



This is a peer-reviewed, final published version of the following document and is licensed under Creative Commons: Attribution-Noncommercial-No Derivative Works 4.0 license:

**Fellenor, John, Barnett, Julie, Potter, Clive, Urquhart, Julie
ORCID logoORCID: <https://orcid.org/0000-0001-5000-4630>,
Mumford, J.D. and Quine, C.P. (2018) The social amplification
of risk on Twitter: the case of ash dieback disease in the
United Kingdom. *Journal of Risk Research*, 21 (10). pp. 1163-
1183. doi:10.1080/13669877.2017.1281339**

Official URL: <https://doi.org/10.1080/13669877.2017.1281339>

DOI: <http://dx.doi.org/10.1080/13669877.2017.1281339>

EPrint URI: <https://eprints.glos.ac.uk/id/eprint/4958>

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.



The social amplification of risk on Twitter: the case of ash dieback disease in the United Kingdom

John Fellenor, Julie Barnett, Clive Potter, Julie Urquhart, J.D. Mumford & C.P. Quine

To cite this article: John Fellenor, Julie Barnett, Clive Potter, Julie Urquhart, J.D. Mumford & C.P. Quine (2017): The social amplification of risk on Twitter: the case of ash dieback disease in the United Kingdom, *Journal of Risk Research*

To link to this article: <http://dx.doi.org/10.1080/13669877.2017.1281339>



Published online: 27 Jan 2017.



Submit your article to this journal [↗](#)





View related articles [↗](#)



View Crossmark data [↗](#)

The social amplification of risk on Twitter: the case of ash dieback disease in the United Kingdom

John Fellenor^{a*} , Julie Barnett^a, Clive Potter^b, Julie Urquhart^b, J.D. Mumford^b 
and C.P. Quine^c

^aDepartment of Psychology, University of Bath, Bath, UK; ^bFaculty of Natural Sciences, Centre for Environmental Policy, Imperial College, London, UK; ^cForest Research, Northern Research Station, Roslin, Scotland, UK

(Received 26 July 2016; final version received 29 November 2016)

It has long been recognised that the traditional media play a key role in representing risk and are a significant source of information which can shape how people perceive and respond to hazard events. Early work utilising the social amplification of risk framework (SARF) sought to understand the discrepancy between expert and lay perceptions of risk and patterns of risk intensification and attenuation with reference to the media. However, the advent of Web 2.0 challenges traditional models of communication. To date there has been limited consideration of social media within the SARF and its role in mediating processes of risk perception and communication. Against this backdrop, we focus on the social media platform Twitter to consider the social amplification of risk in relation to ash dieback disease (*Hymenoscyphus fraxineus*); a tree health issue that attracted intense media attention when it was first identified in the UK in 2012. We present an empirical analysis of 25,600 tweets in order to explore what people were saying about ash dieback on Twitter, who was talking about it and how they talked about it. Our discussion outlines the themes around which talk about ash dieback was orientated, the significance of users' environmental 'affiliations' and the role of including links (URLs) to traditional media coverage. We utilise the notion of 'piggybacking' to demonstrate how information is customised in line with group/individual identities and interests and introduce the concept of the 'frame fragment' to illustrate how information is selected and moved around Twitter emphasising certain features of the messages. The paper affords a detailed consideration of the way in which people and organisations simultaneously appropriate, construct and pass on risk-relevant information. A conclusion is that social media has the potential to transform the media landscape within which the SARF was originally conceived, presenting renewed challenges for risk communication.

Keywords: social amplification of risk; Twitter; social media; tree health; visual analytics; risk communication

Introduction

It has long been recognised that the media has a key role in representing risk, though the nature of its relation with public risk appreciation is complex (Binder et al. 2014). Traditionally, the media have been a key source of information for

*Corresponding author. Email: ljf38@bath.ac.uk

individuals (Smith and McCloskey 1998) and the production and consumption of printed newspapers and broadcast news are seen as central in shaping how people receive information about and respond to hazard events (Renn et al. 1992). Kaspersen et al.'s (1988) social amplification of risk framework (SARF) suggests that the media often play a key role in communicating about risks, influencing the way risks are framed and this and thus affecting how they are perceived and responded to by the publics.

With the advent of Web 2.0 and social media platforms such as Twitter, traditional models of communication and the hegemony of traditional media are increasingly under challenge and there are greater possibilities for other stakeholders and publics to play a significant and visible role in influencing and shaping risk perceptions (Chew and Eysenbach 2010). Whilst commentators such as Chung (2011, 3) suggest that the internet has 'transformed the conceptual framework in which people interpret, perceive, and respond to risks', Lupton (2016) argues that too little attention has been paid to social media and its role in communicating and understanding risk. The current paper thus explores social media and the social amplification of risk in relation to ash dieback disease (*Hymenoscyphus fraxineus*) (thereafter dieback) often referred to as 'Chalara', a tree health issue that attracted intense media attention when it was first identified in the UK in 2012 (Woodward and Boa 2013).

With increasing global trade and climate change enhancing the ability of tree pests and pathogens to extend their range, tree and forest health is now a major concern for many countries (Pautasso, Schlegel, and Holdenrieder 2015; Trumbore, Brando, and Hartmann 2015). Many pests and pathogens, of which dieback is one, are already affecting or are likely to affect UK forests and woodland. Dieback was first recorded in Poland in the early 1990s and since that time has spread across the entire European distribution of its main host, the common ash (*Fraxinus excelsior*) (Needham et al. 2016), causing the widespread decline of ash in countries such as Denmark and Norway (Potter and Urquhart Forthcoming). In the UK, dieback was first discovered at a Buckinghamshire nursery in February 2012, having arrived on a consignment of ash saplings imported from continental Europe (Heuch 2014). In October 2012, it was found in the wider environment in Norfolk and Suffolk and the Forestry Commission conducted a nationwide survey of ash trees in early November. Two government Cabinet Office Briefing Rooms (COBR) crisis response committee meetings were convened to discuss the problem. It has been argued that the dieback 'event' catalysed a change in policy and governance in the domain of plant health and brought the problem firmly into the public domain (Tomlinson 2016). Pidgeon and Barnett (2013) suggest that the high profile of dieback in the media specifically, and the role this played in signalling public concern, contributed to raising the importance of tree health in policy terms. Against a backdrop of increased media coverage of dieback, growing stakeholder engagement with the issue and new policy actions and commitments, this paper explores how dieback was communicated on one particular social media platform: Twitter.

The introduction will unfold as follows. We begin by describing the key tenets of the SARF and how it has been applied to a variety of risk issues. We discuss its relevance to tree health as a particular type of risk and consider the challenges that social media presents to the SARF, before outlining and exemplifying the use of Twitter in risk communication and its application to tree health. Finally, in the light of this, we set out our research questions.

SARF, media, and tree disease risks

The SARF (Kasperson et al. 1988; Renn et al. 1992) is a long-standing conceptual framework that was developed to explore the implications of interactions between official risk communications, media attention, and individual and social responses (Frewer, Miles, and Marsh 2002). The framework suggests that ‘events pertaining to hazards interact with psychological, social, institutional, and cultural processes in ways that can heighten or attenuate public perceptions of risk and shape risk behaviour’ (Renn 1991, 287). In the absence of direct experience of a particular risk, information generally reaches individuals via the media and/or informal personal communication. The nature of media coverage of risk is, of course, selective. It does not reflect expert assessments of risk and may not reflect risk incidence (Eldridge and Reilly 2003), though the amount of media coverage may relate to the societal impacts of a hazard (Renn et al. 1992).

In traditional communication theory, ‘amplification’ is defined as an intensification or attenuation of transmitted signals which result in the original signal having information added or removed before being passed on (Kasperson et al. 1988). The original approach to media in the SARF focused on the volume of traditional media coverage, its tendency to dramatise events and its ability to symbolise or mediate reality (Binder et al. 2014). SARF suggests that media coverage can affect the salience of an issue for the public, either due to coverage volume or the agenda it sets. However, many studies of traditional media have not identified a consistent link between media consumption and public risk perception even though the role of the media has come under increasing scrutiny (Petts et al. 2001). To date there has been limited consideration of social media within SARF (Rains, Brunner, and Oman 2014) and the role it plays in mediating processes of risk perception and communication.

