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User-Generated Content: What Can the Forest Health Sector Learn?

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1 Introduction

Forests are complex and integrated socio-ecological systems (Folke 2007). Given the varied nature of the associated stakeholder investment, societal expectation and environmental dynamics, this presents many challenges for their management (Kelly et al. 2012). Over recent decades, the human dimensions of these systems have rapidly evolved, reflecting growing concern with environmental degradation and facilitated by the emergence of information communication technologies (ICTs), especially user-generated content (UGC): publicly created and readily accessible online material. Such technologies are transforming human interaction and reshaping our experience of self and community.

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For forest health sector (FHS) managers and stakeholders, this is an ontological issue: if our presuppositions about the world are changing, then our knowledge of that world, and how to manage it, should reflect these changes.

This chapter brings to the fore these ontological issues by reflecting on the relationship between UGC and forest health. We outline how concerns central to the human dimensions of tree health have evolved, providing an overview of the uses and potentials of UGC, before drawing on a rapid evidence review of literature to consider UGC in relation to forest health. Finally, we reflect on some broader questions from an ontological perspective, situating the use of UGC in broader debates about how digital technologies shape our relationship with the environment and ourselves.

2 The Changing Profile of Forest Management

Successful forest management requires consideration of a range of human dimensions, often manifesting as conflicting stakeholder perceptions, values and behaviours (Kearney and Bradley 1998). Due to the variability of culture, in which contrasting relational logics make up the non-human realm (Kohn 2013), forest management itself reflects different endogenous knowledge and beliefs (Pretzsch 2005; Sauget 1994). For hundreds of years, forests have been regarded as a commodity requiring the regulation of use, access and control (Michon et al. 2013). The notion of a 'moral forest', which incorporates environmental concerns, including climate change mitigation, has begun to be recognised. More recently, the 'recreational forest' has been constructed by and for an increasingly urban population. Serving the perceived therapeutic benefits of being in 'nature' (Hartig et al. 2014; Nilsson et al. 2011), the recreational forest represents lifestyle choices intersecting with ecotourism. In developing countries especially, forests provide income and employment via designation as national parks or conservation areas, attracting tourists, volunteers and international funding

(Bhuiyan et al. 2011). However, in ontological terms, the 'moral' and 'recreational' forest implies a separation between human and nature. Hence, the manner in which we internalise these notions, to articulate aspects of self-experience and our action in the world, suggests a deeper relation still, where humans and forests as material entities occupy a common ontology (González-Ruibal et al. 2011). This emphasises the intrinsic value of 'nature' and the importance of an 'ecocentric' view (Washington et al. 2017). Nonetheless, forest management has to account for myriad perspectives on human–forest relations. 'Forest health' is a contested term, with normative implications that one ecological state or goal is better than another (Sulak and Huntsinger 2012). The advent of the Internet, in reshaping both social and organisational concerns, affords further possibilities and challenges for forest management and how we envisage human–forest ontologies.

3 The Internet and User-Generated Content

The Internet enhances information sharing. It also presents new demands on forest managers because of a more 'present' public and set of stakeholders. Whilst often used synonymously, it is important to clarify how the term 'Internet' relates to 'World Wide Web' ('www'), 'social media', 'Web 2.0' and UGC. The Internet is essentially a network of networking-technology devices whilst 'www' is a space comprised of interlinked information, accessed via the hardware of the Internet. Web 2.0 describes websites enabling content generated by, and for, many interlinked users. Social media is an area of Web 2.0 that affords real-time creation and mediation of content and information sharing (Obar and Wildman 2015).

Public sector organisations are turning to social media to engage with different audiences and disseminate information (Panagiotopoulos and Bowen 2015). Social media, as a means of recruiting a broader audience, is entangled with a rapidly changing political economy of environmental conservation (Büscher 2013). For example, the decision-making processes of tourists, e.g. where to go and what to do, are increasingly influenced by social media shaping the expectations, perceptions, behaviours and the meanings they infer with regard to what nature is and what engagement with it entails (Cheng et al. 2017; Xiang and Gretzel 2010).

