From Producer to Consumer: Sustainability in the U.S. Beef Industry

by

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Abstract

Sustainability in the livestock industry has been a significant focus in recent years, specifically in areas of environmental impact and animal welfare. Research into consumer perceptions of food systems is important so the industry has more information to make production and marketing decisions. It is also important to consider the beef producers' perspectives regarding on-farm sustainable applications and management practices. Two unique studies were conducted to evaluate perceptions and opinions on sustainable beef production. The beef producer study included an IRB approved online survey with 36 questions that was distributed to Alabama beef producers from July to November 2024. Questions probed producer opinions on the importance of resources and their views about environmental impact and sustainability, knowledge of Climate-Smart Commodities programs, implementation of certain sustainable practices, and what resources are considered necessary for their operation to adopt and/or further improve sustainability practices. A total of 105 primarily cow-calf producers from 42 of the 67 counties in Alabama had varying implementation rates (~9-90%) of practices that can increase sustainability and resource management, specifically grazing management plans, growth-promoting technologies, and animal handling and welfare training. A recurring theme was the need for further information before producers made decisions regarding investing in certain sustainable practices. Providing producers with financial information or counseling on decision making could increase the adoption of sustainability practices. Extension educators may use results from this research to guide development of financial advisory programming and sustainability resource management information for producers. The consumer study used infographics as a mode to deliver information about the beef industry. These communication devices are effective in visually informing audiences and simplifying the messages; however,

there is not a large body of literature on infographic use in agricultural education. An IRB approved Qualtrics survey gathered participants' beef purchasing and consumption habits, their subjective and objective knowledge about resource usage, and their prioritization of sustainability issues to address. Participants then rated their agreement with statements about sustainability, grass-fed and conventional cattle, and hormone use. After viewing three infographics, they were reassessed on the same questions to determine any changes in opinions or knowledge. Results showed a significant increase in self-reported knowledge ($p < .001$) and positive increases in opinions and agreement on statements about sustainability in the beef industry ($p < .001$). Those who do not eat beef had smaller but still significant increases in both metrics. Participants expressed lingering doubt about the hormone information and the possible over- or underinflation of statistics represented. Further research could include more specific infographics focusing on fewer topics to decrease information load and integrating more interactive elements into the infographics themselves to increase participation and interaction. Overall, results from these studies provide more insight into the beef producer and consumer opinions on sustainability and data to encourage further communication and research initiatives to bridge the knowledge gap between these two segments in the beef industry.

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LITERATURE REVIEW

Introduction

Sustainability in agriculture is a key priority for producers, consumers, and other stakeholders in the industry. The United Nations projects that the global population will reach 9.7 billion and 10.4 billion by 2050 and 2100, respectively (United Nations, n.d.). In parallel with this estimated population growth, the Food and Agriculture Organization expects an associated 70% increase in demand of commodities like meat, milk, and eggs (Capper & Hayes, 2012). This growing population will require more food than what is currently produced, and it has been suggested that focusing on increasing animal protein production can aid in food security (Adesogan et al., 2020).

There is, however, a balance between producing this increased quantity of food while also maintaining the environment and natural resources required. Agriculture puts a strain on land, water, and fossil fuels, and it is also blamed for biodiversity loss and major environmental deficits (de Olde & Valentinov, 2019). The animal production industry, specifically beef production, receives blame for global warming and greenhouse gas emissions in the media cycle. The beef industry has been referred to as the most environmentally unsustainable animal production system compared to other major livestock production systems (Poore & Nemecek, 2018). With an increased critical view of animal agriculture's role in greenhouse gas emissions, land and resource usage, animal welfare, and the social well-being of society, agriculture needs to adapt to the changing physical and social environment to produce enough food to feed the world (Eise & Foster, 2018).

The United States and Alabama Beef Industries

The United States has the biggest fed-cattle industry in the world, and the beef industry is its most important agricultural industry with the largest share of cash receipts every year (USDA ERS, 2023ab). As of January 1, 2024, there were 87.2 million head of cattle and calves in the United States, with the average beef cow herd approximately 47 head (USDA NASS, 2024ab). The top-producing states in 2023 in terms of cattle inventory were Texas, Nebraska, Kansas, California, and Oklahoma (USDA NASS, 2024b). The cattle industry utilizes 655 million acres of grazing land with ~770,000 beef cattle production businesses (Bigelow & Borchers, 2017). Cattle production was forecasted to represent 17 percent of the $520 billion in total cash receipts from agricultural commodities at the end of 2023 (USDA ERS, 2023b).

The beef industry is an integral part of the Southeastern United States' agricultural identity and economy. In the state of Alabama, there were 638,000 head of beef cows and 1,170,000 head of all cattle and calves as of January 2024 (USDA ERS Southern Region, 2024). According to the 2022 Census of Agriculture, of the 37,362 farms in Alabama, 18,284 had cattle and calves with 17,071 farms having beef cow inventory reported (USDA NASS, 2024). In 2022, Alabama's cattle industry was worth $2.5 billion (Alabama Cattlemen's Association, n.d.). Cattle are raised in every county, and the top-producing counties are Dekalb County, Cullman County, Chambers County, Marshall County, and Montgomery County (USDA ERS Southern Region, 2024). Alabama is primarily a cow-calf state, and it relies on forage-based systems as the climate allows for grazing almost year-round (Alabama Cattlemen's Association, n.d.).

The industry is usually simply separated into two production sectors: the cow-calf sector and the cattle feeding sector, but there are more sectors throughout the food chain. These include the seedstock sector, cow-calf (including stocker-backgrounder), feedyards, auction market,

packers and processors, retail and food service, and allied industries (USRSB, 2019; USDA ERS, 2023b). Each sector plays an important role in producing high-quality protein.

