Forest Ecology and Management 316 (2014) 9–20

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

# Forest monitoring and social media – Complementary data sources for ecosystem surveillance?

Stefan Daume [a,b,*], Matthias Albert [c], Klaus von Gadow [a,d]

[a] Faculty of Forest Sciences and Forest Ecology, Georg-August-University Göttingen, Büsgenweg 5, 37077 Göttingen, Germany
[b] Stockholm Resilience Centre, Stockholm University, Kräftriket 2B, 114 19 Stockholm, Sweden
[c] Northwest German Forest Research Institute, Grätzelstraße 2, 37079 Göttingen, Germany
[d] Dept. of Forest and Wood Science, University of Stellenbosch, South Africa

ARTICLE INFO

*Article history:*
Available online 29 September 2013

*Keywords:*
Forest monitoring
Forest observational studies
Social media mining
Forest ecosystem services
Anthropocene
Societal context

ABSTRACT

Forest monitoring captures human impacts and other biotic and abiotic influences on forests and is a prerequisite for the sustainable use and protection of forest ecosystems. Forest inventories for example are a key tool to plan sustainable harvesting, whereas Forest Observational Studies provide the empirical basis for an improved understanding and long-term evaluation of forest ecosystem dynamics. To that end detailed data is collected at stand level, often integrated in larger forest observational networks, which feeds into forest ecosystem models. Forests exist however in a constantly changing societal context and the direct or indirect impact of human activity has become a crucial driver on all types of ecosystems. The Millenium Ecosystem Assessment underlines the linkage between social and ecological systems, highlighting the centrality of ecosystem services to human well-being and the requirement for ecosystem monitoring in the "anthropocene" to provide a holistic view of ecosystems as social-ecological systems.

Framing information about the social context of a forest ecosystem, gaining the expertise and providing resources to collect this type of information is usually outside the scope of data collection for forest inventories and monitoring. Studies in other domains faced a similar challenge and turned to data mining informal online information sources to supplement traditional monitoring and data collection strategies.

This paper explores how forest monitoring approaches especially Forest Observational Studies with their long-term and large-scale focus may be complemented by social media mining. We outline (a) how social media mining methods from other domains could be applied to forest monitoring, (b) discuss identification of stakeholders, events and demands on forest ecosystems as examples of social contextual information that could be obtained via this route and (c) explain how this information could be automatically mined from social media, online news and other similar online information sources. The proposed approach is discussed on the basis of examples from a broad set of other domains.



## 1. Introduction

### 1.1. Scope and challenges of forest monitoring

Forest monitoring aims to capture the dynamics of forest ecosystems in response to a broad range of biotic and abiotic influences. Monitoring programmes vary with regard to their primary focus and objective; forest inventories for example have historically been a key instrument in planning sustainable harvests, whereas long-term and large-scale Forest Observational Studies, as defined comprehensively in the introductory contribution to this Special Issue, provide the empirical data basis for analysing ecosystem structure and dynamics. The development of a forest ecosystem is not only the result of "natural" processes, but is largely influenced by human activity. Field data – often integrated in bigger observational networks – allows modelling of forest dynamics, including tree growth, mortality, recruitment and abiotic and biotic risks, in response to site conditions, harvest events and other silvicultural operations.

Despite an assumed long-term perspective, even silviculture, as a direct and planned influence, is characterised by frequent policy changes rather than constancy (Heyder, 1984) and Gadow et al. (2007) conclude that dynamics of managed (or exploited) forest ecosystems is thus predominantly a cultural rather than ecological issue (Gadow et al., 2007).

Forests exist however in an even broader societal context and the Millenium Ecosystem Assessment (2005) underlines the linkage between social and ecological systems. More and more forest management approaches acknowledge this linkage and provide

* Corresponding author at: Faculty of Forest Sciences and Forest Ecology, Georg-August-University Göttingen, Büsgenweg 5, 37077 Göttingen, Germany.
*E-mail addresses:* stefan.daume@ecoveillance.org (S. Daume), matthias.albert@nw-fva.de (M. Albert), kgadow@gwdg.de (K. von Gadow).

0378-1127/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.foreco.2013.09.004

a form of adaptive forest management that aims to identify and prioritise available management options for a forested landscape resulting in a desirable mix of forest ecosystem services (Gadow et al., 2007; Heinimann, 2010; Millar et al., 2007). According to Gadow et al. (2007) the valuation and prioritisation of different forest ecosystem services is thus a typical problem of *Public Choice* that is influenced by and has to accommodate current demands of a broad range of stakeholders.

Forest planning and management thus faces both the challenge of providing an adaptive management regime that can incorporate changing demands as well as the need to obtain the necessary data to identify a desirable mix of services. An evaluation of these demands does however require to assess the perspective of social systems which is usually outside the scope of data collection for forest planning. Adaptive forest management practices will thus also have to bridge the disconnect between the available data and its suitability to assess societal demands on forest ecosystem services.

