality* in the network further increased through tweets not including hyperlinks or shared content created by the international NGO Greenpeace.

5.4.2.2. Amplification of own content. Less prominently, environmental NGOs such as *Greenpeace*, *BUND*, and *NABU* used the *amplification* potential of Twitter to share content linking to their own websites. They did so to back up their claims for changes in the management of forests: "*We need an ecological paradigm shift for forests 🌲🌳. #forests fulfil many important functions for us and for nature. In order for them to withstand #climatechange, we must consistently protect them. #forest summit. https://t.co/xgP8TXiwt0*" (*NABU – weighted in-degree:* 52; *distribution count:* 55). The referred hyperlink leads to a press release and position paper containing a "*twelve-point-paper*" on *"forests and forestry in climate change"* that includes the central political claims of *NABU* concerning the forest damages.

Rather rarely, tweets by media actors achieve high *centrality* through their own tweets, such as the broadcasting services *Deutschlandfunk* (*weighted in-degree:* 48; *distribution count:* 51).

5.4.2.3. Hyperlinks to legitimize claims. Another example of interaction is the way the international NGO WWF included a hyperlink to Tagesspiegel, a daily newspaper based in Berlin. WWF uses that hyperlink to create awareness for the current state of the forest, without linking it to its own political statements: *"One third of Germany is covered with #forest. Yet, of the 11,4 million hectares 110.000 ha are already dried out! #forestsummit https://t.co/KSDq96eWLg"*. The journalistic character of the shared content might increase its legitimacy, as it is perceived as rather neutral compared to original WWF content. Likewise, Kathrin Vogler from the political party *Die Linke* backs up her call for more climate action through an article by the national news service *Tagesschau* produced by the public broadcaster *ARD*.

5.4.2.4. Hyperlinks used to criticize dominant narratives. While most tweets represent agreement with the hyperlinks, the tweet by *Uwe Ness* represents an exception in our data set. In his tweet, he includes a hyperlink to the weekly news magazine *SPIEGEL* that reports on financial support for forest owners. Instead of just sharing and agreeing with the article, he cynically asks in his tweet: *"How could you be against 'saving the forests'? What is saved are the profits of often aristocratic forest owners that they can plant monocultures of spruce, amongst other things, which can withstand neither storms, nor drought, nor bark beetle. #we'refedup@JuliaKloeckner🤦 https://t.co/Jg4V6DxtLu" (weighted in-degree: 147; distribution count: 156)* With his post, he critically sheds light on the predominant prognostic framing of *"saving the forests"* while questioning not only forestry measures, but also the legitimacy of its ownership. He even reinforces his criticism by using the *hashtag "#we'refedup"* directed at *Julia Klöckner*. This hashtag refers to a movement initiated in 2011 by agricultural, environmental, and animal protection organizations calling for an ecologically oriented agrarian change. Despite its criticism, the tweet helped the article to be distributed 176 times while having a low *centrality* (*weighted in-degree*: 12).

6. Discussion – reflecting on the role of actor and tweet-hyperlink-networks in hybrid media systems

6.1. German forests on Twitter – Just calling into the void?

Our results show that only a few actors in the Twitter debate possessed the ability to exercise discursive power by *introducing* and *amplifying* their frames within the tweet-hyperlink-network. In relation to German forests, the discursive power is very context-specific. It wasn't the actors with the highest number of followers that gained highest *centrality*, but rather actors that are generally prominent in forest-related topics. In contrast to traditional political communication (Mack et al., 2024, 2023), forestry and media actors do not represent the most dominant actor groups on Twitter. *Centrality* is mostly reached on an *individual* level by politicians, nature conservation actors, certain *individuals,* and first and foremost by the popular forester and book author Peter Wohlleben. In contrast to other forest-related studies, celebrities, activists, or bloggers did not take up a central role in the debate (Skill et al., 2021).

Our data suggests that hyperlinks did not increase the likelihood of tweets being retweeted as suggested by the literature (Madden et al., 2024). Instead, in line with a German-speaking Twitter analysis on national-parks, we found low degrees of interactions through retweeting, replying, quoting, and liking (Pellicer-Chenoll et al., 2023). However, we found four central dynamics how actors use hyperlinks to expand the information conveyed via their tweet. The first relates to the *amplification* of framing via multipliers. In our case this seems to be an effective strategy due to forest-debate specific *centralities* achieved by

actors. In this form, media actors gain indirect influence in the network, as their content is being shared via hyperlinks. The second refers to the *amplification* of own framing by actors with high *centrality*, using their outreach potential in the twitter network. Legacy media actors, for example, have not realized this potential as they did not gain high *centrality* within the hyperlink-tweet network. The third strategy uses apparently more neutral hyperlinks to news articles, in order to legitimize their own claim. The fourth strategy was to include hyperlinks in order to critically highlight and object dominant discourses represented by legacy media.