The cow-calf sector comprises of operations that have a permanent herd of beef cows for raising calves and retaining some breeding animals to continue production (USDA ERS, 2023b). Animals that are not kept for replacement animals are weaned and enter stocker operation and graze for 3 to 4 months before going to a feedlot. They could also be backgrounded for 90-120 days to acclimatize to silage and other foodstuffs to prepare for the feedlot (USDA ERS, 2023b). Feedlots are the final stage of cattle production where steers and heifers are fed out on a ration of grain, silage, hay, and protein supplements to reach a desired slaughter weight and quality. Cattle feeding operations are in multiple regions of the country, but most of these operations are in the Great Plains region where the land isn't ideal for crop production (USDA ERS, 2023b).

Sustainability and Sustainable Beef

There are many variations of the definition of sustainability and sustainable agriculture. Sustainable agriculture is legally defined in U.S. Code Title 7, Section 3103:

> The term "sustainable agriculture" means an integrated system of plant and animal production practices having a site-specific application that will, over the long-term—
>
> (A) satisfy human food and fiber needs;
>
> (B) enhance environmental quality and the natural resource base upon which the agriculture economy depends;
>
> (C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
>
> (D) sustain the economic viability of farm operations; and

(E) enhance the quality of life for farmers and society as a whole

(7 U.S.C. § 3103, 2018).

Sustainability not only focuses on the environmental footprint, but also on economic prosperity and the workers and communities of the industry. Agriculturalists focus on more than maximizing productivity and profitability; industry goals now focus on optimizing across a far greater spectrum of production, rural development, environmental, social and food consumption outcomes (Bos et al., 2013). More specific goals of sustainable agriculture include increasing profitable farm income and contributing to the quality of life of agriculture producers while simultaneously increasing production to meet rising demand for food and fiber (USDA NIFA, n.d.). Sustainability can be simplified into three key parts: social responsibility, economic viability, and environmental stewardship (NCBA, n.d.). This three-pillar model is frequently used in industry and academic resources to visually and concisely explain how sustainability looks in the beef industry (Purvis et al., 2018; Smith et al., 2024) . The U.S. Roundtable for Sustainable Beef (USRSB) incorporates this in the definition of sustainable beef, which is a "socially responsible, environmentally sound and economically viable product that prioritizes planet, people, animals and progress" (USRSB, 2019). The availability of beef, and by extension all meat products, is essential for achieving a sustainable future both economically and environmentally while also contributing much to livelihoods and social well-being globally, showing the interconnectedness of the pillars of sustainability are important to achieve this goal (Ederer et al., 2023)

Three Pillars of Sustainability: Economic Viability

Any progress towards a fully sustainable system cannot happen if producers cannot stay in business and maintain profitability. A study by McKinsey & Company, a strategy and

management firm based in New York City, found that 90% of farms are aware of sustainable practices. However, their adoption of them is relatively low (Fiocco et al., 2024). Those who are adopting sustainable farming practices are only doing so on less than 30% of their acreage, and smaller operations are more likely to face challenges adopting these practices (Fiocco et al., 2024). It is important to realize that the environmental impact of implementing certain sustainable practices is not enough for producers to adopt; economic viability needs to be kept at the forefront (Briske et al., 2020; Elanco, 2023; Smith et al., 2024). Keeping in mind that economic viability is paramount to producers, possibly the most influential way to get them to adopt sustainable practices is by giving them the information and tools to understand the financial benefits of these practices (Baumgart-Getz et al., 2012; Elanco, 2023).

Other aspects of the economic pillar include improving rural economies and keeping beef affordable (NCBA, n.d.). Forty-six million Americans reside in rural areas, and this is 14% of the country's population (Dobis et al., 2021). Agriculture aids in food security and provides many jobs to rural areas of America; a significant portion of rural communities depend on agriculture to support their economies (Gowda et al., 2018). Agriculture, food, and related industries accounted for 10.4% of U.S. employment in 2022, which equates to over 22 million jobs (USDA ERS, n.d.). There are a variety of careers within the beef industry. From on-farm labor and veterinarians to accountants and social media managers at beef sales companies, the industry employed over 1.6 million Americans in 2023 (IBISWorld, 2024). A 30,000-head feedlot usually requires at least 29 full-time employees, but this direct employment is not the only economic impact (Guerrero et al., 2013). Other areas of the supply chain, such as slaughtering and processing, feed companies, and consulting services, support the industry through employment and further economic activity (Guerrero et al., 2013).

Besides the economics of producers, the availability, affordability, and acceptability of beef to consumers are also important. On a global scale, approximately 3 billion people are unable to afford nutritionally adequate food, and this is mostly due to the high costs of proteins (Ederer et al., 2023). There is also a disparity of meat availability between countries and socioeconomic segments. Providing enough animal proteins to fulfill the global nutrient requirements proves to be a continuing challenge, and this dimension highlights an intersection of economic viability and social responsibility.

Three Pillars of Sustainability: Social Responsibility

Social responsibility is the least understood pillar of sustainability, but awareness around this dimension has increased (Saleh & Ehlers, 2023). In an integrative literature review, Gosnell et al. (2021) identified six social sustainability themes: human health, learning and adaptation, community relations, land ownership, tenure, and succession, and industry structure. These authors add that the variability of these terms is not sufficient enough to fully define or describe social sustainability (Gosnell et al., 2021). Saleh and Ehlers (2023) further said that social sustainability in farming is difficult and almost impossible to define a full understanding or single definition because there are differences in the acceptability of working conditions, social and professional relationships, and cultural traditions.

