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Using Audience Segmentation to Identify Target Audiences for Climate-Smart Beef Production Communication

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Abstract

In the face of increasing consumer scrutiny of the food supply chain, communication practitioners have been determined to understand public perceptions of the food production process from 'farm to fork.' The beef industry has been of particular interest due to the relatively high production emissions and an increased level of public support for environmentally friendly food behaviors, such as eating less beef. To address these concerns, the USDA and industry organizations are creating programs to incentivize and promote climate-smart beef production practices. Further, a new market is being created, where products may be labeled as 'sustainable' or 'climate-smart.' In order for this market to thrive, communicators and educators must strive to educate the public about these production practices; however, little is known about how to educate the public and market these climate-smart production techniques to the public. This study sought to identify and describe unique target audiences for educational communication about climate-smart beef production using audience segmentation. Through a K-means cluster analysis, we identified four strategic target audiences based on respondents' climate change concern, political ideology, trust in science, and perception of the environmental responsibility of the beef industry. After, we described each cluster's demographic characteristics, beef consumption frequency, attitude toward sustainable food products, and preferred communication sources to inform strategic communication efforts. This study provides insight and recommendations for educators and other practitioners communicating about climate-smart beef as well as areas of future research into this emergent area.

Introduction

In the face of increasing consumer scrutiny of the food supply chain, communication practitioners have been determined to understand public perceptions of the food production process

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from "farm to fork" (Nukala et al., 2016). Previous scholars in agricultural education and communications have examined consumer perceptions of the food supply chain, including poultry production (Estes et al., 2015; Powers et al., 2020), animal slaughter (Tarpley et al., 2020), locally produced beef products (Oesterreicher et al., 2018), local strawberries (Ruth & Rumble, 2016), and local food messages (Abrams & Soukup, 2017). Notably, both during and after the COVID-19 pandemic, consumer trends indicated an increase in purchases of food products with labels deeming the product "sustainable" and increases in concerns regarding the environmental impacts of the food and agricultural industry (Frey et al., 2023; Nemes et al., 2021).

The beef sector has been of particular interest to consumers due to the environmental impact of animal agricultural production (USDA, 2022c; Environmental Protection Agency, 2023) and the current public interest in environmentally friendly behavior (Nemes et al., 2021). While beef is the most resource-intensive agricultural sector, agricultural production accounts for only 11.2% of all domestic greenhouse gas emissions (USDA, 2022c; U.S. Roundtable for Sustainable Beef, 2024). Despite this, the beef industry has set multiple climate-smart goals and seeks to move toward more sustainable and climate-smart production practices to achieve climate neutrality by 2040 (American Society of Animal Science, 2015; U.S. Roundtable for Sustainable Beef, 2024). The beef industry aspires to become more climate neutral by implementing on farm practices such as managed or rotational grazing, increased feed efficiency, reforestation, reduced use of farm machinery, and other efforts to contribute to gains in efficiency (de Souza et al., 2017; Gosnell et al., 2021).

The federal government has also prioritized and incentivized the climate-smart agricultural production movement. In 2022, the USDA launched a Partnerships for Climate-Smart Commodities initiative to "expand markets for America's climate-smart commodities, leverage the greenhouse gas benefits of climate-smart commodity production, and provide direct, meaningful benefits to production agriculture, including for small and underserved producers" (USDA, 2022b, para. 1). The initiative invested more than $3.1 billion for 141 agricultural projects (USDA, 2022b). Vytelle, a company which helps producers refine more sustainable beef genetics, was awarded $10 million of this initial sum to help reduce the beef industry's emissions by 50% via technology and genetic selection (Vytelle, 2022). Another recipient of $10 million, Sustainable Northwest, has partnered with Grazewell, an initiative of more than 100 western ranchers, to adopt regenerative ranching practices to "be part of the climate solution" (KTVZ, 2022, para. 2).

The novelty of these practices, beef's relatively high production emissions, and subsequent media coverage have catalyzed the public to consider lowering red meat consumption as an option to lower their individual carbon footprint. Happer and Wellesley (2019) reviewed research in the UK, US, China, and Brazil to understand the media's role in public perception of meat consumption and acknowledged an increase in social campaigns intended to reduce meat consumption for the sake of reducing climate change. Sanchez-Sabate and Sabate (2019) systematically reviewed 34 papers on consumer perceptions of meat consumption in the context of environmental stewardship and found that consumers are generally aware of meat's environmental impact and willing to reduce meat consumption for the sake of the environment. In the public press, the Scientific American published an article titled *Eating less red meat is something individuals can do to help the climate crisis* (Oreskes, 2022). Other news coverage featured the 2019 International Panel on Climate Change (IPCC) report that included a recommendation to reduce meat consumption, such as a Nature article titled, *Eat less meat: UN climate-change report calls for change to human diet* (Schiermeier, 2019). Further, the beef industry has received a "black eye" from the public in this regard (Telg et al., 2018). The beef industry is understandably concerned about the public's perception of its products and processes and what this might mean for the economic viability of the

industry. In fact, the USDA already reported an expected "modest decrease in meat consumption for 2022" (USDA, 2022a, p. 1).

As a reaction to both climate change and public perception, Cusworth et al. (2022) acknowledged a "green rebranding of cattle" (p. 1). In the case of the Climate-Smart initiatives, organizations within the industry are beginning to market products as 'climate-friendly' or 'sustainable.' For example, Tyson Foods has launched a brand to promote 'climate-smart beef,' a result of their partnership with USDA's Climate-Smart Commodities (Tyson Foods, 2024). The mission is to develop a marketplace to promote the work of beef producers striving to incorporate sustainable practices and reduce greenhouse gas emissions (Tyson Foods, 2024). This "rebranding" attempts to educate the public about sustainable agricultural practices and foster a positive attitude of the industry among environmentally conscious consumers and the public.

In line with the mission of changing perspectives, scholarship and practice have documented the importance of understanding who is in the audience and abandoning blanket messaging to deliver unique messages tailored to segmented, target audiences of similar individuals, inspiring and informing attitude and behavior change (Grunig, 1989). For example, within the *Journal of Agricultural Education,* several studies have investigated audience characteristics of water conservation messages to develop tailored, strategic messaging to its publics (Fischer et al., 2018; Huang et al., 2016; Warner et al., 2015; Warner et al., 2017). Others have described the need for advanced quantitative analysis of audience characteristics beyond demographic information (e.g., behavioral characteristics, motivations, issue perceptions) for environmental and scientific communication, such as cluster analysis (Hine et al., 2014), which has seen limited use in our discipline (Essary et al., 2021). In fact, these calls suggest we must determine how to position information to be congruent with the audience's values and beliefs in order for it to be salient and attended to (Fischer et al., 2020). Our study seeks to address this gap by identifying and describing unique target audience segments providing data-driven insights for informed strategic education and communication about climate-smart beef production using audience segmentation beyond demographic information.