News media has traditionally been thought about within the SARF as a significant ‘amplification station’ (Kasperson et al. 1988): an entity with the power to filter, amplify or attenuate risk signals in ways which coincide with the capacity to set agendas and frame issues (Binder et al. 2014). Social media can also be considered as an amplification station. As with traditional media, messages circulating in social media may reflect similar ebbs and flows in attention to an issue (Yang and Leskovec 2011). However, using Twitter as the example, the distinction between news producers and audiences is much less distinct with journalists using Twitter as an information source (Broersma and Graham 2016). The sheer number of accounts on Twitter means that there are numerous options as to which networks to be a part of and who to follow (Ausserhofer and Maireder 2013). Thus, social media such as Twitter can afford exposure to a range of voices and opinions, particularly around events, although choice of accounts to follow can constrain and concentrate this. In relation to the notion of social media as an ‘amplification station’, it can be suggested that there is a greater scope for a message to be translated and diffused in ways that reflect heterogeneous audiences not only using information but also producing it (Newman 2016). Hence, social media also urges us to consider the role of interpersonal communication and individuals as amplification stations, given that social media affords the customisation of information in ways that intersect with different aspects of individuals’ online identity and motivations. So whilst the metaphor of amplification may have led to an unwarranted simplification of the interaction of traditional media and the views of publics and experts (Petts et al. 2001), social

media certainly renders these complexities more visible and connects them to the individual.

In terms of risk and social media in a broader sense, several studies are useful in identifying some of the issues involved in exploring risk in relation to social media and which are relevant for our work. Binder's (2012) study of the extent to which social media play a role in public discourse about nuclear technology provides an insight into the function of tweets in terms of their interpretive or information-providing function and their 'qualitatively different characteristics' (ibid. 270). This differentiation is useful in flagging up the need to develop methods that acknowledge the different layers of how risk is denoted or connoted. Binder (2012) also makes explicit the temporal aspects of how tweet content changes over time as information about an event emerges; this applies to dieback in the sense that emerging knowledge will be revealed not only in tweet content but also in terms of the volume of tweets about a given topic across time. Aula (2010, 44) flags up how social media complicates the relation between risk management and 'expands the spectrum of reputation risks and boosts risk dynamics.' A key insight is that social media content cannot be managed in the same way as messages about risk diffused through traditional media channels. In relation to traditional media, social media therefore urges us to reconsider the authority of traditional media in disseminating and framing risk issues (O'Neill et al. 2015).

Studies using the SARF tend to focus on issues potentially affecting human health such as genetically modified foods (Frewer, Miles, and Marsh 2002), bovine spongiform encephalopathy (Lewis and Tyshenko 2009), zoonotic disease (Busby and Onggo 2012; Chung and Yun 2013; Rickard et al. 2013) and crises such as earthquakes and hurricanes (Vasterman, Yzermans, and Dirkzwager 2005; Miles and Morse 2007). Other work has explored broader environmental concerns such as climate change (Shakeela and Becken 2015) and fracking (Thomson 2015). The profiles of these hazards are variable in terms of their likelihood and consequences, how they are typically perceived in terms of the key parameters of dread, familiarity and controllability (Slovic 1999), the extent to which risk managers are trusted and thus how they are likely to be reported in the media (Renn et al. 1992). Thus far, tree diseases in general and dieback in particular have received little consideration in relation to the changing profiles of public, stakeholder, media and policy attention that SARF seeks to characterise (for an exception see Pidgeon and Barnett 2013). However, dieback in particular exhibits a range of characteristics that make it an interesting candidate for study. To begin with, the invasive pathogen responsible for dieback is likely to impact on a range of public goods and ecosystem services, such as biodiversity, landscape amenity, timber and wood-fuel production and the cultural value of trees, with potential consequences for human health and well-being (Boyd et al. 2013). Moreover, the link to the global trade in live plants and wood products means that it intersects as an issue with broader policy debates and sources of controversy concerning the best way to balance market opening with effective biosecurity (Potter 2013; Pautasso, Schlegel, and Holdenrieder 2015; Trumbore, Brando, and Hartmann 2015). Though dieback does not directly threaten human health and its temporal trajectory is markedly slower than many other natural hazards, its impacts on woodland composition and landscape has attracted attention and concern from many different stakeholders across a range of locations. While dieback might lack some of the crucial fright factors and media triggers for a risk which can intensify public concern and media attention (Pidgeon and Barnett 2013), it does mobilise

questions of blame and political conflict (Urquhart and Courtney 2011) and is therefore a useful case through which to explore the role that social media played in making it a focus of concern and sociopolitical activity (Pidgeon and Barnett 2013).

Twitter and risk communication

Social media is a generic term for internet-based applications that build on the ideological and technological foundations of Web 2.0, enabling dynamic, interactive user-generated content which individuals and communities can find, share, co-create, discuss and modify (Neeley 2014). Twitter, as a specific social media platform, enables real-time communication through which information can be shared as direct comments or in terms of links to other media sites (URLs) or hashtags (#). The latter enable users (where usernames are prefaced by @) to tag, follow and contribute to particular topics of conversation (Bruns and Burgess 2011). Users can interact with targeted individuals or groups but conversations are generally available to wider audiences (Boyd, Golder, and Lotan 2010). As noted by Tufekci (2014), whilst there are many social media platforms in use, Twitter lends itself to research as data is easily accessible, voluminous and has a range of features amenable to analysis. Tweets can be captured over time thus affording insight into longitudinal changes in relation to how an issue such as dieback evolves. This is particularly useful where the ebb and flow of public attention over time is a key interest to risk communicators (Binder 2012; Mellon and Prosser 2016).

Our focus on Twitter can be justified conceptually as well as methodologically. Twitter now has an important role in crisis communication, for example in improving situational awareness during natural hazard events (Vieweg et al. 2010) such as detection during earthquakes (Sakaki, Okazaki, and Matsuo 2010; Earle, Bowden, and Guy 2011), or illustrating how hashtags become 'central coordinating mechanisms' for flood-related user activity (Bruns et al. 2012). Notably, Twitter is a key means of communication for organisations managing risk (Panagiotopoulos and Bowen 2015; Panagiotopoulos et al. 2016). Previous work suggests tweeting practices reflect complex purposes, including sharing information as a means of gaining attention (Rui and Whinston 2012), building networks and social engagement motivated by reciprocity, reputation and efficacy (Syn and Oh 2015) and breaking and contextualising news (Gleason 2010). Twitter content has been considered as a horizon scanning mechanism to alert policy-makers to anticipate emerging risk issues (Amanatidou et al. 2012). This has been directly applied to forest health, where Twitter was scanned for mentions indicative of invasive alien tree pests (Daume 2016). Social media is also increasingly considered a source of valuable information about the societal context and functions of forests (Daume, Albert, and von Gadow 2014). Bogdanou et al. (2013) suggest that social media provide opportunities for the forest industry and related stakeholders to promote communication and influence the general public. Developing social media use also decreases dependence on traditional media outlets (Heuch 2014). The potential value of social media in general, and Twitter in particular, has been recognised in relation to tree health risk assessment, management and communication (Daume 2016).

Using the case of Twitter activity around dieback we will explore the implications that social media has for SARF. To achieve this, we address three main questions. First, what was being said about dieback on Twitter? We address this by identifying the most salient themes conveyed in the tweets and consider how these

relate to risk. Second, who was talking about dieback on Twitter? We explore this by reflecting on types of user and their inferred or reported alignment with environmental issues. We anticipate that users with evidence of environmental allegiances will be more evident in tweets about dieback. Finally, we seek to characterise how Twitter users talked about dieback. To do this, we focus on how URLs and hashtags are deployed in order to conceptualise the ways in which users frame and align their concerns with dieback to other issues.

Methods

The trajectory of dieback in traditional media and the timing of official hazard notifications (Barnett and Breakwell 2003) informed the timing of the collection of Twitter data for this study. Given the close temporal relation that exists between Twitter and traditional media (Farhi 2009; Cataldi, Di Caro, and Schifanella 2010; Grusin 2010) LexisNexis¹ was used to establish the volume of media stories about dieback for 2012. On this basis, the study period for Twitter data procurement was determined as October 23rd to November 20th 2012.

DiscoverText (DT)² software was used to obtain all tweets about dieback. DT incorporates a search function which enables the user to specify the relevant search terms for the period of interest. These are then used to interrogate Twitter's tweet archive. DT then enabled the identification and removal of duplicate tweets, that is tweets with identical content and released more than once, usually from the same account (Wang 2010). Discounting duplicates from our study was legitimate as the focus of the analysis is primarily on content rather than tweet volume. Retweets were retained in the data-set.

DT and Chorus³ software (Brooker, Barnett, Cribbin, and Sharma 2016) were then used for text mining and visualisation in order to aggregate tweets based on time or topic. Using this software allowed us to cluster and organise tweets on the basis of semantic similarity in order to identify related themes. An abductive approach was adopted; as clusters of tweets were explored, analytic insights were generated and then used to frame subsequent interrogation of the data (Paavola 2004; Brooker, Barnett, and Cribbin 2016).

