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Covering Climate Change: How Three American Agricultural Magazines Covered Climate Change Over 20 Years

Ginger Orton[1]
Courtney Meyers[2]
Laura Fischer[3]
David Doerfert[4]

Abstract

Climate change will have an increasing impact on agriculture through both on-farm weather events and climate-related initiatives. However, many farmers, while perceiving the climate as changing, do not believe in climate change's anthropogenic (i.e., human-caused) nature which could prevent farmer buy-in for climate change mitigation and adaptation strategies. Because agricultural magazines have been established as a widely utilized source of information for farmers and media coverage has been shown to relate to perceptions through the agenda setting process, this study investigated the nature of the coverage of climate change articles from three agricultural magazines from 2000-2020 (N = 271). Through a quantitative content analysis, we determined the articles' frames, sources, proposed economic impact of climate change, recommended action or proposed solution, determined cause of climate change, and logic (convinced or skeptical). This analysis revealed the dominant frame of the articles were scientific certainty, followed by political, conflict, and scientific uncertainty. The most frequently used sources were university scientists/Extension, followed by government officials and government research organizations. Articles were most likely to not mention the cause or economic impact of climate change. Articles tended to mention carbon sequestration more than other potential behaviors. The articles mostly portrayed a convinced logic about climate change. This study serves as a cultural artifact of the nature of climate change coverage in agricultural magazines and contributes to the burgeoning research efforts to best communicate this contentious topic to agriculturalists and encourage adoption of climate-smart agricultural practices.

Introduction

As far back as 1997, the USDA has published detailed reports stating farmers would need to adapt production practices in the face of increasing atmospheric CO_2 concentrations (Stelljes, 1997). In 2024, the relationship between climate change and agriculture remains salient in the policy, academic, and social arenas. The Food and Agriculture Organization (FAO) of the United Nations deemed 2010-2019 the "most turbulent decade" (p. 2) with natural disasters steadily on the rise (FAO, 2021). When considering

[1]Ginger Orton, Ph.D., is a Postdoctoral Research Associate of Agricultural Communication in the Department of Agricultural Leadership, Education and Communication at the University of Georgia, 405 College Station Road, Athens, GA 30602, ginger.orton25@uga.edu. https://orcid.org/0009-0005-4582-7700
[2]Courtney Meyers, Ph.D., is a Professor of Agricultural Communications and Graduate Studies Coordinator in the Department of Agricultural Education and Communications at Texas Tech University, Box 42131-Lubbock, TX 79409-2131, courtney.meyers@ttu.edu. https://orcid.org/0000-0001-9099-3613
[3]Laura Fischer, Ph.D., is an Assistant Professor of Agricultural Communications in the Department of Agricultural Education and Communications at Texas Tech University, Box 42131-Lubbock, TX 79409-2131, laura.fischer@ttu.edu. https://orcid.org/0000-0001-9288-462
[4]David Doerfert, Ph.D., is a retired Professor of Agricultural Communications in the Department of Agricultural Education and Communications at Texas Tech University, Box 42131-Lubbock, TX 79409-2131, david.doerfert@ttu.edu. https://orcid.org/0000-0002-1553-3120

agricultural production, these disasters swiftly destroyed acres of structures, crops, and livestock. Less obviously, the steady increase in atmospheric temperature also has slow progressing, yet detrimental, impacts on agricultural productivity. These include the spread of disease and pests as well as unpredictable weather and planting dates, with impact varying by geographic region (Adams et al., 1998; Havstad et al., 2018).

According to the most recent data, 52% of America's land is under agricultural production (USDA, 2021), and 11% of domestic greenhouse gas emissions come from agricultural production (EPA, 2020). Therefore, agriculture has been identified as having the potential to greatly reduce its climate impact, and farmer behavior has come to the forefront of this discussion. These efforts can also be attributed to agriculture's unique ability to both mitigate industry emissions and sequester carbon from the atmosphere through techniques such as reduced tillage, cover cropping, and re-naturalization, essentially reversing emissions (Arbuckle et al., 2015). In November 2021, the Biden Administration unveiled the U.S. Methane Emissions Reduction Action Plan which challenged the USDA to pursue multiple avenues to reduce agricultural methane emissions (White House, 2021). In line with this mission, the USDA invested more than $3.1 billion into a Partnership for Climate-Smart commodities initiative determined to encourage adoption of climate-smart agricultural practices (USDA, 2022). As of May of 2023, 141 projects centrally involving producers have been funded. These carbon-trapping practices have also been incentivized by the private sector in carbon offset markets (Hillyer, 2020).

However, barriers to adoption of novel on-farm practices exist. While few studies have specifically investigated producer perceptions of "climate" related agricultural practices, other studies have described barriers to conservation and sustainable practices. These barriers related to environmental awareness, trust in information sources, perceptions of the practices, and lack of resources (Elias & Marsh, 2019; Ranjan et al., 2019). Yet, unique adoption barriers related to "climate" branded practices, as currently worded by the USDA, may exist. More broadly, research on farmer's perceptions of climate change suggests farmers tend to attribute climate variability to natural patterns, with few who do not perceive the climate as changing at all (Arbuckle et al., 2015; Hoffman, 2011b; Morrison, 2017). This deviation from the scientific consensus toward climate change (NASA, 2021) may be attributed to one of the strongest predictors of an American's beliefs regarding climate change, which is their political party affiliation (Hoffman, 2011a,b). A 2019 PEW research report found 45% of Republican respondents believed human activity contributes "not too much/not at all" to climate change compared to 11% of Democratic respondents (Funk, 2019). It is no wonder, then, that farmers have been central to the climate-skeptic movement, as a 2016 Agri-Pulse survey of farmers with at least 250 acres of farmland found 70% of respondents identified as Republican or leaning Republican. One recent study on American farmers' acceptance of anthropogenic (i.e., human-caused) climate change showed between 55-70% of American farmers disagree with a fundamental concept—that human activity, including agriculture, contributes to climate change and greenhouse gas emissions (Arbuckle et al., 2015). Other research also offers evidence of skepticism and variability by geographic region (Houser, 2018). Rejesus et al. (2013) found 47% of North Carolina farmers, 42% of Wisconsin, 36% of Mississippi, and just 26% of Texas farmers believe in humans' causal role. Gramig et al. (2013) found similar results among farmers in Indiana, as did Prokopy et al. (2015a) in an international review of farmer's perceptions of anthropogenic climate change. Aside from political ideology, other factors impacting climate change perception include prior beliefs and values, trust in information sources and science, as well as demographics and risk perceptions (Cole & Watrous, 2007; Leiserowitz, 2006; Orton et al., 2023).