Conceptual Framework

The public's increased interest regarding the environmental impacts of food production and its systems warrants further communication from agricultural scientists and producers about their production practices and techniques. However, public perceptions regarding science are built upon "deeply held values" (National Academy of Sciences, 2017, p. 54) and beliefs such as political ideology, science trust, and environmental viewpoints (Arbuckle, 2016; Burnier et al. 2021; Hine et al, 2014; McCright et al., 2016). Communicating controversial scientific information may challenge these beliefs, values, and interests; therefore, agricultural educators and communicators must be cautious when disseminating information to those with varying beliefs to avoid converse effects. One technique to mitigate the converse effects is to tailor scientific messages to a singular audience segment while still delivering credible and accurate information (Hine et al., 2014; National Academy of Sciences, 2016). Message tailoring involves aligning a piece of accurate information in a manner that is consistent with audience segment's members' strongly held beliefs morals, and values (Maibach et al., 2009; McCright et al., 2016).

Message tailoring must begin with a thorough understanding of an audience; however, it is important to understand there are multiple groups or segments of an audience, as not all humans are alike or similar (Bostrom et al., 2013). Instead, communicators must strive to divide populations into unique audience subgroups or audience segments to inform their communications strategy. Audience segmentation seeks to create efficient communication specific to target audiences within specific realms who share similar thoughts, perspectives, and values (Slater, 1996). More, scholars

(e.g., Hine et al., 2014; Runge et al., 2018; Warner et al., 2016) and practitioners (e.g., Midan Marketing, 2023) have called for audience segmentation techniques to move beyond demographics and segment values, beliefs, and psychographic traits.

The audience segmentation process evaluates and divides markets into various segments, or groups where individuals share needs, characteristics, and opinions (Tuten, 2021). Additionally, audience segmentation, often referred to as market segmentation, seeks to influence levels of knowledge, concern, or opinions regarding a particular topic in order to reshape or inform one's behavior (Slater, 1996). Grunig (1989) describes audience segmentation in simple terms: "divide a population, market, or audience into groups whose members are more like each other than members of other segments" (p. 202). The technique is an essential tool in the strategic communicator's toolbox, building upon the understanding that knowing your audience is crucial to developing compelling communication. Identifying target audiences through audience segmentation allows for tailored communication to unique subgroups that share similar characteristics (Warner et al., 2016). Communication tailored to an individual's current perceptions (e.g., values, political ideology, behaviors, beliefs, and other worldviews) can be more compelling (Grunig, 1989).

To segment an audience, communicators must follow a specific process (Bonoma & Shapiro, 1984; Slater, 1996). The first step is to identify information from prior literature regarding knowledge, attitude, and behavior within a domain (Slater, 1996). Following, researchers must identify audience segments with distinctive, yet shared, characteristics that are tailored to each realm within the study (Slater, 1996). Lastly, and the most thorough step, is for researchers to determine the best strategy for identifying patterns of each determinant, then placing individuals into specific, distinct segments (Slater, 1996).

When developing climate-related messages, considering audience members' current perceptions and values is essential due to the highly polarized nature of climate change in the United States (McCright et al., 2016). Many communication efforts and studies have used audience segmentation to identify target audiences for climate change related messages with goals to encourage perception and behavior change, such as supporting climate change mitigation policy and participating in environmentally sustainable practices (Bostrom et al., 2013; Detenber et al., 2016; Hine et al., 2014; Maibach et al., 2009). Due to the recent emergence of climate-smart beef production practices, no research has applied audience segmentation techniques to the public to identify target audiences for climate-smart beef communication and public education. Thus, we draw from the literature on climate change, sustainability, and consumer behavior to develop the key constructs for our audience segmentation to inform climate-smart communication about the beef industry (Bostrom et al., 2013; Hine et al., 2014).

Concern for Climate Change

At the forefront of the conversation on climate and environmentally friendly beliefs is an individual's perception or concern for climate change. The way an individual perceives climate change, including how much it worries or concerns them (Bouman et al., 2020; Maibach et al., 2009; McCright, 2009) and how risky they perceive it (Dietz et al., 2007), has been shown to be positively correlated with their likelihood to behave in a climate-friendly way or adopt a climate-smart behavior. Purchasing climate-smart or sustainable products has been linked to mitigating the effects of climate change, and those that hold a higher level of concern for climate change are often more likely to purchase sustainable and climate-friendly products (Trudel, 2019).

Political Ideology

Further, climate change perceptions and participation in environmentally friendly behaviors in the United States have been found to be closely related to an individual's political ideology (Trudel, 2019). Indeed, those who identify as Republican tend to be more skeptical of climate change (Arbuckle, 2016; de Leon et al., 2020; Merkley & Stecula, 2021) and at risk of adverse message effects when receiving climate messages (Chinn & Hart, 2021). A Pew Research study found that even though Republicans considered climate change a lower priority issue, they most highly favored the climate-friendly action of planting trees to absorb carbon emissions (Tyson, 2021). Other research has shown that political ideology is related to willingness to support climate change mitigation policy (McCright et al., 2016) and purchasing sustainable or climate-friendly products (Gromet et al., 2013).

Trust in Science

Closely related to climate change and political ideology is an individual's level of trust in science, which has been found to impact receptiveness to messaging related to climate-friendly behaviors (Cologna & Siegrist, 2020). Because individuals are unlikely to themselves be climate scientists, they must trust the scientific consensus (i.e., climate change is real and primarily human caused) and processes that preceded it (i.e., scientific method). While trust in science has been unexplored in the context of climate-smart beef production, it has been found as a key variable of influence in other environmental behaviors, including general meat consumption (Happer & Wellesley, 2019), reducing energy use, and donating money to environmental groups (Taniguchi & Marshall, 2018).