To address the question of *what* was being said about dieback, we used the DT CloudExplorer and TimeTrack functions to inform a thematic analysis of the data. These functions enable tweets to be identified and then thematised by key terms and organised temporally so that the ebb and flow of a given theme can be characterised and explored in relation to co-occurring themes. Because tweets often reflected a theme but not necessarily based on key terms, it was also necessary to manually scrutinise tweets. This was achieved by using Chorus to identify tweets that were semantically clustered and assigned to a specific 'bucket' of tweets; i.e. a subset of the data that was assigned under a thematic label. Thematic analysis involves the search for patterns [themes] in the data which enable descriptions of different aspects of the phenomenon in question (Daly, Kellehear, and Gliksman 1997). These descriptions, for the present study, reflect the minimal organisation of talk about dieback (Braun and Clarke 2006) into substantive themes. Alongside this analysis, we also took the approach of Binder (2012) and sought to determine the extent to which an explicit risk-related vocabulary was used within themes as well as across the full data corpus. Online thesauruses⁴ were used to generate a list of 22 such synonyms⁵ and searches conducted for any of these which occurred at least five times. The

TimeTrack function of DT was used to visualise the rise and fall in risk synonym use across the data period.

Existing work suggests social media users engage in ‘internet identity-play’ and can re-present their status in terms of relevant identifiers such as age and gender (Sloan et al. 2015). Also, different events systematically attract engagement from groups claiming particular interests and identities (De Choudhury, Diakopoulos, and Naaman 2012). For the present study and to help us identify *who* was tweeting about dieback, criteria were developed to categorise users tweeting about dieback as having an environmental or non-environmental alignment. We established the former on the assumption that their Twitter biography, history of previous tweets or use of images explicitly or implicitly indicated an interest in trees, forests or environmental issues. Non-environmental users were those without any indication of such interests.

To address *how* people talked about dieback, we used the DT capacity for extracting metadata, such as URL and hashtags, to classify tweets and to identify which users were tweeting about a certain topic. Identifying hashtags enables an insight into how users orientate to a topic, whilst the use of URLs contains salient information from web sites. Capturing URLs provides an insight into key media articles about an issue or topic.

Ethical issues surrounding the reuse of public social media remain uncertain, reflecting contrasting perspectives (Bica and Anderson 2016). We follow Boyd and Crawford (2012) in suggesting that tweets are created in a specific context and that users may therefore perceive their use elsewhere as problematic. Thus, throughout this paper all user names are anonymised (e.g. @***S) and semantic content is paraphrased to minimise the possibility of user identification.

Findings and discussion

DiscoverText retrieved 25,652 tweets about dieback, generated by 10,783 users for the period of 23 October to 20 November 2012. 7079 (66%) users tweeted about dieback just once and 1610 (15%) tweeted twice with one user tweeting 103 times. These figures indicate that for the majority of users their engagement with dieback during the one-month peak period of traditional media attention was limited. Two thousand two hundred and 2282 unique words appeared in the corpus. When duplicate tweets were removed, 18,303 (71%) non-duplicate tweets remained, of which 3340 (18%) were re-tweets. The corpus of tweets minus duplicates included 14,756 (81%) URLs, of which 3273 (8%) were unique, and 636 unique hashtags in 6670 (6%) tweets. For completeness, Figure 1 below includes an indication of tweet volume both with and without duplicates.

Figure 1 illustrates an ebb and flow of tweet volume which appears to broadly align with government activity and press releases and reflects the close temporal relation between news media and Twitter (Kwak et al. 2010). The volume of tweets about dieback between 1 January 2012 and 23 October 2012 was less than 150 and this reflects the fact that dieback was not a subject of consistent and intense media attention until the autumn of 2012.

It is important to bear in mind that different topics on Twitter garner different degrees of attention. Our data-set of tweets is relatively small in comparison to the volume attracted, for example, by the Jimmy Saville issue which DiscoverText estimated as over 140,000 tweets in the UK over the same period. This description of

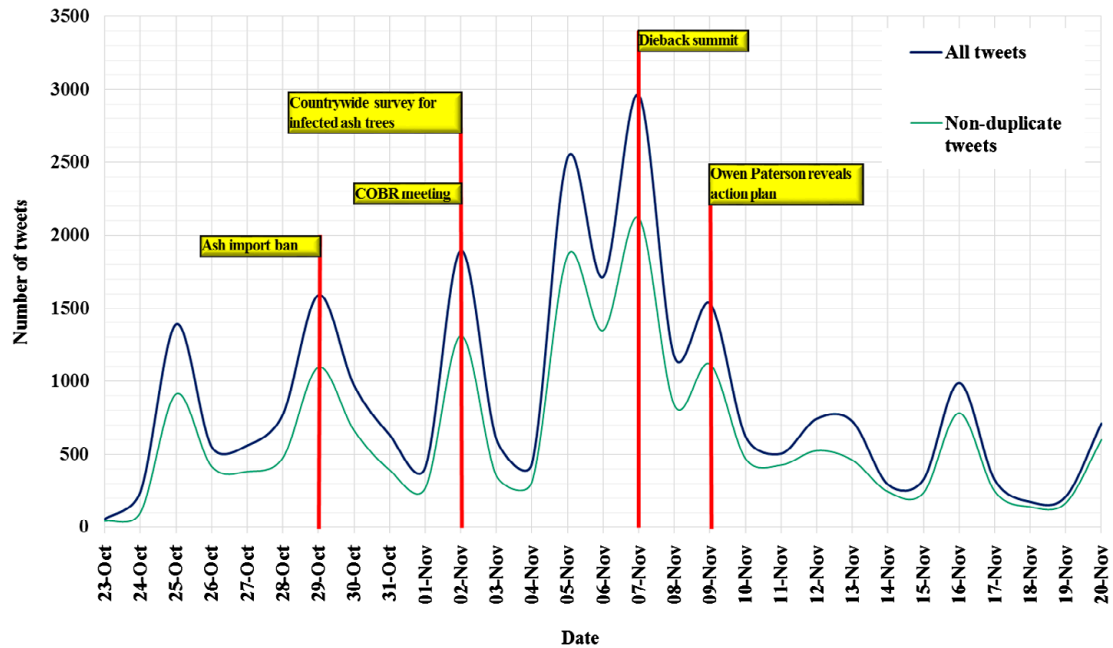


Figure 1. Daily number of tweets about dieback and significant government actions reported in the media.

the changing volume of dieback tweets and the way that they are aligned to other hazard notifications sets the backdrop for considering our three research questions.

What was being said about dieback on Twitter?

Tweets were organised around four main themes that varied in their visibility over time. The most prolific single theme was the notion of the *spread* of dieback, attracting 1288 tweets across the entire period, peaking on October 26th and 29th with 173 and 151 tweets, respectively. This set of tweets involved users referring to spread in a variety of ways. They shared the idea that ‘burning leaf litter spreads (dieback)’, identified specific locations to which the disease had spread and noted that ‘the British public could be banned from forests’ in order to stop its spread. A second key theme of *fighting* dieback was reflected in 248 tweets. They focused on the different options for fighting dieback and this response was mobilised practically and metaphorically, capturing the notion at that stage at least, that the disease could be eradicated. Tweets included URL links to a book sale where the profits would ‘help fight Chalara’, explanations of how gardeners could help by adapting their practices and by calling for large-scale action by the Government. Others depicted ash as fighting back; showing photographs of healthy ash saplings growing in a wood. This theme peaked on October 28th but persisted until the end of the data period. A third theme of it being *too late* to contain dieback, contained 641 tweets, peaking on 7th November with 271 tweets. This theme contains contrasting stances. Many tweets reflected media references to ‘government scientists’ suggesting dieback could not be eradicated, whilst others highlighted government ‘dithering’. *Blame* was the final theme in 282 tweets, peaking on October 29th and November 1st with 63 and 37 tweets, respectively. This theme included blaming UK gardeners, EU trade regulations and ‘chaotic import systems’. It invoked other ‘mismanaged’

affairs such as foot-and-mouth disease and criticised explanations about the potential for dieback spores to have blown across from continental Europe. Reports of government claiming that ‘its hands were tied’ relates to the delay in scientific naming and identification of the pathogen responsible for dieback, which meant that the Government could not regulate against it. Ideas around blame connect to notions of ‘government inaction’ and depict calls for a ban on ash imports from the horticultural sector prior to 2012 being ignored by the Government. Overall, the themes of *spread*, *fight*, *too late* and *blame* connote a problematic state of affairs around dieback and connect to risk insofar as they refer to the possibility of unwanted consequences; although we do not make any inference from this about the nature and extent of public concern.

The themes shed light on how dieback is constructed. For instance, as noted by Nerlich, Hamilton, and Rowe (2002), metaphors [of war] heighten the sense of a risk but simultaneously help different groups understand certain contours of a problem and how to approach it. Apportioning blame is a common way of attributing human failure to identify and prevent risk (Alaszewski and Brown 2011). This certainly appears to be the case with dieback, given that tweets around the theme of blame prioritise the human aspects of the failure to prevent ingress of dieback. This, and indeed each of the other themes we have identified, are likely to some extent to be tropes that can be easily mobilised around such events rather than because of the direct implications of dieback per se.