Gosnell et al. (2021) also stated that social sustainability is defined by the "conditions of social well-being for all those impacted by it." Ensuring "socially sustainable conditions" for the producers and animals involved in the beef industry could include transparency with business practices, understanding stakeholder wants and interests, and ensuring workers are paid fairly, and focusing on worker safety and animal welfare (American Society for Quality, n.d.; NCBA, n.d.). Within that definition from Gosnell et al. (2021), the consumer side of social responsibility

connects to economic viability with a focus on consumer acceptability. For beef to remain economically viable, consumers need to continue purchasing it, so beef production needs to consider consumers' desire for food safety, security, quality, access, affordability, and also animal welfare dimensions (Croney & Swanson, 2023).

Drovers, a magazine owned by Farm Journal, publishes a yearly State of the Beef Industry Report. It includes analyses of cattle numbers and production trends with respect to the cattle cycle, and it also includes surveys of beef producers about various topics. The reports in 2023 and 2024 had similar results in their questions relating to five aspects of consumer pressure and expectations for change in the future: environmental impact, animal welfare, sustainable practices, and desire of high-quality beef (Speer, 2024). For each scenario, the majority of producers either agreed or strongly agreed that each of those items will be of increasing importance in the coming years. In the author's words, "The survey report summarizes it succinctly: 'Producers foresee continued industry change ahead, mostly driven by consumer pressure'" (Speer, 2024)

The National Cattlemen's Beef Association (NBCA) has programs like Beef Quality Assurance (BQA) that educate producers on workplace safety and animal welfare. Resources and templates include guidance on antibiotic use, trailer load capacity, and inventory logs to keep track of medications and vaccines. The BQA Manual also includes chapters specifically about worker safety and emergency action planning to give producers tools to keep workplaces and employees safe and prepared (NCBA BQA, 2019).Working with animals in any capacity carries inherent risks. Cattle are large animals, and if mishandled can lead to serious injuries. The most frequent injuries include cattle striking, trampling, goring, and kicking workers (Whitworth, 2024). Equipping all employees in contact with live animals with the knowledge of how cattle

behave and react to stimuli can greatly increase workplace safety. Furthermore, maintaining clean, well-lit facilities with functional gates and other equipment can decrease the risk of animals or employees slipping or injuring themselves on broken or out of place equipment (NCBA BQA, 2019).

Research in the U.S. and globally continues to learn how producer perspectives tie the social aspect to their operations (Klopatek et al., 2022; Casagranda et al., 2023; Smith et al., 2024). Animal welfare continues to be a top priority for beef producers, and further training and communication initiatives could help improve animal welfare and strengthen consumer trust in the industry (Edwards-Callaway & Calvo-Lorenzo, 2020; Smith et al., 2024).

Three Pillars of Sustainability: Environmental Stewardship

The third pillar, environmental stewardship, is arguably the most focused area of sustainability by the government, industry, and consumers. In fact, consumers tend to consider the environmental aspect as the most important or main element of sustainability, possibly because that is what most advertisements and labels focus on (Peano et al., 2019). Agricultural corporations and organizations are making efforts to market their environmental initiatives to consumers. For example, Tyson Foods has committed to improving multiple environmental metrics by 2030, including fully recyclable or reusable packaging on all products, using at least 50% renewable energy sources, and an aim to purchase all feed ingredients from producers engaging in climate-smart practices (Tyson Foods, 2023).

Environmental goals in the beef industry include air quality, water quality and management, and grazing land management (USRSB, 2019). Each of these environmental goals and metrics look different in each segment. For example, grazing management plans are a large

component of land and water management for cow-calf operations but not for the feedlot or retail sector.

Grazing and Resource Management

The USRSB Framework's land management goals at the cow-calf level include having 365 million acres under a written grazing management plan by 2050 (USRSB, 2019). Grazing management plans are "comprehensive frameworks designed to address resource concerns on grazing lands through conservation strategies and projects, aiming for sustainable grazing practices that include forage yield improvement, wildlife habitat maintenance, and the enhancement of species diversity and water systems" (Tang et al., 2024). Principles of grazing management include using a written grazing plan, optimizing stocking rate, evaluating distribution, practicing adaptive management, prioritizing ecological health, understanding that welfare begets performance, and "thinking beyond the range," which means recognizing external stakeholders and their interests (Jablonski et al., 2024). Rotational grazing systems and intensifying gazing systems by diversifying plant species are examples (Campbell & King, 2022). Overgrazing could lead to loss of soil carbon, so grazing management aims to increase soil carbon sequestration and soil health (Mosier et al., 2021; Stanley et al., 2024). Mosier et al. (2021) conducted an on-farm study on multi-paddock grazing that showed they had 13% more soil carbon and 9% more soil nitrogen compared to conventionally grazed paddocks, providing more evidence that grazing management can sequester soil carbon, retain soil nitrogen, and could contribute to mitigating climate change.

Water management plans are also an important resource management tool in all sectors of the industry. Resource management practices' benefits extend past environmental protections; many rural areas that rely on agriculture as its largest economic support also tend to experience

limited water resources, so ensuring water efficiency supports food security along with economic stability and environmental sustainability (Yadav et al., 2024). There are many resources on how to achieve more sustainable production; as mentioned above, using BQA protocols for animal welfare and worker safety can help on the social responsibility pillar, the USRSB Framework provides metrics for sustainability at all levels of the industry.

Approximately 95% of producers said land conservation is extremely important, and 86% said that they manage their operations in a way that protects natural resources, wildlife, and biodiversity. (NCBA, 2017). The cow-calf sector can greatly benefit from a written grazing management plan because it can improve ground cover resources and root systems, reduce soil erosion and runoff, and increase the carrying capacity of pasture (USRSB, 2019).