In addition to frequently changing silvicultural practices and demands, forest management has to address the uncertainty and surprises that result from the broader human impacts on the Earth's ecosystems (Albert and Schmidt, 2012; Lindner et al., 2010; Schneider and Root, 1996; Spellmann et al., 2011), which extend beyond the harvesting of resources. These impacts are so significant that the term *"Anthropocene"* was coined (Zalasiewicz et al., 2010) to highlight that humans have become the major driver of global change. The Anthropocene is characterised by large-scale, and often uncontrolled human disturbances, and the relatively scattered forest observational networks face the same known challenges as any ecological monitoring programme in picking up and anticipating these disturbances (Wintle et al., 2010). Such disturbances may occur at any time and therefore even large scale forest inventories which have time intervals of 5–10 years between successive assessments, are usually only able to capture such events long after they have occurred.

Even tightly-knit forest monitoring programmes with shorter time intervals in densely populated areas such as Europe face new challenges. Invasive alien species for example have been highlighted as a growing concern in general (EEA, 2012) and forestry has seen devastating impacts through for example *Ash dieback* (Pautasso et al., 2013) or the faster emerging *Pine wilt disease* (Vicente et al., 2012).

Native forest threats like the *Pine* or *Oak processionary* present new challenges as well; there are indications that these species, possibly due to changing climate conditions, are extending their distribution range thus potentially becoming a threat in new areas (Netherer and Schopf, 2010; Petercord et al., 2008; van Oudenhoven et al., 2008). Monitoring programmes for both native and alien invasive species exist but are resource-intensive and regionally divided responsibilities may complicate adequate responses.

In addition, the assessment of the impact is not limited to tangible goods like timber production and will vary with the predominant societal role of the forest. The *Oak processionary* for example is causing major damages to oak forests (Habermann, 2012) but also presents a significant health risk (Gottschling and Meyer, 2006). The latter is of greater importance in e.g. densely populated areas or where forests have a major recreational function. This in turn will influence the actions taken and the most suitable monitoring approach and effort.

Given the multitude of threats and challenges more resources could be committed to even closer monitoring and observational networks. However, we propose that, alternatively or in addition, existing monitoring efforts may be informed by additional, previously unused informal information sources in order to identify changing demands or unanticipated threats and thus guide data collection in existing monitoring networks. Examples of such supplementary information includes identifying stakeholders or societal demands on ecosystems at a local level which may also help to guide adaptations in the type and scope of data collected in forest inventories.

In consideration of this, we propose to mine informal online information sources as an efficient and flexible way to supplement traditional forest monitoring and data collection strategies. We will show with examples how social contextual information and indications of notable events can be mined from social media, online news and other similar online information sources.

### 1.2. Social online media as monitors for social systems

*Social online media* are a class of web-based applications and information sources, that are typically characterised by collaborative content creation driven by explicit or implicit social networks that represent virtual communities of shared interest.

The terms "Social media", "Web 2.0" or "User-generated content" are often used interchangeably to describe the characteristics of these information sources. Despite a certain fuzziness surrounding the term "Web 2.0" (DeveloperWorks, 2006) it can be best described as a set of technologies (i.e. AJAX, RSS) and tools (i.e. Blogs, Wikis, social online networks) which Kaplan and Haenlein (2010) define as "the platform for the evolution of Social Media" where users, to varying degrees, contribute to the creation of content, thus becoming "prosumers" – producers and consumers of content (Ritzer and Jurgenson, 2010; Wikipedia, 2012).

Social media classes vary with regard to the level of "personalisation" or "self-disclosure" and the "richness of the media" employed (Kaplan and Haenlein, 2010); blogs and micro-blogs for example are highly personalised as the author(s) provide personalised content and information about themselves, whereas collaborative projects like Wikipedia have a low degree of personalisation – content is not personalised and author information not as prominent. Both of these have in common that they are employing text as a main medium, in contrast, "content communities" like YouTube focus on video content as the main medium and "Virtual Worlds" like Second Life belong to social media classes that employ even richer media. Table 1 provides a definition and examples of different social media classes.

Another discriminator between the different types of social media focuses on two patterns of information flow. "Information-pull" media (Marques et al., 2012) are applications where a reader or content consumer has to actively visit the information source to obtain content; blogs belong to this class of applications. In "information-push" models (Marques et al., 2012) on the other hand the information is delivered to the content consumer; micro-blogs and social networks like Facebook are typical examples. Information-push models guarantee a broader distribution of information and facilitate recursive dissemination of this information in the networks of readers.

The potential value of informal online information sources in the ecological domain in general was recently advocated by Galaz et al. (2010). In this contribution we discuss whether informal online information sources – specifically social online media – could act as an efficient and representative source for the societal context of forest ecosystems. We will provide an introduction to social media mining, present relevant examples of social media analysis from other domains and discuss three potential areas – (1) identification of stakeholders, (2) detection of events with an impact on forests and (3) identification of demands on forest ecosystems – for which social media analysis could provide insights with regard to forest ecosystem dynamics, early warnings or management options and potentially augment and guide forest observational studies.