Many communicators, including Extension agents, government officials, and agricultural journalists and educators are faced with how to best communicate climate change and related topics to an agricultural audience. To foster effective communication, research on current and potential communication techniques is needed. Logically, farmers may be unwilling to adopt novel on-farm practices for the sake of preventing climate change, when many perceive it as happening regardless of human activity (Morrison et al., 2017). Agreement with the scientific consensus surrounding climate change has even been called a

"gateway belief" to subsequent action (Van der Linden, 2015). Therefore, communicating with farmers about climate change *specifically* may be difficult but essential. Some work has suggested avoiding the topic of climate change all together when communicating these practices (Jemison et al., 2014), while others encourage knowledge transfer focused on agriculture's role in climate change (Hyland et al., 2015). Notably, farmer perception of climate change has been connected to trust in sources of information on the topic (Morrison et al., 2017; Prokopy et al., 2015b; Telg et al., 2018). Borrelli et al. (2018), Cummins et al., (2018), and Rohling et al. (2016) all found farmers trust and prefer other farmers as sources of climate change information. Arbuckle et al. (2015) found farmers who trusted farm groups and the farm press were less likely to perceive climate change as anthropogenic, highlighting the relationship perceptions can have with media.

Media portrayal of an issue such as climate change, to put it simply, matters. Through a process known as agenda setting, journalists "set the agenda" for public perceptions and discourse (Scheufele & Tewksbury, 2007) or provide a metaphorical menu of issue perceptions and responses to choose from. Examining the media that farmers consume, agricultural magazines have maintained a high level of readership across technological generations and in 2018 were considered "the most important information resource, reaching and influencing the most farmers/ranchers" (Agri Media Committee, 2018, p. 6). Despite the established reach of agricultural magazines, only one study to our knowledge has reviewed how agricultural magazines cover climate change (Church et al., 2016), calling the coverage of the 2012 Midwestern drought a "missed opportunity for climate risk communication" (p. 1). Furthermore, as climate change increases in salience in the agricultural industry, it is important to document how the issue has currently been communicated and align these strategies with data-driven recommendations. This study ultimately serves as a cultural artifact of the nature of climate change coverage in agricultural magazines and contributes to the burgeoning research efforts to communicate this contentious topic to agriculturalists and encourage adoption of climate-smart agricultural practices.

Theoretical Framework and Related Literature

Framing

Framing has been used extensively in experimental and descriptive climate change communication studies to examine the nature of a message (Asplund et al., 2012; Dickinson et al., 2013; Shehata & Hopmann, 2012). Goffman (1974) first described frames as mental constructs of meaning shared between individuals through various language transactions. Entman (1993) extended this definition to include framing indicates what the cause of the problem is, what has to be done, who is responsible for causes, consequences, and solutions, and to convey moral judgment. When media employ certain frames, they insist a certain "take" on the situation. Framing, as used in this study and according to Entman (1993), is "to select some aspects of a perceived reality and make them more salient in a communication text, in such a way as to promote a particular problem, definition, causal interpretation, moral evaluation, and/or treatment recommendation" (p. 52). Or, as journalism scholar Van Gorp (2010) conceptualized, "[news frames suggest] an explanation for what happened in the surrounding world" (p. 84). The employed conceptualization of framing follows the constructionist approach (Van Gorp, 2010), which supports that individuals and collective groups construct social reality from many information sources, including each other and the media. Journalists play an active role in this reality-shaping process by identifying common idea packages (i.e., frames) and employing them in their own stories, thus setting the public agenda (McCombs & Ghanem, 2001). Journalists have been shown to be compelled by journalistic and economic norms to emphasize the debate and controversy between the small number of climate change-skeptical scientists and the scientific consensus to create profitable, attention-grabbing headlines (Boyce & Lewis, 2009). Identifying message frames allows for subjective, methodological analysis of the nature of news discourse.

Frame analysis research has scrutinized many areas of scientific communication (Nisbet & Scheufele, 2009), with a major research interest in mass media climate change messages (Li & Su, 2018; Lück et al., 2018; Shehata & Hopmann, 2012). Climate change messages in particular have undergone frame analysis due to the fact that climate change's consequences can seem invisible and far away (Applebome, 2010), despite the current and approaching consequences of increasing temperatures. Additionally, climate change is consistently considered a controversial issue, as many Americans do not believe in humans' causal role or know how society should respond (Leiserowitz, 2006). Gamson et al. (1992) wrote that media discourse allows for "competing constructions of reality" (i.e., frames) attempting to find support from readers who's accumulated experiences will take the "construction of reality" from a media fabrication to a real-world application or belief formation (p. 373). In the case of climate change, many messages intend to create a change in perception or behavior (i.e., recycle, vote pro-climate, believe in the scientific consensus, etc.), and certain frames have been shown to be more effective on certain populations (Aarøe, 2011; Hoffman, 2011a; Gross, 2008), such as farmers.

