Providing Online Crisis Information: An Analysis of Official Sources during the 2014 Carlton Complex Wildfire

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ABSTRACT
Using the 2014 Carlton Complex Wildfire as a case study, we examine who contributes official information online during a crisis event, and the timeliness and relevance of the information provided. We identify and describe the communication behaviors of four types of official information sources (Event Based Resources, Local Responders, Local News Media, and Cooperating Agencies), and collect message data from each source's website, public Facebook page, and/or Twitter account. The data show that the Local News Media provided the highest quantity of relevant information and the timeliest information. Event Based Resources shared the highest percentage of relevant information, however, it was often unclear who managed these resources and the credibility of the information. Based on these findings, we offer suggestions for how providers of official crisis information might better manage their online communications and ways that the public can find more timely and relevant online crisis information from official sources.

Author Keywords
Social computing; social media; crisis informatics; wildfire; risk communication.

ACM Classification Keywords
H.5.3 Groups & Organization Interfaces—collaborative computing, computer-supported cooperative work, organizational design

INTRODUCTION
Timely and accurate communication of official information is a vital component of managing any emergency or crisis event [17,19,29,44]. We define "official information" as that information whose source is perceived by the public as more authoritative and/or trustworthy. Effective official information can provide members of the public with lifesaving protective measures, facilitate relief and recovery efforts, and reduce anxiety and fears [32,38,49]. This information may be distributed by emergency response agencies (e.g., fire and police departments, emergency management organizations, non-profit disaster relief groups), public officials (e.g., city mayors, governors), public works organizations (e.g., transportation authorities, utility companies), or the broadcast news media [10].

A variety of traditional mechanisms exist for distributing official information during a crisis event, including broadcast media (television, radio, and newspaper), sirens, phone messages, face-to-face interactions, and community meetings [16]. In addition, online media (websites, blogs, email, and various forms of social media) have introduced communication mechanisms that support more timely and wide-spread interaction with the public [6,11,15,21]. However, as online communication options continue to proliferate, decisions around how to best communicate official information to the online public have become increasingly difficult. Decisions require knowledge about the capabilities and limitations of each online media type, the affected audience, and the circumstances of the crisis event. Providers of official information must also consider their ability to use and maintain each online communication channel. Similarly, it can be challenging for members of the public to know where to look for official online information and to understand what information can be trusted amidst a flood of socially-generated data [2].

To better understand and address these challenges, we examine how providers of official information used multiple online media during the 2014 Carlton Complex Wildfire. We identify and categorize the types of sources that provided official information in this context and describe their features and communication behaviors. We also examine the relevance and timeliness of the information these sources provide. We conclude with suggestions for how providers of official crisis information might better manage their online communications and ways that the public can find more timely and relevant online crisis information from official sources.

BACKGROUND

Online Media Use in Crisis
This research engages in a *crisis informatics* [8,23] line of inquiry that turns a critical eye to the complex socio-

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technical information environment that surrounds a crisis event. In this context, scholars have examined the role online media (and in particular social media) play around many crisis events, including both natural (e.g., 2004 Indian Ocean Tsunami [20], 2005 Hurricane Katrina [4,30], 2012 Hurricane Sandy [13,27], and 2013 Colorado floods [5]) and man-made (e.g., 2007 Virginia Tech shooting [23], 2010 Deepwater Horizon Oil Spill [41], and 2013 Boston Marathon Bombing [9,43]) disasters. Through online media, those affected by a crisis event converge online to seek and share information and assist in response efforts [12] regardless of location and more quickly than what was previously possible [22]. Official emergency responders and other providers of official information increasingly use online media to communicate and interact with the public that they serve and to gather information that can be used in their efforts [6,11,13,15,42]. In turn, members of the public can find, generate, and distribute online crisis information as they seek to engage with others and understand how a crisis event affects them [21,25,28,36].

Official Information through Online Media

A growing body of research examines how providers of official information use online media to convey their messages [1,6,13,15,26,43]. Social media, in particular, have made emergency responders reconsider the traditional one-way communication model—where they only push information to the public—in favor of a more interactive two-way communication model [11,24]. Through online media, providers of official information can engage in communication with the public, which can help distribute information more quickly and directly [6]. Researchers hypothesize that this two-way communication may result in the exchange of higher quality information and reduced reliance on broadcast media to distribute official crisis communications [11]. Consequently, in this research, we seek to understand whether emergency responders provided better information (in terms of relevance, quantity, and timeliness) around the Carlton Complex Wildfire than broadcast media sources.

Providing timely official information online is important because people affected by a crisis will seek information elsewhere if they cannot find it from official sources [31]. In seeking information from non-official sources, people may act on information that is incomplete or inaccurate. In offering timely, accurate information, providers of official information can also play an important role in mitigating the spread of rumor during crisis events [1]. However, the adoption of tools like social media into emergency responder practice pose many socio-technical challenges such as issues of credibility and trust, lack of support from management, organizational conflicts, poor tools, and a shortage of resources and training [3,11,15,26,33,39].