Growth (and Productivity) Enhancing Technologies

Whether it is a cow-calf farm or a feedlot, advances in grazing management, nutrition, reproduction and genetics, and production technologies have allowed the U.S. beef industry to produce more meat with fewer inputs and cattle. Technologies such as these are also referred to as productivity-enhancing technologies (PETs) or growth-enhancing technologies (GETs). These include growth promotants like growth hormones, feed additives such as ionophores, and beta-adrenergic agonists. Other technologies include genetics and management strategies. To continue a successful and profitable beef industry, it is important to improve productivity and demonstrate the commitment of the industry to sustainability (Capper & Hayes, 2012). A study by Stackhouse-Lawson et al. (2013) also noted that increasing animal productivity can reduce the environmental impact per unit of consumable product and is considered the most promising and sustainable reduction technique to meet the growing demand for high-quality protein.

Growth promotants have been used extensively in the cattle industry for the better part of the last century. They increase feed efficiency, average daily gain (ADG), and muscle leanness (Johnson and Beckett, 2014). The most commonly used growth promotants in the beef industry are anabolic steroid hormone implants. These implants are small pellets that are injected into the middle third of the ear between the skin and cartilage. The product is inside a matrix, which is usually compressed or silicon rubber. The product is slowly released into the blood, and depending on the type of implant, the payout is anywhere from 60-200 days and increases levels of somatotropin and insulin-like growth-factor 1 (Stewart, 2013; Beck et al., 2022). This causes increased muscle protein synthesis, which in turn can increase ADG by 10-30% and carcass weight 5% heavier when used in the feedlot (Preston, 1999; Duckett & Pratt, 2014; Strydom, 2016).

Growth promotants can be used in many stages of production, from nursing, stocker, to feedlot, and an animal is able to have up to three implants during its lifetime (Stewart, 2013). There is also no FDA mandated withdrawal period for implanted cattle, and approximately 90% of feedlot cattle have or have had an implant (Stewart, 2013; USDA APHIS, 2013). Stackhouse-Lawson et al. (2013) mention that anabolic implants net the largest improvements in animal performance.

Feed additives in the cattle world that can improve production levels, efficiency, and animal health (Parish & Rhinehart, 2018). Many feed additives are non-nutritive compounds that positively affect the rumen (Strydom, 2016). Cattle are ruminants, meaning they have a four-chambered stomach. The rumen is the largest part of the digestive tract, and it acts as a fermentation vat. With millions of microbes aiding digestion, cattle and other ruminants can digest materials that monogastric animals cannot, such as corn stalks and grass. Feed additives

aim to improve rumen function and digestibility, increase microbial protein synthesis, and reduce the occurrences of metabolic disorders like diarrhea and bloat (Strydom, 2016).

Feed additives can include medications, such as antibiotics, antimicrobials, and antiparasities. Unmedicated additives include probiotics and prebiotics, which are commonly used in many people's supplemental routines; enzymes, phytogenics, and even essential oils are also supplemented in cattle feed (Beck & Biggs, 2022). Non-medicated feed additives can help address consumer concerns about production practices in the industry, such as the use of antibiotics and greenhouse gas emissions (Beck & Biggs, 2022). Since the rumen is also the most important part of the digestive system, focusing on rumen management will improve feed efficiency and animal health (Strydom, 2016). Many producers choose to include feed additives for growth in their cattle's diets, as there is usually a 10% improvement in growth rate and feed efficiency compared to those animals not given growth additives (Gadberry, 2015).

Beta adrenergic agonists are growth promotants that bind to β-adrenergic receptors on cell membranes to mimic the effects of norepinephrine and epinephrine (Strydom, 2016). Ractopamine chloride (RC) and zilpaterol chloride (Z) are popular beta agonists that mimic adrenaline to cause the body to direct nutrients and energy to muscle tissues, which in turn increases muscle fiber size and meat yield (Parish & Rhinehart, 2018). Using beta agonists in the last 20 to 40 days in the feedlot can have drastic increases on carcass weight and muscle yield, and there is only a 3-day withdrawal period for Z and no withdrawal for RC (Smith et al., 2019; Davis & Belk, 2018; Lean et al., 2014, as cited in Aboagye et al., 2021). Since beta agonists and ionophores "alter microbes in the rumen and increase nitrogen retention in the animal, [it may also] lead to changes in greenhouse gas, volatile organic compound, and ammonia emissions from feedlot cattle" (Stackhouse-Lawson et al., 2013).

Ionophores are compounds derived from *Streptomyces* fermentation (Strydom, 2016). Ionophores work to improve rumen efficiency by reducing the methane production and decreasing the acetate to propionate ratio (Strydom, 2016). They alter the fatty acids created in the rumen and allow for more undigested protein to enter the intestines for absorption (Parish & Rhinehart, 2018). Ionophores also improve nitrogen utilization in the rumen, and overall enhance microbial protein synthesis (Strydom, 2016.) Products like monensin, lasalocid, and salinomycin are available for use in beef cattle. Monensin is the most used ionophore and is classified as a polyether antibiotic. In a study by Duffield et al. (2012), monensin improved growth efficiency by 6.4% and ADG by 2.5%. It also controls coccidiosis and has no withdrawal time, meaning that the animal does not need to be off the medication a specified amount of days before slaughter (Gadberry, 2015).

These technologies are incredibly helpful to beef producers, as they can reduce the cost of production and therefore improve efficiency. PETs do not come without stipulations, however. All growth-promoting implants and medicated feeds are regulated by the FDA. There are also clear feeding and usage instructions that producers need to follow in order to ensure a safe and acceptable product. Growth promotants mentioned in the previous paragraphs go through FDA reviews and testing to make sure they are safe to use in animals and in the food chain (Johnson & Beckett, 2014). Some of the medicated feeds mentioned above are considered antibiotics, and consumers and some in the industry worry about the subtherapeutic overuse of antibiotics causing resistance. Many countries have banned the use of certain antibiotics since they are also used to treat humans (Aboagye et al., 2021). There are no established connections between antibiotic use in livestock and antibiotic resistance in humans or human medicine (Gadberry, 2015), but the FDA now requires Veterinary Feed Directives (VFDs) to control and record the

use of antibiotics in animals. Producers and feed manufacturers cannot use certain medicated feed without a written prescription from a veterinarian.