Research has distinguished several recurring frames in mass media coverage of climate change with dominant themes of scientific uncertainty and skepticism (Antilla, 2010; Hoffman, 2011a). Early climate change framing research of McComas and Shanahan (1999) and Brossard et al. (2004) identified the apparent frames of new evidence of research, scientific background, consequences, economics, domestic politics, international relations, and current weather in newspaper coverage of climate change. Soon after, Antilla (2005) identified four main frames in U.S. newspaper coverage of climate change: valid science, ambiguous cause or effects, uncertain science, and controversial science. Li and Su (2018) published a meta-analysis of climate change message framing research that included 10 studies from 2010 to 2017. They outlined five major frames present: morality, environment and biodiversity, geographical identity, public health, and economy (Li & Su, 2018). The review of literature identified only one analysis of message framing in specialized farm magazines which was completed in Sweden (Asplund et al., 2012). The researchers analyzed the frames presented in coverage of climate change in two Swedish specialized farming magazines from 2000-2009. They found three frames of coverage: conflict, scientific certainty, and economic burden.

Despite framing's wide application, no studies have applied a frame analysis of climate change messages to American agricultural magazines. The current study recognizes this research gap and the powerful influence of message framing as it investigates American agricultural magazines' coverage of climate change. While message frames capture the nature of a news article, this descriptive study additionally attempts to document other relevant message characteristics not captured at the frame level. These attributes include the articles' source, mention of economic impact, recommended action/proposed solution, cause of climate change, and dominant logic (discussed further in Methods).

Purpose and Research Objectives

The purpose of this study was to explore the coverage and framing of climate change messaging in agricultural magazines published between 2000-2020. The following research objectives were addressed:

RO1: Identify the prevalent frames utilized in agricultural magazine coverage of climate change over time.
RO2: Document the variety and frequency of sources cited within agricultural magazine articles discussing climate change.
RO3: Describe the projected economic impacts attributed to climate change within the agricultural magazine articles.
RO4: Characterize agricultural magazine articles' recommended action or proposed solution in response to climate change.
RO5: Investigate how the articles authors discuss the cause of climate change.

RO6: Analyze the dominant logic (convinced or skeptical about climate change) of the articles.

Methods

This study used a quantitative content analysis approach to study the selected magazine articles between 2000 and 2020 in three agricultural publications. Content analysis has been used across academia and commercial research to investigate media coverage of relevant issues (Neuendorf, 2017). Content analysis research can identify patterns in news coverage and has been used extensively to guide news framing analysis (Van Gorp, 2010).

Sample

This study's sample included three agricultural publications from 2000 - 2020: *Beef, Farm Journal*, and *Farm Industry News*. For magazines to be included in this sample, the archive must have been accessible online, and the magazine must have been agriculturally focused. Some magazines could have had higher readership but did not have an online archive. In addition to the sample's reach (having the highest readership levels in the archive platform), another reason for choosing these agricultural magazines is that they promote themselves by delivering helpful, objective information to benefit producers. While they are not immune to political influence or other private organization vulnerabilities (i.e., advertising pressures and self-censorship), the selected magazines' mission statements mentioned an adherence to updating producers on research, policy, technology, and/or weather.

The "Gale Business Insights: Essentials" online platform was used to access digital archives of each magazine. The archive of each magazine was searched for the following keywords: "climate change," "greenhouse gas," and "global warming." This resulted in an initial sample of 120 articles from *Beef,* 139 from *Farm Journal*, and 162 from *Farm Industry News*. Of the total 421 magazine articles, 150 were removed from the sample due to irrelevance. Once these were removed, *Farm Journal* had 66 relevant articles, *Beef* had 89, and *Farm Industry News* had 116. Due to the manageable number of relevant articles, all 271 articles were included in the sample and coded by the lead investigator after establishing intercoder reliability, discussed in the Codebook Formation section.

Codebook Formation

To begin creating the utilized codebook, we went through both an inductive and deductive process as outlined by Van Gorp (2010). Even though this study is a quantitative content analysis with variables specified a priori, the fundamental step of specifying frames and other variables involves collecting and analyzing the media under scrutiny and relevant literature (Van Gorp, 2010). As there is no American research surrounding climate change message framing in agricultural magazines, and frames have been shown to be influenced by time and place (Scheufele, 2006), attention was given to framing literature of magazines and climate change messages generally as well as to the sample. This explorative process allows the researcher to reason with existing frames prominent in the literature as well as the unique characteristics of the messages under scrutiny (Neuendorf, 2017). We also reviewed the codebooks and variables of interest researched in other climate change content analysis/framing studies (see: Antilla, 2005; Asplund et al., 2012; Brossard et al., 2004; Ford & King, 2015; Hoffman, 2011a; Li & Su, 2018; McComas & Shanahan, 1999).

Through this review, we created an initial codebook with 10 variables. This manuscript reports solely on five variables: frame, source, proposed economic impact of climate change, recommended action or proposed solution, determined cause of climate change, and logic (convinced or skeptical) in an independent analysis from the other variables. The research team, consisting of faculty with expertise in content analysis and climate change communication research, reviewed this codebook to ensure face validity (Krippendorf, 2004). Minor revisions were made when we entered the deductive phase (Van Gorp, 2010), where we completed a pilot test to measure the extent to which these variables were actually applied in a sample from a magazine not included in this study but otherwise similar to the sample. This pilot study

consisted of two coders who analyzed 10% of the articles. The initial codebook was refined to four frames (conflict, scientific certainty, scientific uncertainty, and other).