It is clear that tweets from these themes can refer to the notion of risk without containing any risk-related words, for example ‘@horse All horse riders are told to look at horses hooves to fight dieback <http://bit...>’. The notion of risk here is implied by communicating that hooves can carry disease and not checking them can lead to its spread. Building on this, we specifically explored the extent to which an explicit risk vocabulary was used in the data.

Overall, only 9 of 22 risk synonyms appeared in tweets. The highest frequency term with 232 instances was ‘threat’, peaking three times across the data period. In each case, the peak coincided with a key media story or event. Specifically, most risk synonyms were located within a media headline in the tweet and linked by a URL to the original article. For example, the most frequent use of ‘fear’, with 104 uses in total, peaked towards the start of the data period on October 27th with 72 tweets which all contained the same *Guardian* headline and its URL link. The most prominent synonym within a specific theme was ‘threatening’ with 34 instances found in the theme of ‘too late’. Each tweet contained a headline referring to dieback as a deadly disease threatening ash trees with no extra content added. These findings suggest that rather than a general risk vocabulary being deployed to articulate concerns around dieback, the use of risk-related terms reflected the content of specific news story headlines that tweets were linked to.

Who was talking about dieback?

We first explored whether there were more tweets about dieback from those with environmental interests. Using the criteria outlined above, we assessed the 50 users contributing the greatest number of tweets; 2447 in total. Of these users, 35/50 (70%) were categorised as *environmental*. This group accounted for 1846/2447 (75%) tweets and, in line with their indicators of explicit or implicit attention to

environmental matters, were more likely to tweet about dieback. 18 (36%) of the top 50 contributing users represented organisations and of these 15 were environmental accounts. This also suggests that many of those talking about dieback on Twitter have a strong environmental orientation or motivation.

Further analysis of these user categories revealed instances of specific types of news story or topic being shared amongst small groups of similar users. For example, gardeners shared information about gardens, bird watchers about affected bird habitats and horse riders about washing horses' hooves. Whilst each of these stories were associated with dieback, the attention to dieback appeared to be anchored in a shared group affiliation and suggested that group membership was operating as an affordance that enabled but also delimited the types of tweets and range of other users with which people engaged (Argyris and Monu 2015).

The top individual user, @****C, was categorised as *environmental* and tweeted 128 times about dieback and 494 times in total across our data period. On the day of peak Twitter activity, November 7, this user tweeted 13 times, invoking the themes of *spread* and *fight*. @****C perhaps typifies what official communicators would think of as an 'environmentally concerned citizen': socially minded and actively engaged with a broad range of environmentally orientated issues (Tucker 1978) beyond trees (such as fracking and immigration); sufficiently concerned to tweet that 'dieback makes my heart ache #dieback'. However, 9 of this user's tweets were re-tweets covering a range of topics and different URLs such as the Tree Health and Plant Biosecurity Taskforce created to advise the government on the current threats to tree health and plant biosecurity, the value of involving communities, citizen science and sharing information about how to spot dieback. This suggests a user engaged in actively searching for and contributing information. When tweeting about dieback, @****Cs asks questions of other users directly or indirectly, shares URLs and information and references their own tweets which convey emotion and concern about dieback. Over the data collection period, tweets were largely tree orientated but not restricted to dieback. The preoccupations of @****C extend beyond dieback and environmental concerns as demonstrated in tweets about mundane affairs such as 'painting walls is boring!' Further exploration of Twitter beyond the data-set revealed that whilst relatively prolific within the dates of this study, @****C did not tweet again about dieback after 27 November 2012. Focusing on individual users helps us bear in mind that data is always produced in a context and mitigates against conceptualising amplification in an abstract manner.

If those tweeting can be regarded as individual amplification stations (Kasperson et al. 2003) then an analysis of URLs, biographies and tweets shows some of the strategies in Twitter being used to communicate about dieback, and in so doing sometimes also to be communicating about risk. It is also suggestive of the iterative processes that Kasperson et al. (1988) suggest are involved in the development of narratives of concern.

How do people talk about dieback on Twitter?

In addressing the third and final research question, we discuss how hashtags and URLs relating to dieback were deployed. The analysis of how URLs are used leads to the introduction of two concepts: frame fragments and piggybacking.

Hashtags

The most prolific hashtags in the data-set are illustrated in Table 1. The final appearance of any of these hashtags was 20 November 2012. #ashdieback was the hashtag most associated with dieback. It first appeared in June that year when it was used by an NGO Twitter account to ask people to watch out for and report signs of dieback to the Food and Environment Research Agency (Fera) or the Forestry Commission. This mention precedes the peak of media attention to dieback by three months. In our data-set, #ashdieback peaked on November 7th with 330 tweets. #ash is associated with a wide range of topics and uses such as volcanic ash, Pokemon and hair colour. It therefore does not have the specificity of use to establish a community of users or topic but may serve to accidentally introduce users to unanticipated topics and illustrates the sometimes ad hoc way in which people may encounter dieback. It also illustrates how hashtags can be used to orientate users to a broad topic or more specialist sub-topics (Bruns and Burgess 2011). #ashtreeaction attracted 132 tweets beginning on November 7th with 31, peaking on November 9th with 34 before dropping to 4 the next day. This hashtag appears to be representing the ash tree summit of November 7 and the bulk of tweets are from government accounts and NGOs sharing ‘facts’ from that summit and is an example of a specific attempt at organising related dieback information on Twitter. Competing hashtags can thus emerge and work then has to be done by users to keep a hashtag free of irrelevant ‘distractions’ and to maximise its reach (Bruns and Burgess 2011). This is clearly not always easy: one individual environmental user tweeted ‘hashtags confuse me: #ash #ashaction #chalaraash #ashtag #ashdieback...’

URL sharing

Sharing URLs is an important way to disseminate information, with users serving as ‘information brokers’ who distribute web-based information to other users (Hughes and Palen 2009). Each day of the data period contained tweets with URLs and the link ratio range (ratio of tweets with URL/without URL) was 0.65 – 0.89. The

Table 1. Most prolific hashtags used around ash dieback.

Hashtag	Frequency	Date of first appearance in data-set
Ashdieback	2992	23.10
Ash	668	23.10
Chalara	589	24.10
Environment	403	24.10
Ashtrees	328	25.10
News	318	24.10
Trees	251	23.10
Ashtag	222	28.10
Nature	166	24.10
Ashtreeaction	125	7.11
Green	104	24.10
Teamfollowback	103	25.10
Ashtree	98	23.10
Saveourforests	89	25.10

standard deviation of link ratios was 0.06. This indicates that the much of what was occurring on Twitter included passing on information via URLs but also that across the data period there was low variation in the proportion of tweets with URLs, despite the ebb and flow of different themes. Twitter users tend to talk about headline news and share fresh news items (Kwak et al. 2010) and it can be suggested that dieback was a novel news topic that warranted sharing. Hughes and Palen (2009) indicate that the percentage of URLs shared in a general sample from 2007 equalled 13%, whereas in 2009 it was 24% and approximately 50% for a crisis event. Thus, the figure of 80% of all our tweets containing URLs may reflect the upward trend in URL tweeting and information sharing in general but may also reflect unfamiliarity with dieback and hence the provision of information. Given Binder's (2012) discussion of a changing profile of URLs over time in his analysis of #Fukushima we might surmise that patterns of information sharing are likely to be affected by a range of factors and that more case studies are needed in order to identify these.

Twitter users sharing URLs about dieback were more likely to have linked to a BBC story than any other information source. About 34 out of the 50 most shared URLs linked to the BBC. The first official URL (the Forestry Commission dieback information page) appeared at number 12 and was only shared in 132 tweets. The 11 BBC URLs preceding this were included in 3067 tweets.

The most prolific URL related to a BBC story entitled 'Ash dieback: Government faces possible legal action'. Dated November 5th, it was tweeted 668 times by 558 users. This storyline connects to the theme of *blame* and depicts government inaction in terms of a tree nursery obliged to destroy 50,000 infected ash saplings at their own cost and with no prospect of compensation. The owner is reported as considering legal action against the Government for failing to impose a pre-emptive import ban. The persistence of this URL on Twitter and hence the story with which it is associated declines from 668 tweets on November 5th to 3 tweets, two days later. Short duration and single tweeting is a feature of media URLs (Wu et al. 2011) and dieback on Twitter conforms to this observation.

Frame fragments

An extensive body of work has explored how stories are framed in traditional media, the purpose of framing, how agendas are set, the hegemonic role of media sources and the increasing influence of the public and social media in agenda building and advocacy (see, for example: Gamson and Lasch 1983; Entman 1993; van Gorp 2005; McKeever 2012). Framing is used to describe the manner in which messages are packaged by the media in order to foster a particular interpretation in the mind of the receiver. Due to the affordances of Twitter, users have to tweet within the confines of the 140 characters that comprise a tweet; thus, simply conveying a fragment of a frame that is contained in the URL.