Implants are also regulated by the FDA. There has been some worry about added hormones in meat products, with more brands marketing their beef, chicken, and pork as "hormone-free." There are a few rebuttals to this claim and evidence to ease their worries. Firstly, there is no such thing as "hormone-free" meat, as all animals have hormones, therefore their products cannot be without hormones since they are essential for its production (Stewart, 2013; Blair, 2022). It is more appropriate to claim that a product is without *added* hormones, saying that the animal did not receive any kind of implants or other hormone technologies during its life. To the worry about hormone residue in the meat—referred to as estrogenic activity—there have been numerous studies measuring the estrogenic activity of beef and other popular proteins. If people are worried about the amount of hormones in implanted beef versus non-implanted beef, they would be correct in assuming that the implanted beef has more estrogenic activity, with a 3 oz. serving of beef from an implanted steer containing 1.2 units of estrogenic activity. A 3 oz. serving from a non-implanted steer has 0.85 units. However, compare these to eggs, tofu, and soy flour. A 3 oz. serving of eggs contains 94 units; 3 oz. of tofu has 19,306,004 units, and 3 oz. of soy flour has 128,423,201 units of estrogenic activity. Soy proteins have a significantly higher amount of estrogenic activity than implanted beef, and with the amount of hormones that males (136,000 ng) and females (513,000 ng) produce a day, eating implanted versus non-implanted beef is "relatively inconsequential" (Preston, 1997, as cited in Beck et al., 2022 and Blair, 2022).

PETs and the Environment

There are multiple studies about the use of PETs and the subsequent effects on the environment, including the effects of removing all of these technologies from beef production. People outside the livestock industry may not understand the positive relationship between increased productivity and environmental benefits, and consumers are ignorant of the possible consequences of eliminating all PET use (Capper & Hayes, 2012)

Capper and Hayes's 2012 study wanted to measure the environmental and economic impacts of removing PETs (called GETs in this study). Their study compared a production system using implants and fed hormones, ionophores, and beta agonists, referred to as the conventional system or "CON," and one without the use of GETs, called no technology or "NOT" system. Both systems had cow-calf, stocker, and feedlot sections, and the animals entering those sections from the dairy industry (cull cows and dairy calves) were factored in. Capper and Hayes wanted to show the differences in inputs, outputs, and animals required to produce 454,000,000 kg of beef. This equates to over 1 billion pounds, which is a fraction of the yearly U.S. beef production: 28.3 billion pounds in 2022 (USDA ERS, 2023a).

This study showed improved productivity of the CON system versus the NOT system. They mention the "dilution of maintenance" that refers to individual animals and populations needing lower nutrient requirements to maintain the "vital functions" of the animal. The vital function in the beef cattle is their growth rate. If nutrient requirements are less, then the input resources to raise those animals, such as water, feed, and land, are also lower. The same can be said for the outputs, which are waste, manure, and GHG emissions. Furthermore, the NOT group had lower slaughter weights and dressing percentages, meaning that more animals were required to produce the same amount of beef. Animals in the CON system weighed on average 53 kg

more than those in the NOT system, and this combined with the dressing percentage means that the NOT system would need 385,000 more animals than the CON system to produce the 454,000,000 kg of beef. This almost 12% increase in animals also means a 10.6% increase in feedstuffs and a 10.0% increase in land. Capper and Hayes used the U.S. beef production in 2010 to contextualize the amount of extra land needed on a completely GET-free system, which would be larger than land area of Texas (Capper & Hayes, 2012). Removing GETs would increase the GHG emissions of the industry. This study states that carbon emissions would increase by 714,000 tons and the usage of fossil fuels by the equivalent of 8,999,000 liters of gasoline. Overall, this would mean a 9.8% increase in the carbon footprint intensity. They conclude their study saying that removing GETs from the U.S. beef industry would "reduce both the economic and environmental sustainability of the industry" (Capper & Hayes, 2012).

A study out of the University of California, Davis in 2011 titled "Feedlot efficiency implications on greenhouse gas emission and sustainability" wanted to compare the inputs and outputs of two feedlot systems to assess the sustainability implications (Cooprider et al., 2011). The system without antibiotics, growth promotants, or animal by-products is "NE3," and the system with metabolic modifies is "CON." 104 Angus crossbred steers were randomly assigned to one of the systems. While the NE3 group received neither implants nor feed additives, the CON group got trenbolone acetate (TBA) and estradiol benzoate implants at days 1 and 70, fed monensin and tylosin throughout the entire study, and received beta agonists during the last 29 days on feed. Neither of these production systems completely fulfill the environmental, social, and economic goals of agricultural sustainability (Cooprider et al., 2011). The CON system decreased cost of body weight gain, days on feed (and subsequently feed use), which satisfies the economic pillar. This system also reduced methane emissions, which aligns more with the

environmental pillar. In contrast, the NE3 system yielded animals that better aligned with the social pillar, fulfilling consumer preferences of better marbling and tenderness and meeting the demand for "naturally raised beef." While both systems reach sustainable goals, they fall short of fully meeting the definition by achieving all three pillars of sustainability (Cooprider et al., 2011).

A more recent study from Aboagye et al. in 2022 compared the productivity, carcass quality, and environmental impact of feedlot cattle raised with and without PETs. In this study, the researchers found that eliminating implants increased land and water use by 14.6% and 19.5% respectively, and increased greenhouse gas emission intensity by 10.5% and 15.8% for heifers and steers (Aboagye et al., 2022). Implanted and conventionally treated cattle also saw improvements in growth and carcass traits compared to their counterparts. They write that removing these technologies would increase the environmental footprint across domestic and international markets (Aboagye et al., 2022).

