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The Nexus of Science and Story: Data versus Perceptions of Climate Change

by

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Abstract

Although the IPCC can be credited with significant efforts to bridge communication between scientist and policy makers, there is still a noticeable discrepancy between the scientific consensus and public perception of the existence and causes of climate change that hamper the implementation of policies aimed at the mitigation and adaptation. Most people gain their understanding of science through the media, and in this contribution I investigate how journalists portray climate change affecting people in a comprehensive case study across Canada.

The study is based on a content analysis of more than 3000 English language newspaper articles published across Canada from 2000 to 2013. I examined how climate or weather related events were portrayed, and whether or not the article linked the event in question to climate change. The reported events were then compared against historical climate data from 1950 to 2013 to determine if the event was correctly or incorrectly attributed to a climate change trend (true or false positives), or was correctly or incorrectly not attributed (true or false negatives).

Perhaps conforming to expectations, temperature and precipitation related events reported in the news media were largely portrayed as harmful to both humans and ecosystems, but articles that attributed events to climate change were in the minority. Only a small number of climate events, such as permafrost thaw in northern Canada and the pine beetle epidemic in British Columbia were consistently linked to climate change. In general, journalists started to reliably attribute events to climate change when the observed climate change signal exceeded 1.5°C. Thus, attribution to climate change only emerges near a threshold that the scientific community considers dangerous (≥2°C). Events linked to changes in precipitation were reliably associated with seasonal anomalies exceeding a 50% increase or decrease over normal conditions but were rarely attributed to long term trends, which was generally correct.

In summary, reporting of climate related events in print media was surprisingly accurate with respect to true positives when the climate change signal exceeded 1.5°C, and also for true negatives when an observed climate change signal was absent. However, for an intermediate warming signal between approximately 0.5 and 1.5°C, I observed a large proportion of false negatives. This represents a missed opportunity for journalists to communicate impacts of global climate change. To better link weather related news stories to moderate climate warming, web-based tools to access historical climate data are provided for journalists to communicate climate change impacts with more confidence at an earlier stage.

Zusammenfassung

Der Zwischenstaatlicher Ausschuss über Klimaveränderung (IPCC) ist allgemein für eine verbesserte Kommunikation zwischen Wissenschaftlern und Politikern anerkannt. Dennoch gibt es weiterhin eine deutliche Diskrepanz zwischen dem wissenschaftlichen Konsens und der öffentlichen Meinung, welche die Umsetzung von politischen Maßnahmen zur Minderung von Klimaänderungen behindert. Die meisten Bürger gewinnen ihr Verständnis von wissenschaftlichen Ergebnissen durch die Medien, und in diesem Beitrag, untersuche ich in einer umfassenden Fallstudie, wie Journalisten Klimawandel in ganz Kanada in lokalen Printmedien porträtieren.

Die Studie basiert auf einer Inhaltsanalyse von mehr als 3000 Artikeln in Englisch sprachigen Zeitungen in Kanada, veröffentlicht zwischen 2000 und 2013. Ich untersuchte, wie wetterbedingte Ereignisse dargestellt wurden, und ob die Artikel das betreffende Ereignis langfristigem Klimawandel zuschreiben. Die berichteten Ereignisse wurden dann mit historische Klimadaten von 1950 bis 2013 verglichen um zu bestimmen, ob das Ereignis korrekt oder fälschlicherweise dem Klimawandel zugeschrieben wurde (richtig positiv r_p oder falsch positiv f_p), oder korrekt oder fälschlicherweise nicht dem Klimawandel zugeschrieben wurde (richtig negativ r_n oder falsch negativ f_n).

Wahrscheinlich entsprechend den Erwartungen, Änderungen in Temperatur und Niederschlag in berichteten Ereignissen wurden mit weitgehender Mehrheit als schädlich für Mensch und Ökosysteme porträtiert. Dennoch waren Artikel, die wetterbedingte Ereignisse dem Klimawandel als Ursache zuschrieben in der Minderheit. Nur eine kleine Anzahl von Klimaereignissen wie Permafrost Tau im Norden Kanadas und der Borkenkäfer-Epidemie in British Columbia wurden zuverlässig mit langfristigem Klimawandel verbunden. Normalerweise wurden berichteten Ereignisse langfristigem Klimawandel als Ursache zugeschrieben, wenn die beobachtete Klimaänderungssignal 1,5 °C überschritten hat. Somit wird Klimawandel nur dann zuverlässig als Ursache erkannt, wenn Änderungen beobachtet werden welche die wissenschaftliche Gemeinschaft als gefährlich einschätzt (≥2°C). Ereignisse die mit Veränderungen von Niederschlägen verbunden waren, wurde nur selten auf langfristige Klimaänderung zurückgeführt, was in der Regel korrekt war.

Zusammengefassend ist festzustellen daß Berichterstattung über klimarelevante Ereignisse in den Printmedien überraschend präzise ist in Bezug auf richtig positive (r_p) Ereignisse, wenn ein Klimaänderungssignal von 1,5°C überschritten wird. Auch für richtig negative Ereignisse (r_n), ist die Berichterstattung akkurat wenn ein beobachtetes Klimaänderungssignal abwesend ist. Für ein Klimaänderungssignal zwischen etwa 0,5 und 1,5°C ist ein großen Anteil von falsch negative Ereignissen (f_n) bemerkenswert. Dies repräsentiert eine verpasste Gelegenheit für Journalisten die Auswirkungen des globalen Klimawandels zu kommunizieren. Um eine bessere Verbindung von wetterbezogene Nachrichten mit Klimaerwärmung zu unterstützen, stellt diese Studie Internet-basierte Datenbanken und Software zur Verfügung.

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Table of Contents

List of Tables

List of Figures

1. Introduction

1.1 Climate change and journalistic reporting

The Intergovernmental Panel on Climate Change (IPCC) has been clear in communicating the negative impacts that climate change has caused and has been predicted to cause in the future. The IPCC (2014) states with *high confidence* that the temperature of our atmosphere has successively become warmer, particularly over the past three decades. This has led to mean sea level rise, warming and acidification of ocean surface water causing the bleaching of coral ecosystems, a decrease in sea ice and reduction of snow and ice cover in the Arctic and Antarctic, the shrinking of glaciers worldwide, and the increased severity of weather events, especially those impacting coastal regions (IPCC, 2014). There is strong scientific consensus that climate change is happening and is affecting life on earth on all scales (Alexander et al., 2006; Anderegg, Prall, Harold, & Schneider, 2010; Heal & Kriström, 2002; Oreskes, 2004).

It has been well established that media reports have the power to shape public perspectives and influence the interpretation of environmental issues (Anderson, 2009; Boykoff & Boykoff, 2007). Many members of the public rely on the media, sometimes exclusively, to inform them of global issues, and studies suggest that this is especially true for the propagation of scientific information such as that pertaining to climate change (Wilson, 2000). Therefore, one essential aspect of journalism should be the transmission of unbiased, or as Wilkins (1993) puts

it, “neutral” knowledge that allows readers to make sense of how the issues at hand can shape their everyday lives.

Despite an overwhelming acceptance of climate change as a fact among scientists, the news media has been accused of publishing articles that miscommunicate science by framing them to emphasize uncertainty, skepticism, and controversy among the scientific community (Antilla, 2005; Bell, 1994b; Boykoff & Boykoff, 2004). To some degree, this is understandable: climate change is a complex phenomenon spanning several scientific fields, and this makes it difficult to transmit the urgency and importance of climate change issues in a way that is easy for the general reader to comprehend (Ungar, 2000). With unforgiving deadlines, journalists have limited time to comprehensively review original literature, interview qualified professionals and report key data and facts, well supported by scientific research, to the public (Zamith, Pinto, & Villar, 2012). Wilson (2000) found that specialization has positive outcomes: reporters who work full time on environmental issues and who use scientists as their primary source of information produce the most accurate articles regarding climate change. General news reporters, particularly those working for smaller publications with limited budgets, generally do not achieve the same level of quality in their reporting when compared to dedicated environmental journalists.

Lack of time and knowledge is, however, not the only issue in climate reporting. Journalists occasionally, perhaps unconsciously, report particular interpretations of certain facts while ignoring others (Zamith et al., 2012). This is known as framing. A ‘frame’ in this context is the journalists’ perspective on a story. The goal is to captivate and inform the public with a selection of facts and arguments selected by the journalist to match their chosen perspective on a

given issue. Framing is usually considered a legitimate journalistic tool in apolitical context to filter information and inform on relevant and important contemporary issues. The manner in which journalists frame a story can significantly impact how the reader assimilates the information into their daily life, and the work of Zamith et al. (2012) points out how the frame influences how readers attribute responsibility and form policy opinions. In the context of climate change, and reporting on scientific research in general, this can be problematic. When reporters select marginalized views from certain "claim makers" and "authorized definers" conflicts over climate change are privileged and dramatized, often producing bewilderment rather than understanding (Boykoff, 2013). Outlier voices are disproportionately reported, which contributes to the miscommunication, misunderstanding and the amplification of particular voices whom individual journalists permit to speak on behalf of climate change (Boykoff, 2013).

Reporting both sides of an issue is generally considered an appropriate and responsible approach to journalism. When it comes to the question of scientific research, however, journalists must investigate broadly and determine which claims are genuinely factual (Gelbspan, 1997). A commonly quoted piece of wisdom in this context reads "Everyone is entitled to his or her own opinion, but no one is entitled to his or her own facts" (Moynihan, 2010). Media sources commonly make the mistake of including opinions alongside scientific facts in a misguided effort to remain unbiased. This practice, as studied in American and British newspapers by Boykoff (2007), results in a significant divergence of scientific consensus of the human attribution for global climate change.

1.2 Intangibility of climate change

When most people think about climate change, they tend to think of shrinking ice caps or polar bears trapped on ice floes instead of long-term temperature and precipitation trends that change in their own communities and might impact them financially, socially and personally. The perceived reality is that climate change is largely intangible. From the receivers' perspective, climate change is in most cases not tied to any concrete event and is largely future oriented preventing it from being seen as a crisis issue (Ungar, 2000). If a journalist was to help readers better understand their environment, coverage needs to be placed in a context that allows the reader to relate to the issue at hand. The goal is to make it less challenging for readers to make sense of *how* climate change shapes their lives. The media should help them acknowledge and act on issues that are seemingly invisible instead of wasting opportunities to help the public engage and deal with the complex challenges and long term consequences of climate change (Trumbo, 1996; Zamith et al., 2012). So how do I make climate change a reality for the general population?