Perception of Environmental Responsibility of the Beef Industry

Another variable closely connected to an individual's likelihood to purchase climate-smart beef is their perception of the environmental impacts of the beef industry. Burnier et al. (2021) measured environmental impact in a study of Brazilian consumers' perceptions of sustainable beef production processes to find this perception relevant to consumer decision making. Gosnell et al. (2021) documented U.S. beef industry leaders' perceptions of the industry's social sustainability, including environmental factors. Other more generalized studies have found that an individual's level of environmental concern influences pro-environmental behavior (Tam & Chan, 2018).

Other Variables

In addition to the aforementioned variables used to form the audience segments (discussed in detail in the methods section), we also describe other relevant characteristics of the audience members, including their beef consumption frequency, attitude toward sustainable food products, preferred communication sources, and demographic characteristics to further describe each segment for richer message development insight.

Purpose and Objectives

The beef industry has been of particular interest due to the relatively high production emissions and an increased level of public support for environmentally friendly food behaviors, such as eating less beef. To address these concerns, the USDA and industry sectors are creating programs to incentivize and promote climate-smart beef production practices. Further, a new market is being created, where products may be labeled as "climate smart." Although there has been an emergence of climate-smart beef production techniques, little is known about how to educate and promote these climate-smart production techniques to the public. Further, the industry needs to strategically educate the public about sustainable agricultural practices that foster a

positive attitude of the industry among environmental consumers. Therefore, the purpose of this study was to conduct an audience segmentation to identify and describe unique target audiences for educational communication about climate-smart beef production techniques. We used the following objectives to guide the study:

RO1: Identify audience segments based on respondents' climate change concern, political ideology, trust in science, and perceived environmental impacts of the beef industry.
RO2: Describe the identified audience segments' demographic characteristics.
RO3: Describe the identified audience segments' beef consumption frequency
RO4: Describe the identified audience segments' preferred communication sources.

Methods

To develop recommendations for strategic educational communication about climate-smart beef practices, we distributed an online Qualtrics survey instrument to identify audience segments based on respondents' opinion toward climate change concern, political ideology, trust in science, and perception of environmental responsibility of the beef industry. The data in this study are part of a larger questionnaire determined to understand public perception of climate-smart beef practices.

To fulfill the purpose of the study, we sourced a third-party company, Qualtrics, to collect a non-probability, opt-in sample of U.S. residents aged 18-years or older. Non-probability sampling is a technique using non-random techniques to invite respondents that match specific characteristics to participate in online research questionnaires through incentives (Baker et al., 2013; Donsbach & Traugott, 2007; Lamm & Lamm, 2019; Lehdonvirta et al., 2021). This technique has become a popular method to gathering U.S. public opinion through an online format, and it has been found to be an acceptable sampling technique due to the increased access of internet across the U.S., access to an accessible population, and ability to reach a wide range of respondents (Baker et al., 2013; Donsbach & Traugott, 2007; Lamm & Lamm, 2019; Lehdonvirta et al., 2021). Further, these non-probability sample techniques have been documented to provide higher response rates in comparison to random digit dialing of landline numbers in our modern society (Baker et al., 2013). Albeit, non-probability samples have bias and limitations due to potential exclusion, selection, and participation bias; thus, readers should be cautioned to generalize the findings of the study (Lamm & Lamm, 2019; Lehdonvirta et al., 2021).

Population and Sample

To recruit respondents, we used Qualtrics Market Research Services to source respondents from their actively managed research panels to gather responses from U.S. residents in October and November 2022. Qualtrics initially contacted 2,340 U.S. residents to participate in our study. However, our final sample included 1,425 usable responses. Useable responses were deemed acceptable for respondents who matched the nationwide census characteristics, known as 'quotas,' for age, race, and gender (see Table 1). Additionally, respondents who did not meet our quality checks (i.e., speeding through survey, extreme time to take the survey, incomplete responses, or failed attention checks) were eliminated from our sample. Due to the polarizing nature of climate change and its close relationship with environmental concern, we also removed the respondents who selected "prefer not to answer" and "other" to the political ideology question. Based on the number of respondents who started the study and the number of respondents who were kept for the final sample, the completion rate for our study was 60.89%. Table 1 describes the U.S. Census population percentages and how our respondent sample matched the characteristics.

Table 1

Respondents' Demographic Characteristics Compared to U.S. Population (N = 1,441)

Demographic Characteristic	US Census	Sample	
	%	*f*	%
Gender[a]			
Male	49.6%	647	44.90%
Female	50.4%	781	54.20%
Non-Binary/Third Gender	n/a	9	0.62%
Prefer not to say	n/a	4	0.28%
Age[b]			
18 – 34	29%	413	28.66%
35 – 54	33%	455	31.58%
55+	38%	573	39.76%
Race/Ethnicity[ac]			
Hispanic	19.1%	206	14.30%
Non-Hispanic	81.1%	1235	85.70%
White	75.5%	1099	76.27%
Black or African American	13.6%	196	13.60%
Asian or Pacific Islander	6.1%	66	4.58%
American Indian, Native American, or Other Pacific Islander	0.3%	50	3.47%
Prefer not to answer	n/a	52	3.61%
U.S. Region[d]			
Northeast	17.1%	261	18.11%
Midwest	20.6%	312	21.65%
West	38.6%	476	33.03%
South	23.6%	366	25.40%

[a] (US Census, 2022b)
[b] Respondents were asked to enter their age in years. After, we recorded this numerical number into the three categories (US Census, 2022c)
[c] Respondents were asked to select if they were of Spanish, Hispanic, or Latino origin. After, they were asked to choose one or more races that they consider themselves to be.
[d] Respondents were asked to select their state of residence, which was converted into regions. (US Census, 2022a)

Instrument Development

Data were collected through a series of questions derived from the prior literature (Bouman et al. 2020; Burnier et al., 2021; McCright et al., 2013) to acquire relevant information to form the audience segments. To ensure face and content validity, a panel of experts reviewed the survey instrument for content accuracy, clarity of wording, readability, and survey flow (Dillman et al., 2014; Wimmer & Domminick, 2014). The panel of experts comprised of faculty and industry experts in the animal sciences (beef, dairy, and meat), sustainability, and agricultural communications. To ensure reliability, prior to launching the survey questionnaire, a pilot test was conducted with 50 respondents to ensure the reliability of the adapted and developed scale items (Dillman et al., 2014). All scale items were found to be reliable (α = .80 or higher), and we proceeded with the data collection process (Dillman et al., 2014; Wimmer & Domminick, 2014).