UGC is the common thread that connects social media and other aspects of Web 2.0, comprising content such as blogs (diary style text), wikis (collaboratively modifiable content), discussion forums, audio files and images. All social media platforms utilise UGC but not all UGC is limited to social media platforms (Luca 2015). UGC draws attention to a wider range of user, website and content (Kaplan and Haenlein 2010), i.e. data generated in different contexts for different purposes (Krumm et al. 2008). UGC impacts both economic and social processes (Luca 2015). As these processes are foundational dimensions of forest health management, it is incumbent on FHS organisations to have a clear grasp of what UGC is, what it does and what it might do.

UGC can be categorised thus:

- *Social networking*: e.g. Facebook, Twitter and Weibo. Interaction between public or closed communities to share information including images, videos and memes.
- *Social news aggregation*: e.g. Reddit, Buzzfeed and Digg. Selection, aggregation and up-voting of news items.
- *Image and video hosting*: e.g. Flickr, YouTube and Dailymotion. Used for uploading and sharing visual content.
- *Information, discussion, pattern search and learning*: e.g. Wikipedia and Google Trends. Researching and discovering search trends and producing/sharing resources.
- *Product search and discovery services*: e.g. TripAdvisor and Expedia. Enables product search and evaluation; provides personalised recommendations based on browsing history and interests.
- *Social commerce*: e.g. Amazon, eBay and Etsy. Sites or mobile apps supporting social interaction and user contributions to facilitate online retail.
- *Crowdsourcing*: e.g. Crowdrise, Kickstarter and IndieGoGo. Sites enabling individuals or groups to solicit funds, services or ideas.

Some of these platforms are immediately relevant to the FHS. Others may be equally important and yet remain unconsidered. YouTube, Facebook and Twitter are used by the Forestry Commission and the Department for Environment, Food and Rural Affairs in the UK to release information about various issues. These organisations are beginning to look at information and pattern recognition sites such as Google Trends to determine patterns in media coverage and consumption of FHS information. Social commerce sites are also relevant. For example, despite their own strict guidelines, eBay potentially provides a means for circumventing import regulations by users who sell plant material that may carry pests or pathogens.

Ontologically, UGC, in terms of the digital traces people create, blurs the distinction between the individual as a human presence and as a 'digital artefact' (Hogan 2010). The digital artefact mediates how people participate in the world and with each other. Whereas humans act in real time, the digital artefact is an accumulation of past interactions and performances and, as such, is a representation of an historical presence. However, both are often afforded the same ontological status—i.e. both are perceived as 'real' (Reed 2005). Reflecting on this issue enables a useful perspective on the role that UGC can play in forest health.

4 Rapid Evidence Review

Rapid evidence review is a quick and efficient way of synthesising the most relevant conceptual and empirical evidence pertaining to an issue or topic and meets the needs of stakeholders and policy makers working in, and responding to, rapidly evolving and dynamic socio-material environments (Thomas et al. 2013). With respect to how UGC intersects with the FHS we carried out a rapid evidence review of academic literature. We aimed to explore the ways in which UGC is utilised and to reflect on the issues associated with UGC, to enable a deeper appreciation of the benefits and challenges with regard to its potential. Our primary concern was a focus on the social and organisational processes underpinning the use of UGC and how these implicate different stakeholders and publics.

This approach was premised on the notion that literature around UGC use would be representative of domains, including communication, management, plant pathology and governance. We scrutinised ScienceDirect, Web of Science and Scopus as these databases provide access to eclectic material covering the range of scientific, technological and social scientific disciplines. Items included full-length articles published in refereed academic journals, conference articles, conference proceedings and theses.[1] An item was initially included if it addressed any conceptual or empirical aspect of UGC in the field of tree health, forestry or related areas such as environment, ecotourism and land management. Items without a primarily social or organisational focus and from the fields of mathematics, physics and computer science were excluded. Following Levy and Ellis (2006), we used forward and backward searching of items explicitly focussed on the use of UGC in the FHS and, if appropriate, added further items to the corpus. Eighty-six papers were reviewed in depth. For each paper, we established a categorisation of its premise, e.g. 'describes the application of a smart technology' or 'discusses technological challenges with respect to data mining'. We organised these categories into overarching areas capturing their most salient features (see Table 1). Whilst thirty-seven studies related to UGC and forest health, the majority related to the forest sector in general. Hence, to explore the role and potential of UGC, we draw broadly on those studies most applicable *and* transferable to forest health.