The key is to make it noticeable, to close the gap between global trends and the impacts on people at local scales. Even though there are studies of regional newspapers, these studies find that the articles largely focus on national, international and global scales (Ahchong & Dodds, 2012; Liu, Vedlitz, & Alston, 2008). Saturation of articles about climate change affects the public's perception of an issue, but it does not seem to affect solution strategies because most of the articles written about climate change lack scientific information and instead correspond with world climate conferences, release of the IPCC reports, etc. (Ahchong & Dodds, 2012; Liu

et al., 2008; Wilkins, 1993). Papers from Liu et al. (2008) and Ahchong and Dodds (2012) both found that articles were focused on national governmental leaders and that the government was portrayed as responsible for the treatment of climate change effects. If the public does not think they are a responsible party, then why would they feel the need to take action (Wanta, Golan, & Lee, 2004)?

It is believed that local people need to be connected with the issue in order to act (McManus, 2000). Climate change impacts are rarely linked to local scale issues like the change of temperature or precipitation trends which could be noticed by citizens on a daily basis. Long-term trends have a strong bearing on the frequency and severity of newsworthy weather events. It is in these types of articles that give reporters the opportunity to showcase how long-term climate change trends affect local weather events. If appropriately reported, such articles can serve to enlighten the public on how new climate realities have changed the norm that once was characteristic of that region.

2. Literature review

2.1 Values and framing in scientific reporting

Climate change, whether it be studied under its other aliases of the greenhouse effect or global warming, has been documented since the industrial revolution (Victor, 1995), but it was not until the late 1980's that coverage peaked, declining thereafter for a short period of time, making its way into mainstream news agendas (Bell, 1994a; Wilson, 2000). Originally articles were strictly about scientific findings and progress (Wilkins, 1993). Wilkins (1993) conducted a

four year study of four U.S newspapers and a news wire's coverage of the greenhouse effect to determine if the application of values and frames could influence readers' response to scientific news articles expanding on Gans (1980)'s work on values in the news. Stories about the greenhouse effect dominated the first two years of the study, with top sources being scientists and the focus on progress and new findings. Later on, a large number of articles, 69%, were linked with specific environmental events like a hot summer instead of scientific discoveries or events.

Governmental officials and special interest groups also became "experts" in the field and prominent sources claiming the application of technology would help remedy the problem. Wilkins (1993) made a point to show that this type of reporting did not acknowledge the impacts the greenhouse effect would have on people, and did not provide people with knowledge on how they could change themselves or their own activities. Journalists kept the greenhouse effect based in the realm of physics and chemistry of the atmosphere and oceans, not something relatable to the general population. Both Wilkins (1993) and Gans (1980) suggested that attributing values to the stories would help journalists determine what to cover and how to frame their accounts to help alter how people behaved and responded to scientific reports. Straying from news reports of pure scientific facts would increase public awareness and understanding leading to, perhaps, demands for political action.

Trumbo (1996) also looked at how frames can impact understanding of climate change in newspaper content. Studying five U.S. national newspapers for ten years, it was found that scientists are usually associated with frames that emphasize problems and causes, while stories

about politicians and special interest groups not only had a lack of scientists as sources, but were associated with frames emphasizing judgements and remedies (Trumbo, 1996). Antilla (2005) studied one year of climate change coverage in a small number of national U.S. newspapers and hundreds of community U.S newspapers finding that the articles are a vital source of climate science news but that they framed climate change science as uncertain, with lots of controversy and skepticism.

McCright and Dunlap (2000) studied certain U.S. conservative think-tanks and their efforts to dismiss the reality of climate change between 1990 and 1997. These think-tanks promoted three different framing techniques to accomplish their cause: criticize scientific evidence, promote the benefits of climate change for the U.S, and indicate the economic threat to the U.S for ameliorating any problems that did result from climate change. Boykoff (2008a) went outside the realm of North American quality newspapers and instead looked at United Kingdom tabloid papers for a seven year period. Frames included those that promoted fear, misery and doom with a focus on weather events, charismatic megafauna and political actors (Boykoff, 2008a). An evident trend emerging was that, although placing values and framing climate change was important for readers to understand the issues they are facing, misrepresentation of climate change could lead to a misunderstanding of the scientific information. This is especially true when journalists try to achieve balance in their coverage. Boykoff and Boykoff (2004) found bias through balance in the coverage of global warming causes and required action.

2.2 Changes in prevalence of climate change reporting

Many scientific journal articles focus on studies of salience, which is the pervasiveness or significance of a specific topic. In this context, there are many studies that wanted to see how frequently scientific issues, including climate change, were discussed in news media and if this increased or decreased over time. Pellechia (1997) performed a content analysis of the salience of science in three daily U.S. newspapers over three decades, reporting that scientific issues increased during the time period but articles frequently omitted pertinent contextual information which was critical for a complete understanding of scientific topics. Pellechia (1997) also mentioned that "science" is a diverse topic covering many fields and the audience requires adequate background information about scientific issues so they can develop knowledge enabling them to make informed decisions.

Liu et al. (2008) performed a content analysis on one of the largest regional newspapers in Texas studying, among other things, salience of climate change. During the study period of thirteen years, attention to climate change was found to come in waves; however, in their first year there were a total of 43 climate change articles compared to the 80 published in the last year of their study indicating an overall increase in the salience of climate change. Ahchong and Dodds (2012) compared the contents of a regional Canadian newspaper and a national Canadian newspaper in a very similar way to Liu et al. (2008)'s study and found, despite ebbs and flows, in both cases there was a three-fold increase in the salience of climate change throughout their study period of twenty-two years.

McComas and Shanahan (1999) looked at these cyclical patterns of global warming in two U.S. newspapers from 1980 to 1995. Not only did they find that the salience of global warming increased during their study period but they also determined the type of coverage during the ebb and flow periods. During peak periods, the contents of the articles heavily emphasized the danger and consequences of global warming, while during lulls the focus switched to controversy between scientists and the economic issues related to the impacts of global warming (McComas & Shanahan, 1999).

Atwater, Salwen, and Anderson (1985) looked at salience of environmental issues in three U.S. newspapers for three months in 1983 and emphasized the importance of the role of news media in transferring more than salience to the audience. The transferring of detailed levels of information about an issue is much more important. The goal should be creating a personal experience between the issues and the readers which in itself will make the issues salient among the audience (Atwater et al., 1985).

2.3 Portrayal of climate changes as a threat

The portrayal of issues by journalists as having a negative, neutral, or positive impact on humans and their connectivity to daily life are important factors in understanding how humans relate to the world around them. Scope, issue image, solution strategies and identifying responsible parties are alternate ways journalists portray impacts to humans. Wanta et al. (2004) conducted a multileveled agenda-setting assessment analyzing whether coverage of foreign nations in the news influenced how individuals viewed how important they were (salience), as

well as whether or not positive or negative coverage of foreign nations would influence individuals' perception of the countries. As media coverage for a nation increased, so did its perceived vitality to the U.S. interests, a statistically significant finding supporting the idea that the salience affects public perception of an issue (Wanta et al., 2004). More interestingly, the second part of the study found that negative coverage of nations correlated to negative public views of the nations by the respondents, whereas positive coverage of nations had no influence on public perceptions (Wanta et al., 2004).

Ahchong and Dodds (2012) in their regional and national Canadian newspaper analysis, and Liu et al. (2008) in their regional US based study had extraordinarily similar climate change portrayal results. An overwhelming majority of 78% of news articles studied by Liu et al. (2008) portrayed climate change as harmful. In the Canadian newspaper study by Ahchong and Dodds (2012), this result was supported, determining that the regional newspaper found climate change to be portrayed as a destructive issue 98% of the time and 97% of the time in the national newspaper. For regional newspapers from both studies, 82% of their study articles portrayed climate change as a national, international or global problem with a predominant focus on mitigation as opposed to adaptation strategies (Ahchong & Dodds, 2012; Liu et al., 2008).

2.4 Policy change

Many authors assert that if the public is provided with sufficient and accurate information on how climate change is impacting the world, then they are more likely to take actions to counteract the damaging effects that result from climate change (Ahchong & Dodds, 2012; Liu et

al., 2008; McCombs & Shaw, 1972; McManus, 2000; Wilkins, 1993). But does this action actually affect the development and changes of policy? Cook et al. (1983) explored the agenda setting effects of a televised investigative news report on members of the general public, interest groups, and governmental policy makers with the goal to determine if the mass media have an ability to influence agenda-setting, or rather, the ability to influence policy making. Although the media event was not related to environmental issues, the authors discovered some interesting findings. The media does have the ability to influence views among the public and government policy makers, but the change in public opinion *did not* lead to policy changes (Cook et al., 1983).

Soroka (2003) studied the connection between foreign policy media content and its impact on public opinion and found that there is a strong correlation of salience between the two. This agenda-setting analysis, like Cook et al. (1983), also demonstrated the powerful effect of media content on the salience of an issue for the public. However, Soroka (2003) found that the media coverage had a profound effect on public opinion affecting foreign policymaking despite the fact that foreign affair events most often take place outside of the realm of personal experience. Unlike these two studies that are outside the realm of science, Boykoff (2008b) studied how media's representation of climate change shapes policy and affects current international science. In conjunction with Soroka (2003), mass media does indeed play a significant role in shaping the construction and maintenance of discourse on climate change when it comes to developing scientific policy (Boykoff, 2008b). Unfortunately, this has yet to become reality for change in climate change policy on a significant enough scale despite the

large amount of studies conducted that look at the relationship between how media reports climate change and its impacts on humans and the environment.

If this is the case, then the key to reaching the public on a large enough scale so that they might overcome this inability to impact policy changes is by showing them how climate change impacts them on a personal and daily level. The issue all these studies have in common is scope. When newspapers report on climate change and its negative impacts, they rarely, if ever, relate it to experiences of people's everyday lives. This lack of context combined with the transmission of misinformation prevents the salience of climate change articles from affecting public perception in a useful and productive manner.

3. Thesis objectives

There are many scientific studies related to news reporting and how it influences public perception and understanding. From research, I know that journalists are the gateway of transmitting important information to the general population and that how they frame their articles influences public opinion. With respect to climate change, unbiased and accurate journalistic reporting is key to not obscure the true issue at hand: that climate change is altering the environment. That said, linking local news stories to global climate change is not an easy task and in this thesis I investigate how well media reports correspond to regional and local climate trends that were actually observed over a 60-year period. To my knowledge no media analysis has been conducted that links content analysis with actual data from climate science.