Despite much empirical work, we still know little about how online media fit into official crisis communication strategies [11,13]. Further, prior research is limited in that it tends to focus on how a single emergency responder or type of responder uses online media (typically a single platform) to communicate official information. In this paper, we seek to better understand the different types of official information providers and how they use multiple online platforms (i.e., websites, Facebook, and Twitter) to communicate crisis information. We also evaluate the relevance and timeliness of official online crisis information, to determine what online platforms and official sources provide the most relevant and timely information.

Event of Study – Carlton Complex Wildfire

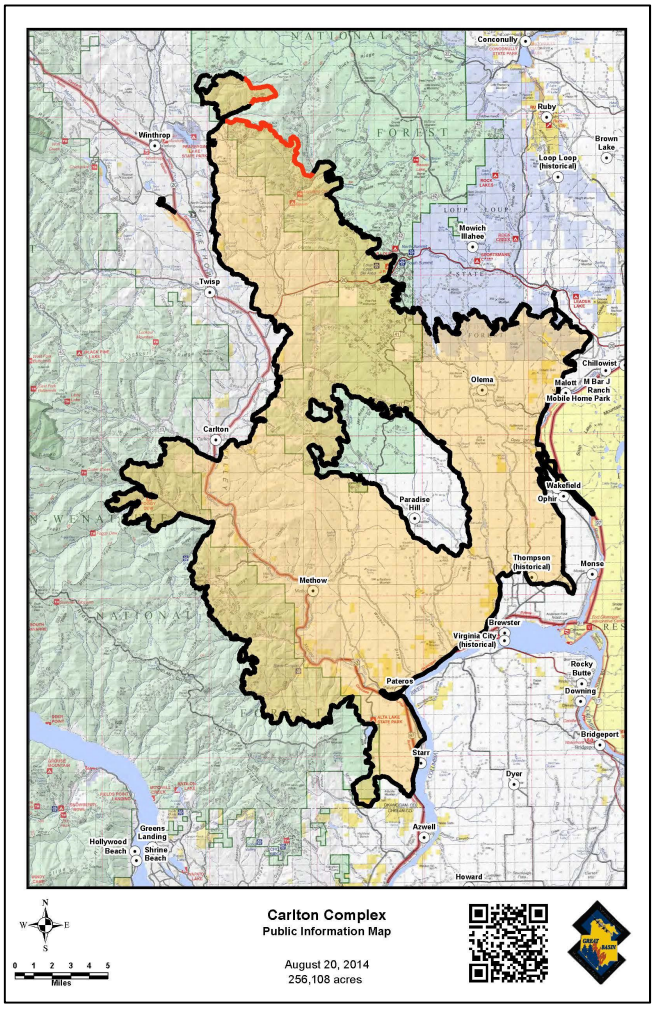

Figure 1. Carlton Complex Wildfire Perimeter Map for August 20, 2014 [46]

On July 14, 2014, lightning in the Methow River Valley started four wildfires: the Cougar Flat, French Creek, Gold Hike, and Stokes fires. These fires later merged (by July 20) to form the Carlton Complex Wildfire.

The Carlton Complex Wildfire burned 256,108 acres to become the largest wildfire in the history of the US state of Washington [18,34], affecting the cities and communities of Okanogan and Chelan counties (see Figure 1). The wildfire caused several closures, evacuations and power outages in

and around the cities of Pateros, Malott, Brewster, Carlton, Methow, Twisp and Winthrop. The wildfire consumed more than 322 homes as well as 149 other structures and cost at least $60 million in damages [18]. On July 23, 2014, US President Barack Obama declared the Carlton Complex Wildfire a federal emergency disaster. The fire slowed due to rain on July 24, allowing 60% containment by July 26 [34]. Finally, the fire was 100% contained by August 24, 2014 [48].

METHOD

Identifying Official Information Sources

We began this research by investigating the Carlton Complex Wildfire and the circumstances surrounding the event. Primary sources included media coverage found through Google searches and InciWeb (an interagency all-risk incident web information management system that is run by the United States Forest Service). Through this investigation, we identified the geographic regions affected by the wildfire and many of the official information sources associated with the event (i.e., emergency responders and news media from the affected regions, cities, communities, and counties). Our purpose was to identify sources that those who were directly affected by the Wildfire would have turned to for official information. Names of many of the agencies who participated in the event response were obtained from the Carlton Complex Wildfire's InciWeb page [47]. We also found information sources by searching on "Carlton Complex Wildfire" using the Google, Facebook, and Twitter search engines. Finally, we uncovered additional official sources as we analyzed information sent from our initial list of sources. Using iterative sorting and clustering, we divided these official sources into four categories based on their purpose: 1) Event Based Resources, 2) Local Responders, 3) Local News Media, and 4) Cooperating Agencies. In total, we identified 8 Event Based Resources, 25 Local Responders, 7 Local News Media, and 5 Cooperating Agencies.