Sometimes, the frame fragment actually relates to a single message contained in the URL. For example, the user @***GU, a government Twitter account, tweeted 21 times, with these tweets attracting 334 re-tweets. One tweet read, 'Myth smashed: there are no plans to stop public accessing forests to battle ash dieback #ashtree bit.lx/3**' where the URL referred to a media article claiming that the Government planned to restrict woodland access to the public. However, many users appeared to reframe elements of news stories about dieback. The following example of frame

fragments illustrates the confusing picture of the rate of spread of dieback. The user @****B links to a Department for Environment, Food and Rural Affairs (Defra) statement that frames the spread of dieback in terms of rapid action by the Government and explicitly states that new sites being found does not mean that the ‘disease is spreading rapidly’. However, @****B represents this in terms of the ‘unstoppability’ of dieback, thus providing an example of how people capture frame fragments and enrol them to serve different and sometimes contradictory processes. Mechanisms such as frame fragments, ostensibly how users pick up an element of a story or media URL, is one of the processes which renders visible the heterogeneity of response to dieback on Twitter. Just as the ‘concept of framing is used to investigate how media and audiences co-construct news events [and] holds similarities to concepts of the explanatory theme and discourse analysis’ (O’Neill et al. 2015), our notion of the frame fragments falls within a similar domain; one which directs us to consider the intersection between the media, user and audience on Twitter. However, our notion of the frame fragment does not refer to a framing analysis of dieback.

Piggybacking

We term a further way in which people used URLs in Twitter as *piggybacking*. For example, the user @****S tweets ‘three problems beyond the Chalara debate but there is one solution: [business name]. http://bit.*****hg’. The URL is connected to a story which suggests that a solution to affected ash trees is to turn them into bio-sterilised charcoal. It seems that this user’s tweet does not arise from a primary concern with dieback but rather that dieback provided a platform to flag up and link to the business they represent. This is an example of how users piggyback on the main story in order to direct attention to a particular interest. In this case, tweeting about dieback provides a convenient vehicle for self-promotion.

Another group-based example of piggybacking can be seen in the tweets aligned around a story about horse riders and the need to wash horses’ hooves to prevent dieback being spread. Ten of these users tweeting about this had biographies explicitly related to horse eventing and riding. What defines this group is primarily a shared identity around horse-related affairs and sharing information about dieback is piggybacking on this identity and the activities it is associated with. When we consider the concept of piggybacking in relation to amplification, it would seem important to consider the extent to which the issue has implications for individual and group interests and consider who might be motivated to appropriate it and how. The amplificatory potential of an issue might reflect the extent to which it can be enrolled into or by existing concerns.

Thus, we can see that through use of URLs, of frame fragments and through piggybacking that Twitter provides users with opportunities to propagate customised information about an issue that is in line with their motivations, perspectives and identities.

Conclusions and further reflections

Whilst significant attention has been paid to the role of traditional media in SARF, there has been limited examination to date of the implications for SARF of social media practices. In light of the changing nature of the media and the increasingly ubiquitous role that social media plays in many people’s lives, it is crucial that risk

research considers its role in changing patterns of lay, stakeholder and expert attentiveness to hazards. Having set the scene by describing the rise and fall of Twitter interest aligned against some of the official hazard notifications, we have presented an empirical analysis of *what* people were saying about dieback on Twitter, *who* was talking about it and *how* they did so.

Whilst engagement with dieback on Twitter was on the one hand constrained by the transient and fragmented nature of communication and information exchange, on the other, it utilised the affordances of the medium by supplementing comments through hashtags, URL links to other media and engaging in interactions with targeted or non-specified users. In considering *what* was being said, Twitter talk represented a trajectory about dieback that evolved from initial concerns with its ‘spread’ and the ‘fight’. Later, these themes declined in prominence and the themes of ‘blame’ and then finally ‘too late’ were most prolific. However, there was an ebb and flow of engagement with these entwined themes across the data period, which often reflected stories in traditional media trending on the day. Moreover, assessing our data for the use of particular synonyms for risk revealed that where risk synonyms were used, these largely reflected their appearance in specific media stories subsequently propagated on Twitter, rather than as part of original content created by users. The vocabulary of risk was thus not generated directly by Twitter users – rather generally it was appropriated from traditional media coverage.

Analysis of *who* was talking about dieback revealed small groups of users engaging with dieback in line with established group concerns. Those whose biographies suggested support for, or affiliations to, environmental issues were more prominent in tweeting about dieback. Within this, user tweets and interactions were often framed by their individual or group affiliations, interests and identities. These data supplied a nuanced picture of how Twitter-using publics orientated towards dieback and hence provide an opportunity to move beyond working with a generalised and often decontextualised notion of the public and their concerns. Examination of the activity of the most active tweeter indicated a complexity that cannot readily be related to characterisations of intensified or attenuated concern. Emotive mentions of regret and the implications of dieback sat alongside tweets conveying official information about dieback, broader environmental concerns and the prosaic matters of everyday life. Organisations responsible for managing dieback were also using Twitter to communicate their agendas and concerns. Thus, individuals and groups may or may not perceive dieback as a risk, the information they pass on may or may not communicate that dieback is a risk and yet risk nevertheless forms part of the information being exchanged. The volume of this information exchange may then, somewhat erroneously, be read as an indicator of risk intensification or of public concern. So although Twitter and other social media platforms provide a lens to more directly view the perspectives of a range of publics and stakeholders than traditional media does, these are enmeshed in networks of communication in which expert views are presented and re-presented by others in fragments and in full. This presents a more complex picture than we might expect from the foundational assumptions of SARF, namely that the essence of risk amplification is a discrepancy between expert and lay understandings of risk (Renn et al. 1992) and that volume of media attention is a marker of intensification or attenuation.

Finally, we considered *how* users talked about dieback on Twitter. The affordances of the platform, such as hashtags and embedding URLs, in line with SARF, allow users to heighten the salience of certain aspects of messages so that certain

responses in those who receive them are invited (Kasperson et al. 2003). Two concepts were developed, *frame fragments* and *piggybacking*, to further illustrate how users engaged with dieback in ways beyond simply sharing or passing on information. The concept of *frame fragments* allowed us to show how information is selected and moved around Twitter and how certain features of messages are emphasised. The notion of *piggybacking* was used to show how information is customised in line with group identities and individual interests. Twitter users may have an active role in re-presenting risk. These communicative actions may draw on existing group or individual identities or interests but the affordances of Twitter may also have a role in enrolling users within these networks of issue, interest or identity. Despite the active ways in which hashtags can be used to organise users around a topic to facilitate issue-centred ‘publics’ (Ausserhofer and Maireder 2013), they can also connote more fluid conversations across a networked public space. A broadly appealing hashtag can connect otherwise disparate individuals and groups and infiltrate apparently unrelated conversations. However, as noted above, Twitter contains a mix of ‘expert’ voices with various other users who were more or less invested in and expert in the issue at hand. This undermines reliance on the practice of distinguishing between experts and laypersons or between ordinary citizens and their political representatives [in which we would also include traditional media] (Callon, Lascoumes, and Barthe 2009). Thus, volume as well as the manner in which topics are constructed and debated on Twitter is a product of *both* expert *and* lay engagement.

Whilst unsurprising, given that each draws on the other (Tufekci 2014), the rise and fall in the volume of social media broadly relates to the rise and fall in traditional media coverage (Shan et al. 2013) different processes underlie their production and their significance for SARF. Exploring Twitter revealed a two-way relationship between tweets and traditional media, enabling us to see the interaction of various strands of media, government statements and user content. Users did not simply and passively receive messages from authoritative sources and pass them on. Existing literature suggests that as more information appears online, individuals are more able to find and share their own information (Newman, Dutton, and Blank 2011).

In considering the implications of social media for the social amplification of risk, it is helpful to think about risk in terms of a socio-material ‘assemblage’ of the hazard to which the risk pertains, the digital platform, the users and how these intersect with the broader networks of policy and media. The upshot is that ‘whereas risks have always been virtual, it is through their materialisation as mediators within complex information and communication processes that they themselves have become active agents (actants) imbued with [power]’ (van Loon 2014, 446). Conceptualising risk in this manner shifts the emphasis away from a static view of risk to one where it is always being mediated and in a process of ‘becoming’ (Busby 2016). Given the evolving nature of the risk assemblage and especially the affordances of social media platforms, those responsible for managing risk should be aware of the range of ways in which their communications, whether direct or indirectly through traditional media, may be appropriated and re-presented through the affordances of social media platforms.