Here I contribute a content analysis of more than 3,000 printed English language newspaper articles published across Canada from 2000 to 2013 by Sun Media Corporation and relate them to actual observations of local climate trends over the last 60 years. According to data published by Vividata ("Vividata 2015 Q4," 2015) weekday print media newspaper readership is the most dominant way in which Canadians 18 years and older, of both genders, access local news and information. With seven out of ten Canadians still reading printed weekday newspapers ("Vividata 2015 Q4," 2015) I are targeting the largest audience possible. Canada is an excellent subject for this study because it spans latitudes from a latitude of 42°N with moderate or no warming trend to the 83°N with significant warming trends in the high arctic.

I am fact checking how media coverage of climate change actually corresponds to locally observed trends, an approach not taken by previous studies. We also provide the same web-based tools used in this study for journalists to investigate local climate trends that may be related to a news story to communicate causes of climate change impacts with more confidence at an earlier stage.

The specific objectives of this thesis are to:

1. Provide a quantitative analysis of how news articles reference scientific research, attribute climate change as a cause of local events, or specifically state that climate change is not a cause.

2. Evaluate what topics are being portrayed as negatively, neutrally, or positively impacted by climate change in different natural resource sectors and through direct effects on humans and infrastructure.

3. Check reported events against historical data to determine if the event was correctly or incorrectly attributed to a climate change trend (true or false positive), or was correctly or incorrectly reporting an event that was not attributed to climate change (true or false negative).

4. Materials and Methods

4.1 Content analysis: coarse filtering process

There are eight prominent corporate owners of community weekly and daily newspapers across Canada. Sun Media Corporation was the largest press group in Canada in 2013 publishing over 15 million copies each week of paid and free community weekly and daily newspapers in both English- and French-speaking Canada, with three times more papers in circulation than their next closest competitor Torstar Corporation ("Newspapers Canada, Daily Newspaper Circulation Review," 2013). I have chosen to focus the study strictly to print media from Sun Media Corporation as it was the leading provider of local news and information with representation in the largest number of provinces compared to its competitors.

In making this choice I recognize some potential bias in choosing the viewpoints and reporting style of only one media conglomerate. Sun Media has a history of being somewhat

conservative leaning, especially when looking at their major city publications like the Edmonton or Toronto Sun which are highly circulated with a large readership. However, local community newspapers tend not to be as influenced by the political views of the corporation for several reasons. In almost every case they are the only daily newspaper that exists for a community therefore readership and circulation is limited to the population of the town. Also, the main focus of local papers is to report local news and events, rarely high profile political arguments and agendas. For information concerning political news, the public has a tendency to turn to the largely circulated prominent national newspapers as oppose regional ones. With more papers in circulation than other corporations, Sun Media local newspapers remain a significant untapped resource for information about local weather and climate related events, largely unconnected to political viewpoints.

Newspaper articles can be efficiently queried through a subscription service to the Sun Media Corporation newspaper database, SAVE, covering 38 paid daily newspapers and 159 community weeklies, representing a larger urban and non-urban market across western Canada than its competitors. Coverage was examined between January 2000 to February 2014 in 115 free and paid specialty, daily and community weekly tabloid and broadsheet newspapers circulated in British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario (Table 1). The study was restricted to English-speaking content, excluding Quebec newspapers as sources, but nevertheless many articles were captured that covered events within Quebec.

Table 1. Number of newspapers from each province and the number of articles that passed the coarse filtering process.

Province	Number of Newspapers	Number of Evaluated Articles
British Columbia	1	12
Alberta	39	774
Saskatchewan	4	8
Manitoba	11	190
Ontario	60	2806

A total of fourteen queries, organized into two groups, impacts on natural resources and direct climate impacts on humans and infrastructure, were conducted (Table 2). These two categories were considered to be the most important and relevant to study. Canada is a resource dependent country with a large contribution from the forestry sector and agriculture industry to its gross domestic product. Provincial and municipal infrastructure includes updates not only to roads, highways, bridges, public transit systems and airports, but more importantly to wastewater and drinking water infrastructure, disaster mitigation, brownfield redevelopment, tourism, recreation and community energy systems. All of these, and more, affect the economy of Canada, job creation and standard of living for Canadians - areas that can be affected by climate change impacts.

Table 2. The number of newspaper articles retrieved, screened and evaluated for each topic separated into two broad categories of Natural Resources and Direct Climate Impacts.

		Number of Articles		
Topic	Query	Retrieved	Screened	Evaluated
Natural Resources				
Bumper Crop	(‘bumper crop’) & (‘climate’ or ‘weather’)	624	624	390
Crop Failure	(‘crop failure’) & (‘climate’ or ‘weather’)	149	149	74
Mountain Pine Beetle	(‘pine beetle’) & (‘climate’ OR ‘weather’)	693	693	350
Ash Borer	(‘ash borer’) & (‘climate’ OR ‘weather’)	295	295	140
Dieback	(‘dieback’ OR ‘mortality’) & (‘tree*’ OR ‘forest*’) & (‘climate’ OR ‘weather’)	312	312	139
Forest Fire	(‘forest fire’) & (‘climate’ OR ‘weather’ OR ‘drought’)	3382	411	217
Direct Climate Impacts				
Flood	(‘flood’) & (‘climate’ OR ‘weather’)	9257	323	207
Drought	(‘drought’) AND (‘climate’ OR ‘weather’)	8809	361	246
Heat Wave	(‘heat wave’) & (‘climate’ OR ‘weather’)	3364	306	251
Extreme Events	(‘extreme’ OR ‘unusual’) & (‘climate’ OR ‘weather’)	24990	1429	712
Permafrost	(‘permafrost’) & (‘climate’ OR ‘weather’) & (‘melt’ OR ‘melting’ OR ‘thaw’ OR ‘thawing’)	743	743	531
Early/Late Fall	(‘early fall’ OR ‘late fall’ OR ‘early autumn’ OR ‘late autumn’) & (‘weather’ OR ‘climate’)	2111	2111	354
Early/Late Spring	(‘early spring’ OR ‘late spring’) & (‘climate’ OR ‘weather’)	4235	515	169
Total		58964	8272	3790

The queries yielded between a few hundreds and tens of thousands of returns (Table 2). To maintain a broad spectrum of topics, I targeted a few hundred stories for each query in a two-step screening process: First, very large query returns were randomly sub-sampled to no more than about 2000 (Table 2, column 2), and this subset of articles was then screened for relevance (Table 2, column 3). For example, articles that only offered predictions or documented past

events were excluded. Weather or climatic related dimensions reported had to coincide with the year the article was published. Any article that simply mentioned climate change or global warming without it being the main focus or linked to another issue was discarded as well. In many cases, articles that matched the query terms had very little, sometimes even nothing at all to do with the topic being investigated. A large proportion of articles were about, for example, a review of a Volkswagen Beetle, its climate controlled interior and performance on mountain roads. These articles and many others like them, although matching the query terms, were discarded, with a final tally of between 74 and 712 articles per topic. By establishing these parameters, the total number of evaluated articles was reduced by 80% for a total of 3790 articles. These articles were then subjected to a detailed coding procedure.

4.2 Content analysis: coding

A protocol for assessing and quantifying coverage of weather and climatic information, as well as their related impacts, was established and developed in accordance with content analysis procedures outlined by Daniel Riffe, Lacy, and Fico (2014) and Neuendorf (2002). The newspaper content analysis focused on articles that had an explicit or implicit temperature or precipitation related dimension or focused on climate change and/or global warming. Three main criteria were used to identify articles with these qualities: articles stating or describing temperature or precipitation events (i.e. unusually large amount of rain in the summer), articles covering or linking issues to temperature or precipitation related events (i.e. early spring temperature has allowed people to golf earlier), and articles covering issues related to climate change and/or global warming.

Articles complying with at least one of these stated conditions were analyzed further with coding topics adapted from Liu et al. (2008) and Ahchong and Dodds (2012) and include issue attributes (image, scope, linkage and impact), participants, treatment solutions and responsible parties, and the source of scientific information. Measuring weather data described in the articles was also important so that it could be compared to historical records and trends, a novel addition to the coding sheet.

The coding sheet was set up as a survey using SurveyGizmo.com. This allowed for quicker input of information and an easily accessible online format for coders to use. Each article was given a unique identification number so that each survey completed represented data from one article. Most questions were multiple choice selections, including the coding topics adapted from Liu et al. (2008) and Ahchong and Dodds (2012) for example, regarding the association of responsibility (responsible, not responsible, not applicable) and portrayal (harmful/destructive, not harmful/ constructive, mixed, not applicable) of climate change or weather related events, and if scientific sources were cited or referenced in the newspaper article (yes or no). Coders were also responsible for answering other general information including which newspaper printed the article (i.e. the Grande Prairie Herald Tribune), the location of the content in the article, and the month and year the article was published. This step allowed us to separate the temperature and precipitation related data by season and year.

Much more difficult was tracking the weather content. A table was created in the survey where the coder could select a number of variables that would correspond to the information reported in the article (Table 3). Two of these tables were present in the coding sheet so that if

the article mentioned temperature and precipitation related events, *both* could be documented. Multiple choice selections were allowed in an effort to be as concise as possible.

Table 3. Summary of weather data variable options to describe the reported event from the article published**.**

Mandatory		Qualifiers		
Seasonal Variable	Weather Variable	Mandatory	Optional	
Winter	Temperature	Increase	High or Low	Wet or Dry
Spring	Precipitation	Decrease	Heavy or Light	Permafrost
Summer			Hot or Cold	Flood or Drought
Fall			Extreme or unusual	Record or Rare

4.3 Coder reliability testing

Each variable in the analysis was tested by looking at how the coders have agreed on using the relevant values of the variable being tested. A random selection of content samples for reliability testing was used. This controls inevitable human biases in selection and also results in a sample reflective of the overall population of content being studied. This approach appropriately reflects the full range of potential coding decisions. The coding protocol and coding sheet were tested twice, the first time with 87 articles and the second with 148, both with randomly selected articles. Amendments to the coding protocol and coding sheet where deemed appropriate were made. Intercoder reliability is important because it validates the coding sheet (the surveygismo.com survey), and using multiple coders is practical because it results in less work and reduces potential coding bias.

Reporting intercoder reliability constants is not the norm for social sciences. There is no uniform standard or test for intercoder significance; however, Neuendorf (2002) suggests several different tests each with their advantages and disadvantages. Krippendorff's *alpha* was chosen because it takes into account chance agreement, magnitude of the misses, and adjusts for whether the variable measured is nominal, ordinal, interval, or ratio (Neuendorf, 2002).