Event Based Resources

Event based resources were named after the Carlton Complex Wildfire and were dedicated to reporting information about it. An example of this resource type is the public *Carlton Complex Wildfire* Facebook page, which describes itself as a provider of "official fire information." These resources are of particular interest because while they appear to be sources of official information about the Wildfire, it was often unclear who actually maintained and posted the information found there. Event Based Resources have been mentioned in prior research [37], but not beyond noting that they exist and provide information specific to the crisis event they are associated with.

Local Responders

Local responders are the agencies of the affected cities and communities who were most directly involved in the Carlton Complex Wildfire response. Examples of Local Responders include the police, fire and emergency medical services of the affected region, and the emergency management agencies of the affected counties.

Local News Media (LNM)

Local news media include the broadcast media agencies of all the affected cities, communities, and counties. The area did not have a local television station, but they did have several newspapers and radio stations that maintained an online presence. We did not include media sources outside the immediately affected region in our dataset, though the Wildfire did receive national attention; non-local media sources tend to repeat information already conveyed by the local media but with less detail and frequency [40].

Cooperating Agencies

Cooperating agencies are those agencies that assisted in the response to the Carlton Complex Wildfire, yet their assistance was usually on the periphery and not as central as Local Responders. This category includes non-profit service organizations (e.g., American Red Cross), federal agencies (e.g., Bureau of Indian Affairs, Bureau of Land Management, and Fish and Wildlife service), and state agencies (e.g., Washington State Department of Natural Resources, and Washington State Department of Transportation).

Data Collection

Next, we determined the websites, public Facebook pages, and Twitter accounts that belonged to each of the official information sources identified above—if they existed. We assumed that if a webpage or social media page or account could not be reasonably found via a basic web search (or a couple of basic web searches) using the Google, Facebook, and Twitter search engines, it was unlikely to have served as a useful source of official information around the event. Table 1 shows the number of websites, Facebook pages, and Twitter accounts found for each official information source type.

Official Sources	# Websites	# FB Pages	# Twitter Accounts	Total
Event Based Resources	1	5	2	8
Local Responders	20	15	7	42
Local News Media	4	7	7	18
Cooperating Agencies	5	4	5	14

Table 1: Number of Websites, Facebook (FB) Pages, and Twitter Accounts that belong to Official Information Sources

We then collected all the Facebook posts and tweets of these official information sources using the Facebook Graph API and the Twitter Search API respectively. The relevant pages (those concerning the Carlton Complex Wildfire) from the identified websites were downloaded and stored as pdf documents for coding and analysis. The data collection

timeframe was July 14 – Aug 24, 2014. We chose these dates because the Carlton Complex Wildfire began on July 14, 2014 and was reported 100% contained on August 24, 2014. Table 2 lists the number of websites, pages, or accounts found, and the number of pages, posts, or tweets collected for all three online media.

Online Media	# Websites, Pages or Accounts	# Pages, Posts or Tweets	# On-Topic Pages, Posts or Tweets
Websites	30	83	83
Facebook	31	2,232	1,576
Twitter	21	3,416	2,466

Table 2. Number of Websites, Facebook Pages, & Twitter Accounts and the Related Pages, Posts, & Tweets Analyzed

Data Analysis

We began data analysis by reading all the collected pages, posts, and tweets to determine which were about the Carlton Complex Wildfire. All coding schemes were iteratively developed between the two authors (both experienced coders). Each author labeled the posts separately, after which the results were compared. Any conflicts were collaboratively discussed until consensus could be reached. Messages relevant to this event, such as size of the wildfire, wildfire containment, wildfire progression, evacuation related information, weather and smoke conditions, donations, fundraisers, etc., were marked as on-topic. Messages that were irrelevant to this event, such as updates about other wildfires (that were burning at the same time as the Carlton Complex Wildfire but did not directly impact the same area), construction closures, and other local news, such as information about thefts, road accidents, etc., were marked as off-topic. Table 2 lists the total numbers of on-topic pages, posts, and tweets analyzed.