We note two main limitations to our work. Firstly, focusing as we do on the content of the tweets and the accompanying biographies, this analysis excluded any consideration of networks of Twitter users – the followers of the people that were tweeting or retweeting about dieback. These followers may have read tweets about

dieback, and even marked them as favourites but they were invisible to us as they did not pass them on. Secondly, Twitter is only one social media platform and has its own set of characteristics and audiences. Our findings cannot be generalised to other platforms – indeed any analysis of any platform needs to take account of its particular affordances. More generally there is an issue with representativeness at the level of mechanisms and not just at the level of sampling (Tufekci 2014). With Twitter, its rapid life cycle and the short nature of tweets means that it cannot elucidate the mechanisms of other platforms such as blogs that involve longer texts and longer life spans.

The SARF remains a dominant framework for exploring risk and its effects in a social setting. Given its ubiquity, we have to consider it afresh now that social media is an integral part of that setting. In our focus on one social media platform, we have sought to locate some of the social and individual processes identified in the SARF. Using the example of dieback, the SARF framework and the importance accorded to traditional media has provided a useful stimulus for examining both individual and social processes of communication. Twitter provides a back channel between media articles and individuals producing them and referenced in them. It allows us to observe how fragments of otherwise complex news articles can be selected and re-presented on Twitter and then moved explicitly or implicitly between users. It contrasts with the idea that in news media expert sources often set the dominant frame about risk (Holland et al. 2012), which are simply propagated onto and through Twitter.

For the SARF, a significant consideration of social media becoming a key communication channel is that the nature of content and the myriad ways in which this is generated, circulated and used is directly related to the motivations and the practices of any number of more or less interested and invested parties – resulting in a much more complex communication process (Rutsaert et al. 2013). Twitter and other social media channels complicate the way that risk is negotiated and communicated and has transformed the media landscape within which the original SARF was conceived, intensifying the challenges for risk communication (Neeley 2014) as well as creating new opportunities. For risk researchers, the challenges are theoretical and methodological but the growing use of social media across experts, stakeholders and lay publics and the interactions between them renders empirical work in this area necessary and hopefully fruitful. We hope that this paper will encourage further conceptual and analytic attention to social media and risk.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The study reported in this paper was produced as part of the UNPICK (Understanding public risk in relation to tree health) project funded jointly by a grant from BBSRC, Defra, ESRC, the Forestry Commission, NERC and the Scottish Government, under the Tree Health and Plant Biosecurity Initiative [grant number BB/L012308/1].

Notes

1. Search terms used with LexisNexis and then DiscoverText were developed using the Twitter search API to explore tweets about dieback and reading extant literature. This

- iterative process resulted in the final set of search terms used to retrieve all tweets posted about dieback within the search period and were ultimately comprised of (ash AND dieback) OR (ash AND dieback AND chalara) OR (chalara AND ash) OR (chalara AND dieback) OR ashdieback OR hymenoscyphus OR fraxineus.
2. <http://discovertext.com/>
 3. <http://chorusanalytics.co.uk/>
 4. Sources used: www.thesaurus.com, freethesaurus.com, www.collinsdictionary.com and www.merriam-webster.com
 5. Synonyms were danger, endanger, endangered, fear, hazard, jeopardise, jeopardised, jeopardy, liability, menace, peril, risking, risky, threat, threatened, threatening, trouble, troubling, uncertain, uncertainty, vulnerable and vulnerability.

ORCID

John Fellenor  <http://orcid.org/0000-0002-1396-8550>

J.D. Mumford  <http://orcid.org/0000-0001-8964-1784>

References

- Alaszewski, Andy, and Patrick Brown. 2011. *Making Health Policy: A Critical Introduction*. Cambridge: Polity.
- Amanatidou, Effie, Maurits Butter, Vicente Carabias, Totti Konnola, Miriam Leis, Ozcan Saritas, Petra Schaper-Rinkel, and Victor van Rij. 2012. "On Concepts and Methods in Horizon Scanning: Lessons from Initiating Policy Dialogues on Emerging Issues." *Science and Public Policy* 39 (2): 208–221. doi:10.1093/scipol/scs017.
- Argyris, Young Anna, and Kafui Monu. 2015. "Corporate Use of Social Media: Technology Affordance and External Stakeholder Relations." *Journal of Organizational Computing and Electronic Commerce* 25 (2): 140–168. doi:10.1080/10919392.2015.1033940.
- Aula, Pekka. 2010. "Social Media, Reputation Risk and Ambient Publicity Management." *Strategy & Leadership* 38 (6): 43–49.
- Ausserhofer, Julian, and Axel Maireder. 2013. "National Politics on Twitter: Structures and Topics of a Networked Public Sphere." *Information, Communication & Society* 16 (3): 291–314. doi:10.1080/1369118X.2012.756050.
- Barnett, Julie, and Glynis Breakwell. 2003. "The Social Amplification of Risk and the Hazard Sequence: The October 1995 Oral Contraceptive Pill Scare." *Health, Risk & Society* 5 (3): 301–313. doi:10.1080/13698570310001606996.
- Bica, Melissa, and Jennings Anderson. 2016. "You Are What You Tweet!" *the Ethics of (Re) Publishing Public Data as Crafted Narratives*. Accessed July 26, 2016. <https://ethicalencountershici.files.wordpress.com/2016/03/bica-and-anderson.pdf>
- Binder, Andrew R. 2012. "Figuring out #Fukushima: An Initial Look at Functions and Content of US Twitter Commentary about Nuclear Risk." *Environmental Communication* 6 (2): 268–277. doi:10.1080/17524032.2012.672442.
- Binder, Andrew, Michael Cacciatore, Dietram Scheufele, and Dominique Brossard. 2014. "The Role of News Media in the Social Amplification of Risk." In *The SAGE Handbook of Risk Communication*, edited by Hyunyi Cho, Torsten Reimer and Katherine McComas, 69–85. London: Sage.
- Bogdanou, T., C. B. Starr, A. Weatherall, and A. D. Leslie. 2013. "Use of the Internet and Social Media in the Forestry Profession in the United Kingdom." *International Forestry Review* 15 (2): 147–159. doi:10.1505/146554813806948521.
- Boyd, Danah, and Kate Crawford. 2012. "Critical Questions for Big Data: Provocations for a Cultural, Technological, and Scholarly Phenomenon." *Information, Communication & Society* 15 (5): 662–679. doi:10.1080/1369118X.2012.678878.
- Boyd, Danah, Scott Golder, and Gilad Lotan. 2010. "Tweet, Tweet, Retweet: Conversational Aspects of Retweeting on Twitter." 43rd Hawaii International Conference on System Sciences (HICSS), Honolulu. doi:10.1109/HICSS.2010.412.
- Boyd, I. L., P. H. Freer-Smith, C. A. Gilligan, and H. C. J. Godfray. 2013. "The Consequence of Tree Pests and Diseases for Ecosystem Services." *Science* 342 (6160): 823.

- Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101.
- Broersma, M., and T. Graham. 2016. "Tipping the Balance of Power: Social Media and the Transformation of Political Journalism." In *The Routledge Companion to Social Media and Politics*, edited by Axel Bruns, Gunn Enli, Eli Skogerbo, Anders Olof Larsson, and Christian Christensen, 89–103. Milton Park: Routledge.
- Brooker, Phillip, Julie Barnett, and Timothy Cribbin. 2016. "Doing Social Media Analytics." *Big Data & Society* 3 (2): 48. doi:10.1177/2053951716658060.
- Brooker, Phillip, Julie Barnett, Timothy Cribbin, and Sanjay Sharma. 2016. "Have We Even Solved the First 'Big Data Challenge?' Practical Issues concerning Data Collection and Visual Representation for Social Media Analytics." In *Digital Methods for Social Science*, 34–50. Basingstoke: Palgrave Macmillan.
- Bruns, Axel, and Jean E. Burgess. 2011. "The Use of Twitter Hashtags in the Formation of Ad Hoc Publics." Proceedings of the 6th European Consortium for Political Research (ECPR) General Conference 2011, Reykjavik, Iceland.
- Bruns, Axel, Jean E. Burgess, Kate Crawford, and Frances Shaw. 2012. "#Qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods." Brisbane. <http://eprints.qut.edu.au/48241/>.
- Busby, Jerry. 2016. "Why Risk is Recursive and What This Entails." In *Routledge Handbook of Risk Studies Burgess, Adam*, edited by Alberto Alemanno and Jens Zinn, 73–80. London: Routledge.
- Busby, Jerry S., and Stephan Onggo. 2012. "Managing the Social Amplification of Risk: A Simulation of Interacting Actors." *Journal of the Operational Research Society* 64 (5): 638–653.
- Callon, Michel, Pierre Lascoumes, and Yannick Barthe. 2009. *Acting in an Uncertain World*. Cambridge, MA: MIT press.
- Cataldi, Mario, Luigi Di Caro, and Claudio Schifanella. 2010. "Emerging Topic Detection on Twitter Based on Temporal and Social Terms Evaluation." *Proceedings of the Tenth International Workshop on Multimedia Data Mining 4*. ACM. <http://pageperso.iut.univ-paris8.fr/~cataldi/papers/mdm-kdd2010.pdf>
- Chew, Cynthia, and Gunther Eysenbach. 2010. "Pandemics in the Age of Twitter: Content Analysis of Tweets during the 2009 H1N1 Outbreak." *PLoS ONE* 5 (11): e14118. doi:10.1371/journal.pone.0014118.
- Chung, Ik Jae. 2011. "Social Amplification of Risk in the Internet Environment." *Risk Analysis* 31 (12): 1883–1896. doi:10.1111/j.1539-6924.2011.01623.x.
- Chung, Ji Bum, and Gi Woong Yun. 2013. "Media and Social Amplification of Risk: BSE and H1N1 Cases in South Korea." *Disaster Prevention and Management: An International Journal* 22 (2): 148–159. doi:10.1108/09653561311325299.
- Daly, Jeanne, Allan Kellehear, and Michael Gliksman. 1997. *The Public Health Researcher: A Methodological Approach*. Victoria: OUP Australia and New Zealand.
- Daume, Stefan. 2016. "Mining Twitter to Monitor Invasive Alien Species – An Analytical Framework and Sample Information Topologies." *Ecological Informatics* 31: 70–82.
- Daume, Stefan, Matthias Albert, and Klaus von Gadow. 2014. "Forest Monitoring and Social Media—Complementary Data Sources for Ecosystem Surveillance?" *Forest Ecology and Management* 316: 9–20. doi:10.1016/j.foreco.2013.09.004.
- De Choudhury, Munmun, Nicholas Diakopoulos, and Mor Naaman. 2012. "Unfolding the Event Landscape on Twitter: Classification and Exploration of User Categories." *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*, 241–244. <https://www.semanticscholar.org/paper/Unfolding-the-event-landscape-on-twitter-Choudhury-Diakopoulos/a66accffcd8b4c3ecdac3e1ffceaa46d33125921/pdf>.
- Earle, Paul S., Daniel C. Bowden, and Michelle Guy. 2011. "Twitter Earthquake Detection: Earthquake Monitoring in a Social World." *Annals of Geophysics* 54 (6): 708–715. doi:10.4401/ag-5364.
- Eldridge, John, and Jacquie Reilly. 2003. "Risk and Relativity: BSE and the British Media." In *The Social Amplification of Risk*, edited by Nick Pidgeon, Roger Kasperson and Paul Slovic, 138–155. Cambridge: Cambridge University Press.
- Entman, Robert M. 1993. "Framing: Toward Clarification of a Fractured Paradigm." *Journal of Communication* 43 (4): 51–58.

- Farhi, Paul. 2009. "The Twitter Explosion: Whether they are Reporting about it, Finding Sources on it or Urging Viewers, Listeners and Readers to Follow them on it, Journalists Just can't Seem to Get Enough of the Social Networking Service. Just How Effective is it as a Journalism Tool?" *American Journalism Review* 31 (3): 26–32.
- Frewer, Lynn J., Susan Miles, and Roy Marsh. 2002. "The Media and Genetically Modified Foods: Evidence in Support of Social Amplification of Risk." *Risk Analysis* 22 (4): 701–711. doi:10.1111/0272-4332.00062.
- Gamson, William A., and Kathryn E. Lasch. 1983. "The Political Culture of Social Welfare Policy." *Evaluating the Welfare State: Social and Political Perspectives* 95: 397–415.
- Gleason, Stephanie. 2010. "Harnessing Social Media: News Outlets are Assigning Staffers to Focus on Networking." *American Journalism Review* 32 (1): 6–8.
- van Gorp, Baldwin. 2005. "Media Framing of the Immigration Issue: The Case of the Belgian Press." In *Unexpected Approaches to the Global Society*, edited by Humbert de Smedt, Lut Goossens and Christiane Timmerman, 125–148. Antwerp: MAKLU.
- Grusin, Richard. 2010. "The Affective Life of Media." Chap 5. In *Premediation: Affect and Mediality after 9/11*. Basingstoke: Palgrave Macmillan. doi:10.1057/9780230275270_5.
- Heuch, Jon. 2014. "What Lessons need to be Learnt from the Outbreak of Ash Dieback Disease, Chalara Fraxinea in the United Kingdom?" *Arboricultural Journal: The International Journal of Urban Forestry* 36 (1): 32–44. doi:10.1080/03071375.2014.913361.
- Holland, Kate, R. Blood, Michelle Imison, Simon Chapman, and Andrea Fogarty. 2012. "Risk, Expert Uncertainty, and Australian News Media: Public and Private Faces of Expert Opinion during the 2009 Swine Flu Pandemic." *Journal of Risk Research* 15 (6): 657–671. doi:10.1080/13669877.2011.652651.
- Hughes, Amanda Lee, and Leysia Palen. 2009. "Twitter Adoption and Use in Mass Convergence and Emergency Events." *International Journal of Emergency Management* 6 (3/4): 248–260. doi:10.1504/IJEM.2009.031564.
- Kasperson, Roger E., Ortwin Renn, Paul Slovic, Halina S. Brown, Jacque Emel, Robert Goble, Jeanne X. Kasperson, and Samuel Ratick. 1988. "The Social Amplification of Risk: A Conceptual Framework." *Risk Analysis* 8 (2): 177–187. doi:10.1111/j.1539-6924.1988.tb01168.x.
- Kasperson, Jeanne X., Roger E. Kasperson, Nick Pidgeon, and Paul Slovic. 2003. "The Social Amplification of Risk: Assessing Fifteen Years of Research and Theory." In *The Social Amplification of Risk*, edited by Nick Pidgeon, Roger Kasperson and Paul Slovic, 13–46. Cambridge: Cambridge University Press.
- Kwak, Haewoon, Changhyun Lee, Hosung Park, and Sue Moon. 2010. "What is Twitter, a Social Network or a News Media?" *Proceedings of the 19th International Conference on World Wide Web*, 591–600. Raleigh, NC: ACM. doi:10.1145/1772690.1772751.
- Lewis, Roxanne E., and Michael G. Tyshenko. 2009. "The Impact of Social Amplification and Attenuation of Risk and the Public Reaction to Mad Cow Disease in Canada." *Risk Analysis* 29 (5): 714–728. doi:10.1111/j.1539-6924.2008.01188.x.
- van Loon, Joost. 2014. "Remediating Risk as Matter–Energy–Information Flows of Avian Influenza and BSE." *Health, Risk & Society* 16 (5): 444–458. doi:10.1080/13698575.2014.936833.
- Lupton, Deborah. 2016. "Digital Risk Society." In *Routledge Handbook of Risk Studies Burgess, Adam*, edited by Alberto Alemanno and Jens Zinn, 301–309. London: Routledge.
- McKeever, Brooke Weberling. 2012. "News Framing of Autism: Understanding Media Advocacy and the Combating Autism Act." *Science Communication* 35 (2): 213–240. doi:10.1177/1075547012450951.
- Mellon, Jonathan, and Christopher Prosser. 2016. "Twitter and Facebook Are Not Representative of the General Population: Political Attitudes and Demographics of Social Media Users." Available at SSRN. doi:10.2139/ssrn.2791625. <https://ssrn.com/abstract=2791625>
- Miles, Brian, and Stephanie Morse. 2007. "The Role of News Media in Natural Disaster Risk and Recovery." *Ecological Economics* 63 (2–3): 365–373.
- Needham, Jessica, Cory Merow, Nathalie Butt, Yadvinder Malhi, Toby R. Marthews, Michael Morecroft, and Sean M. McMahon. 2016. "Forest Community Response to Invasive Pathogens: The Case of Ash Dieback in a British Woodland." *Journal of Ecology* 104 (2): 315–330. doi:10.1111/1365-2745.12545.