Data Collection Procedure and Variables

To complete the questionnaire, the respondents were first asked to complete the Texas Tech University approved IRB consent form. After, they were asked to respond to a series of questions to form their audience segments, such as climate change concern, perceived environmental responsibility of the beef industry, trust in science, and political ideology. Following, they answered other questions regarding their information sources and demographics. Finally, the respondents were thanked for their time, and Qualtrics provided an incentive for their participation in the study. Qualtrics Market Research was responsible for disturbing the incentive for the individual's participation in the study based on their recruitment partnerships. Qualtrics and their partners provide incentives from a variety of sources. For example, respondents may be airline customers who will be compensated through airline miles, retail customers will receive points at their preferred retail outlet, and others may participate in exchange for cash or gift cards (Qualtrics, n.d.). However, we paid Qualtrics $5.25 for each response.

Audience Segmentation Variables

The climate-smart beef audience segments identified in this study were developed based on the prior literature. Specifically, scholars have indicated audience segments should be based less on demographic characteristics (Hine et al., 2014; Warner et al., 2016); but instead, audience segments should be based on the psychographic characteristics of the audience. The variables collected in our public opinion survey questionnaire reflect the climate-smart beef psychographic insights driven by the prior literature to develop audience segments. Specifically, scholars have indicated consumers differ based on their political ideology (McCright et al., 2016), concern for climate change (Bouman et al., 2020; Dietz et al., 2009; Maibach et al., 2009; McCright et al., 2009), level of trust in science (Cologna & Siergrist, 2022; McCright et al., 2013), and perception of the environmental impact of the beef industry (Burnier et al., 2021). We describe these variables in detail in the below sections:

Political Ideology. Political ideology was measured and accounted for in the audience segments due to its relationship with environmental and climate behaviors and perceptions (Arbuckle, 2016; de Leon et al., 2020; Merkley & Stecula, 2021). To measure political ideology, respondents were asked "how would you describe your political view," with option statements of *very liberal*, *slightly liberal*, *moderate*, *slightly conservative*, *very conservative*.

Concern for Climate Change. Concern for climate change (Cronbach $\alpha = .921$) has been found to be highly correlated to the likelihood to believe in a climate-smart behavior (i.e., purchasing climate-smart products), and thus was a critical addition to the audience segments (Bouman et al., 2020; Maibach et al., 2009; McCright, 2009). We measured concern for climate change based on an adaptation of Bouman et al.'s (2020) construct. Respondents were asked to rate their agreement to the following (1 = *strongly disagree*, 5 = *strongly agree*): "I am worried about climate change," "I believe that climate change will harm humans," and "I believe that climate change will harm plants and animals" (Bouman et al., 2020).

Trust in science. Trust in science has also been found to be highly related to perceptions of environmental and climate initiatives, such as climate-smart products. Simply, those who trust the scientific consensus tend to trust climate-smart practices and are more willing to trust and purchase climate-smart products (Cologna & Siegrist, 2020; Happer & Wellesley, 2019). Thus, we measured respondents trust in science (Cronbach $\alpha = .880$). It was measured by asking respondents how much they trust scientists based on a 5-point Likert scale (1 = *completely distrust*, 5 = *completely trust*) to the following items: "Create knowledge that is unbiased and accurate," "create knowledge that is useful," "advise government officials on policy," and "inform the public on important issues" (McCright et al., 2013).

Perceived environmental impacts of the beef industry. In addition to understanding the respondents' perceptions toward the climate, we also sought to understand the perceived climate impact of the beef industry. Both popular press and scholars have indicated a differentiation in the publics' viewpoints toward agricultural climate impacts of specific sectors and production techniques (Burnier et al., 2021; Gosnell et al., 2021; Tam & Chan, 2018). Because our study sought to identify potential target audiences for sustainable, climate-smart beef products, we specifically identified how consumers viewed the environmental responsibility of the beef industry. To do so, we used Burnier et al.'s (2021) scale to assess the respondents perceived environmental impacts of the beef industry (Cronbach $\alpha = .84$). Respondents were given the following statements and asked to rate their level of agreement with them (1 = *strongly disagree*, 5 = *strongly agree*): "I am concerned if producers adopt practices that reduce greenhouse gas emissions," "I am concerned if beef comes from farms that have not undergone deforestation," and "I am concerned if beef comes from farms that conserve water and avoid its waste."

Other Variables

In addition to our segmentation variables, this study sought to describe how the audience segments varied by demographic variables, their beef consumption frequency, and preferred sources of information. These variables can help communications and education professionals to better educate and market climate-smart beef practices to consumers.

Beef consumption frequency. Beef consumption frequency was measured to understand how frequently the sample consumed beef. We asked the respondents, "In a typical week, how often do you eat beef or beef products?" with the following options: *never, 1-2 days per week, 3-4 days per week, 5-6 days per week* (Fischer et al., 2023).

Preferred Information Sources. Preferred information sources captured where people seek information about animal agriculture. Respondents were asked to, "Please select your level of agreement with the following items. When seeking out information about animal agriculture, I seek out the following sources:" with sources listed in results section. Each source was rated from 1 = *strongly disagree* to 5 = *strongly agree.*

Data Analysis

To develop the audience segments, data were analyzed using SPSS 29 by conducting a two-step cluster analysis. To create unique clusters, we analyzed variables based on the prior literature (political ideology, climate change concern, trust in science, and perception of the environmental impacts of the beef industry). These variables were initially converted into Z scores to achieve comparable scales (Runge et al., 2018; Ward, 1963). We then conducted a Hierarchical Cluster Analysis (HCA) using Ward's method to provide a visual representation (a dendrogram) of the agglomeration schedule (Ward, 1963). The agglomeration schedule figure showed an initial break from the group around point four, indicating significant differences between respondents sorted into four groups (Everitt et al., 2011). Then, a K-means cluster analysis assigned each respondent to one of the four identified segments. Following, a series of analysis of variance (ANOVAs) and descriptive crosstabs were conducted to determine how the clusters compared based on descriptive means and frequencies of beef consumption frequency, preferred communication sources, and demographic characteristics.

Results

RO1: Identify audience segments based on respondents' climate change concern, political ideology, trust in science, and perceived environmental impacts of the beef industry.