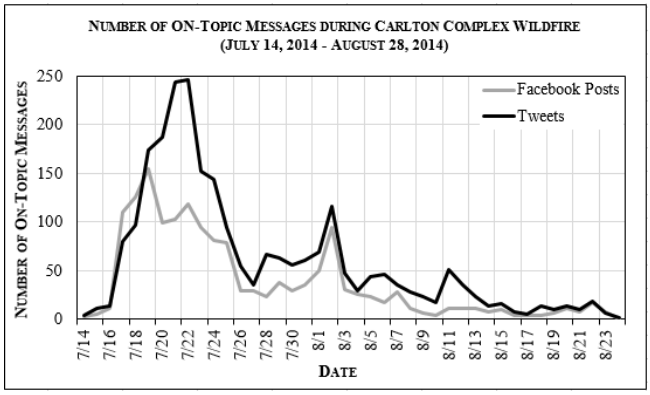

Figure 2: Number of On-Topic Messages during the Carlton Complex Wildfire (July 14, 2014 – August 24, 2014)

Figure 2 shows the number of on-topic Facebook posts, and tweets during each day of the collection timeframe. The significant increase in on-topic posts around July 22 related to the growing size of the wildfire, which resulted in mass evacuations and property damage. The spike on August 2 was caused by another fire—the Rising Eagle Road Fire—that started on August 1 [50]. Due to its proximity, this fire was later included in the Carlton Complex Wildfire [51].

To better trace when information was available and who was providing it across the online media in our datasets, we identified two important pieces of public information typically conveyed during a wildfire event: 1) the number of homes destroyed by the fire and 2) the current fire evacuation level for the affected communities. Information regarding the number of houses consumed by a wildfire indicates the effect of the fire on the community and the severity of the wildfire when compared to other (or previously experienced) fires. Information regarding evacuation levels can inform protective measures and save lives [45]. In addition to their importance, we used these two pieces of information because they were easier to track compared to other more variable types of information such as the location of evacuation centers, donation drop-off areas, roads/forest closures, etc. We read and coded every tweet, post, and webpage to determine if they contained information about the number of houses consumed by the wildfire and/or fire evacuation levels.

Next, we plotted this data by time for the reports of homes burned and evacuation levels (reported later in this paper). These plots allowed us to cluster the data around particular pieces of information within the larger information stream, such as a report of a level 3 evacuation or a report that 100 homes had burned. These clusters were then used to determine what information source first reported each piece of information in our data set. Finally, we also determined who posted the most relevant (on-topic) information as well as the highest percentage of relevant information.

FINDINGS

We report our findings in two sections. The first section describes the characteristics and information sharing behaviors of the four types of official information sources identified in this study. The second section traces official reports of the number of houses burned and evacuation levels during the Carlton Complex Wildfire.

Official Information Sources

Event Based Resources

Event Based Resources refer to online media that were specifically dedicated to the Carlton Complex Wildfire. The name of each of these resources typically made them easier to find and helped people know that they offered information about the Carlton Complex Wildfire. Some resources were named directly after the Wildfire (e.g., *@CarltonComplex*), while some were named after the Wildfire's location (e.g., *Methow Valley Fire Information*). Other resources had names that described their purpose. For example, the *Carlton Complex, WA Wildfire Lost and Found Pets-NDARRT* Facebook page was dedicated to helping pets displaced by the Wildfire. In another case, we discovered that the administrator of the *@CarltonComplex* Twitter account had

stopped updates once the fire had subsided and started channeling communications through the *@upperfallsfire* Twitter account:

> **@CarltonComplex via Twitter** (08/11/2014 04:23pm): In an effort to consolidate fire information sources, @CarltonComplex will no longer be updated. Follow @upperfallsfire for updates.

The Upper Falls Fire was another prominent fire in the area at the time. Because of the message above, we suspected that the *@upperfallsfire* Twitter account might also be a source for information about the Carlton Complex Wildfire. Indeed, we found that 37.8% (see Table 3) of the messages posted by *@upperfallsfire* were relevant to the Carlton Complex Wildfire, and so we included it in our dataset as an Event Based Resource.

Name	First Post	Last Post	# On-Topic
Website			
Carlton Complex Assistance Network	07/27/14	03/26/15	4
Facebook Pages			
Carlton Complex Wildfire	07/17/14	08/11/14	172 (89.1%)
Carlton Complex (Camp)	07/20/14	09/16/15	2 (100%)
Carlton Complex Fire Relief & Assistance Network	07/23/14	10/15/16	47 (52.2%)
Methow Valley Fire Information	07/17/14	08/25/16	88 (97.8%)
Carlton Complex, WA Wildfire Lost and Found Pets-NDARRT	07/18/14	10/14/16	96 (88.1%)
Twitter Accounts			
@CarltonComplex	07/19/14	08/11/14	406 (95.3%)
@upperfallsfire	08/06/14	08/23/14	17 (37.8%)