Despite the outstanding *centrality* of a few actors, their discursive power has to be reflected against the absolute outreach of the analyzed tweets and general structures of the hybrid media system. While the importance of Twitter in German political communication is generally low compared to other countries (Newman et al., 2023), Twitter's relevance in the forest debate seems marginal. Within the analyzed timeframe, we identified 2405 Twitter users engaging with forest-related issues. Accordingly, the most *central* tweet was merely retweeted 193 times and received 364 likes. These numbers appear negligible compared to the outreach of legacy media (cf. Behre et al., 2023; Mack et al., 2023), the 2.5 million German copies sold of books authored by Peter Wohlleben (Penguin, 2024), or the global Twitter outreach provoked by the Amazon Fires in 2019 (Skill et al., 2021). Furthermore, the Twitter debate did not affect reporting in legacy media or political processes (cf. Mack et al., 2024, 2023) in the way wildfire-related movements did in Greece (Gerosideris and Ferra, 2020). The scattered and unnoticed character of the Twitter "debate" might also reflect the lack of one coherent hashtag which could have created the distinguishable communication space necessary for social mobilization (Jungherr and Schroeder, 2022), as presented in other forest-related debates (Gerosideris and Ferra, 2020; Karamichas, 2007; Skill et al., 2021). With regard to the theoretical framework (Chadwick, 2017; Jungherr et al., 2019), we conclude that, in contrast to legacy media (Mack et al., 2023), actors did not achieve sufficient discursive power to *introduce* and *amplify* the *topic* of forests in the larger Twitter debate beyond the rather sparse network. With regards to the large media attention the forest damage generated (Mack et al., 2023), it underscores the relevance of legacy media in setting and sustaining forest-related topics as relevant in public debates. Thus, the Twitter "debate" on the German *forest dieback 2.0* seems to have been a sole calling into the void.

6.2. Polarization between forestry vs. nature conservation and beyond?

Despite the limited outreach of the Twitter debate, we can still draw some conclusions for forest debates based on the analysis of frames and the role of actors. This is especially true because the network structure of Twitter data enabled the analysis of frame resonance (cf. Snow and Benford, 1988), which is not possible when exclusively looking at legacy media. In contrast to other forest-related examples (Gerosideris and Ferra, 2020), our results show that the debate on social media is largely in line with traditional media, as it is also dominated by the cleavages between forestry and nature conservation frames. Despite being criticized more strongly, the forestry sector still holds its dominant position in being legitimized to manage future forests.

In this context, despite the accessible character of Twitter, our results show neither clear signs of polarization nor deliberation. Whereas the lack of deliberative potential is demonstrated by few constructive dialogues amongst Twitter users and the lack of strategic hashtags that might have led to societal mobilization or attention in legacy media, signs of polarization have to be considered in a more differentiated way (Esau et al., 2024). Despite the insulated communication networks of central actors, we cannot support claims regarding *echo chambers* or *filter bubbles*, as our data is restricted to one issue without considering the broader personal on- and offline networks of the respective actors (cf. Bruns, 2023, 2019). Further, referring to the five symptoms of *destructive polarization* in digital communication proposed by Esau et al. (2024), we observed *discrediting of information* (i) as well as a *simplification of arguments* (ii) in part of our data. While this reduction of complexity is partially explained by the limited characters allowed on Twitter, it is partially countered by hyperlinking to more thorough articles that back up the argument. In contrast to the debate in newspapers and press releases (Mack et al., 2024, 2023), the framing in the Twitter debate is expanded towards more general societal discourses. While climate change also plays an important role in legacy media reporting on forests, the framing on Twitter refers more genuinely to a critique and claims concerning climate change policies. In these framings, the current situation of forests is not in the center, but merely used as a case to back up the climate-related arguments. With regard to climate change, Twitter opens a *communication space for extreme positions* (iii) referring to climate skepticism and denial, arguments that are scientifically conceptualized as post-truth (Fischer, 2019). These tweets use the situation to underscore their skepticism towards climate change by questioning the scientific foundation of the measures taken. The case of dying forests seems very convenient in this context, as the argumentation is backed by parallels drawn to the *forest dieback* 1.0, a debate with profound political implications that has never been thoroughly evaluated and that has been criticized for being staged by the media (Holzberger, 1995). However, these tweets are marginal and mostly countered by more or less factual replies showing that these disagreements did not lead to a *breakdown of communication* (iv) nor to a complete *exclusion driven by affective polarization* (v). Nevertheless, if being fully appropriated by and aligned with meta discourses of climate skepticism or the far-right, social media can contribute to further societal polarization becoming *destructive* (Al-Rawi et al., 2021; Bruns, 2023; Chen et al., 2021; Esau et al., 2024; Kubin and von Sikorski, 2021; Treen et al., 2020; Tyagi et al., 2020; Völker and Saldivia Gonzatti, 2024).