5 Findings and Discussion

The number of items where a specific type or aspect of UGC and its relation to forest health was the central concern of a paper was relatively limited. UGC was more often mentioned in passing or as a generic concluding comment, e.g. 'management practices can be enhanced by using social media'. Studies from different countries were represented. There was a marked increase in the volume of articles from 2015 onward.

Table 1 Organisation of categories into overarching areas

Overarching area	Sub-categories	Number of papers in category
Management and communication	• How the web facilitates participation and communication • Developing management practices • Recommendations for social media use • Public engagement with tree initiatives • The role of the public and stakeholders as part of a collaborative process	29
Linking data and linking stakeholders	• Use of web portals to streamline data access • Models of unified databases to aid standardisation • Information sharing and interoperability • Use of Geographic information systems (GIS) as a means of enhancing data connectivity. • Remote sensing and plant tagging to aid micro- and macro-management of the environment	24
Citizen science and crowdsourcing	• Smartphone technology enhancing data collection • Citizen science; examples, strengths and weaknesses • Crowdsourcing applications	17
Monitoring invasive alien species (IAS), data mining and horizon scanning	• Horizon scanning for new outbreaks of pests/pathogens • Social media data mining, automatic classification of data, data scraping • Tracking of pests and pathogens • Technological challenges	16

5.1 Management and Communication

Perspectives on UGC in relation to forest management in general were prolific in the reviewed papers, but less so with regard to a focus on forest health.

Kelly et al. (2012) evaluated the adaptive management[2] process and an interactive website as one of several methods facilitating public participation in the Sierra Nevada Adaptive Management Project (SNAMP), a multi-agency initiative utilising adaptive management to examine the effects of fuel treatments.[3] Google Analytics data was collected to assess who was visiting the website and to infer temporal trends in user focus. This data was combined with a survey of members of the public involved with SNAMP, to explore their views on management, and a content analysis of UGC on the website's interactive discussion board. Peaks in web activity coincided with key public participation and outreach events. The discussion board received low use in relation to other methods such as public meetings and outreach. Sixty per cent of posts to the discussion board came from researchers and forty per cent from the public. It was concluded that whilst the web played a key role in the adaptive management process via dissemination of information to the public, 'the SNAMP public are not the typical content providers found in the online community literature' (ibid., p. 7), i.e. the discussion board facilitated researchers rather than the public.

These findings, alongside the evolving nature of UGC, indicate the need for an evolving and adaptive management approach to forest health. Management should account for the local and particular nature of forests and benefits from the input of local people and stakeholders, all essential components of adaptive approaches (Messier et al. 2015). Although Web 2.0 technologies enhance the scope for stakeholder groups to participate in discussions, they are not in themselves sufficient. They may provide one foundation for the collaborative decision-making and feedback required of adaptive management but are not a replacement for personal contact, direct communication or the 'mutual learning' that occurs through approaches such as participatory workshops or co-creation exercises (Kelly et al. 2012). Lei and

Kelly (2015) explored adaptive management, as a means of fostering collaboration between stakeholders, by comparing content analysis with an automated mapping algorithm[4] to identify patterns in public meeting notes made available for sharing on the SNAMP website. Analysis revealed that meetings largely focussed on key aspects of the project, such as the science involved and that, across time, discussion topics evolved; earlier discussions focussed on project logistics, whereas discussions about issues such as tree health were more persistent.

UGC incorporates the perspectives of individuals and groups. As part of an open flow of information, this enables policy makers and communities to become aware of how management is perceived and how different stakeholders are implicated. An open flow of information enables stakeholders to respond to their local forests and environment in times of crisis in a sensitive manner, and local communities can become more proactive in their own governance (Chandler 2015). Open information also facilitates an awareness of differences in endogenous beliefs. Finally, FHS managers are becoming aware of a meta-level of engagement with stakeholders in that UGC lends itself to the techniques of Big Data[5] analysis; stakeholder analysis is crucial for effective collaborative resource management. However, shifting the onus towards analysing what people do and say, in terms of UGC, requires that an equal amount of time and resources need to be applied to developing or adapting conceptual systems that can handle the vast amounts of UGC data available.