To calculate Krippendorff's alpha package *irr* was installed in R programming (R Core Development Team, 2013), an open-source programming software for statistical computing. The test statistic of interest in this package was *kripp.alpha* which compares each variable between each coder to determine if the values are the same or different. Matching values deliver a higher alpha level whereas values that do not match provide a lower alpha. Data was arranged so that each row represented a coder, 1 and 2, as well as an individual question, with the columns containing the answer per article for the question. Nineteen questions were analyzed in this project, so there were 19 pairs of rows. The variables tested were those included in the analysis of this study (Table 4).

Table 4. Values of Krippendorff's alpha for each question asked during the coding process and the mean coder reliability score.

Question		Krippendorff's α	
	Options for answers	First	Second
1	Is this a generalized paper about climate change?	0.68	0.72
	a) Yes		
	b) No		
2	Does the article mention...	0.92	0.99
	a) Climate change		
	b) Global warming		
	c) Climate change & Global warming		
	d) Neither		
3	Is climate change considered responsible?	0.9	0.97
	a) Yes		
	b) No		
	c) Does not say		
4	How is climate change or the weather related issue portrayed?	0.86	0.9
	a) Harmful/destructive		
	b) Not harmful/constructive		
	c) Mixed		
	d) Neither/Undetermined/Does not say		
5	What are the treatment solutions given?	0.78	0.83
	a) Mitigation		
	b) Adaptation		
	c) Both		
	d) No solution offered		
6	If a solution was offered, who is considered responsible?	0.68	0.92
	a) Government		
	b) Private and/or Public		
	c) Both		
	d) None Identified		
7	What is the main focus of the article?	0.86	0.96
	a) Climate change		
	b) Weather/Climate related issue		
	c) Neither (do not continue survey)		
8	What impact does climate change or the weather related issue have on the General Ecosystem?	0.8	0.79
	a) Negative		
	b) Positive		
	c) Mixed		
	d) Not Applicable		
9	What impact does climate change or the weather related issue have on	0.67	0.8

	the Wildlife? a) Negative b) Positive c) Mixed d) Not Applicable		
10	What impact does climate change or the weather related issue have on the Invasive species? a) Negative b) Positive c) Mixed d) Not Applicable	0.28	0.67
11	What impact does climate change or the weather related issue have on the Freshwater? a) Negative b) Positive c) Mixed d) Not Applicable	0.4	1
12	What impact does climate change or the weather related issue have on the Forestry? a) Negative b) Positive c) Mixed d) Not Applicable	0.13	0
13	What impact does climate change or the weather related issue have on the Oceans? a) Negative b) Positive c) Mixed d) Not Applicable	0.64	1
14	What impact does climate change or the weather related issue have on Humans in general? a) Negative b) Positive c) Mixed d) Not Applicable	0.63	1
15	What impact does climate change or the weather related issue have on Human health? a) Negative b) Positive c) Mixed d) Not Applicable	0.57	1
16	What impact does climate change or the weather related issue have on Human food? a) Negative	0.29	0.84

	b) Positive c) Mixed d) Not Applicable		
17	What impact does climate change or the weather related issue have on Human costs? a) Negative b) Positive c) Mixed d) Not Applicable	0.58	0.79
18	What impact does climate change or the weather related issue have on Human water use? a) Negative b) Positive c) Mixed d) Not Applicable	0.7	0.8
19	Are scientific sources provided (check all that apply)? a) Academic b) Scientific citation c) Government d) Industry e) NGO Group f) None	0.57	0.77
Median coder reliability score		0.67	0.84

Tentative conclusions are considered acceptable at an alpha ≥0.667 however, a reliability alpha ≥0.800 is ideal and assures the data under consideration are similarly interpreted by researchers (Krippendorff, 2004a, 2004b; D Riffe, Lacy, & Fico, 2014). The data set complies with the Krippendorff alpha stipulations. After the first round of testing, the protocol needed to be amended to clarify how certain questions were expected to be answered based on key words found in the articles. With this change, and a subsequent reliability test, reliability increased to a higher acceptable level allowing us to consider the answers from both coders to be considered similar enough to be analyzed together.

4.4 Checks against historical climate trends and anomalies

To analyze whether the information journalists documented in their articles coincides with factual scientific data, an analysis of attribution was performed. The goal is to determine if the articles' weather and climate related events match on-the-ground scientific recordings. To do this, the location that each article described the temperature, precipitation or climate change related event was logged and then changed into the corresponding latitude and longitude. For example, if the article mentioned a record abundance of rainfall in the summer of 2000 in Grande Prairie, Alberta, then the ID of this article was matched up with the latitude and longitude that corresponds to Grande Prairie, Alberta. Articles that did not have a specific location, for example those describing changes in the prairies of Canada, were unable to be tagged with a latitude and longitude and were discarded for this analysis. Also, all articles must have passed the previously mentioned filtering process.

Specific locations allowed the use of the open source programs Climate NA v5.10 (Hamann, Wang, Spittlehouse, & Murdock, 2013) and Climate WNA v.4.62 (Wang, Hamann, Spittlehouse, & Murdock, 2012). Historical monthly data for a wide range of variables was readily available and easily accessed for each specific location using these programs. For the queries for this study, I was interested in a time series of data from 1950 to 2013. With close to three thousand articles matched with latitudes and longitudes and sixty-four years' worth of seasonal data variables (i.e. mean winter temperature, mean winter precipitation, etc.), the amount of information collected was assembled into one master spreadsheet where all analyses

could be performed from. For all analyses the articles recorded from 2014 were discarded because the climate software only provided data until the end of 2013.

Since I coded article events by season, the climate analysis was also carried out on a seasonal basis. A seasonal time step was chosen because climate trends may be significantly different between seasons, for example a strong spring and winter warming, but virtually no change in summer (Beaubien & Hamann, 2011), but long-term climate trends are usually not too different from month to month.

Temperature and precipitation related information as well as the attribution of these events to climate change was already collected during the coding process previously mentioned. With the generated scientific data, comparison of the article's weather information (Table 3) to the historical data was made possible and allowed the determination of whether the event was correctly or incorrectly attributed to a climate change trend (true or false positive), or was correctly or incorrectly reporting an event that was not attributed to climate change (true or false negative).

4.5 Data processing for histograms and error matrices

Seasonal average temperature (°C) was calculated and then a slope value was determined for each season. This slope value indicated the change over time for each season and for each specific location. Slope units for temperature were measured in °C/decade. The information the journalists claimed was happening in the article was then compared to the historically calculated

slope. The same was done for precipitation where variables for precipitation were measured in millimeters (mm). Slope units were % precipitation/decade. This analysis allowed us to determine if the articles showing increases or decreases in either temperature or precipitation were attributing the cause to climate change.

The R code for calculating °C/decade took the historical climate data produced from the climate software, selecting the seasonal temperature columns of interest, and then ran a loop to calculate the slope value for every article ID.

```
dat1=read.csv("Historical Climate Output.csv")
data.frame(names(dat1))
dat1=dat1[,c(2,1,9,11,15:18)] # select variables

output=matrix(nrow=length(unique(dat1$Art_ID)),ncol=6)

for (v in 1:6){
  for (a in 1:length(unique(dat1$Art_ID))){

    dat2=dat1[dat1$Art_ID==unique(dat1$Art_ID)[a],]

    b=coef(lm(dat2[,v+2]~dat2$Year))[2]*10

    output[a,v]=b[2]
    }
  }

output=data.frame(unique(dat1$Art_ID),output)
names(output)=names(dat2[,-2])
write.csv(output, "temp trends.csv", row.names=F)
```

The R code for attaching the weather variables described in each article (Table 3) with the historical weather data simply required the merging of tables. In this example, the columns that

corresponded with information regarding an increase in temperature were selected from the coding sheet (tinc1) and merged with the historical weather data (temp trends.csv). This was also done for a decrease in temperature, and an increase and decrease in precipitation.

```
dat1=read.csv("Weather Variables.csv")
data.frame(names(dat1))

dat1=dat1[,c(1,19:277)]
data.frame(names(dat1))

tinc1=dat1[,c(1,38,39,41,43,45,
               128,129,131,133,135,
               146,147,149,151,153)]
data.frame(names(tinc1))
library(reshape2)
long1=melt(tinc1,id.var="Art_ID")
long2=long1[!is.na(long1$value),]
long3=long2[long2$value!="",]

dat2=read.csv("temp trends.csv")
head(dat2)

dat3=merge(long3, dat2, by="Art_ID", all.x=T, all.y=F)
dat4=transform(dat3, b=ifelse(value=="1 - Winter",Tave_wt,
       ifelse(value=="1 - Spring",Tave_sp,
              ifelse(value=="1 - Summer",Tave_sm,Tave_at))))
```

Any duplicate data entries were deleted and then the data was graphed as a histogram using the *ggplot2* package in R.

ArcGIS (ESRI, 2012) was used to visualize the places in Canada that the articles were mentioning to gain a deeper understanding of where there were an abundance of stories as well as where there are gaps in coverage. Articles were displayed based on their location and colour-

coded according to their attribution to climate change and an increase or decrease in temperature or precipitation.

Temperature and precipitation anomalies were also of interest. To determine if the journalists were correctly reporting seasonal information, the articles were separated into the years they were published and the data corresponding to the year and the season, taken from Climate NA, were compared with the overall sixty-year trend. All analyses were performed using R programming (R Core Development Team, 2013) software. Weather anomalies may not necessarily correspond to long-term climate trends, so accounting for these stories may explain variation seen in overall historical trend analysis.

5. Results

5.1 Portrayal and impacts

The types of climate change impacts in Canada that were most clearly attributed to climate change were thaw of permafrost in the arctic and subarctic regions, and the mountain pine beetle epidemic in British Columbia (Fig. 1). Both of these impacts were also found to have proportionally the largest number of references to scientific authors or papers in the news articles. All other queries, both with impacts on natural resources and direct climate impacts on humans and infrastructure, were attributed to short term weather anomalies or not attributed to any climate pattern more than 50% of the time. Rarely, climate change was explicitly excluded as a potential cause of the observed event. This was primarily restricted to reports of extreme weather events and droughts. Out of all of the queries, flooding was the only category where

climate change was never mentioned as a responsible cause despite a reasonably large sample size (n=207 stories).