Table 3: Event Based Resources and On-Topic Posts

Most (5 of 8) of the Event Based Resources did not provide information about who or what organization managed these websites and social media accounts. Thus, it was not always clear whether the information provided was accurate or who was accountable for the information. One resource (the *@CarltonComplex* Twitter account) was described as a source of "official information" but no further evidence was offered around who was running the account. In another case, we discovered that the US Forest Service managed one of the Event Based Resources (the *Carlton Complex Wildfire* Facebook page). However, this information was only discovered indirectly through a Facebook post by a Local News Media agency. Because these Event Based Resources were so tied to the Carlton Complex Wildfire (unlike the other resources in our dataset), we tracked how long these resources remained active following the event (see Table 3). We defined event based resources as 'active' if they had some kind of recent activity on their pages or accounts within the past year (2016). This is interesting because event based resources, in most cases, were created to provide information about a particular event. If they remain active today (after 2+ years), it is evident that their purpose has changed over time. Findings show that some (3 of 8) resources became inactive within two months after 100% containment of Wildfire. A few (2 of 8) resources were still active up to a year following the event, while the last three resources remain active today (having most recently posted in August and October 2016). These three active Event Based Resources have since broadened their scope of concern beyond the Carlton Complex Wildfire to include wildfire events at the county and/or state level.

Online Media Type	# On-Topic Messages
Facebook	405 (83.7%)
Twitter	423 (89.8%)

Table 4: Average Number of On-Topic Posts by Event Based Resources on Facebook and Twitter

Event Based Resources averaged the most on-topic Facebook (83.7%) and Twitter (89.8%) posts of any official information type. Even though none of these Event Based Resources existed prior to the Wildfire, they attracted much interest in a short amount of time. The most popular Facebook Page—*Carlton Complex Wildfire*—collected over 10,500 likes. The *Carlton Complex Wildfire* Facebook Page (172 on-topic posts) and *@CarltonComplex* Twitter account (406 on-topic tweets) were the most active Event Based Resources.

Local Responders

The dataset of Local Responders includes the official websites, Facebook pages, and Twitter accounts of the public officials, fire and police departments, and emergency management agencies of the affected area.

Different Local Responders have different jurisdictions. For example, a county agency has responsibilities around the entire county, whereas a city agency is responsible only for city activities. This difference is reflected in the online messages of these agencies:

> **Okanogan County Sheriff Office via Facebook** (07/19/2014 10:11am): Currently the information available to us is that there have been NO STATUS

CHANGES. Omak is still at Level 0 Okanogan is at Level 1 and Malott is at Level 3.

Winthrop Washington via Facebook (07/21/2014 12:37pm): The latest update is that Winthrop expects to have power restored by the weekend!

In the first post, the Okanogan County Sheriff Office offers information about three different cities that fall within their county. In the second post, Winthrop city officials provide information for the city of Winthrop only.

More than half of the online messages (72% Facebook posts and 56% tweets) posted by the Local Responders were wildfire-related (see Table 5). The *Okanogan County Sheriff Office* Facebook Page (189 on-topic posts) and *Chelan County Emergency Management* Twitter account (700 on-topic tweets) were the most active.

Online Media Type	# On-Topic Messages
Facebook	224 (72.0%)
Twitter	757 (56.0%)

Table 5: Average Number of On-Topic Posts by Local Responders on Facebook and Twitter

Local News Media

Our Local News Media dataset consists of the official websites, Facebook pages, and Twitter accounts of the online local news media (e.g., Okanogan Valley Gazette-Tribune, Quad City Herald, and Methow Valley News) and the online local radio stations (e.g., Okanogan County Amateur Radio Club W7ORC and KTRT 97.5 The Root). The Local News Media have a broader scope of concern compared to the Local Responders who were primarily dedicated to a specific aspect of the response effort. Thus, their websites, Facebook pages, and Twitter accounts posted a wide variety of information around the wildfires, including messages about the number of houses burned by wildfire, fire evacuation levels, local events, business closures, power outages/restoration, and road closures.

The Local News Media averaged the second highest number of on-topic messages, following the Event Based Resources. Table 6 shows that 79.5% Facebook posts and 80.3% tweets by Local News Media were on-topic. The *Methow Valley News* Facebook Page (479 On-Topic posts) and the *@MethowNews* Twitter account (442 On-Topic tweets) were the most active Local News Media.

Online Media Type	# On-Topic Messages
Facebook	910 (79.5%)
Twitter	937 (80.3%)

Table 6: Average Number of On-Topic Posts by Local News Media on Facebook and Twitter

Cooperating Agencies

Our dataset of Cooperating Agencies comprises the websites, Facebook pages, and Twitter accounts of service organizations, and federal and state agencies that supported the Wildfire response. Every agency in this category had a narrowly defined role and set of responsibilities with regard to the Carlton Complex Wildfire. For example, the Washington Department of Fish and Wildlife (WDFW) mostly posted about the effects of wildfire on natural habitats, whereas the Washington State Department of Transportation (WSDOT) posted about the effects of wildfire on transportation (e.g., road closures and detours).

Cooperating Agencies averaged the least on-topic Facebook (12.6%) and Twitter (38.9%) posts of any official information type (see Table 7). This low level of relevant content was likely because these agencies were less involved in the Carlton Complex Wildfire response efforts. The *Washington State Department of Natural Resources* Facebook page (32 on-topic posts) and *@waDNR_fire* Twitter account (221 on-topic tweets) were the most active Cooperating Agencies.