Communication also implicated UGC, e.g. the existing use or recommendation of social media to communicate with stakeholders, and a focus on the evolving ecology of communication within a broader organisational context. Stakeholders include those seeking to commodify forest products, as well as those concerned with their conservation (Gazal et al. 2016; Montague et al. 2016). Studies assessed social media use in the US forest products industry and social media adoption at the organisational level within business-to-business contexts. Twitter and Facebook are being used to facilitate communication and advertise and market products or services, implying the adoption of marketing models for management, rather than conservation or biosecurity. However, a lack of awareness, for example, of the issues involved in the movement of wood products hampers responding to the unintended consequences of such movement (Marzano et al. 2015), such as the spread of pests and pathogens.

These studies highlight the tension between different stakeholders and imperatives, making explicit the need for stakeholder engagement in all aspects of communication and consultation in decision-making processes. From the perspective of UGC, a simplistic stance towards how social media affects communication tended to be adopted, essentially a linear model of information dissemination, such that a message posted on social media reaches an easily specified audience and is attended to accordingly, akin to the 'hypodermic needle' model.[6] In this regard, Fellenor et al. (2017) and Hearn et al. (2014) draw attention to the deeper issues around UGC and communication.

Fellenor et al. (2017) harvested tweets mentioning ash dieback (ADB) disease during peak media attention to the issue during late 2012. The most prominent tweeters were people or organisations already affiliated to forest or environmental issues. Individual or group affiliations, interests and identities framed small groups of users engaged with ADB. Hence, engagement tended to reflect an existing concern, such as horse riders tweeting about cleaning horses' hooves to prevent spread, i.e. interactions. This contrasts with the perception that there is a homogeneous public waiting to be communicated with in a linear and unproblematic manner. Hearn et al. (2014) used communicative ecology theory to describe innovations in urban food systems according to their technical, discursive and social components, suggesting that social media combines with existing communication strategies to enhance the ability of organisations to achieve their goals. In relation to the ecology of communication, social media is part of a broader ontological shift where people can be connected in real time to the outcomes of their behaviour and practices.

5.2 Linking Data, Linking Stakeholders

Digital forestry (DF) is the systematic procurement and analysis of digital information to support sustainable forests and integrates all aspects of forestry information across different spatio-temporal scales (Zhao et al. 2005). At the heart of DF is the perceived need for open and accessible data to enhance communication and information dissemination. DF, alongside traditional methods, utilises digital technologies including remote sensors, GIS, GPS, visualisation software and computer modelling to collect and integrate vast amounts of data, with the aim of optimising forest management. If forest health management has to achieve multiple, complex and sometimes conflicting purposes, the tools and technology required have to be similarly complex and integrated (Tang et al. 2009). However, such technologies are often designed without integration in mind. Nonetheless, the emphasis is on enhancing the interoperability of systems by promoting connections between stakeholders using or producing digital technologies (Reynolds and Shao 2006). From this perspective, UGC becomes part of a much broader system which datafies[7] the interrelations between forests and people, an ontological shift in itself. The more these interrelations become datafied, the more transparent and readable the causal relations and contingencies which bring them together (Chandler 2015). Hence, whilst it is important to understand the uses and types of UGC at a pragmatic level, equal if not greater consideration has to be given to how the social, technological and organisational dimensions are entangled.

Six studies explored the quality and accessibility of information available to stakeholders, and the possibility of unifying systems and data. Despite initiatives seeking to harmonise the types of currently distributed information available about forests, data is often incomplete or incompatible due to the lack of interoperability of technological systems at both a global scale and local scale (McInerney et al. 2012). These authors developed a portal to provide access to forest-resources data, as well as providing the analytical capacity for monitoring and assessing forest change. The portal, ideally, integrates data from formal monitoring and from users employing technology as part of GIS, to serve initiatives concerned with forest health as well as the societal and ecological benefits of forests. Web-based social networks and users are themselves data sources representing a huge and heterogeneous repository of geo-referenced data that provide insights into the social impact of forest and other environmental phenomena, and complements 'standard' scientific data. Hence, UGC can be exploited by harvesting content from social media platforms and integrating it into a web portal for retrieval and scrutiny. Whilst both publics and experts need to be able to access distributed information of all types, the value of this information increases when it is integrated with an overarching modelling or geographic information infrastructure.