A K-means cluster analysis, a technique to group similar respondents together, was performed to segment or group the sample into four unique groups (Everitt et al., 2011). The K-means analysis provided the Z scores of the final centroids for the four specified clusters (see Table 2; Figure 1). The segments were validated using ANOVAs, which indicated each variable contributed to the cluster formation and the segments were statistically significantly different at $p < .001$ (Everitt et al., 2011; Runge et al., 2018).

Table 2

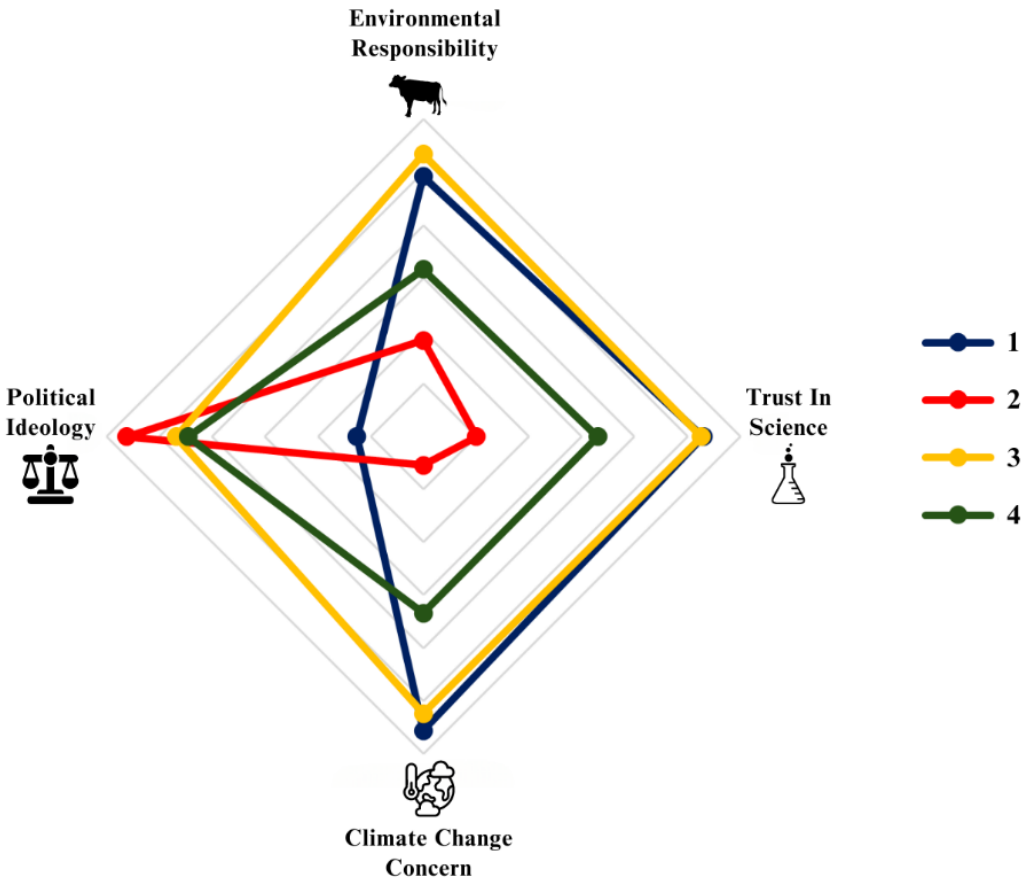
Z scores of Final Cluster Analysis Centers resulting from K-Means Analysis (N =1425)

	Cluster 1 (*n* = 300)	Cluster 2 (*n* = 189)	Cluster 3 (*n* = 421)	Cluster 4 (*n* = 515)	*F*(3,1424)	*p*
Political Ideology	-1.37	.81	0.34	0.23	550.09	.001
CC Concern	0.78	-1.73	0.62	-0.33	995.69	<.001
Trust in Science	0.65	-1.50	0.63	-0.35	576.15	<.001
Env. Responsibility	0.46	-1.09	0.67	-0.42	313.39	<.001

Note. Variables are standardized using Z scores. For political ideology, a negative Z score represents a person who identifies more liberally, and a positive Z score represents a person who identifies more conservatively. For climate change concern, trust in science, and perceived environmental responsibility of the beef industry, a negative Z score represents lower levels of concern, trust, and responsibility, and a positive score represents higher levels of these areas.

Figure 1

Radar Chart of Cluster Z Scores



We found the K-means analysis indicated four unique audience segments described below. *Cluster 1* (n = 300) was composed of those who were very liberal (Z Score = -1.37), were concerned about climate change (Z Score = 0.78), trusted science (Z Score = 0.65), and thought the beef industry had high climate impacts (Z Score = 0.46). *Cluster 2* (n = 189) represented those who were slightly conservative (Z Score = 0.81), very unconcerned with climate change (Z Score = -1.73), very untrusting of science (Z Score = -1.50) and believed the beef industry had low climate impacts (Z Score = -1.09). *Cluster 3* (n = 421) consisted of those who were politically moderate (Z Score = 0.34), were concerned about climate change (Z Score = 0.62), trusted science (Z Score = 0.63), and believed the beef industry had slightly high climate impacts (Z Score = 0.67). *Cluster 4* (n = 515) was composed of those who were politically moderate (Z Score = .23), moderately concerned about climate change (Z Score = -0.33), moderately trusting of science (Z Score = -0.35), and believed the beef industry had slightly low climate impacts (Z Score = -0.42).

RO2: Describe the identified audience segments' demographic characteristics.

Although it is important to recognize psychographic traits related to the development of audience segments, it is also critical to understand the segments' demographic makeup as factors such as gender and age can influence communication and education strategy.

Once the audience segments were identified through the K-means cluster analysis, we sought to understand how these segments differed based on their demographic characteristics (Table 3).