"Climate-Smart" Beef Initiatives and Practices

Utilizing resources more efficiently and raising more productive cattle is a key part of sustainability. Many universities and organizations are investing in research on "climate-smart beef" production practices and producer support for adopting sustainable initiatives. Partnerships for Climate-Smart Commodities is a USDA initiative started in 2022 to fund research and projects for climate-smart commodities. "This effort will 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, 2024). There are a wide range of projects across the country, from wetland management to alternate wetting practices for rice fields to multiple beef

projects. The Biden-Harris administration provided up to $7.7 billion in assistance for 2025 to aid agricultural producers in adopt conservation practices, which is more than double the amount the previous year (USDA Press, 2024). The USDA website has an interactive dashboard that shows each state's projects filtered by commodities and supported practices.

The beef projects cover topics such as feed management to reduce enteric emissions, prescribed grazing, and soil and manure management. South Dakota State University's climate-smart proposal is titled "The Grass is Greener on the Other Side: Developing Climate-Smart Beef and Bison Commodities," which aims to support and educate producers on climate-smart practices and data management most suited for their operations (USDA, 2024). The University of Tennessee is leading a project with eleven other universities and multiple industry and conservancy groups titled "Climate-Smart Grasslands—The Root of Agricultural Carbon Markets." It aims to help over 245 grassland farms enter the carbon economy with scientifically sound practices that improve soil carbon, reduce greenhouse gas emissions, and maintain operational profitability and resiliency (USDA, 2024). Alabama (as of January 2025) has 29 projects that supports 48 commodities with 113 climate-smart practices.

Social Media and Communicative Tools in Agriculture

Research initiatives in the beef industry are discovering new insights that contribute to improving agricultural practices and reducing the industry's environmental footprint. Effectively communicating these findings to producers, consumers, and other stakeholders is essential to ensure understanding and informed decision-making. More communication classes and initiatives are being integrated into animal sciences coursework, as the next generation of agricultural professionals need effective communication skills to explain scientific information to lay audiences and combat misinformation about livestock production (Norris-Parish, 2024). It is

also important for graduate programs to extend beyond a student's core classes and focus to strengthen oral and written communication skills with various audiences (Kantar et al., 2023).

Social media is a popular source of information for consumers and producers alike. Some agricultural producers have turned to social media as a means of promoting their businesses or earning supplemental income (Morris & James, 2017; Tao et al., 2020). It has also been suggested that incorporating social media training into resources for producers could aid in integration of sustainability practices (Prost et al., 2022). Analyzing social media posts and interactions can also uncover the public's feelings toward agricultural innovations. A study by Ofori and El-Gayar (2019) collected posts from Twitter, Reddit, forums, online news and blogs between January 2010 and December 2018 to understand public perception on smart agriculture applications, such as drones, artificial intelligence, and solar farms. Their analysis showed that 52% of emotional interactions expressed joy, 21% anger, and 12% sadness. They were able to extrapolate drivers and challenges for smart agriculture to better understand stakeholder expectations (Ofori & El-Gayar, 2019). Harnessing the reach of these social media sites could help with information dissemination. A study by Hawley et al. (2018) asked members of the National Association of Farm Broadcasting how they use social media to reach farmers and ranchers. Facebook and Twitter were used more frequently than blogs and YouTube, and respondents stated that social media provided a quick and convenient way to communicate (Hawley et al., 2018).

There is some worry about consumers only turning to social media for information on agriculture, as individuals with large followings who share false or critical views can lack credibility, and this could lead to confusion for consumers on what to believe about their food choices (Sutherland et al., 2020). With this knowledge, social media can be utilized to reach

consumers and present them with factual and appealing content. In a study by Locke et al. (2023), participants viewed Instagram posts that were either cognitively or emotionally oriented and completed pre- and post-exposure surveys to determine if they changed their perceptions on the topics of the posts. Participants' views on animal welfare in the beef industry significantly improved ($p < .05$), but there was still some uncertainty on the topics of human diet and health and the environment (Locke et al., 2023). Exposure to agricultural content on social media could also increase perceived knowledge by consumers (Coursen et al., 2023).

With the evidence of social media use and its potential benefits in agricultural communications, it is important to go a step further and understand how to best present data and information to different audiences. An in-depth study from Orton et al. (2024) segmented audiences to determine unique target audiences for information on climate-smart beef production. These authors stated a need for consumer education in order for the success of climate-smart beef, and they identified a knowledge gap on best practices for these education initiatives. Four unique audience groups (clusters) were identified with specific communication strategies. The first cluster, "beef? No, thanks," comprised more liberal, urban people that didn't eat a lot of beef and also had a high level of trust in science. They tend to trust federal organizations like the Environmental Protection Agency and Food and Drug Administration. The second cluster, "beef or bust," had the highest beef consumption with a low level of trust in science and leaned politically conservative. These first two groups had opposing views on the importance of climate change, and were considered "low priority audiences," as efforts to engage them with information about the beef industry may have limited impact. These audiences either already demonstrate a high level of trust in industry information or they constitute a small

proportion of the population and hold strong opposing views to new research, making them less significant in terms of outreach efforts.

Cluster three was named “environmentally conscious beef eaters. A prime audience.” They had the highest concern for the environment, and the authors theorized that they would be the best and most receptive audience for climate-smart beef information (hence the “prime” word play). The authors suggested that communication should focus on trusted sources and promote the environmental benefits of climate-smart beef. The fourth cluster was the moderate middle, or “*moo-vable.*” This was the largest group with moderate perceptions, and they were beef eaters, and with a trust in a variety of sources, this group could benefit from early intervention and connecting with information from both online messaging (social media) or government communication (Orton et al., 2024). This research highlighted the heterogeneity of consumer perceptions of beef production and sustainable agriculture. The authors believe that this study is the first to apply a human-centered cluster analysis in agricultural science, so this offers the opportunity to further explore modes of communication and trust in information to various audiences.