Google Fusion Tables (GFT) is a web-based data management and publishing application designed to allow non-specialist users to host, collaborate, manage and publish data (Shen 2012). They provide a common interface for different stakeholders, from individuals to government organisations, to upload, access and utilise a range of UGC. Bowie et al. (2014) utilised Google Maps and Fusion Tables to develop an interactive means of mapping and communicating the presence and ecological benefits of urban trees on a Toronto university campus. A secondary aim was to assess the efficacy of GFT for spatial data management. Data collected and integrated into the GFT included tree species, location, canopy cover, air pollution and climate data. GFT enables data storage that eschews the complexity of large formal databases in favour of systems that are easier to implement and interrogate for a variety of purposes. 'Scientific' aspects of data can be combined with UGC, e.g. the human dimensions of how people interact with trees, formal observation records and wiki-type collaboration. This study is implicitly from the perceptive of people and UGC integrated into overarching systems where different stakeholders and different data are intrinsically linked. UGC was also salient in studies exploring its integration into broader networks of various data types and technologies, literally connecting trees into a digital network. Qian et al. (2015), for example, integrated remote sensing and tree chipping with farming information, such as temperature and pesticides applied to trees, and collected via smart phone technology to assess the capacity to micromanage an orchard. Pushing the notion of connection even further, Luvisi and Lorenzini (2014) allude to the 'Internet of Things' (IoT) (Kopetz 2011),[8] suggesting that Web 2.0 technology will eventually facilitate 'wired, shared, digital, user friendly and rationalized [smart cities]' (ibid., 630). The premise that characterises the IoT, implicit in the literature around UGC and the forest sector, is the notion of interoperability via uniform access to data. Moreover, the IoT represents a new market for emerging ICTs and the tacit belief that objects, including trees, can be micro-managed for improved economic benefit.

Central to forest health is information flows around networks invoking different types of actor. Trees become part of this flow once technologies that wire them into the network, such as tagging devices, are introduced. The ontological issue is visible in that how actors are invoked, or rather what they are invoked as or for, depends on the perspective adopted. For the timber trade, trees are a commodity, for conservationists they need protecting, for computer scientists they are data to be incorporated into systems and models. Along with people, trees are enrolled into networks and treated as information. Hence, UGC is situated as part of a sociotechnical-material context, where the 'material' is trees, people and technological devices. Ontologically, this may be beneficial for forest health as long as all actors, humans included, are afforded a necessary and equal status. It is important not to lose sight of these dimensions because these are somewhat effaced by a simplistic reading of terms such as 'user' and 'UGC'.

5.3 Citizen Science and Crowdsourcing

Citizen science (CS) creates a nexus between policy, science, education and the public that, in conjunction with ICTs, pushes the boundaries of ecological research (Newman et al. 2012). Given that economic and political constraints are coincident with forest ecosystem services under increased pressure, forest managers have to constantly generate and evaluate cost-efficient means of monitoring forests and reaching and educating the public (Daume et al. 2014). Despite extensive literature around citizen science and crowdsourcing, our review revealed a paucity of literature where UGC was the central focus in relation to forest health. Instead, literature tended towards assessing the reliability of citizen science data in relation to expert data. For example, an exploration of the opportunities afforded by short-term hypothesis-led citizen science to quantify the relationship between the amount of damage to the leaves of the horse-chestnut tree, *Aesculus hippocastanum*, with the length of time that the horse-chestnut leaf mining moth, *Cameraria ohridella*, had been present (Pocock and Evans 2014). This study employed smart phone technology to test the concordance between participant-scored assessments of photographs of leaf damage with those from experts. Results indicated high concordance between scores, suggesting that citizen science data were accurate. Hence, the wide availability and existing uptake of technology facilitating UGC, such as smart phones, provide a cost-effective way of engaging the public with relatively little cost. However, UGC technology, especially smart phone apps and capacity, constantly evolves. If UGC is to be used as data, a commensurate, dynamic and evolving methodology that optimises its potential is necessary (Hawthorne et al. 2015).