Table 3

Cluster Membership Demographic Characteristics by Cluster Segment (N =1425)

	Cluster 1		Cluster 2		Cluster 3		Cluster 4		
	(*n* = 300)		(*n* = 189)		(*n* = 421)		(*n* = 515)		
	f	%	*f*	%	*f*	%	*f*	%	Total
Gender									
Man	118	39.3	93	49.2	197	46.8	230	44.7	638
Woman	179	59.7	91	48.1	223	53	281	54.6	774
Non-Binary	2	0.7	2	1.1	1	0.2	4	0.7	9
Prefer not to say	1	0.3	3	1.6	0	0	0	0	4
Age									
18-24	28	9	15	8	25	6	71	14	139
25-34	49	16	17	9	93	22	104	20	263
35-44	47	16	15	8	94	22	120	23	276
45-54	38	13	20	11	40	10	65	13	163
55-64	35	12	43	23	62	15	52	10	192
65+	103	34	78	41	107	25	103	20	391
Income									
Less than $25K	71	23.7	41	21.7	101	24	133	25.8	346
$25,000 - $49,999	82	27.3	56	29.7	109	25.9	148	28.7	395
$50,000 - $74,999	53	17.7	39	20.6	73	17.3	86	16.8	251
$75,000 - $99,999	22	7.3	18	9.6	55	13.1	64	12.4	159
$100,000 - $149,999	47	15.7	24	12.6	56	13.3	46	8.9	173
$150,000 or more	11	3.7	6	3.2	25	5.9	15	2.9	57
Prefer not to say	14	4. 7	5	2.6	2	0.5	23	4.5	44
Education									
Some High School	7	2.3	5	2.7	12	2.9	19	4	43
High School Graduate	66	22	40	21.2	102	24.3	159	31	367
Some College	58	19.3	47	24.9	74	17.6	133	26	312
2 Year Degree	37	12.3	26	13.8	71	16.9	75	14	209
4 Year Degree	80	26.7	45	23.8	111	26.4	96	19	332
Graduate/Professional Degree	51	17	25	13.2	50	11.9	31	6	157
Race[a]									
White	231	77	158	83.6	325	77.2	372	72.2	1163
Am, Indian/Native American or Alaska Native	14	4.7	6	3.2	5	1.2	24	4.6	49

Native Hawaiian or Other Pacific Islander	1	0.3	1	>1	3	1	5	1	10
Black or African American	37	12.3	16	17.9	63	15	78	15.1	194
Asian	12	4	3	1.5	20	4.7	23	4	58
Hispanic	43	14.3	25	13.2	46	10.9	87	16.9	201
Other	8	2.7	6	3.2	14	3	24	5	52
Prefer not to say	3	1	2	1	3	1	7	1	15
Residence Type									
Farm in Rural Area	7	2.3	16	8.5	11	2.6	19	3.7	53
Downtown area in city or town	38	12.7	13	6.9	33	7.9	30	5.8	114
Rural area, not a farm	48	16	51	27	78	18.5	122	23.7	299
Urban or suburban area outside of city limits	154	51.3	77	40.7	221	52.5	243	47.1	695
Subdivision in a town or city	53	17.7	32	16.9	78	18.5	101	19.7	264

[a]Race totals do not equal 100% due to the option to choose multiple.

RO3: Describe the identified audience segments' beef consumption frequency

To inform communication, it is important to understand how often each segment consumes beef. Below, we present the beef consumption frequency for each identified cluster group (Table 4). Most respondents in each group consumed beef 1-2 days per week. A chi-squared test did not indicate statistically significant differences between groups, $X^2(9) = 15.94$, $p = .07$. Group 2 contained the most respondents who consumed beef 5-6 days per week ($n = 31$; 16.4%). Group 1 contained the most respondents who never consume beef ($n = 43$; 14.3%).

Table 4

Crosstabs of Beef Consumption Frequency by Cluster (N = 1,425)

	Cluster 1 (*n* = 300)		Cluster 2 (*n* = 189)		Cluster 3 (*n* = 421)		Cluster 4 (*n* = 515)	
	f	%	*f*	%	*f*	%	*f*	%
Never	43	14.3	13	6.9	32	7.6	42	8.2
1-2 days per week	133	44.3	90	47.6	204	48.5	251	48.7
3-4 days per week	92	30.7	55	29.1	123	29.2	151	29.3
5-6 days per week	32	10.7	31	16.4	62	14.7	71	13.8

RO4: Describe the identified audience segments' preferred communication sources.

To inform strategic communication to the audience segments, we also sought to understand the respondents preferred communication sources (Table 5). Understanding who and from where the audience seeks out information regarding agricultural products is important to delivering information strategically about climate-smart beef and agriculture.

Table 5

Cluster Memberships Preferred Communication Sources (N = 1,425)

	Cluster 1 (*n* = 300)		Cluster 2 (*n* = 189)		Cluster 3 (*n* = 421)		Cluster 4 (*n* = 515)		F		
	M	*SD*	M	*SD*	*M*	*SD*	*M*	*SD*	(3,1424)	*p*	h^2
EPA	**4.00**	1.06	2.15	1.19	3.84	1.13	3.07	1.02	153.84	<.001	0.25
FDA	3.98	1.02	2.44	1.24	**3.91**	1.05	**3.15**	0.98	125.54	<.001	0.21
Univ. Scientists[b]	3.85	1.11	2.35	1.20	3.70	1.14	2.95	0.98	110.66	<.001	0.19
Gov. scientists[c]	3.81	1.07	2.03	1.12	3.72	1.14	3.03	1.02	141.58	<.001	0.23
Television News	3.64	1.09	2.30	1.11	3.55	1.18	2.96	1.02	81.50	<.001	0.15
Gov. press and press conferences	3.52	1.19	2.04	1.14	3.43	1.20	2.84	1.05	87.79	<.001	0.16
Websites	3.49	1.23	**2.74**	1.34	3.51	1.24	3.04	1.07	27.72	<.001	0.06
Newspapers	3.46	1.21	2.19	1.14	3.37	1.28	2.93	0.98	61.03	<.001	0.11
Industry scientists[d]	3.25	1.30	2.11	1.11	3.48	1.20	2.87	0.97	71.07	<.001	0.13
Local officials	3.20	1.30	2.53	1.21	3.42	1.27	2.88	1.03	31.17	<.001	0.06
Radio news	3.08	1.30	2.21	1.16	3.21	1.23	2.86	1.02	33.98	<.001	0.07
Friends, family, and neighbors	3.07	1.41	2.25	1.24	3.54	1.29	2.93	1.04	35.33	<.001	0.07
Medical doctors	3.06	1.42	2.16	1.16	3.19	1.39	2.91	1.08	30.63	<.001	0.06
Family doctors	2.93	1.42	2.17	1.17	3.16	1.38	2.91	1.12	26.42	<.001	0.05
Blogs	2.86	1.46	2.13	1.22	3.01	1.42	2.75	1.11	20.65	<.001	0.04
Facebook	2.65	1.48	1.79	1.08	2.84	1.50	2.75	1.20	29.10	<.001	0.06
Twitter	2.54	1.49	<u>1.72</u>	1.06	2.71	1.49	<u>2.49</u>	1.15	24.97	<.001	0.05
Instagram	2.50	1.50	1.78	1.10	2.75	1.51	2.62	1.10	24.73	<.001	0.05
TikTok	2.46	1.49	1.72	1.07	<u>2.61</u>	1.50	2.58	1.20	22.13	<.001	0.05
Influencers	<u>2.45</u>	1.45	1.79	1.13	2.71	1.45	2.61	1.15	23.47	<.001	0.05