- Neeley, Liz. 2014. "Risk Communication in Social Media." In *Effective Risk Communication*, edited by Joseph Arvai and Louie Rivers III, 143–164. London: Routledge.
- Nerlich, Brigitte, Craig Hamilton, and Victoria Rowe. 2002. "Conceptualising Foot and Mouth Disease: The Socio-cultural Role of Metaphors, Frames and Narratives." *Metaphorik 2* (2002): 90–108.
- Newman, Todd P. 2016. "Tracking the Release of IPCC AR5 on Twitter: Users, Comments, and Sources following the Release of the Working Group I Summary for Policymakers." *Public Understanding of Science*: 1–11. doi:10.1177/0963662516628477.
- Newman, Nic, William H. Dutton, and Grant Blank. 2011. "Social Media in the Changing Ecology of News Production and Consumption: The Case in Britain." *Oxford Internet Institute Working Paper; Reuters Institute for the Study of Journalism Working Paper*. doi:10.2139/ssrn.1826647.
- O'Neill, Saffron, Hywel T. P. Williams, Tim Kurz, Bouke Wiersma, and Maxwell Boykoff. 2015. "Dominant Frames in Legacy and Social Media Coverage of the IPCC Fifth Assessment Report." *Nature Climate Change* 5 (4): 380–385. doi:10.1038/nclimate2535.
- Paavola, Sami. 2004. "Abduction as a Logic and Methodology of Discovery: The Importance of Strategies." *Foundations of Science* 9 (3): 267–283. doi:10.1023/B:FODA.0000042843.48932.25.
- Panagiotopoulos, Panos, and Frances Bowen. 2015. "Conceptualising the Digital Public in Government Crowdsourcing: Social Media and the Imagined Audience." In *International Conference on Electronic Government*, 19–30. Thessaloniki. doi:10.1007/978-3-319-22479-4_2.
- Panagiotopoulos, Panos, Julie Barnett, Alinaghi Ziaee Bigdeli, and Steven Sams. 2016. "Social Media in Emergency Management: Twitter as a Tool for Communicating Risks to the Public." *Technological Forecasting and Social Change* 111: 86–96. doi:10.1016/j.techfore.2016.06.010.
- Pautasso, Marco, Markus Schlegel, and Ottmar Holdenrieder. 2015. "Forest Health in a Changing World." *Microbial Ecology* 69 (4): 826–842. doi:10.1007/s00248-014-0545-8.
- Petts, Judith, Tom Horlick-Jones, Graham Murdock, Diana Hargreaves, Shelley McLachlan, and Ragnar Lofstedt. 2001. *Social Amplification of Risk: The Media and the Public*. Sudbury: HSE Books.
- Pidgeon, Nick, and Julie Barnett. 2013. *Chalara and the Social Amplification of Risk*. London: Defra. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/200394/pb13909-chalara-social-amplification-risk.pdf
- Potter, Clive. 2013. "A Neoliberal Biosecurity? The WTO, Free Trade and the Governance of Plant Health." In *Biosecurity: The Socio-politics of Invasive Species and Infectious Diseases*, edited by A. Dobson, K. Barker, and S. Taylor, 123–136. London: Routledge.
- Potter, Clive, and Julie Urquhart. Forthcoming. "Tree Disease and Pest Epidemics in the Anthropocene: A Review of the Drivers, Impacts and Policy Responses in the UK." *Forest Policy and Economics*. doi:10.1016/j.forpol.2016.06.024.
- Rains, Stephen A., Steven R. Brunner, and Kyle Oman. 2014. "Social Media and Risk Communication." In *The SAGE Handbook of Risk Communication*, edited by Hyunyi Cho, Torsten Reimer and Katherine McComas, 228–240. London: Sage.
- Renn, Ortwin. 1991. "Risk Communication and the Social Amplification of Risk." In *Communicating Risks to the Public*, edited by Roger Kasperson and Pieter Stallen, 287–324. Dordrecht: Springer.
- Renn, Ortwin, William J. Burns, Jeanne X. Kasperson, Roger E. Kasperson, and Paul Slovic. 1992. "The Social Amplification of Risk: Theoretical Foundations and Empirical Applications." *Journal of Social Issues* 48 (4): 137–160.
- Rickard, Laura N., Katherine A. McComas, Christopher E. Clarke, Richard C. Stedman, and Daniel J. Decker. 2013. "Exploring Risk Attenuation and Crisis Communication after a Plague Death in Grand Canyon." *Journal of Risk Research* 16 (2): 145–167. doi:10.1080/13669877.2012.725673.
- Rui, Huaxia, and Andrew Whinston. 2012. "Information or Attention? An Empirical Study of User Contribution on Twitter." *Information Systems and e-Business Management* 10 (3): 309–324. doi:10.1007/s10257-011-0164-6.

- Rutsaert, Pieter, Áine Regan, Zuzanna Pieniak, Áine McConnon, Adrian Moss, Patrick Wall, and Wim Verbeke. 2013. "The Use of Social Media in Food Risk and Benefit Communication." *Trends in Food Science & Technology* 30 (1): 84–91. doi:10.1016/j.tifs.2012.10.006.
- Sakaki, Takeshi, Makoto Okazaki, and Yutaka Matsuo. 2010. "Earthquake Shakes Twitter Users: Real-time Event Detection by Social Sensors." *Proceedings of the 19th International Conference on World Wide Web*, 851–860. Raleigh, NC. doi:10.1145/1772690.1772777.
- Shakeela, Aishath, and Susanne Becken. 2015. "Understanding Tourism Leaders' Perceptions of Risks from Climate Change: An Assessment of Policy-making Processes in the Maldives using the Social Amplification of Risk Framework (SARF)." *Journal of Sustainable Tourism* 23 (1): 65–84. doi:10.1080/09669582.2014.918135.
- Shan, Liran, Áine Regan, Aoife De Brún, Julie Barnett, Maarten C. A. van der Sanden, Patrick Wall, and Aine McConnon. 2013. "Food Crisis Coverage by Social and Traditional Media: A Case Study of the 2008 Irish Dioxin Crisis." *Public Understanding of Science* 23 (8): 911–928. doi:10.1177/0963662512472315.
- Sloan, Luke, Jeffrey Morgan, Pete Burnap, and Matthew Williams. 2015. "Who Tweets? Deriving the Demographic Characteristics of Age, Occupation and Social Class from Twitter User Meta-data." *PLoS ONE* 10 (3): 1–20. doi:10.1371/journal.pone.0115545.
- Slovic, Paul. 1999. "Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-assessment Battlefield." *Risk Analysis* 19 (4): 689–701.
- Smith, Denis, and Jo McCloskey. 1998. "Risk and Crisis Management in the Public Sector: Risk Communication and the Social Amplification of Public Sector Risk." *Public Money and Management* 18 (4): 41–50. doi:10.1111/1467-9302.00140.
- Syn, Sue Yeon, and Sanghee Oh. 2015. "Why do Social Network Site Users Share Information on Facebook and Twitter?" *Journal of Information Science* 41 (5): 553–569. doi:10.1177/01655515155585717.
- Thomson, Ian. 2015. "Commentary: Understanding and Managing Public Reaction to 'Fracking'." *Journal of Energy & Natural Resources Law* 33 (3): 266–270. doi:10.1080/02646811.2015.1030912.
- Tomlinson, Isobel. 2016. "The Discovery of Ash Dieback in the UK: The Making of a Focusing Event." *Environmental Politics* 25 (4): 709–728. doi:10.1080/09644016.2015.1118790.
- Trumbore, S., P. Brando, and Henrik Hartmann. 2015. "Forest Health and Global Change." *Science* 349 (6250): 814–818. doi:10.1126/science.aac6759.
- Tucker, Lewis R. 1978. "The Environmentally Concerned Citizen some Correlates." *Environment and Behavior* 10 (3): 389–418.
- Tufekci, Zeynep. 2014. "Big Questions for Social Media Big Data: Representativeness, Validity and Other Methodological Pitfalls." <http://arxiv.org/abs/1403.7400>.
- Urquhart, Julie, and Paul Courtney. 2011. "Seeing the Owner behind the Trees: A Typology of Small-scale Private Woodland Owners in England." *Forest Policy and Economics* 13 (7): 535–544. doi:10.1016/j.forpol.2011.05.010.
- Vasterman, Peter, C. Joris Yzermans, and Anja J. E. Dirkzwager. 2005. "The Role of the Media and Media Hypes in the Aftermath of Disasters." *Epidemiologic Reviews* 27 (1): 107–114. doi:10.1093/epirev/mxi002.
- Vieweg, Sarah, Amanda L. Hughes, Kate Starbird, and Leysia Palen. 2010. "Microblogging during Two Natural Hazards Events: What Twitter May Contribute to Situational Awareness." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1079–1088. Atlanta, GA. doi:10.1145/1753326.1753486.
- Wang, Alex Hai. 2010. "Don't Follow Me: Spam Detection in Twitter." In *Proceedings of the 2010 International Conference on Security and Cryptography (SECRYPT)*, 1–10. Athens: IEEE.
- Woodward, Steve, and Eric Boa. 2013. "Ash Dieback in the UK: A Wake-up Call." *Molecular Plant Pathology* 14 (9): 856–860. doi:10.1111/mpp.12084.
- Wu, Shaomei, Jake M. Hofman, Winter A. Mason, and Duncan J. Watts. 2011. "Who Says What to Whom on Twitter." *Proceedings of the 20th International Conference on World Wide Web*, 705–714. Hyderabad. doi:10.1145/1963405.1963504.
- Yang, Jaewon, and Jure Leskovec. 2011. "Patterns of Temporal Variation in Online Media." *Web Search and Data Mining* 177–186. doi:10.1145/1935826.1935863.