Coding and Intercoder Reliability

In line with recommendations from Neuendorf (2017), Krippendorf (2004), and Riffe et al. (1998), much time, attention, and research were invested in the coder training process. Two example articles not included in the sample were coded independently during the training session, and the coding team discussed the rationale behind each coding selection. To establish intercoder reliability, three coders analyzed 10% of the sample (n = 42) (Lombard et al., 2004). We used an online reliability calculator called "ReCal3" (Freelon, n.d.) to calculate a Krippendorf's agreement coefficient alpha (Krippendorf, 2004). An acceptable level was considered to be an alpha of 0.80 or higher, as recognized by Neuendorf (2017) and Riffe et al. (1998). We did not reach an acceptable level of intercoder reliability on the variables of frame ($\alpha = 0.66$), economic impact ($\alpha = 0.28$), or cause ($\alpha = 0.54$). A review of the articles and discrepancies led to minor modifications. All articles were then recoded, and this revision led to a Krippendorf alpha level of 0.94 for the frame variable. The 10% sample was re-reviewed for these characteristics. Intercoder reliability was then met on the variables of frame ($\alpha = 0.94$), source ($\alpha = 0.90$), economic impact ($\alpha = 0.81$), recommended action/proposed solution ($\alpha = 0.90$), logic ($\alpha = 0.81$), and cause ($\alpha = 0.83$).

Variables of Interest

Frames

Framing analysis has been challenged with consistently demonstrating the relationship between the posed frame and the patterns and characteristics of the text that prompt a coder to choose the appropriate frame (Van Gorp, 2010). It must be acknowledged that content analysis is inherently subjective—although systematic techniques and clear definition of frame elements and devices as well as formatting devices can provide more reliable analysis of news text (Van Gorp, 2010, p. 91). Van Gorp (2010) also insisted that quality, replicable frames have characteristics that are mutually exclusive (p. 99). Based on this guidance, the following frames were utilized: conflict (1), scientific certainty (2), scientific uncertainty (3), political (4), and other (5) (see Table 1). Coders chose the dominant frame for each article by selecting the assigned number.

Table 1

Frame Descriptions and Examples

Frame	Description	Examples
Conflict (1)	Article focuses on agricultural contributions to GHG emissions or contrasts production systems, sectors, or industries.	Keywords: war, fight, vs., against Sample titles: "Meat Eating Vs. Driving: Another Climate Change Error?" & "War on Burgers Continues with False Environmental Impact Claims"
Scientific certainty (2)	Article has dominant "matter of fact" tone & presents stories as unquestionable evidence that contribute to a culture of acceptance; little to no attention to uncertainties; mentions climate change impacts on agricultural production to suggest climate change is certainly impacting agriculture; and focuses on how agriculture can mitigate climate change.	Key characteristics: likely to cite scientific sources or the scientific consensus and mention mitigation Sample titles: "Major USDA Research Underway on Crops and Climate & Benefits of Conservation Agricultural Practices "

Scientific uncertainty (3)	Article questions the cause of climate change, agriculture's contributions, climate change manifestations, etc. Focuses on lack of scientific consensus.	Keywords: hoax, natural cycles, Mother Nature Sample titles: "Who says climate change isn't a natural process?", "Science Is No Longer the Only Answer", and "Fighting the Global Warming Scam."
Political (4)	Article focuses less on climate change and more on policy or regulation. Has little or no attention to cause or skepticism. Can emphasize positive or negatives to regulation, political actors, etc.	Keywords: regulation, election, Washington, D.C. Sample titles: "Senate Climate Bill: Ag Unimpressed" & "Where Do Clinton, Trump Land on Ag Issues?"
Other (5)	Article is obviously not framed in any of these perspectives.	Sample title: "New Film Celebrates Environmental Benefits of Cattle Grazing" & "How Will Corn Dry Down This Year?"

Sources

The source variable identified both direct quotes and direct sources the author used regarding climate change. Coders recorded each use of source in the article, in a "check all that apply" style option. The source options were university scientist/ Extension agent (1), industry scientist (2), governmental scientist (3), government research organization (4), government official (5), human or animal medical doctor (6), farmer/ rancher (7), agricultural interest group or NGO (8), environmental interest group or NGO (9), business/corporation (10), journalist (11), and other: please describe. The "other, please describe" data was analyzed post hoc and revealed two additional source classifications of author (12) and celebrity (13).

Sources have been analyzed in the light of credibility and trust by much climate change communication research (Arbuckle et al., 2015; Morrison et al., 2017; Rohling et al., 2016; Prokopy et al., 2015b). Giddens (1990) posited that society has become increasingly dependent on what he termed "abstract or expert systems" in the face of globalized phenomena that people cannot "opt out of" (p. 84). In the case of climate change, the public depends on the media as a source and the sources the media coverage employs.

Proposed Economic Impact of Climate Change

This proposed economic impact of climate change variable identified if the author posed any economic consequences of climate change, potentially through impacts of regulation, emerging markets, weather, etc. Coders were informed the article must explicitly reference profit, incentive, financial opportunity, or financial consequence. The options were economic burden (1), economic opportunity (2), mentions both economic burden and opportunity (3), and no mention of the economic impact of climate change (4), as first introduced by Asplund et al. (2012). Each article was attributed to one of these categories.

Recommended Action or Proposed Solution

This recommended action or proposed solution variable recorded any recommended action or behavior in the face of climate change. It also identified any proposed solutions to climate change. Coders recorded any mention of the following: no-till/ reduced tillage, cover cropping, planting dates, crop varieties, drainage systems, land management regimes, reduction of greenhouse gas emissions, carbon sequestration/storage, mitigation, adaptation, cap and trade, soil health, and other (with a prompt to describe any cases of 'other'). Coders recorded a "1" for each word's presence or a "0" for the word's absence.

Logic (Convinced or Skeptical)

This variable identifies the article's overall opinion on climate change—either convinced it is happening due to human activity or skeptical of the scientific consensus on some front, as introduced by Hoffman (2011a). Coders rated each article as convinced (1) or skeptical (2).

Cause of Climate Change

As the root of the skepticism in the agricultural community is not whether climate change is happening but whether it is human caused (Arbuckle et al., 2015), this variable recorded how or if the article discussed the cause of climate change. It prompted coders to place every article into one category regarding the presented cause of climate change, either: human activity (1), natural variations (2), inconclusive science (3), multiple viewpoints and perspectives (4), or no mention of cause (5).