Conclusions

The cattle industry remains the largest and most important segment of U.S. agriculture, and both producers and consumers are taking a vested interest in sustainable agriculture. There is significant research into sustainable production practices in the beef industry, but there appears to be a knowledge gap in producer perceptions of various parts of sustainability and implementation of certain practices. Furthermore, research into disseminating information to consumers is abundant, but there remains opportunities in agricultural communications to share innovations in the beef industry.

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Chapter II

Exploring Alabama Beef Producers' Implementation of Sustainable Practices

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ABSTRACT

Objective: With sustainability in the agriculture industry becoming a greater focus, it is important to understand how beef producers view sustainability and sustainable initiatives. The objective of this research study was to assess Alabama beef producers' opinions of sustainability, sustainable practices within the industry, and their implementation rate of those practices.

Materials and Methods: An online survey with 36 questions was developed and distributed to Alabama beef producers from July to November 2024. Questions asked producers their opinions on the importance of resources and stakeholders when it comes to environmental impact and sustainability, their knowledge of Climate-Smart Commodities programs, their implementation of certain sustainable practices, and what tools or resources are necessary for their operation to adopt and/or further improve sustainability practices.

Results and Discussion: Results show that 105 primarily cow-calf producers from 42 of the 67 counties in Alabama have varying implementation rates (~9-90%) of practices that can improve sustainability and resource management, specifically utilizing grazing management plans, growth-promoting technologies, and animal handling and welfare training. There appears to be a stated interest in learning more about sustainable practices, but further research and financial information are important for continuing interest in sustainability and implementation.

Implications and Applications: Providing producers with information or counseling about the financial implications of sustainability practices and carbon programs could increase interest or implementation on their operations. Extension professionals can use the results from this survey to inform financial programming development and sustainability resources to provide information to producers in the region.

Key words: Alabama, beef producer, economic efficiency, Extension, grazing management

INTRODUCTION

Sustainability in the livestock industry has been of increased focus in recent years, specifically in areas of environmental impact and animal welfare (Strydom, 2016). There are many sustainable production practices that beef producers are already implementing, but there have been instances of refusal or hesitancy for further adoption (Campbell and King, 2022). It is important to understand cattle producers' opinions about new technologies and on-farm applications; however, there is a lack of research into how producers define sustainability or how to achieve it (Smith et al., 2024). It is also necessary to understand producers' willingness to interact with sustainable messaging and efforts if there is to be a change in behavior and practices in a more sustainable direction (Campbell and King, 2022).

Smith et al. (2024) conducted a secondary analysis of a 2021 data set from Trust in Food to determine what "sustainable beef" means to beef producers. These authors identified themes from the three-pillar model for producers to form a definition, and as a collective, they defined sustainability as multidimensional and interconnected, semi-closed and regenerative, long-lasting, and producer centered. However, there was not a single perspective that connected all these aspects.

Elanco Animal Health published a joint consumer and producer survey study titled "Leave it Better™ Beef Sustainability Perspectives" (Elanco, 2023). The feedlot sector tends to focus on the economic viability piece of sustainability the most due to the high input costs, but 50% of producers in this study still mention environmental sustainability as important, too. In fact, 67% of those producers surveyed indicated that they think it is very or extremely likely that the packers will start to require certain environmental sustainability benchmarks or goals from the feedlots before taking their animals. Keeping in mind that economic viability is paramount to producers, possibly the most influential way to get them to adopt sustainable practices is by

giving them the information and tools to understand the financial benefits of these practices (Elanco, 2023). The objective of this study was to assess Alabama beef producers' opinions of sustainability, sustainable practices within the industry, and their implementation rate of those practices.

MATERIALS AND METHODS

This study was approved by the Auburn University Office of Human Research, Protocol #24-865 EX 2405. A survey instrument was created with Qualtrics and consisted of 36 multiple choice, Likert scale, and rank order questions. The topic and content of this survey was modeled from previously published survey instruments and used information from peer-reviewed and industry resources on sustainability and practices in the beef industry (Lemenager et al., 2011; USRSB, 2019; Elanco, 2023; NCBA, 2024). To establish validity, the survey instrument was reviewed and edited by leadership from Alabama Cattlemen's Association, two professors and two Extension specialists in the Department of Animal Sciences at Auburn University.

The online survey was distributed via email through the Alabama Cooperative Extension System and the Alabama Cattlemen's Association. The instructional email contained an information letter that stated the purpose, time commitment of the study, the opportunity to win one of seven gift cards, and the link and QR code to the Qualtrics survey. The survey link was also shared through the Alabama Cooperative Extension System website and the Alabama Forage Focus Program Facebook pages. The survey was also presented at an Alabama Cattlemen's Association meeting on August 22, 2024, and at the Alabama Beef Cattle Conference on October 4, 2024. The survey was active and started gathering responses on July 9, 2024, and closed on November 19, 2024**.**

When the respondents first accessed the survey, the opening screen contained the full information letter clearly stating who is invited to complete the survey and why, what is involved, if there were any risks or discomforts or costs, the opportunity for compensation, and how their data will be utilized. If they chose to participate, they clicked on an arrow in the bottom right corner to continue.

Qualifying demographic questions requested respondents to state their age and if they own or manage beef cattle within the state of Alabama. Respondents needed to answer "yes" to owning or managing cattle in the state or they would be sent to the exit screen, and they were required to enter a whole number of at least 18 to continue the survey to ensure that no minors were participating. Requested demographic information included gender identity, years of experience in the industry, their county, how many head of cattle managed, and categorization of their operation.