Online Media Type	# On-Topic Messages
Facebook	37 (12.6%)
Twitter	349 (38.9%)

Table 7: Average Number of On-Topic Posts by Cooperating Agencies on Facebook and Twitter

Relevance of Official Information Sources

Event Based Resources averaged the highest percentage of on-topic messages within their own message streams, followed by the Local News Media, Local Responders, and finally, Cooperating Agencies. This order reflects the role that each of these official information sources played in the response. The purpose of the Event Based Resources was to report information around the Wildfire. The Local News Media were heavily involved in distributing important crisis information to the public. Local Responders were responsible for much of the local response effort, but their reporting of the event was less significant, and once the Wildfire lessened in severity, many responders moved on to reporting other, unrelated types of information. Cooperating Agencies had the least relevant information, which is not surprising considering they were more peripherally involved with the Wildfire response efforts.

ANALYSIS OF ONLINE MEDIA CONTENT

Houses Consumed by Wildfire

First, we analyzed the number of houses consumed by the Carlton Complex Wildfire. This information can help city and government officials to estimate the damage caused by a fire. It is also useful for determining if a disaster qualifies for a federal emergency declaration and federal aid [7]. This information can also help affected citizens understand the severity of the fire, which in turn might affect their decision to take protective action or to evacuate.

We plotted the collected data (see Figure 3) to determine 1) how the information regarding houses consumed by wildfire

was conveyed over time, and 2) the first reporters of the information. The graph depicts how the Wildfire temporally progressed, showing how reports of the number of houses burned changed from only a few houses on July 17 to around 300 houses on July 25—a span of only 8 days.

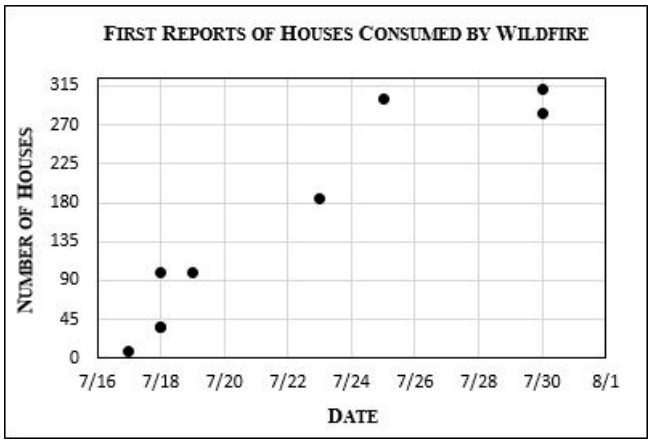

Figure 3. First Reports of the Number of Houses Consumed by the Carlton Complex Wildfire

Information around the number of houses burned was sometimes difficult to graph. In a few instances, agencies did not report the exact number of houses burned, but rather gave a range (e.g., 80-100 homes burned) or they described it using non-specific, approximate language (e.g., several homes burned). Such data is not represented in Figure 3.

Official Sources	# Web Pages	# FB Posts	# Tweets	Total
Event Based Resources	0	29	7	36
Local Responders	0	3	25	28
Local News Media	13	76	54	143
Cooperating Agencies	2	1	3	6

Table 8. Number of Official Web Pages, Facebook (FB) Posts, and Tweets that Reported the Number of Houses Consumed by the Carlton Complex Wildfire

Official Sources	# Web Posts	# FB Posts	# Tweets	Total
Event Based Resources	0	0	0	0
Local Responders	0	1	1	2
Local News Media	2	2	4	8
Cooperating Agencies	2	0	0	2

Table 9. First Reports of Houses Consumed by the Wildfire

Local News Media (143 posts) were the most active reporters for houses consumed by the wildfire (see Table 8). Most first reports of the number of houses consumed by fire came from the Local News Media (66.7%), and in most cases, the Local News Media reported this information via Twitter (see Table 9). This finding suggests that the official Twitter accounts of Local News Media sent information earlier than the other information resources in our dataset. However, care should be taken when applying this finding because the sample rate is low (N=12).

Fire Evacuation Levels

Next, we analyzed reports of fire evacuation levels during the Carlton Complex Wildfire. The evacuation level for a community is a critical (possibly lifesaving) piece of information. Here we analyze the messages regarding evacuation levels, the way these levels changed during the fire, and when they were reported to the public through the online media examined in this study. The evacuation levels for this wildfire ranged in severity from 0 to 3. Level 0 indicates no evacuations, while level 3 indicates immediate emergency evacuations.

To simplify our analysis, we considered fire evacuation level messages only for cities. We did not consider levels given for forests and roads because they were difficult to map to a particular geographic location for comparison. No fire evacuation levels were issued at the county level.