Data Analysis

All data were processed in Microsoft Excel to calculate frequencies and percentages. Qualitative *source* data recorded in "other, please describe" were also categorized into apparent themes *post hoc,* and these frequencies were also calculated in Excel.

Results

RO1: Identify the prevalent frames utilized in agricultural magazine coverage of climate change over time.

We first sought to identify the frequency of apparent frames in the sample and how they appeared over time. Table 2 reports the results stratified by each magazine in the sample. The most common frame was scientific certainty, with 130 articles (48%) categorized as framed this way. The next most identified frame was political with 62 articles (23%) classified this way. The third most frequently employed frame was conflict, which represented 16% of the sample (n = 44). The most seldom employed frame was scientific uncertainty with 11% of articles (n = 29) categorized this way.

Table 2

Frequency of Frames Identified in Magazine Articles (N = 271)

	Farm Journal (n = 66)		*Beef* (n = 89)		*Farm Industry News* (n =116)			
Frames	*f*	%	*f*	%	*f*	%	Total	% of Sample
Scientific certainty	35	53	22	25	73	63	130	48
Political	28	42	17	19	17	15	62	23
Conflict	2	3	30	34	12	10	44	16
Scientific uncertainty	1	2	18	20	10	9	29	11
Other	0	0	2	2	4	3	6	2
Total	66	100	89	100	116	100	271	100

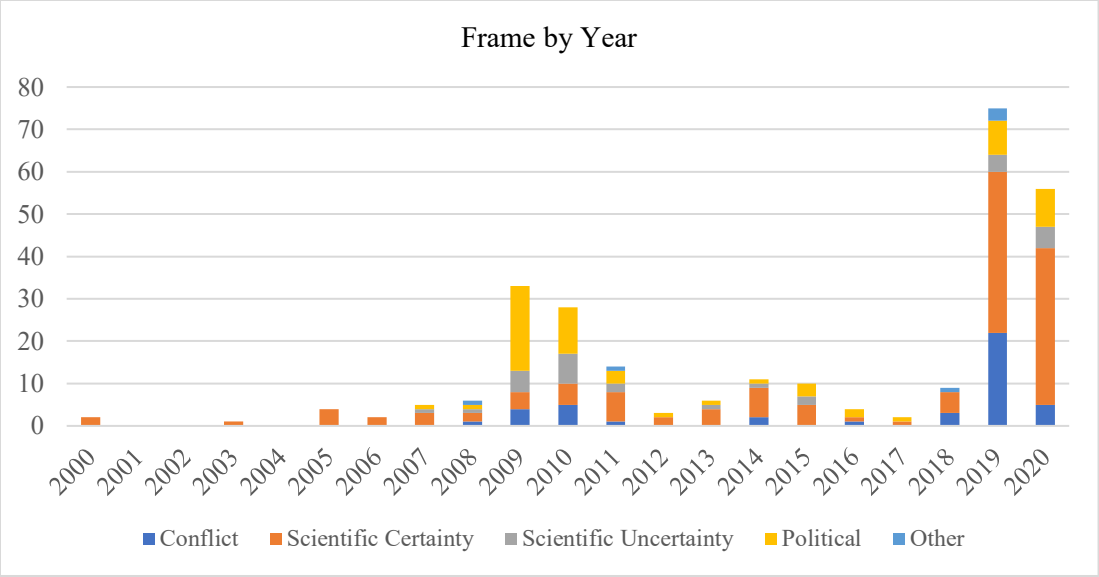
Table 3 categorizes the frequency of each frame by year to show that in the first two years of heightened coverage (2009 and 2010) the most frequently used frame was political. In the next peak of coverage in years 2019 and 2020, the scientific certainty frame was mostly used, totaling 57% of the articles in these two years (n = 131). Figure 1 represents this data visually.

Table 3

Frames Over Time ($N = 271$)

	Frequency (*n*)					
Year	Conflict	Scientific Certainty	Scientific Uncertainty	Political	Other	Total
2000	0	2	0	0	0	2
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	1	0	0	0	1
2004	0	0	0	0	0	0
2005	0	4	0	0	0	4
2006	0	2	0	0	0	2
2007	0	3	1	1	0	5
2008	1	2	1	1	1	6
2009	4	4	5	20	0	33
2010	5	5	7	11	0	28
2011	1	7	2	3	1	14
2012	0	2	0	1	0	3
2013	0	4	1	1	0	6
2014	2	7	1	1	0	11
2015	0	5	2	3	0	10
2016	1	1	0	2	0	4
2017	0	1	0	1	0	2
2018	3	5	0	0	1	9
2019	22	38	4	8	3	75
2020	5	37	5	9	0	56
Total	44	130	29	62	6	271

Figure 1



RO2: Document the variety and frequency of sources cited within agricultural magazine articles discussing climate change.

The second research objective's purpose was to report the sources used in agricultural magazine coverage of climate change. Some articles contained multiple sources, and all sources are reported in Table 4. The most frequently used sources in the sample were university scientists/Extension (n = 81), followed by government officials (n = 66) and government research organizations (n = 61). Industry scientists were used as sources 52 times in the sample, followed by 46 uses of agricultural interest groups/ NGOs. Notably, each magazine had a unique most frequently used source.

Table 4

Sources Used in Magazine Articles (N = 271)

Sources	*Farm Journal* (n = 66)		*Beef* (n = 89)		*Farm Industry News* (n =116)			
	f	%	*f*	%	*f*	%	Total	% of Sample
University Scientist/ Extension	18	15	26	15	37	23	81	30
Government official	23	19	21	12	22	14	66	24
Government research organization	18	15	34	20	9	6	61	22.5
Industry scientist	16	13	16	9	20	12	52	19
Agricultural interest group/ NGO	11	9	17	10	18	11	46	17
Business	13	11	7	4	18	11	38	14
Journalist	1	1	22	12	11	7	34	12.5
Farmer/ Rancher	9	8	7	4	12	7	28	10
Environmental interest group/ NGO	1	1	10	6	9	6	20	7
Governmental scientist	7	6	5	3	3	2	15	5.5
Author[a]	2	2	3	2	2	1	7	2.5
Celebrity[a]	0	0	3	2	0	0	3	1
Human or animal medical doctor	0	0	2	1	0	0	2	1
Total	119		173		161		453	-

Note. Total does not equal 100% of the sample, as multiple sources could be selected.
[a] represents variables that were analyzed *post hoc* from qualitative data recorded in the "other, please describe" category.