Adriaens et al. (2015) reviewed two specific smart phone apps, 'That's Invasive!' and 'KORINA', for recording invasive alien species (IAS)[9] in North Western Europe, addressing the issues of data integration, openness, quality and interoperability. The challenges presented by these apps included omitted observer details, missing data due to server errors and image-resolution problems. KORINA had a low uptake and whilst this may reflect a short study period, it may also reflect a low degree of smart phone use amongst conservationists and/or low population density of the study area. Organisational attributes such as an organisation's culture are also a factor which can impede adaptive solutions (Dunning 2017; Lei and Kelly 2015). The non-governmental organisation responsible for managing the existing monitoring system was reluctant to promote apps to volunteers that did not already link to an existing system and perceived the new apps as either useless additions which would fragment recording, or as a competitor which might undermine the existing system (Adriaens et al. 2015). In terms of smart phone technology, whilst literature tended to focus on the technological challenges as well as the opportunities, organisational issues also need to be considered.

With regard to crowdsourcing,[10] Rallapalli et al. (2015) used gamification[11] to devise a Facebook game called Fraxinus to enable non-scientists to contribute to the genomics study of the ADB pathogen, *Hymenoscyphus pseudoalbidus*. DNA sequence alignment is resource intensive and can also be error prone. Human pattern recognition skills can improve such alignments; the game involved players aiming to produce the best alignment. In fifteen per cent of cases, computational alignments of genetic sequences were improved but most players engaged with the game in a transient manner, with the majority of the work performed by a small number of dedicated players. Findings such as this are important because they lead to further issues that need to be addressed, such as characterising the demographic engaging with such initiatives. Moreover, whilst individuals appear to be willing to share information using tools provided by Web 2.0, ensuring ongoing engagement from volunteers, especially those that require active, offline engagement, remains an issue to be addressed (Díaz et al. 2012).

As a collaborative outcome and because UGC is usually analysed in terms of large data sets, responsibility for a particular data point is often unknown. This can lead to concerns about data quality and is a factor behind the mistrust of citizen science in some quarters of the scientific community (Butt et al. 2013; López-Aparicio et al. 2017). Moreover, recognition of the potential of citizen science as a data source is also detracted from by a mistrust of UGC, especially UGC generated opportunistically; both UGC and CS data tend to be opportunistic (Daume 2015; Daume and Galaz 2016). Whilst social media is most often unstructured (e.g. tweet content can be presented in various ways), data generated for a specific purpose (e.g. using a dedicated phone app) comes with a structured format that makes curation somewhat easier. The aspects of CS UGC data that appear most challenging are the lack of complete and accurate geolocation data alongside the lack of accurate taxonomic detail.

A subset of UGC is the use of web tools to voluntarily create and disseminate geographic data, i.e. volunteered geographic information (VGI). VGI is considered as an empowering and democratising new form of citizen science (Foster and Dunham 2015) but may also reinforce the 'digital divide': the notion that disparities exist in access to and use of communication technologies because of differences in ethnicity, gender, class and socio-economic factors. In relation to communicative ecology, if ICTs change the nature of how organisations operate then we have to pay attention to the ideational, systemic and social aspects of these changes. Hence, what comes to the surface in terms of citizen science is a human dimension relating directly to the context of production of UGC that is not so much about the status of data but rather about a deeper layer which comprises these social and ideational and ontological aspects.

5.4 Monitoring Invasive Alien Species (IAS), Data Mining and Horizon Scanning

Policy makers need to be able to understand how emerging issues might affect current *and* future policy and practice. Hence, horizon scanning[12] has become a dominant activity across many policy domains, especially those relating to the environment. Having prospective information about IAS and the threats they pose to our forests means that actions can be carried out to reduce the likelihood of their ingress (Jones et al. 2017). This is more beneficial and cost-effective than trying to manage IAS once they have arrived.

The premise behind the use of UGC in relation to horizon scanning for IAS is that people use social media to discuss various aspects of their daily lives and this may include references to IAS, which FHS managers can utilise. Social media can be mined to discern where novel pests and pathogens are being talked about, monitor the proliferation and geographic range of pests and pathogens and predict future trends. Whilst platforms such as Instagram and Twitter lend themselves to content useful for flagging up potential IAS threats, or providing high-quality images (Daume and Galaz 2016), ninety per cent of Instagram users are under age thirty-five and the greatest proportion of users live in urban areas. Moreover, geolocation metadata is often absent from UGC but is crucial for event detection and building models and maps of IAS spread. If FHS managers use social media to reach an audience, they have to know who and where their audience is and how to leverage UGC content. FHS managers should be aware that the questions they need to ask about the ubiquity of social media and its potential in relation to IAS reflect a meta-level of enquiry into the social, ideological and particular technical affordances of the data and platforms in question.