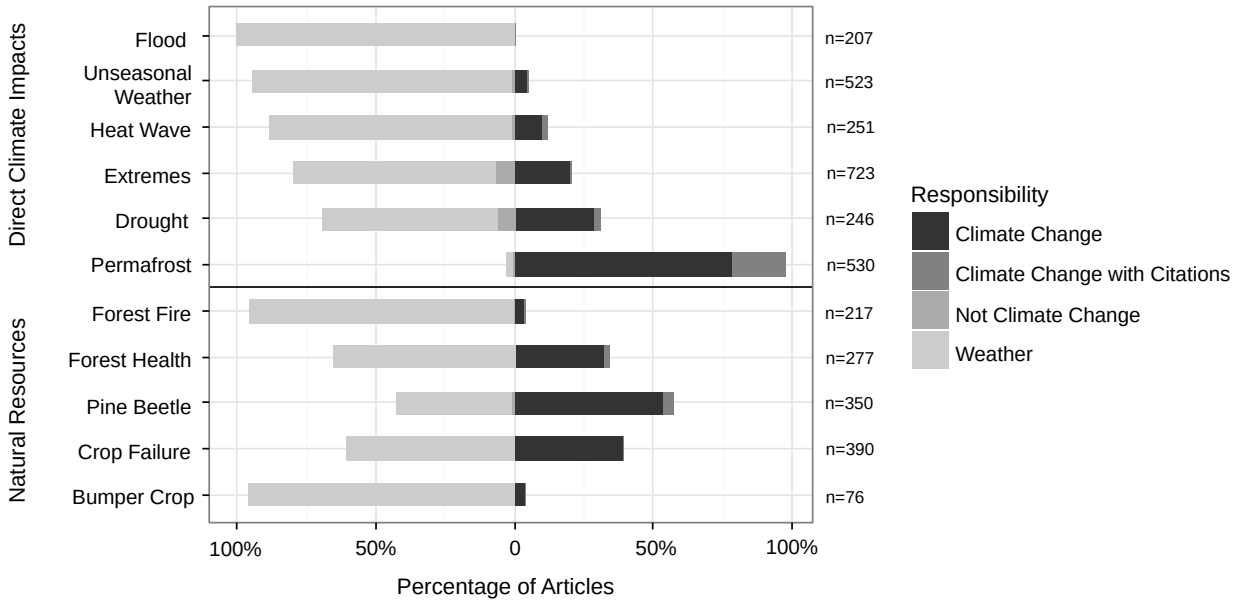

Figure 1. Percentage of articles and their attribution to climate change for direct climate effects and natural resources.

To provide further detail of how weather related events and climate change articles were portrayed to the reader, I further summarized stories by specific sectors, both human and ecosystem related that have a high propensity of being impacted by climate (Fig. 2). The articles in this study clearly communicate a negative or harmful perception to the readers. This is especially noticeable for ocean ecosystems, economy and human health. More specifically, articles falling into these three categories documented events such as changing temperature of ocean surface water resulting in negative impacts on fish and coral reefs, threats to infrastructure and cost of adaptation strategies to prepare for climate change impacts, as well as loss of human life, increase in allergies and other various human health risks.

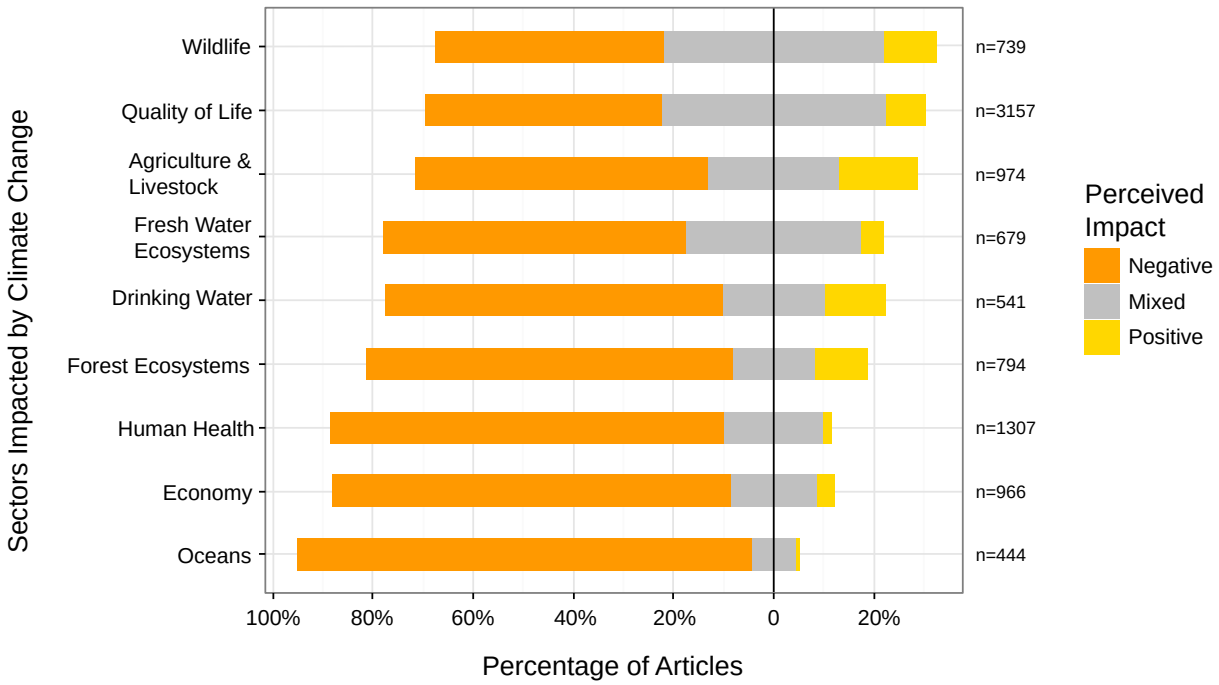

Figure 2. The portrayed impact of weather events on key issues that impact both humans and ecosystems.

Interestingly, the 'Quality of Life' category does not seem to be perceived as negatively impacted despite the perceived harmful impact on other human related sectors such as economy and human health. This sector had the highest number of articles analyzed (n=3157) and a majority of them were documenting mixed perceptions, for example, articles pertaining to recreational activities that have the potential to be enjoyed for a longer or shorter period of time due to unseasonal weather changes. Quality of life is driven by warmer weather in Canada generally being appreciated.

Surprisingly, the perceived harmful impact on 'Agriculture & Livestock' was much smaller than expected since many of the newspaper locations were in farming communities.

There was quite a mixture of stories where uncharacteristic weather would help one crop but hurt the growth of others. Previously noted (Fig. 1), variability in weather, not climate change, was reported to be responsible for bumper crops, crop failures and unseasonal weather events. Many farmers quoted in the articles were under the impression that skill and weather had more impact on crop success than long-term trends linked to global climate change. This is significant because agriculture and livestock production are very large industries in Canada. The smaller negative signal that is presented here most likely corresponds to the potential benefit climate change impacts might have for some types of crops despite hindering other crop productivity that may be mainstays of the industry.

5.2 Attribution of news stories to climate change

The first stage of quantitative historical data analysis that linked news stories to actually observed long-term climate trends was to determine temperature increase and decrease for all the geographic locations outlined in the articles and then to see which articles claimed the attribution was due to climate change. The trend for all locations reflects a significant overall increase in temperature over the last 60 years, with virtually no story location linked to a decrease in temperature (Fig. 3). This graph shows a histogram of seasonal long-term temperature trends for story locations, e.g. a story about a summer heat wave was linked to a summer temperature trend over 60 years preceding the story. Stories that attributed climate change as probable cause correspond to actual increases ranging from 0.5°C to almost 4°C in the far North of Canada. The majority of articles correctly attributing climate change to warming events were documenting

increases upwards of 1.5°C (true positives). Notably, the overall historical temperature trends for all the locations derived from the articles were found to be increasing during the 60-year period.

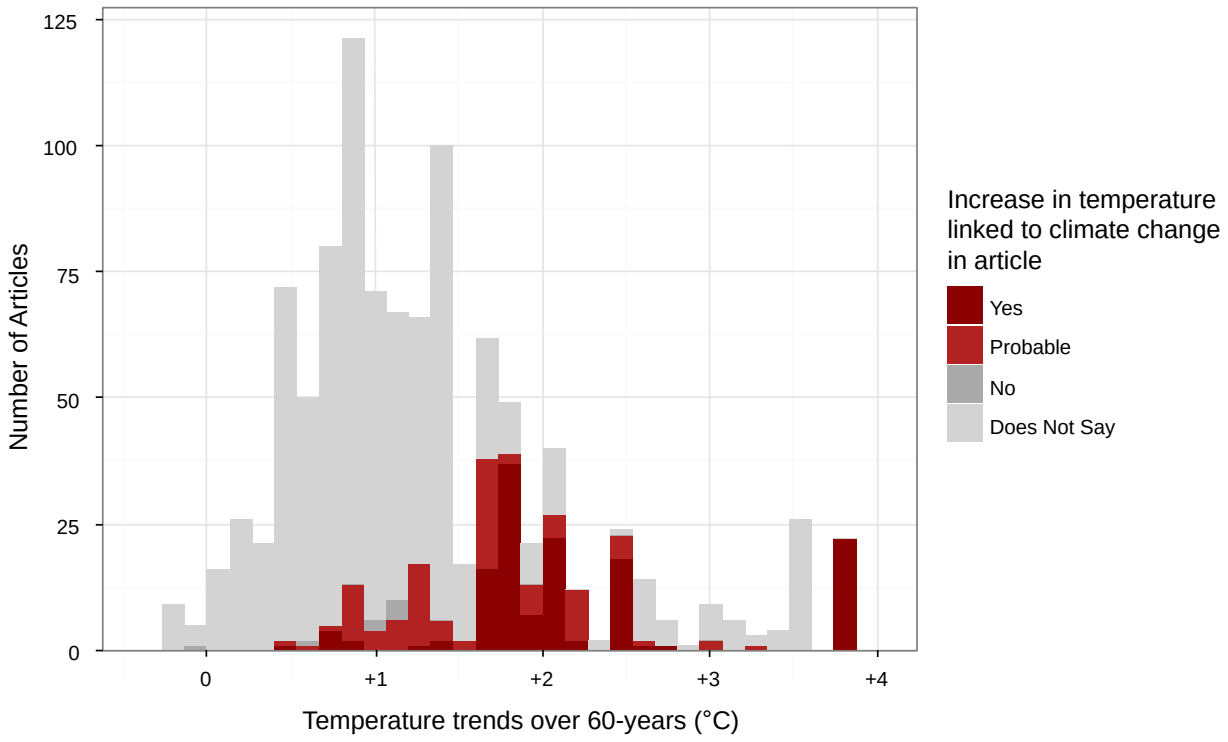

Figure 3. Historical trends for seasonal temperature corresponding to articles indicating an increase in temperature, coloured by their attribution to climate change.