RO3: Describe the projected economic impacts attributed to climate change within the agricultural magazine articles.

Table 5 displays the frequency that articles included any mention of potential economic impact of climate change on agricultural production. The articles were most likely to not mention any economic impact (n = 189; 70%). Of those that did mention the economic impact of climate change, 40 included economic opportunity, with economic burden having 30 recorded mentions in the sample. Twelve articles mentioned both economic burden and opportunity.

Table 5

Economic Burden or Opportunity Mentioned in Article (*N* = 271)

Economic impact	*Farm Journal* (*n* = 66)		*Beef* (*n* = 89)		*Farm Industry News* (*n* =116)			
	f	%	*f*	%	*f*	%	Total	% of Sample
Economic burden	5	7	20	22	5	4	30	11
Economic opportunity	13	20	5	6	22	19	40	15
both burden and opportunity	3	5	5	6	4	4	12	4
No mention	45	68	59	66	85	73	189	70
Total	66	100	89	100	116	100	271	100

RO4: Characterize agricultural magazine articles' recommended action or proposed solution in response to climate change.

Table 6 represents the number of times articles in the sample included a recommended action or proposed solution to climate change and its manifestations. This was recorded by specifying 10 categories *a prioi* and recording the presence of these. Additionally, any proposed solution or recommended action not included in these 10 categories was recorded qualitatively and analyzed *post hoc* for frequency. These categories are marked with an ([a]) in Table 5.

The most frequently mentioned recommendation is carbon sequestration/ storage (*n* = 67) followed by reduction of greenhouse gas emissions (*n* = 57). Reduced tillage or no-till was proposed 35 times in the sample.

Table 6

Recommended Action/ Proposed Solution (*N* = 271)

Action/ Solution	*Farm Journal* (*n* = 66)		*Beef* (*n* = 89)		*Farm Industry News* (*n* =116)			
	f	%	*f*	%	*f*	%	Total	% of Sample (N = 271)
Carbon sequestration/ storage	13	20	14	16	40	35	67	25
Reduction of GHG emissions	14	21	14	16	29	25	57	21
Reduced/No-till	13	20	2	2	20	17	35	13
Cover crop	6	9	2	2	18	16	26	10
Adaptation	2	3	1	1	22	19	25	9
Cap and trade	10	15	12	14	3	3	25	9
Soil health	6	9	2	3	13	11	21	8
Mitigation	1	2	6	7	13	11	20	7
Biofuel[a]	9	14	2	2	3	3	14	5
Renewable energy[a]	2	3	7	8	5	4	14	5

Crop varieties	3	5	1	1	7	6	11	4
Planting date	3	5	0	0	3	3	6	2
Total	82	-	63	-	176	-	321	-

Note: Total and percentages do not equal sample size because each article could contain more than one recommended action or proposed solution.
[a] represents a classification recorded in the "other, please describe" category and analyzed *post hoc.*

RO5: Investigate how the articles' authors discuss the cause of climate change.

Table 7 displays the frequency of articles that mentioned a cause of climate change. Each article was attributed to only one category, defined as human activity, natural variations, inconclusive science, multiple viewpoints and perspectives, or no mention of cause. Slightly less than half (n = 123, 45%) of articles in the sample made no mention of the cause of climate change. Of the categories that mentioned cause, 91 articles (34%) mentioned human activity as the explicit cause of climate change, 27 articles (10%) mentioned multiple viewpoints and perspectives, 27 (10%) mentioned climate science is inconclusive, and 3 articles (.01%) mentioned natural variations in the climate as the explicit cause of climate change.

Table 7

Attributed Cause of Climate Change (N = 271)

	Farm Journal (n = 66)		*Beef* (n = 89)		*Farm Industry News* (n =116)			
Cause	*f*	*%*	*f*	*%*	*f*	%	Total	% of Sample
No mention of cause	39	59	30	34	54	47	123	45
Human activity	17	26	28	31	46	40	91	34
Climate science inconclusive	4	6	17	19	6	5	27	10
Multiple viewpoints/ perspectives	6	9	13	15	8	7	27	10
Natural variations	0	0	1	1	2	1	3	1
Total	66	100	89	100	116	100	271	100

RO6: Describe the dominant logic (convinced or skeptical about climate change) of the articles.

We recorded the dominant logic of each article. Each article was categorized as convinced or skeptical regarding the reality of anthropogenic climate change. Table 8 displays the dominant logic stratified by magazine. Most articles shared a convinced dominant logic (n = 217) with 80% of articles categorized this way. The remaining 54 articles (20%) were considered to be skeptical toward anthropogenic climate change.

Table 8

Dominant Logic in Magazine Articles (N = 271)

	Farm Journal (*n* = 66)		*Beef* (*n* = 89)		*Farm Industry News* (*n* =116)			
Logic	*f*	%	*f*	%	*f*	%	Total	% of Sample
Convinced	61	92	56	63	100	86	217	80
Skeptical	5	8	33	37	16	14	54	20
Total	66	100	89	100	116	100	271	100

Discussion, Conclusions & Implications

This study sought to describe how American agricultural magazines cover climate change in order to describe how agricultural journalists have "set" the media agenda.