Note. **Bold** represents the highest mean for that cluster. <u>Underlined</u> represents the lowest. Aggregate scores based on question stem 'when seeking out information about animal agriculture, I seek out the following sources' with Likert scale options of 1 = *Strongly disagree,* 2 = *Somewhat disagree,* 3 =*Neither agree nor disagree,* 4 = *Somewhat agree*, and 5 = *Strongly agree*.

[b]Refers to academic scientists, University Researcher, and Extension Agents (i.e., University faculty, County Extension Agents)

[c]Refers to government scientists (scientists who work for governmental agencies such as the USDA)

[d]Refers to industry scientists (scientists who work for for-profit organizations such as Bayer, Pfizer, Tyson, Cargill, etc)

Our results indicated the audience segments, or clusters, had differing opinions of preferred information about animal agriculture and production. Cluster 1, Cluster, 3, and Cluster 4 most preferred to receive information from governmental sources such as the EPA, FDA, and University Scientists. However, their level of agreement toward these sources being their preferred sources of information varied. Specifically, Cluster 1 and Cluster 3 overall agreed that they preferred information from the EPA (Cluster 1: $M = 4.00$; Cluster 2: $M = 3.84$), FDA (Cluster 1: $M = 3.98$; Cluster 2: $M = 3.91$), and University Scientists (Cluster 1: $M = 3.85$; Cluster 2: $M = 3.70$). However, although these sources were the highest for Cluster 3, this group neither agreed nor

disagreed that they would seek out information from the EPA (M = 3.07), FDA (M = 3.15), or University Scientists (M = 2.95).

Cluster 2 was the most skeptical about receiving information about animal agriculture. This audience segment generally neither agreed nor disagreed that they would seek out information about animal agriculture. Specifically, they neither agreed nor disagreed that they sought out information from websites (M = 2.74, SD = 1.34) and local officials (M = 2.53, SD = 1.21); however, they generally disagreed that they sought out information via social media such as Twitter or TikTok (M = 1.72, SD = 1.06), Facebook (M = 1.79, SD = 1.08).

Conclusions, Implications, and Recommendations

The purpose of this study was to identify and describe unique target audiences for educational and strategic communication about climate-smart beef production. Despite multiple calls for audience segmentation beyond demographics (Hine et al., 2014; Runge et al., 2018; Warner et al., 2016), there are limited studies within agricultural education and communication to have conducted audience segmentation to create groups for tailored communication. This process provides an opportunity for communicators and educators to provide human-centered analysis approaches to group populations based on shared needs, characteristics, and opinions (Tuten, 2021), providing a pathway for tailored communication and education techniques specific for each group (Warner et al., 2016). Communication and education *beyond the demographics* are critically important for controversial, or even polarized topics, such as agricultural science innovations and environmental impacts, as information that challenges prior beliefs, values, or interests, has often led to backfire or converse effects (Hine et al., 2014; National Academy of Sciences, 2016, p. 54). Instead, we posit the identification of these subgroups, and their associated characteristics, provides an opportunity for communicators and educators to carefully and strategically understand how to craft their messages.

People are continuously inundated with information constantly – whether it be scrolling on social media, choosing which TV show to watch, or walking through the grocery store. As agricultural science communicators and educators, we must begin to fully understand how to make information salient, so the public pays attention to this information (Fischer et al., 2018; Fischer et al., 2020; Hine et al., 2014). Prior literature has noted varying audience groups have different needs when determining if information is relevant. For example, with agricultural producer audiences, information must be designed to be technical and informative; whereas, with members of the public, information that is designed to be testimonial and narrative in nature is more salient (Fischer et al., 2018). However, despite these calls, limited research has fully described the psychographic belief systems pertaining to agricultural topics. The implications from audience segmentation research provide practitioners and scholars with recommendations on how to communicate with these specific audience groups.

Our psychographic analysis was rooted in recommendations from prior literature pertaining to public perceptions of climate and environmentally friendly behaviors and agricultural production practices. The variables selected for the audience segmentation focus on understanding and examining shared perspectives of climate change (Bostrom et al., 2013; Detenber et al., 2016; Hine et al., 2014; Maibach et al., 2009; McCright et al., 2016), political ideology (Arbuckle, 2016; de Leon et al., 2020; Merkley & Stecula, 2021; Trudel, 2019), trust in science (Cologna & Siegrist, 2020; Happer & Wellesley, 2019), and beliefs toward the beef industry's impact on the climate (Burnier et al., 2021; Gosnell, 2021). By understanding how individuals *group together* based on these beliefs and perspectives, we can later design communication messages that align or are congruent to common belief structures and disseminate the messages from their most trusted sources.

While we did not experiment with messages and therefore cannot state what messages are the most effective, the results of this study provide potential best practices for reaching and connecting with tailored audience segments based on the psychographic groupings. Our conclusions are based on our findings and the prior literature stating that identifying and describing target audiences is the first step to developing compelling messages (Grunig, 1989; Maibach et al., 2009; McCright et al., 2016; Warner et al., 2016). Thus, the results from our study can guide the development and design of messages from agricultural educators, communication practitioners, and Extension interested in fostering positive public perceptions of climate-smart beef practices and products.

Respondents in Cluster 1 were the most politically liberal and had the highest levels of climate change concern and trust in science. They had the second highest level of perceived environmental responsibility of the beef industry and the highest level of those who never eat beef. Therefore, we named this group "Beef? No, thanks." This cluster had a favorable attitude toward sustainable food products and preferred information from government scientists and agencies (e.g., EPA, FDA). Due to the low levels of beef consumption in this group, but the high levels of climate change concern and perceived environmental responsibility of the beef industry, perhaps this group would be compelled by learning about the ongoing sustainability efforts in the industry. This group may purchase beef labeled as climate-smart due to their favorable attitude toward sustainable food products but may be considered the most difficult-to-budge market due to their low meat consumption.