Further analysis to determine the proportion of stories that linked climate change to the increase in temperature documented in the articles, based on the corresponding histogram (Fig. 3), was important to verify the temperatures at which journalists are correctly reporting climate change impacts. Three temperature ranges were analyzed to better understand at which temperatures the stories attribute climate change. Highest positive attribution occurs at

temperatures greater than 1.5°C (Table 5). Mild temperature deviations as well as no temperature changes at all are rarely linked with climate change.

It appears that journalists were correctly documenting increasing temperature changes but only close to a level of warming that would be considered a dangerous level by most scientists (above 2°C). Approximately 60% of the articles that have temperature increases above 1.5°C were attributed to climate change (true positives), but only 10% of true positive articles with temperature increases between 0.5 and 1.5°C have a linkage to climate change. It is important to note that in cases of reported temperature increase, particularly between 0.5 and 1.5°C, there were a large percentage of articles that did not say whether the event was due to climate change (false negatives). This seems to be a largely missed opportunity for reporters to connect climate or weather related stories to directional climate change trends. Nevertheless, Overall, climate change linkages to increasing temperature trends of more than 1.5°C are accurately reported in local newspapers.

Table 5. Climate change linkage between articles reporting an increase in temperature and trends of historical data for those locations. True positives are underlined, true negatives are italicized and false negatives are in bold.

	Link to climate change in article			
Temperature	Yes	Probable	No	Does not say
> 1.5°C	40%	18%	**0%**	**42%**
0.5 to 1.5°C	1%	7%	**1%**	**91%**
<0.5°C	0%	0%	*5%*	*95%*

Articles that linked a decrease in temperature to climate change were generally not supported by historical temperature trends (Fig. 4). Again it can be seen that the overall historical

temperature trends for all the locations derived from the articles were found to be increasing during the 60-year period. Articles that linked climate change to a decrease in temperature were found to correspond to a temperature increase between 0°C and 1°C. That said, there were significantly fewer articles that falsely attributed a definite or probable decrease in temperature to climate change (false positives).

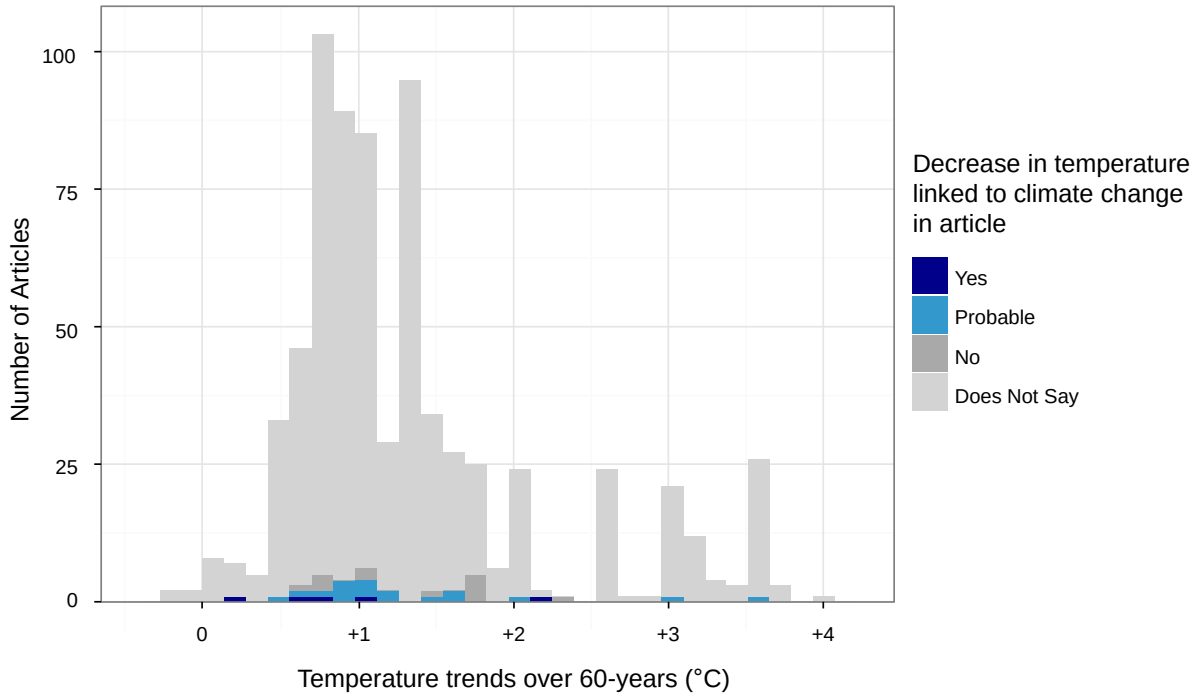

Figure 4. Historical seasonal temperature trends for articles documenting a decrease in temperature or a cold event, coloured by their attribution to climate change.

The same analysis was carried out for precipitation and dryness index. Historical data shows a slight increasing trend of percent of precipitation and dryness for the locations mentioned across Canada; however, when this was connected with climate change attribution from the stories there were no trends evident.

5.3. Visualization of climate change trends

The articles in this study represent locally reported temperature and precipitation increases and decreases across Canada as well as their attribution to climate change. Mapping the locations of each article allows us to visualize which regions in Canada have been experiencing temperature and precipitation trends. In Fig. 5, each temperature related article is represented by a coloured marker. Shades of red refer to an increase in temperature and a definite attribution of the story to climate change (darker) or a probable link to climate change (lighter). Temperature decreases are coloured blue with the same shading principles for attribution. These markers were overlaid on temperature trends derived from interpolated weather station data. The colours of markers are similarly matched to the derived weather station data indicating that the articles are reporting the current temperature trends across Canada. Strong warming trends are evident in northern Canada with high attribution to climate change (true positives). Overall, an increasing warming trend across Canada is apparent.

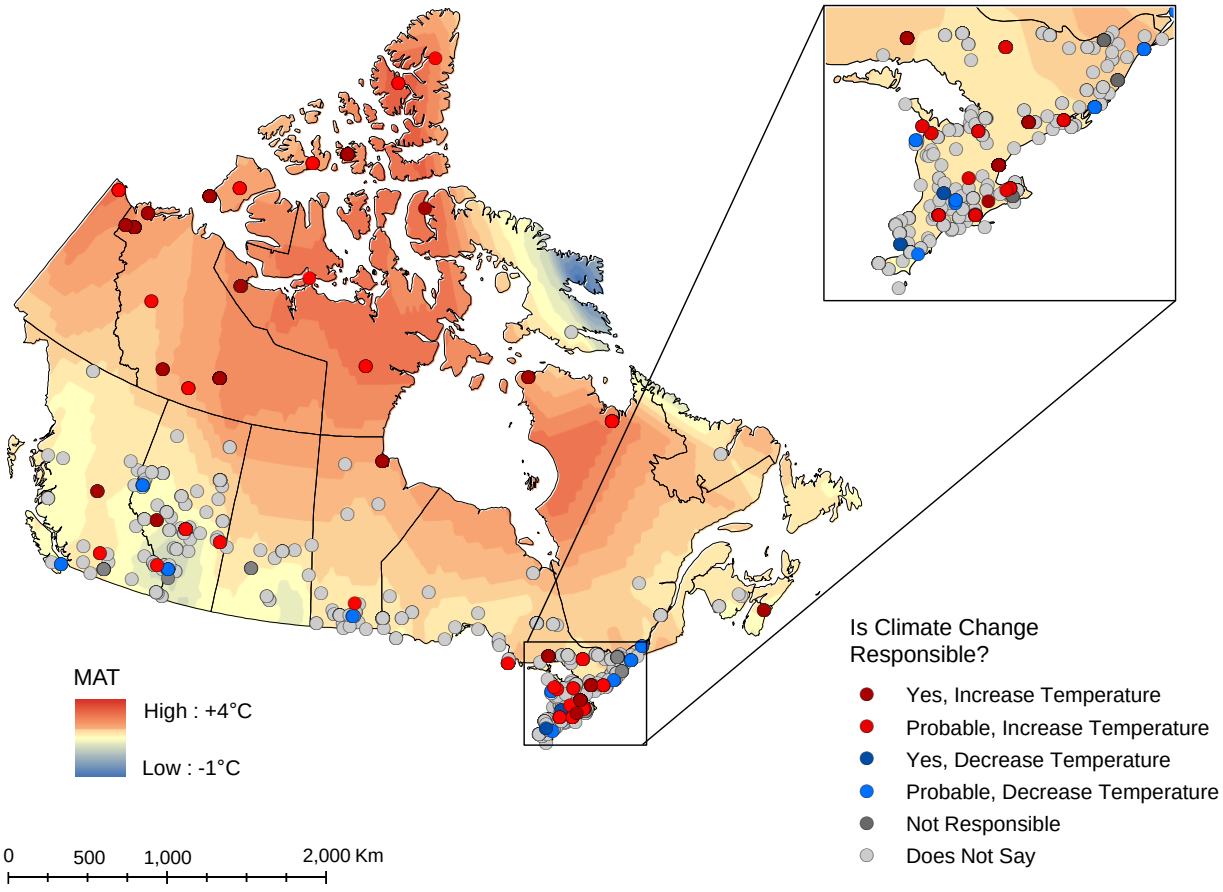

Figure 5. Map of Mean Annual Temperature (MAT) trends in Canada with dispersed markers representing the location of articles and their attribution to climate change.

Similarly, precipitation articles were represented by coloured markers (Fig. 6). Stories about increases in precipitation are coloured green and the shade refers to an attribution to climate change (darker) or a probable attribution to climate change (lighter). Precipitation decreases are coloured brown with the same shading principles for attribution to climate change. These markers were overlaid on precipitation trends derived from interpolated weather station data. Overall, there are very few data points that attribute climate change to an increase or decrease in precipitation and the colour of the markers do not particularly align with the derived weather station data.

The lack of attribution of precipitation-related articles to climate change is not unusual, as it is much more difficult to link highly stochastic precipitation events to climate change. The most evident trend based on the weather station data is an overall drying in the western regions of Canada. Indeed this corresponds to severe droughts in Alberta and unprecedented fire seasons in British Columbia, specifically during 2002-2004. This is not to say that drought events have not been reported in the west, simply that they just have not stated that climate change is to blame for these occurrences (true negatives).