Three papers in our review reflected on the generic conceptual challenges with regard to the presentation of social media data and the nature of metadata. Daume (2016) analysed a corpus of tweets with direct or descriptive references to IAS, sampled across a three-year period. Three target IAS, oak processionary moth (*Thaumetopoea processionea*), emerald ash borer (*Agrilus planipennis*) and Eastern Grey squirrel (*Sciurus carolinensis*), were followed and the sample assessed for information completeness and relevance. If tweets are merely descriptive and with no accompanying metadata or links, they are difficult to verify as relevant and accurate. Moreover, the sheer volume and structural features of data present practical challenges to using it (Brooker et al. 2016). Whilst there may be useful instances of data relating to sightings of IAS in new locations, the effort required to extract what amounts to a fraction of the overall data is considerable. However, social media can act as a real-time data source and provide early warnings for ecosystem shifts. Social media may be of use to IAS managers because it provides a communication channel with which to explore public perceptions and to garner public support or to provide information. These insights highlight that the social and organisational dimensions around UGC are entangled with scientific and pragmatic concerns. As traditional search methods often look at historical information, and in order to consider more current and less structured information, tools that can search social media are useful because of their up-to-date, real-time capacities.

The aggregation of large volumes of content is accompanied by the risk of losing important information. Actors that have a stronger affinity to social media may for example 'drown out' minority stakeholders or specific issues. The ease of information propagation, e.g. a 'like' on Facebook or a 'retweet', may not be a true reflection of the importance of certain issues. Nonetheless, Daume et al. (2014) suggest that aggregated social media content (ASMC) could be correlated with spatial and temporal patterns obtained through existing forest monitoring networks. ASMC may also generate information not covered by forest monitoring such as observations in private gardens, revealing new geographic areas that warrant closer inspection. Hence, ASMC represents a cost-effective and real-time data source.

Challenges remain with regard to how traditional data management practices may obstruct a rapid response to IAS, given that both horizon scanning and monitoring UGC involve the need to access and disseminate up-to-date and eclectic data. Whilst monitoring UGC may identify IAS, it does not necessarily prevent an incursion. According to Groom et al. (2015), IAS science struggles to meet the growing demand for IAS data. This partly reflects policy makers having to keep up to date with a rapidly changing digital environment, the risk of out-of-date information and developing policy frameworks that enable the use and sharing of data. Beyond this, there remains the question of the threshold at which the information obtained about an IAS identified from UGC would lead to action. In horizon scanning, issue selection is based on estimates of the likelihood and impacts of a risk in relation to a specific aspect of society or the environment (Van Rij 2010). However, risks may arise for a variety of reasons and these interact with the horizon scanning process itself. The challenges associated with utilising UGC for horizon scanning and identifying IAS are not just technological but also conceptual and organisational (Groom et al. 2015). Different types of expert and stakeholder knowledge need to be integrated into the process. UGC contributes to evidence thus forming a basis for decision-making but its content is not only a source of domain information but also reflects the societal context of its production. UGC as data can never be value-free. It is therefore important to develop an appreciation of the social, organisational, ontological and epistemological issues involved.

5.5 UGC, Forests and Our Sense of Self: Ontological Questions

How people understand forests and trees and how they attribute meaning and engage with them reflects their broader relationships and wider sociocultural influences and beliefs (Doody et al. 2014). Hence, those responsible for forest health management should consider how people construct their sense of self[13] in relation to their particular social, geographic and economic relationship with forests and trees (Cantrill and Senecah 2001). The question of ontology, of whether the Internet and UGC fundamentally change peoples' relationship with themselves and the world, is as important as questions about the pragmatics of using UGC. Turkle (2011), for instance, suggests that in our present era we have learned to see ourselves as 'plugged in technobodies' where our political and economic lives are articulated through a language of machine intelligence and distributed, networked and emergent organisation. This coincides with the erosion of traditional forms of community and institutions, and the emergence of a self, predicated on notions of multiplicity, heterogeneity and fragmentation. For those interested in and managing the FHS, this translates into a need to understand the ontological underpinnings of why and how people participate in activities contributing to the care of forests and trees. Understanding the endogenous knowledge of communities, their particular relationship with forests, is crucial. If a dispersed and online general public is less likely to engage with an issue than a localised, motivated and active community (Massung et al. 2013), then a problem for managers seeking to communicate and utilise 'plugged in' 'communities' is how to overcome this inertia.