Frames

The most frequent frame of scientific certainty (*n* = 130, 48%) presented climate change as a matter of fact, with little to no attention given to inconclusive science or skepticism. These articles were considered to contribute to the overall culture of climate change acceptance and often contained information related to research reports or ways to participate in the climate-smart movement as well as the impact of climate change on agricultural production. A *Farm Industry News* article considered to be framed in scientific certainty was headlined "Climate change expected to increase cost of farm programs" (Farm Industry News, 2019). This frame was also apparent in previous content analysis framing analysis research of national newspapers (Antilla, 2005) as well as Asplund et al.'s (2012) analysis of Swedish specialized farming magazines. Based on the current study's sample, before 2019, *conflict* was the dominant frame, but in 2019 *scientific certainty* became the most frequently used frame, with 51% of articles in 2019 framed this way. In 2020, the same was true with 66% of articles framed in *scientific certainty*. This shows over time, agricultural magazine coverage of climate change has shifted toward scientific certainty.

The second most identified frame was political, found in 23% of the articles. This indicated the close connection between climate change and the political and regulatory landscape, especially regarding agriculture. In 2009 and 2010, the first two years of substantial climate change coverage, the most frequently used frame was political. The next most employed frame was conflict, which appeared in 16% of the sample. Articles framed in conflict posed two economic sectors against one another, often in the light of contribution to greenhouse gas emissions. For example, one headline in *Beef* magazine read, "How NYC's Meatless Mondays campaign is hurting poor communities" (Radke, 2019). In fact, of the 44 articles framed in conflict, 30 of them (68%) were from *Beef* magazine. These articles represent the theme of conflict between cattle production and other groups such as consumers, the environment, and transportation companies. Additionally, the conflict frame experienced its highest use in 2019, with 29% of those 75 articles being framed this way. Asplund et al. (2012) also found the dominant presence of conflict frames in Swedish agricultural magazines. The public's criticism of the agricultural industry has positioned many agriculturalists on the defensive (Telg et al., 2018) and presents the opportunity for this frame to emerge as journalists compare the emissions of agricultural production to other industries.

Finally, scientific uncertainty was the least employed frame with only 11% (*n* = 29) of the sample framed this way. Articles framed in scientific uncertainty emphasized the perceived scientific debate and focused on natural variations being the cause of any change in climate in addition to inconclusive or

otherwise faulty science. A *Beef* article in the scientific uncertainty frame was titled "Have we been lied to on global warming?" (Beef, 2009). This frame has prevailed in framing analysis of U.S. news reporting (Boykoff, 2007), but Asplund et al. (2012) did not find it to be a prevalent frame in Swedish specialized farming magazines. Although it was not a prevalent frame in our study, it did experience a peak in 2010 with 24% (n = 7) of its total use being in this year. Even though this was the most seldom employed frame, the historical use of this frame contributes to the culture of skepticism in the agricultural community.

Sources

The most frequently used sources were university scientist/Extension (n = 81), government official (n = 66), government research organization (n = 61), industry scientist (n = 52), agricultural interest group/ NGO (n = 46), business (n = 38), journalist (n = 34), and farmer (n = 28). The use of university and industry scientists as well as government research organizations supports the predominant presence of the scientific certainty frame as agricultural magazine coverage of climate change appears to be largely based on the scientific process and consensus regarding climate change. Using scientific sources also supports agricultural climate change messaging recommendations from Arbuckle et al. (2015), Morrison et al. (2017), and Prokopy et al., (2015b), as these studies showed farmers and general audiences have high levels of trust in these sources. Furthermore, scientific sources are more likely to perpetuate the scientific consensus.

Prior research has found Extension agents to be a primary source producers trust and prefer (Borelli, 2018; Prokopy et al., 2015b), specifically when communicating about climate change. In the current study, Extension was coded under university scientists, which was the most frequently used source classification. This finding supports the qualitative data Prokopy et al. (2015b) gathered that suggested farmers' trust Extension due to their "down the middle of the road" approach and scientific nature (p. 264). The use of university scientists/ Extension as the leading source indicates journalists are perpetuating the scientific viewpoint, as Extension has been disseminating climate change science for the agricultural community for years. However, Telg et al. (2018) did find that Extension agents in Florida may be hesitant to discuss climate change with agricultural producers due to its polarized nature. We echo Telg et al.'s (2018) call for further training of Extension agents to communicate this contentious topic strategically.

The presence of government officials as a major source also supports the second most frequently used political frame, because many articles included quotes from politicians and other government officials to bolster points on regulation, elections, and policy. This again highlights the almost inseparable nature of climate change, agriculture, and the government, especially with net zero national benchmarks and related agricultural policy (White House, 2021). However, consideration should be taken when implementing government officials as sources considering the politically divisive nature of climate change (Dunlap, 2013). Citing politicians on either "side" could reduce message effectiveness for a considerable amount of the population, since political party affiliation is one of the strongest predictors of an American's belief in anthropogenic climate change (Hoffman, 2011a,b).

Agricultural interest group/ NGO being cited 46 times in the sample shows that groups such as Farm Bureau and commodity organizations play a role in the modern climate change conversation. As these groups have been historically anti-climate change policy and somewhat skeptical toward climate change (Dunlap & McCright, 2010), they could be contributing to the culture of skepticism in the agriculture community. Arbuckle et al. (2015) found farmers were more skeptical of information from environmentally-oriented interest groups but placed more trust in agricultural interest groups. Notably, farmers/ranchers were used 28 times as sources. In light of Cummins et al. (2018) and Rohling et al.'s (2016) finding that farmers both trust and prefer other farmers as a source of climate change information, farmers were perhaps underutilized as a source.

Economic Impact

The high amount of discussion on the economic opportunity of climate-related intiatives indicates journalists are choosing to highlight the positive economic benefits to adopting climate-smart practices, both from increases in production efficiency and the emergence of carbon offset markets. The prevalent mention of economic burden suggests the opposite—that some journalists are choosing to highlight negative and costly aspects of climate change regulation or climate-smart practices. The inclusion of both in 12 articles is an example of balanced reporting acknowledging the potential burdens and opportunities. Morrison et al. (2017) suggested that messages emphasizing the connection between on-farm financial problems and the financial benefits of addressing climate change could be preferred. Asplund et al. (2012) found economic burden to be an emergent frame in their analysis of Swedish specialized farming magazines from 2000-2009.