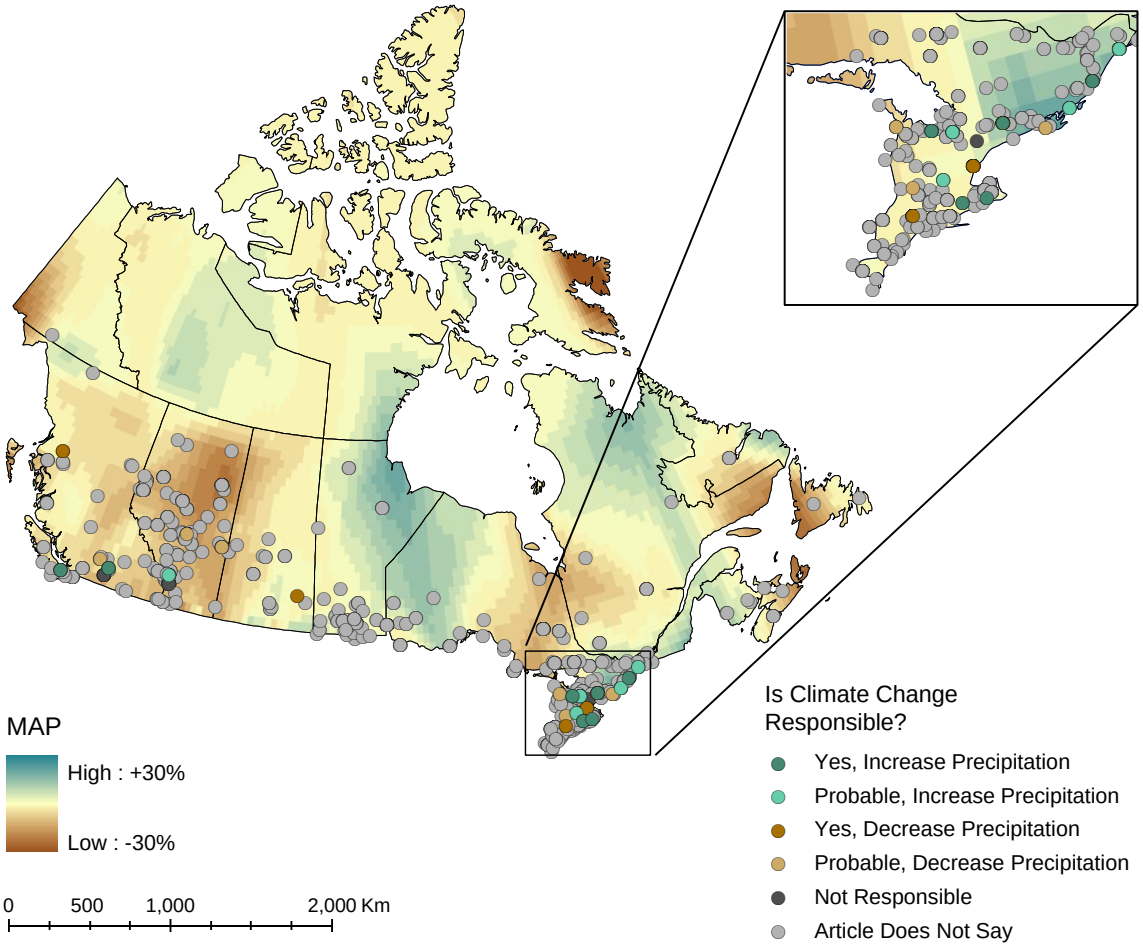

Figure 6. Map of Mean Annual Precipitation (MAP) trends in Canada with markers representing the location of articles and their attribution to climate change.

5.3 Temperature and precipitation anomalies

Each article in this study represents a temperature or precipitation event taking place in a specific year and season. Up until this point, analysis did not consider the year or the season of the events documented, but focused on the correspondence of news stories to a 60-year trend in historical data. This approach was useful because it allowed us to visualize overall trends for both precipitation and temperature events across Canada and whether or not they were attributed to climate change.

In this section I instead compare the historical data, based upon the year and season for each article, with the overall historical trends in an effort to see how accurately journalists report events and not attributed to climate change. For instance, there could indeed be an overall increasing trend in temperature for a location, but an article could be documenting a decrease in temperature in a specific year and season correctly. These are considered weather anomalies that do not correspond to historical data trends, but still correctly document an event taking place during a specific year and season. I want to confirm whether journalists are accurately reporting on the climate anomalies which could potentially indicate areas where climate attribution should've been considered.

For the majority of stories journalists were accurately reporting seasonal temperature anomalies as the temperature increased upwards of 0°C to more than 2°C at least 80% of the time (Table 6). Overall, there is a 75% correct documentation, with the 25% incorrectly documented events underlined in Table 6.

Table 6. Articles that correctly and incorrectly reported on temperature anomalies.

Temperature Anomaly	Number of Stories documenting a Warm event	Cold event
> 2°C	137	25
0°C to 2°C	603	122
-2°C to <0°C	153	205
<-2°C	25	18

Also for the majority of stories on precipitation anomalies, journalists were accurately reporting seasonal precipitation anomalies (Table 7). Overall, there is a 69% correct documentation, with the 31% incorrectly documented events underlined in Table 7. The reason this relatively high true negative rate is not reflected in Figure 6 is because these stories, although correctly reported, are not attributed to climate change and thus, trends cannot be visualized.

Table 7. Articles that correctly and incorrectly reported on precipitation anomalies.

Precipitation Anomaly	Number of Stories documenting a high event	low event
>50%	61	4
0 to 50%	357	121
-50 to <0%	186	278
<-50%	2	4

6. Discussion

Communication through local print newspapers is still one of the most dominant ways local news and information is transmitted to the public. Schafer (2010) contends that print media is a dying source of communication and that more studies should be done on online mediums, especially online articles which reach larger audiences and propagate information faster than print media. The trouble with online articles is that a majority of them are "big picture" in the sense that they present climate change as Ungar (2000) suggested – future oriented. Print media exists for a reason; it provides local communities with local news, specific information about local events, local weather and local issues. This is where efforts should be placed to present climate change to the public, this is how you increase tangibility and urgency, and this is how you change perceptions and connect science with story.

In this study I analyzed how the public are presented issues related to climate change through local print media newspapers. Similar to previous research for other countries, I examine how climate change is portrayed in general, but I also examine if local scale weather events are reported accurately, if they are connected with climate change and if climate change is attributed to an event correctly.

Not surprisingly, an overwhelming percentage of articles for various topics were documented as being negatively affected by local weather events. These articles can be organized into two main categories: those related to short term unseasonal weather, and those related to long term climate trends. By categorizing articles this way it becomes clear why

permafrost thaw and pine beetle infestation were most commonly associated with climate change. They are the only topics that document long term climate trends and consistently associated the related negative impacts on humans and ecosystems to climate change.

6.1 Long term climate impacts

Permafrost thaw and early ice breakup greatly affects those living in the northernmost parts of Canada, and articles concerning this topic appeared in every year of the study period attributing an increase in temperature to the destruction of infrastructure built on permafrost soils in these communities. Permafrost thaw has been accelerating since the 1950s (Camill, 2005), so the prevalence of these articles and their connection to climate change by reporters is unsurprising. Articles pertaining to permafrost thaw were most often connected to the drastic changes required in the way of life for those living in the northernmost areas of Canada.

In one article, a town in Quebec contemplates relocating their village as a solution to the unrelenting and unforgiving negative impacts of melting permafrost. Sinking buildings and roads, unstable utility poles and pipelines, and the erosion of once frozen shorelines has forced residents to alter the way they live and potentially where they will live in the future. In Sachs Harbour, N.W.T. on Banks Island, the environment has changed so drastically that oral traditions and cultural hunting practices are no longer reliable or applicable, a dangerous prospect since these communities have drawn upon their elder's traditional knowledge for survival (Ford, Pearce, Gilligan, Smit, & Oakes, 2008). Indeed, many places in northern Canada have been experiencing increasing temperatures leading to uncharacteristic weather patterns and storm

events that have impacted travel and hunting safety (Furgal & Seguin, 2006). In one of the earliest dated articles collected in this study, the Inuit describe the lack of seals during hunting season because an increase in temperature has led to later sea ice freeze and an earlier break up shortening the winter hunting season, a finding that Ford et al. (2008) have been noticing since the 1970's. These changing ice conditions are reducing access to traditional food and altering traditions of seasonal hunting practices (Ford et al., 2008). Hunters have claimed to have fallen through ice because it looked different than what their parents had taught them. Additionally, animal, bird, and fish species, like salmon, robins, barn swallows, and grizzly bears, which have never been seen that far north before are taking up residence in the town.

Where learning to read the weather from the signals in nature was once a way to survive and thrive in the north, now this knowledge compromises their everyday way of life because it is no longer reliable. Articles in this study that document this type of information are framed as an ongoing long term climate related problem with easily understandable and identifiable negative effects. The reporters make it very clear that unseasonal long term increases in temperature are responsible for the changes to these ecosystems and more importantly, they are labeling these impacts as a side effect of climate change.

The forestry industry in Canada is a vital economic renewable resource, especially in British Columbia whose interior has been gutted by the mountain pine beetle outbreak. Articles about mountain pine beetle have evolved from stories of mass tree mortality in British Columbia, to the discovery that increasing winter temperatures aid in their propagation eastward, and then solution strategies being employed to minimize damage and salvage as much wood as possible to

maintain a prosperous forest industry and stop the spread of the beetle. The problem is that many of the susceptible and suitable trees that the mountain pine beetle prefers have not experienced frequent beetle epidemics and climate change-driven range expansion to the east towards greater populations of these types of trees can result in disaster (Cudmore, Björklund, Carroll, & Staffan Lindgren, 2010). A majority of the articles are about how winter temperature has not been cold enough to stop the devastation of the mountain pine beetle. This link is made year after year and is connected to climate change by reporters. Articles also connect the damages of the mountain pine beetle to direct negative impacts on people's lives, for example, collapsing traditional forestry practices and potentially industries, ruining the aesthetic of many people's communities, and changing the famous scenery of popular National Parks on the border of British Columbia and Alberta.

The link between climate change and the impacts on both of these ecosystems is strong and identifiable because the articles talk about long term climate trends and negative impacts on people making the topics more relatable. Reports about short term unseasonal weather changes, like those affecting small scale tourism or infrastructure, require one to look at local weather patterns for a longer period of time to identify their connection to climate change as well as a significant negative impact to humans, as oppose to what most articles tend to write about, for example, a slight irritation that the ski hills have not been opened yet due to warm weather.