Cluster 2 contained the most conservative respondents who had the lowest levels of climate change concern, trust in science, and environmental responsibility of the beef industry. This group consumed beef the most frequently (5-6 days a week for 16% of these respondents), so we named them "Beef or bust."They also had the least favorable attitude toward sustainable food products. This group indicated they were the least likely to seek out information about sustainability practices. Because of this group's high level of beef consumption and low levels of trust and environmental concern, they may not need communication intended to increase beef consumption and should not be met with communication containing *climate change* less risk adverse message effects (Chinn & Hart, 2021). Future research should investigate whether this audience group has a favorable attitude towards climate-smart beef products if labeled this way.

Those in Cluster 3 were politically moderate, were concerned about climate change, trusted science, and had the highest level of perceived environmental responsibility of the beef industry. Respondents in this group were most likely to eat beef 1-2 days a week and had the highest positive attitude toward sustainable food products of any cluster. Like cluster 1, they preferred communication from government scientists and agencies (e.g., FDA, EPA). Due to this group's high level of perceived environmental responsibility of the beef industry, they should be a prime audience for communication intended to educate about ongoing sustainable efforts, particularly those funded by government agencies like the USDA. Based on their positive attitude toward sustainable food and moderate beef consumption, Cluster 3 should be an audience of priority for strategic communication. Because of this, we named this group the "Environmentally conscious beef eaters. A prime audience."

Cluster 4 was composed of those who were politically moderate, had moderate concern about climate change, moderate trust in science, and moderate perceptions of environmental responsibility of the beef industry. This group tended to eat beef 1-2 days a week and had a relatively positive attitude toward sustainable food products. They too preferred communication from government scientists and agencies. Because this group was rather neutral for each category,

it represents the *moveable middle* of an audience, or those without rigid preconceptions. Because of this and their moderate views, we named them "Moo-vable, moderate middle." In line with this thinking, this was the largest group, suggesting most respondents have moderate perceptions and a relatively positive attitude toward sustainable food products. This group is *moveable* in the sense that those without hardened viewpoints are more likely to centrally engage with a message and perhaps change their perception. It should be encouraging that should blanket messages need to be delivered to the general public, our findings suggest most people will be in this category. Messages for this group should educate recipients on the positive ongoing sustainability efforts within the industry, such as the adoption and incentivization of climate-smart beef production practices and their impacts, as well as the relatively low emissions of American beef production compared to other countries. Table 6 summarizes the distinct characteristics of each group and potential pathways forward for communication.

Table 6
Summary Table of Group's Defining Characteristics & Recommended Communication Strategies

Cluster Number	Group Name	Description	Communication Recommendations
1	Beef? No, thanks.	This group was the most concerned about climate change, politically liberal, urban, and had the highest level of trust in science, with their most trusted sources being the EPA and FDA. They also ate the least beef of any group.	Due to this group's low beef consumption, we recommend this as a low-priority audience. However, they may trust communication from government agencies showcasing beef sustainability efforts.
2	Beef or bust.	This group was the smallest, most politically conservative and rural group. They had the lowest levels of climate change concern and were very distrusting of science. They ate the most beef of any group and trusted websites and local officials for information.	Due to this group's high level of beef consumption and low level of climate change concern, we recommend this as another low-priority audience.
3	Environmentally conscious beef eaters. A *prime* audience.	This group was concerned about climate change, trusting of science, and had the highest level of perceived environmental responsibility of the beef industry. They also trusted the EPA and FDA as sources. They tended to eat beef 1-2 days a week and had the most positive attitude toward sustainable food products.	Due to this group's high levels of climate concern and perceived environmental responsibility of the beef industry, they may be a prime audience for climate-smart beef communication and products. Communication should be science-focused from trusted scientific sources and highlight the environmental benefits of purchasing beef produced this way.
4	*Moo-vable*, moderate middle.	This group was the largest and most moderate but tended to eat beef 1-2 days a week. They trusted the FDA and websites for information.	Due to this group's large size, moderate perceptions, and tendency to eat beef, we recommend "catching them early" with climate-smart beef communication showcasing the positive impacts of climate-smart production. They trusted a variety of sources and may be effectively targeted through online messaging or government correspondence.

Recommendations for Future Research

This study serves as an exploratory, descriptive effort to identify and describe unique target audiences for climate-smart beef production education and communication. The natural next steps for this line of inquiry would be to experiment with messages tailored to each group to understand the effect of message characteristics on likelihood or intent to purchase climate-smart beef products. Due to the novelty of the market and research in this area, it will remain to be determined if consumers will have more positive trust toward climate-smart beef production practices or if they will pay more for beef produced this way, which has shown to come with an increased production cost (de Souza et al., 2017). However, this study provides foundational work to inspire agricultural industry organizations to communicate with members of the public more strategically about climate-smart production practices. Therefore, we recommend further research examine effects of communication and educational materials framed toward these audience segmentation groups.

Audience segmentation is a technique thoroughly explored in traditional marketing and advertising realms; however, studies in agricultural education and communications have traditionally only segmented groups based on demographic characteristics such as age, generations, and income levels. However, the scientific community has long called for audience segmentation toward scientific topics (National Academy of Sciences, 2016), and scholars have conducted this technique in climate change (Hine et al., 2014) and toward trust in science as a whole (Runge et al., 2018). However, this is the first study of our knowledge that has applied this technique of human-centered cluster analysis to an agricultural science topic. We recommend further segmentation of a variety of agricultural topics to continue to understand perspectives.

In addition to the aforementioned proposed research ideas, we also propose modifications to the current scales and questions. For example, one limitation of the study was the methods to which the frequency of beef consumption was asked. In the current study, we did not ask questions regarding how many times per month beef was consumed. However, for future research, we recommend a more nuanced approach to asking this question with scale items for options with 1 time in the past month, 2-3 times in the past month, 1 time per week, 2 times per week, 3-4 times per week, 5-6 times per week, 1 time per day, and 2 or more times per day. Additionally, although multiple trusted information sources were used, it would be appropriate to evaluate the level of trust for commodity organizations such as National Cattlemen's Beef Association, Certified Angus Beef, and the United States Department of Agriculture.

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