City	Number of Evacuation Level Messages
Winthrop	48
Carlton	38
Twisp	38
Pateros	33
Pleasant Valley	32
Brewster	23
Chiliwist	16
Omak	12
Okanogan City	11
Chelan	6
Malott	6
Manson	6
Tonasket	3
Union Valley	1

Table 10. Number of Evacuation Level Messages per City

We grouped our data based on geographic regions, creating a different group of data for each city affected by the Carlton Complex Wildfire. Table 10 shows the number of evacuation level messages for each of the 15 cities found in the data. The more severely a city was affected by the wildfire, the more evacuation level messages were issued.

Fire evacuation levels were always reported with respect to a specific geographic region. Unlike reports of the number of homes burned, evacuation level reports were always expressed in integer values (in the range 0-4), and were never reported in a range or in a descriptive way:

> **@CarltonComplex via Twitter** (07/21/2014 03:48pm): #CarltonComplex Urgent Update: Pleasant Valley area now under LEVEL 3 IMMEDIATE EVACUATION. Highway 20 closed between Twisp & Okanogan

The Local News Media were the most active reporters of fire evacuation levels (see Table 11).

Official Sources	# Web Pages	# FB Posts	# Tweets	Total
Event Based Resources	0	101	100	201
Local Responders	0	52	98	150
Local News Media	47	204	202	453
Cooperating Agencies	15	2	16	33

Table 11. Number of Official Web Pages, Facebook Posts, and Tweets that Contain Evacuation Level Information

Next, we mapped the data for each cities and identified the first reporters of each change in evacuation level. The Local News Media were the first to report 57.3% of the fire evacuation levels (see Table 12). The Local News Media reported most of this information (all but 3 messages) equally across Facebook and Twitter. Upon further investigation, we discovered that some of the Local News Media had linked their Facebook and Twitter accounts and many identical messages were pushed out over the two platforms at the same time. In this case, the official Twitter accounts and Facebook pages of Local News Media sent information earlier than the Local News Media's websites.

Official Sources	# Web Pages	# FB Posts	# Tweets	Total
Event Based Resources	0	7	4	11
Local Responders	0	9	1	10
Local News Media	3	18	18	39
Cooperating Agencies	8	0	0	8

Table 12. First Reports of Evacuation Levels for the 15 Cities Affected by the Carlton Complex Wildfire

Relevance of Provided Information

Using the data collected around the number of houses consumed by fire and the evacuation levels, the Local News Media provided the most relevant information in terms of quantity, followed by Event Based Resources, Local Responders, and lastly, Cooperating Agencies. Local News Media sources provided more than double the number of messages that the Event Based Resources provided. This finding demonstrates how much more involved the Local News Media were in sharing information, and as a result they may be a richer source of crisis information for the affected public.

DISCUSSION

In this paper, we identified four types of official information sources and analyzed the timeliness and relevance of the information these sources provided during the 2014 Carlton Complex Wildfire. This categorization better articulates the roles, interests, and responsibilities of different official information sources and helps explain what type of information emergency responders, members of the public, and researchers might expect from these sources. We now discuss broader implication of this research and offer recommendations for how to improve the effectiveness of official online crisis communications.

Timeliness of Official Information Sources

For both the number of houses consumed by fire and the evacuation levels, the Local News Media had the most first reports of this information. Earlier, we hypothesized that local responders would provide the most timely information because they now have more ability through online media to share information directly with the public through social media [11]. The data, however, disproves this hypothesis because it demonstrates that the Local News Media are still heavily relied upon to distribute timely information to the public in an online setting (at least for the Carlton Complex Wildfire).

Event Based Resources

We included Event Based Resources as sources of official information because we found that in many cases these resources either claimed to be a source of official information or they were managed by an official emergency response agency. In other cases, where "official" status was not so clear, the name of the online account tied it to the Carlton Complex Wildfire. So, at least in name, the account appeared to be official. Recent research has shown that official accounts can shape social media conversation and mitigate misinformation and false rumor around a crisis event [1]. Thus, understanding who manages these Event Based accounts, their purpose in creating these accounts, and the current intentions of account owners is important and would reveal much about the lifecycle of these accounts and their usefulness for crisis information seekers. To this end, we plan to study Event Based Resources more deeply in future crisis events.

Three of the Event Based Resources in this study continue to remain active long after the Wildfire for which they were originally created. These resources clearly filled an outstanding need in the community and continue to do so. Thus, Event Based Resources can serve another purpose in bringing community needs and challenges around a crisis event to the attention of a broader audience. As such, these resources may be a good place for emergency responders, humanitarian organizations, and volunteers to look for unmet crisis needs that they can help address. From a Human Computer Interaction (HCI) perspective, we might consider how we can better support the shifting purpose and role of a social media group or community over time. For instance, how can we design a platform that makes the history of an online community more transparent?