6.2 Short term unseasonal weather impacts

Unseasonal or unusual short term weather occurrences were the subject of the largest number of stories in this study. Since I focused on local news, the majority of the articles were all accounts of how local weather was impacting communities. While many of the events could be related to long-term climate trends and could have educational value in directly impacting the lives of local community members, this opportunity was rarely taken advantage of by journalists, with a large majority of stories not mentioning climate change at all (Fig 3, gray area between 0.5 and 1.5°C warming). This seems to be the failure or the gap that prevents the public from recognizing climate change in their own backyards. It can be seen in topics such as availability of natural resources, wildfires, tourism, infrastructure failures, and agriculture. In the following, I provide some examples of repetitive topics that were generally found to be negatively affected by short term weather related events, when in fact often attributable to long-term climate change impacts.

Many of the articles focusing on shifting species distributions were stories about how the fishing catch was changing, how new species were being found and old, staple species were moving more northward for cooler environments. Species distribution shifts caused by ocean warming have been cited in literature (Cheung et al., 2010; Cheung, Watson, & Pauly, 2013; Harley et al., 2006) finding that immediate adaptation strategies are important to maintain food security and the economy. This is also true for many migratory bird species which are nesting or returning too early from migration due to unseasonable weather, resulting in a decline in population due to mistiming of peak food sources (Both et al., 2004; Both, Bouwhuis, Lessells,

& Visser, 2006; Inouye, 2008; Inouye & McGuire, 1991). Caribou population in northern Canada also seem to be facing devastating mortality numbers due to unusual fall weather decreasing food availability, warmer summertime temperatures increasing insect parasites, and earlier spring weather causing food to appear substantially earlier on calving grounds with pregnant migrating cows arriving too late to capitalize on the freshness and abundance of the food source. Post et al. (2009) have found this trend present in Low Arctic Greenland, where an advanced onset of plant growing season in response to climate change has caused a change in plant-herbivore relationships. Reproductive caribou females are arriving significantly later than seasonal peak of resource availability reducing survival of calves (Post et al., 2009). All of these examples of course create larger problems not only in changing food chain dynamics but as human food sources for aboriginal communities.

Forest ecosystems have also been altered due to climate change impacts. Many articles blame record breaking spring temperatures and unusually dry warm and windy spring seasons for increased presence of wildfire. Wolfgang, Parida, Martin, Donald, and Markus (2013) found that since the 1980's there has been an earlier onset of spring and this shift in seasonality for North American boreal forests has resulted in a drying in the middle of the growing season over western regions resulting in increases in tree mortality and fire activity. Some articles have also blamed summer heatwaves and above normal hot and dry early fall weather for bringing about a higher risk of wildfires. Gillett, Weaver, Zwiers, and Flannigan (2004) have documented that as the summer seasonal temperatures continually increase, the area burned by forest fires in Canada has increased over the last four decades. This also impacts the tourism industry in Canada. In 2003 a hot dry summer in Alberta contributed to one of the worst forest fire seasons affecting

visitation to many national and provincial parks (Scott & Jones, 2006). Furthermore, Peng et al. (2011) suggests that a combination of increasing warmer temperatures and more severe drought, regardless of the season, makes the Canadian boreal forests vulnerable to tree mortality. High mortality of trees results in negative impacts on the ecosystem with increased risk of wildfires, and economic loses for the forest industry and tourism (A.L. Carroll, Taylor, Regniere, & Safranyik, 2003; A. L. Carroll, Taylor, Regniere, & Safranyik, 2004; Cudmore et al., 2010; Dale et al., 2001; Flannigan, Stocks, & Wotton, 2000; Flannigan & Wagner, 1991; Kurz et al., 2008; Scott & Jones, 2006; Soja et al., 2007; Stocks et al., 1998; Westerling, Hidalgo, Cayan, & Swetnam, 2006).

Tourism has both been negatively and positively affected by weather and climate related events, depending on the readers' point of view. The best example would be tourism during unseasonal warm winter temperatures. There are many articles of both positive and negative impacts, for example golfers who are still playing 18-holes in January because the weather has been favorable. Conversely, unseasonal warm fall and winter negatively affect many ski businesses where in one case seasonal staff were being laid off and season pass holders were being offered refunds. Scott and Jones (2006) mention that warm-weather outdoor recreation activities like golfing will benefit from climate change but that winter recreation such as skiing and winter festivals would be negatively impacted. These sorts of changes affect provinces economically, especially those who rely on winter activities as a main revenue.

Infrastructure failure and transportation was one particular category that showed the most variation in weather related attribution. For example, mild or unusual warm winters have

negatively affected roadways and building stability in places where permafrost has begun to melt. This has also caused problems on runways at the Yellowknife airport, where levelling was required every six years and now it is needed every other summer. These northern communities also rely on ice roads and frozen river crossings for the transportation of goods, which are forming later and melting earlier in recent years. Flooding was heavily covered during the 2013 catastrophic Calgary flood that caused evacuations, billions of dollars in damages to property and even required the aid of over two-thousand Canadian Forces troops for disaster relief. Yet, when I look at the articles, there was not a single flooding event covered that was connected to climate change or supported by scientific findings despite the prevalence in literature (Brody, Zahran, Vedlitz, & Grover, 2008; Milly, Wetherald, Dunne, & Delworth, 2002).

Impacts to agriculture were usually discussed as a result of unfavorable seasonal weather, both in increases and decreases of precipitation and temperature, rarely making any connections to climate change unless there was a significant crop failure. Agricultural stories are plentiful and significant since Canada is the world's fifth largest exporter of agriculture and agri-food products contributing over $100 billion annually to Canada's gross domestic product and employing over two million Canadians (Strategic Policy Branch, 2015). Reports on how climate change is impacting the weather is vital for them to adapt and mitigate the effects, such as crop failure, they are and could eventually be experiencing. This category seems to be important especially since many of the local communities in this study are farming towns. There are many adaptation strategies that could be implemented to reduce the negative impacts of climate change in the agricultural industry in North America and have been proven to show that climate change is not an insurmountable obstacle (Easterling, 1996). However, as previously stated, without the

realization that the observed events are attributable to climate change and pose a significant future threat, it is hard to convince farmers to change standard practices.

In summary, I note the lack of recognition and climate change connection to short term unseasonal weather event articles by reporters. Journalists have not yet capitalized on the opportunity to see the big picture by connecting regularly recurring events with each other and recognizing the trends so that they could convey them to their audience. However, a database of news stories connected to climate data, as in this study, should provide reporters with the tools to showcase on-the ground impacts of climate change (or also accurately report on true weather anomalies that are not connected to long-term trends).

6.3 Trends versus anomalies

Understanding the historical changes in temperature and precipitation trends in Canada was vital in determining if the journalists were reporting events correctly and if they were connecting climate change properly to their reports. This portion of the study looked at historical temperature and precipitation trends for all the locations identified in the articles and analyzed the articles that associated that trend with climate change. For temperature it was found that there were a large number of stories that correctly documented increases of temperatures, especially above the 1.5°C mark, and claimed that climate change was to blame (true positives). However, it should be noted that there were also a large number of articles that did not say whether the event was due to climate change when in fact a local warming trend between 0.5 and 1.5°C was observed (false negatives). This seems to be a largely missed opportunity for reporters to connect

climate or weather related stories to directional climate change trends. Journalists' were also shown to be reporting temperature short-term anomalies correctly as not related to climate change 75% of the time. Overall, long term climate trends from weather station data closely corresponded to stories based on local and regional climate events (as shown in Fig. 5).

Articles documenting precipitation related events had very few ties to climate change. The majority of the articles did not say what was responsible for the recorded events, although when historical trends for the locations were analyzed, there was found to be a slight positive trend in the percentage of precipitation per decade. These trends in the mean annual precipitation weather station data are visualized in Figure 6; however there are too few articles that connected any event to climate change that could support any trends. Articles of precipitation anomalies of increases upwards of 50% were correctly reported 94% of the time. Conversely, decreases in precipitation events were accurately reported at least 60% of the time. In general, the lack of attribution of precipitation anomalies to long-term directional climate change in news stories is expected and represents accurate reporting because these events are highly stochastic and do not closely correlate to the overall regional precipitation trends (as shown in Fig. 6).

7. Conclusions

The IPCC (2014) has documented that parts of Canada are experiencing a rate of warming twice the global average resulting in more frequent and intense extreme weather events. Canadian community journalists are accurately reporting these trends to the public and indicating where climate change impacts have been most noticeable. There are some gaps in coverage and

areas related to natural resources and direct impacts on humans that require stronger attribution to climate change; however, there are tools that journalists can utilize to fill these gaps in attributing climate change to local events when applicable.

The weather related events that journalists document are well attributed for temperature increases of more than 1.5°C, but in many respects, articles reporting temperature increases greater than 1.5°C are actually too late. Articles attributing climate change to an increase of temperature between 0.5 and 1.5°C are much more important. This temperature range is significant because it is slightly below a threshold generally considered dangerous in science and policy making, and attribution to climate change in this range could provide an opportunity for communities to implement adaptation and mitigation strategies. Unfortunately, very few articles attributed climate change to increased temperature in this range indicating an area of largely missed opportunities.

Missed opportunities of connecting events to climate change may be a reason why citizens are not noticing the negative effects that climate change is having on their communities. An interesting study by Szafran, Williams, and Roth (2013) was determining the length of time it would take for people to believe in climate change if local weather was their only indicator. They claim the public has difficulty recognizing the effect of climate change on local weather patterns because the changes are gradual (Szafran et al., 2013), and this stalls action and policy adjustments. Timelier reporting of articles with temperature trends between 0.5 and 1.5°C and their correct attribution to climate change could significantly change Szafran et al. (2013)'s

findings. If the public are exposed to articles linking local trends to climate change there will be an increased awareness that might lead to demands for action and policy changes.

The same tools that were used to extract climate trends for particular locations in Canada for this study are also available for the general public as a downloadable database with an easy-to-use software front-end (http://tinyurl.com/ClimateNA). The software can be run on any Windows computer without installation to efficiently extract climate data at monthly, annual, or decadal time steps for any location and time period of interests. Journalists can use this tool to fortify their stories with scientific data and correctly attribute climate change if it is responsible for the event. The ClimateNA software package covers all of the North American Continent, and similar packages are available for South America (http://tinyurl.com/ClimateSA) and Europe (http://tinyurl.com/ClimateEU). More data will become available in the future for other regions of the world (http://tinyurl.com/ClimateAB).

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