Implicit in the reviewed literature was a conflation of the categories of the person in the human sense and as a digital artefact. This results in mis-conceptualising who the object of communication, e.g. the audience, is. When we act towards the artefact rather than the person, there is a tendency to idealise what can be achieved. In some sense, an 'idealised citizen' has been tacitly imagined as this object: an individual interpolated in such a way that they are responsive to how the government and other organisations want them to act. This conceptualisation fails to problematise the complexities of subjectivity, and that the virtually mediated environments which extend into many aspects of our lives and which result in plural identities are complex and increasingly predicated, for example, on consumption as a mandatory practice (Șerban 2016).

6 Conclusion

Our primary concern in this chapter was to focus on the social and organisational processes underpinning the use of UGC in the FHS. UGC needs to be understood not only in terms of what it facilitates (i.e. linking stakeholders and data) but how this facility exists as part of the changing face of the human dimensions of forest health.

Organisations, researchers and workers in the FHS, interested in UGC, need to pay equal attention to social psychological processes as much as they do the mechanics and technical aspects of utilising ICTs and developing technological infrastructures.

Processes of commodification, transformed into a perception of forests in terms of the recreational and therapeutic benefits they afford, sit uncomfortably with the belief that forests need to be looked after on their own terms and be available free from human exploitation. Communication and organisational change in relation to the FHS needs to reflect both action *and* research that can be identified from across different levels, including the technological, the discursive (ideologies and beliefs underpinning the content of communication) and the social (the different stakeholder groups involved and their relationships). If ICTs and UGC radically change the nature of how organisations operate, then we have to pay attention to the ideational, systemic and social aspects of these changes. Understanding why and how people engage with UGC rests on a set of complex relationships that belie the notion of homogeneous audiences, unitary selves, straightforward communication and ideal citizens. Alongside research and development which focusses on implementing UGC and social media in the FHS, we feel that equal, if not primary, consideration needs to be afforded to how UGC and social media change our perception of ourselves and the world in the first place.

Notes

1. Following exploratory work, final search terms were applied to article abstract, title and key words. Terms capture the manner in which ICTs and UGC are usually represented: ('user generated content' OR 'social media' OR 'web 2.0' OR 'smart phone') AND ('forest' OR 'tree health'). Year selection was 2012–2017.
2. Adaptive management approaches acknowledge address forest systems as complex and adaptive and eschew traditional top-down management in favour of innovation, collaboration, learning and action in the face of incomplete and uncertain scientific knowledge (Lawrence 2017; Westgate et al. 2013).

3. Thinning, and removing trees and underbrush to mitigate fire risk.
4. Specifically self-organising maps; see Kohonen (2013).
5. 'Big Data' denotes massive amounts of structured and unstructured data that cannot be analysed using traditional techniques. The challenges involved in making sense of such data include issues of storage, curation and creating utilities that can harvest and process it accordingly. Different disciplines have different ideas on what Big Data is and what it can be used for.
6. An outdated model of communications based on the premise that an intended message is directly received and wholly accepted by the receiver.
7. 'Datafication' denotes the transformation of our social lives into online quantified data, enabling real-time surveillance and predictive analysis.
8. The envisaged convergence of technologies including wireless communication, real-time analytic capacity, machine learning, remote sensing and embedded systems.
9. Organisms with a tendency to spread to a degree that causes damage to other species, the human economy and health.
10. A definition of crowdsourcing is individuals or organisations using contributions from Internet users to obtain services. Hence, some crowdsourcing projects will also be CS projects but some will not.
11. 'Gamification' is a motivational technique using game elements, such as point scoring, competition and questing in a non-gaming context.
12. The practice of seeking, gathering and analysing information about emerging threats so that policy makers can develop a resilient, long-term plan of action more able to cope with uncertainty.
13. 'Self' is an extensive and complicated concept. For our purposes, it can be thought of as a materially situated yet inward directed awareness, providing for a sense of continuity and consistency of experience across time and place.

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