Toward More Effective Official Online Crisis Information

We suggest several ways that providers of official information can improve their communication efforts. First, information providers should clearly identify themselves and their purpose when using online media. Doing so lends credibility to the information source and gives the affected public someone to hold accountable for the quality of information [10]. Many of the Event Based Resources were managed by reputable emergency response agencies, but they never clearly identified themselves. Similarly, we could not identify the source for several Event Based Resources that made claims that they were official sources of information, whether through the name of the resource or through its description. We recommend that official emergency responders monitor these accounts to ensure that the information they provide is accurate, especially if the public sees them as a source of official information. Monitoring these accounts will allow emergency responders to adjust their own communications to correct misinformation or respond to requests for information. Responders may even point the public to these sources if the information they provide is credible and meets a particular need that cannot be met by the official response (e.g., helping reunite pets with their owners).

We also offer insight into how members of the public might choose information sources from the many available options to obtain better official information during a crisis event. Based on our findings, the Local News Media provided the timeliest information and the highest number of relevant messages around the event, which suggests that the Local News Media were the best source of general information about the Wildfire. While the Event Based Resources provided the highest percentage of relevant information, it was not always clear how trustworthy the information was. If members of the public are looking for a specific type of information (i.e., road closures), the best source of information is likely to be an official source more directly affiliated with that information (i.e., a transportation authority). Lastly, most social media platforms are open and anyone can create an account/page around a particular event or topic. One solution for helping the public understand which Event Based Resources are more authoritative is to verify the resource's account. On some social media platforms, accounts can be verified so that people know that the account is run by the entity that claims to own the account. However, this verification process can take considerable time to complete. The problem is that Event Based Resources are created in response to a specific event (usually unforeseen), which leaves no time to complete such a verification process before the account would need to be used. Streamlining the verification process, or perhaps allowing a new account to be directly linked to a previously verified account may be a possible technical solution to this problem.

Broader Implications

Though this research only looks at data from the Carlton Complex Wildfire, findings can also inform future research of crisis information more broadly. Specifically, this research unpacks who is providing official information during a crisis and identifies the different types of information each provides. This analysis lays the foundation for richer and more nuanced study of official crisis information sources, beyond assuming they all share similar motivations, behaviors, challenges, and scopes of concern—a simplifying assumption that much research in the domain makes. Better understanding of the types of official information available around a crisis and their features can also inform machine learning algorithms and text classifiers that seek to extract important crisis information from social media streams [14]. For example, a tool that automatically detects new Event Based Resources around an emerging crisis event could benefit both emergency responders and members of the public as they try to quickly assess the impact of the event.

Beyond the crisis context, this research also applies to other HCI domains where it is important to understand what online information is available and what online sources are credible. For example, the design considerations shared above around how to provide a more robust verification process for social media accounts and how to support the shifting purpose and role of a social media group over time are broadly applicable to more general use of any social media platform. As another example, social media accounts are created and used every day around different types of non-crisis events (e.g., political rallies, sporting events, celebrations, etc.), and Event Based Resources regularly appear during these events (i.e., a Twitter account created to report on a particular political election). Study of the characteristics and content of these event specific social media accounts (as was done in this study) can help researchers and the public better understand how to interpret and filter the information these accounts provide.

Limitations & Future Work

Our focus on online media limits what can be said about all the official information available to those affected by the Carlton Complex Wildfire. Further, we used trace online data

in our analyses, which does not allow us to account for the intentions of those who provided the information. Future work could take a more comprehensive approach to mapping the public information space around a crisis event by including additional sources of official information such as briefings and public meetings, TV news media content, and physical information booths and boards. This information could be supplemented with interviews of official information providers. Together these data would allow researchers to create a more complete picture of how official information is created and shared around a crisis event and across both online and offline media platforms. Next, when designing this research, we considered conducting interviews with the public affected by this Wildfire to understand how the public used and perceived online official information, but too much time had passed. The challenge of collecting ephemeral data is a well-known problem in the disaster research domain [35]. Thus, our ongoing research will seek to develop interview protocols for obtaining timely feedback from populations affected by disaster events. Finally, we may also look at the information dissemination patterns for other types of events (such as terrorist attacks, hurricanes, etc.) in the future to see if findings from this research apply in different contexts.

CONCLUSION

By analyzing the online media posts of official information providers during the Carlton Complex Wildfire, we offer new empirical insight into who provides this information, how the information is provided, and the timeliness and relevance of the information. In particular, we note that the Local News Media continue to play a primary role in distributing official crisis information online despite new possibilities for emergency responders to share information directly with the public through social media. As online communications continue to proliferate, it becomes increasingly difficult for the public to sort through the deluge of available data to find credible crisis information that is relevant and helpful. This research is an important first step toward understanding what types of official online information is provided and how members of the public might find it.

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