Recommended Action/ Proposed Solution

Many climate change messages intend to inspire behavior or perception change (Ford & King, 2015). In the case of agricultural climate change messages from Extension, NGOs, or government agencies, behavior change often regards on-farm action to adapt to or mitigate climate change (Dinesh et al., 2017). The most frequently recommended action was carbon sequestration or storage (n = 67), which supports the ever-increasing attention to this practice as a major way to reduce atmospheric carbon dioxide; therefore, reducing temperatures and creating a profitable market for some farmers. Notably, many other included solutions relate to the carbon sequestration process. Cap and trade was suggested 25 times, and other major recommendations were reduced or no-till techniques, cover cropping, adjusting planting dates, planting crop varieties, and improving soil health generally.

Much of the public scrutiny toward agriculture has been directed toward livestock's methane emissions with some attention to agriculture's emissions generally. The second most frequently proposed solution was the reduction of greenhouse gas emissions, mentioned in 57 articles. Because mitigation inherently involved reducing human's impact on the climate through reduced emissions, support for reducing agriculture's contributions to climate change was included in 77 articles after adding the 20 that mention mitigation. Mitigation and reducing greenhouse gases are both established on the fundamental concept that humans play some role in climate change. Considering this alongside the contention farmers feel toward the anthropogenic nature of climate change, Arbuckle et al. (2015) recommended also avoiding these topics in climate change messaging for farmers. Instead, they suggest messages focus on the reactive capacities of agriculture (i.e., adaptation) that align with farmer's perception of climate change—that it is happening but not because of human activity (Arbuckle et al., 2015; Prokopy et al., 2015b). Adaptation in general was mentioned in 25 articles, which indicates the understanding that society is approaching the point of irreversible climate damage that will have direct impacts on agricultural productivity which will warrant modification of the status quo. Agriculture will need to adapt in the face of more variable temperatures and increased instances of natural disasters, presenting an opportunity for agricultural educators and communicators to facilitate.

Cause

Notably, slightly less than half (45%) of articles made no mention of the cause of climate change. This could be due to the apprehensiveness of journalists to address this more contentious aspect of climate change. In fact, not mentioning the cause of climate change is a major recommendation for climate change messaging to farmers (Arbuckle et al., 2015; Morrison et al., 2017; Prokopy, 2015b; Rohling et al., 2016.) This has been posed as a messaging best practice based on the Theory of Planned Behavior (Ajzen, 1985) by increasing the positive attitude toward the issue and message by avoiding "controversial but correct aspects of climate change" (Morrison et al., 2017, p. 17). Of the articles that did mention cause, 91 (34%) mentioned human activity as the explicit cause of climate change, 27 (10%) mentioned multiple viewpoints or perspectives (including human activity and either inconclusive science *or* natural variation), 27 (10%) also mentioned climate science is inconclusive. The high number of articles that

mentioned human activity as the explicit cause contribute to the culture of scientific certainty and take the issue head on by supporting the scientific consensus. However, when it is considered that a combined 54 articles (20%) mentioned inconclusive science or natural variation, it is no surprise the culture of skepticism lingers. Six articles (.01%) mentioned natural variations as the only cause of climate change, suggesting that this is seldom the case in agricultural magazine coverage of climate change.

Logic

Most of the magazine articles were coded as presenting anthropogenic climate change as happening, with 80% of the articles categorized this way. This supports those who criticize deficit model thinking (Sturgis & Allum, 2004; Costanzo et al., 1986), because if farmers' perceptions of climate change were formed through education of the scientific consensus alone, one would expect to find most farmers to be convinced that humans have caused climate change after reading these articles. However, this is not the case (Arbuckle et al., 2015).

Additionally, 54 articles (20%) were considered to be skeptical. For articles to be coded this way, the author must have explicitly questioned the science or accredited natural variations as the most likely cause of climate fluctuations. Even though these messages were the vast minority, it could be suggested that they have a "louder" presence than the convinced articles. Because these skeptical viewpoints likely align with the audience members' current perception of climate change, they may reinforce their current opinion and experience a heightened level of attention and retention (Petty & Cacioppo, 1986).

Additionally, considering the logics stratified by magazine, *Beef* had the highest proportion of skeptical articles, with 37% being categorized this way. This compares to *Farm Industry News* having 14% considered skeptical and *Farm Journal* having 8% skeptical articles. *Beef* magazine had high readership levels in the sampled timeframe (Roybal, 2013), and perhaps this attention to skepticism has influenced or supported audience perceptions of climate change.

Recommendations

This study's findings provide an opportunity to pause and consider how to best communicate about climate change with farmers over the next 20 years. In some ways, the study provides more questions than answers due to its descriptive nature but does establish a bedrock from which to establish these inquiries.

Research

Future research should work toward providing data-driven communication techniques to those who communicate to producers about climate change. This involves research describing both audience and message characteristics and how these two constructs interact. The variables presented in this study serve as message attributes or features that could be manipulated in future message testing experiments, including the frame and cause of climate change. These messaging decisions should be based on other research reporting farmers' views about anthropogenic climate change, trust in sources, sentiment to climate change terminology, and how willing they are to modify their operations with climate-smart practices. Rich communication insights could come from data on agriculturalists' motivations to address climate change, as motivation and values are key indicators of likelihood to centrally process messages and be influenced by them (Petty & Cacioppo, 1986).

Generally, more research building on the study at hand is needed to examine the intersection of agriculture and climate change in U.S. media, as most studies identified through the review of literature were from an international or adjacent (e.g., "sustainability") context. The tendency to portray the scientific consensus in agricultural magazines suggests research of this nature will continue to be relevant as audience perceptions and media coverage interact.

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