To conclude, the Twitter debate on the *forest dieback 2.0* shows a potential for polarization also beyond the forest, respectively beyond the cleavage between forestry and nature conservation sector. However, regarding the limitation of our data, we would not consider it destructive (yet) (cf. Esau et al., 2024). Tenets of constructive journalism could help to mediate and set (online) debates into context (Mäder and Rinsdorf, 2023), but only if they achieved *discursive power* in digital spaces. Further studies will need to set a more specific focus on polarization in contemporary media systems. In this context, research should account for the variety of actors that engage in debates around forests by considering a more differentiated analysis of actor categorizations. Studies already provide a more differentiated view of ideas, perceptions, and values of forest managers (Ruppert-Winkel and Winkel, 2011), forest owners (Ekström et al., 2024; Ficko et al., 2019; Ní Dhubháin et al., 2007), and nature conservation actors, highlighting the importance of mutual exchange and learning (Bethmann et al., 2018; Joa et al., 2020; John et al., 2024). Along with these scholars, we claim that these sectoral dichotomies, also reinforced by (our) previous analyses (Mack et al., 2023; Sotirov and Winkel, 2016; Winkel and Sotirov, 2011), should not be taken for granted and may reinforce emergent polarization.

6.3. Reflections on the operationalization of analyzing discursive power in hybrid media systems

With our case study on controversies about German forests, it was our aim to operationalize the analysis of discursive power in contemporary hybrid media systems by referring to the framework suggested by Jungherr et al. (2019). By analyzing *standing* and *centrality* within the tweet-hyperlink-network, we were able to depict discursive power of actors at the intersect of old and new media logics. Despite the data being genuinely digital, our analysis reveals the complex entanglements and interactions between logics of legacy and social media. Especially with regard to the theoretical framework (Chadwick, 2017; Jungherr et al., 2019), our results show the importance of distinguishing between the *introduction* and *amplification* of frames across different platforms.

While we were able to analyze the quality of the frame *amplification* for hyperlinks, replies, and quotes, Twitter data provides limited information about whether retweeting was intended to endorse or object to the original tweet (cf. Molyneux, 2015). An additional focus on mention-networks could expand and improve the analysis of interactions between actors (Bossner and Nagel, 2020).

Focusing on one critical discursive event implied some limitations, also with regard to the theoretical framework. First, it was not possible to analyze if actors, besides *introducing* and *amplifying* framing, were also able to *maintain* their framing over time, which would require longitudinal studies. In this context, it would be crucial to analyze the continuity of framing with regard to the recently published German forest inventory and its impact on the climate mitigation argument. This is particularly relevant as it not only underscores the previous underestimation of the damage, but also describes the transformation of forests from carbon sinks to sources (BMEL, 2024). Second, the sampling period implied a framing bias towards cooperative instruments, as they mostly refer to the forest summit.

Further, to reflect the holistic complexity of hybrid media systems, the tweet-hyperlink-network seems too narrow. Expanding the analysis towards other platforms and materials, such as popular science books and talk shows, would help to reduce the platform bias (Bode and Vraga, 2018; Pearce et al., 2019). Additionally, the issue-related sampling did not account for the broader networks of actors (Bruns, 2023). Qualitative analyses with regard to the emotional turn in media studies (Wahl-Jorgensen, 2019), or approaches considering the role of platforms and devices in shaping public participation (cf. Marres, 2015), could contribute to an understanding of discursive power that goes beyond the actor-centered focus applied in this study by taking into account the role of subjectivity and materiality.

7. Conclusion

By combining Twitter data with the referenced hyperlinks, this paper represents a first study on how German forests are being debated in hybrid media systems. Further, it presents a contribution on how to operationalize the analysis of discursive power in hybrid media systems. The presented tweet-hyperlink-network shows different entanglements and interactions between old and new media logics, being bridged through hyperlinks. Discursive power is restricted to few debate specific actors that do not necessarily have the highest number of Twitter followers. In this context, legacy media in particular did not use its potential to influence the digital debate. However, the *central* actors and tweets operate mostly within insulated retweet networks that did not provoke further reactions outside their networks. Therefore, we did not see significant signs for either deliberation or polarization.

Nature conservation frames are more prominent on Twitter as opposed to in legacy media. While actors *introducing* forestry-related frames are underrepresented and critiques towards their sector is frequent, the dominant legitimation of forestry related measures is also underscored in the Twitter debate. Besides the common line of conflict between forestry sector and nature conservationists, calls for more climate action on the one hand and expressed skepticism towards the urgency related to forest damage on the other hand indicate the potential for larger societal polarizations. When engaging with forest-related conflicts, it bears keeping in mind that (re)negotiations on forests are mostly embedded in larger societal discourses. But for the current debate, communication on Twitter appeared to be a calling into the void.

CRediT authorship contribution statement

Philipp Mack: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Ida Wallin:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Mariella Susann Zwickel:** Methodology, Formal analysis. **Jonas Pfistner:** Methodology, Formal analysis. **Lena König:** Methodology, Formal analysis. **Daniela Kleinschmit:** Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2025.103447.

Data availability

The authors do not have permission to share data.

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