The body of the survey consisted of questions organized into blocks and sections for grouping purposes. After the demographic section, the respondents were supplied with the USDA definition of sustainability (USDA NIFA, n.d.) and given a summary of the three-pillar model that is commonly used in sustainability informational resources (Beef Check Off, n.d.).

To ascertain these producers' perceptions of sustainability in the industry, respondents were asked to rank how concerned they thought consumers were about greenhouse gas emissions; land resource usage and pollution; water resource usage and pollution; animal welfare, which includes the physical treatment of animals, living conditions, slaughter, etc.; animal wellness, which includes usage of antibiotics and medications, diet and feedstuffs, etc.; and the affordability of beef (NCBA, 2024). Then they ranked how concerned they themselves were on the six items. Finn and Louviere (1992) stated this ranking system forces respondents to "make trade-offs" when they rank items or qualities by their importance. This ranking format

and modified versions have been used in agricultural economic and consumer research (Lusk and Briggeman, 2009; Ellison et al., 2017).

Additional questions were modeled from the producer survey study published by Elanco titled "Leave it Better™ Beef Sustainability Perspectives" (Elanco, 2023). A Likert scale matrix asks the respondents to rank how important their operation's potential environmental impacts are on each of seven stakeholders. The last question modeled from the Elanco survey asked participants to rank from most to least needed what the producer and/or operation needs to adopt or improve sustainable practices.

The next section focused on the USDA investments into climate-smart agricultural commodities and Alabama-specific projects focusing on carbon sequestration and low-carbon beef production (USDA, n.d.). After reading the supplied paragraph, respondents state if they are familiar with any climate-smart programs in the beef industry, and if they would be interested in any programs that offered marketing incentives.

The last section uses the metrics from the U.S. Roundtable for Sustainable Beef (USRSB) Framework (USRSB, 2019) including water and land resources, air and greenhouse gas emissions, and animal health and wellbeing, the last of which includes questions about their usage of Beef Quality Assurance training (NCBA BQA, 2019; Klopatek et al., 2022). Finally, participants were invited to leave any comments about their opinions on the survey or anything else they liked to share.

At the end of the survey, before they clicked the arrow for the last time to submit their responses, there was a message thanking them for their participation and stating that they will be taken to another page to enter their email for a chance to win one of seven gift cards worth $50 or $100. Their emails were not connected to their survey responses, and they could choose not to enter anything and close the window.

IBM SPSS (Version 29) was used to analyze the data using descriptive statistics and frequencies. Cronbach's α acceptability ($\alpha \geq .50$) determined the reliability of the Likert scale subsets (Pallant, 2010; Sheposh, 2024).

RESULTS AND DISCUSSION

Producer and Operation Demographics

At the closing of the survey, there were 121 recorded responses on Qualtrics. After removing responses that stated that they did not own cattle in Alabama or did not complete the demographic questions, there were 105 responses. The average time to complete the survey was 17.78 minutes (*SD* = 34.06 minutes). The respondents were 82 males (78.1%) and 23 females (21.9%), which proportionally is lower than the reported 37% of U.S. beef producers being women (USDA NASS, 2024b). The average age was 49.26 years (*SD* = 17.18 years), with the youngest respondent being 18 and the oldest being 85 years old. The average number of years of experience in the beef industry was 23.83 years (*SD* = 16.60 years), with fewest years of experience being 1 year and the most being 70 years. The sample represented in this study was almost 10 years younger than the USDA's census report of the average beef producer in the U.S. (58.3 years old, $p < .001$), and this sample was similarly experienced, with 23.83 years of experience versus the census reporting 23.4 years (USDA NASS, 2024).

Respondents in this survey represented 42 of the 67 counties in Alabama. The top counties represented were Colbert with 10 respondents, Franklin with 7 respondents, and Lauderdale and Marion with 6 respondents each (Figure 1). Participants could classify their operation as cow-calf, stocker, seedstock, backgrounder, finisher, or bull developer, and they were able to choose as many options as they saw fit to characterize (Table 1). The Alabama Cattlemen's Association states that Alabama cattle producers are primarily cow-calf, and 89.5% of this sample identified as cow-calf (Alabama Cattlemen's Association, n.d.). A total of 28.6%

of producers chose more than one option to classify their operation, with 93.3% of those multi-options being cow-calf and at least one other option. One producer identified their operation as both a seedstock and bull developer; one producer identified their operation as a bull developer, seedstock, and a finisher. One operation was identified as all the options except finisher. Two identified as a cow-calf and a finisher. Three operations identified as cow-calf, seedstock, and finisher; four identified as cow- calf and a backgrounder. Six identified as cow-calf and stocker, another six identified as cow-calf and seedstock, and another six identified as cow-calf, seedstock, and bull developer. Figure 2 shows the graphical representation of this sample's herd sizes, with 19% of producers stating they had 31-50 head on their operation, which closely aligns with the national average cow herd size of 47 head (USDA NASS, 2024). A total of 58% of this sample was above the national average herd size.

Producer Concerns about Sustainability

When asked what they believe consumers think is the most important to address when it comes to sustainability in the beef industry, they ranked animal welfare, affordability or availability of beef, and animal wellness as the most important to consumers, and greenhouse gas emissions and water and land usage (a tied ranking) as the least important (Table 2). This question was posed again but now asking which was the most important in their own opinion as a producer (Table 3). Producers ranked animal welfare, land resource usage, and animal wellness as the most important to them, and affordability or availability of beef, water resource usage, and greenhouse gas emissions as the least important. Animal welfare took the top spot in both rankings, and greenhouse gas emissions ranked as the least important by both groups. These producers perceive that they prioritize sustainability similarly to consumers, but with an increased focus on protection and utilization of their land compared to consumers. In previous studies, producers also tend to adopt the identity of "steward of the land" and consider taking

care of it as a quality of being a "good farmer" (Kessler et al., 2016; King and Settle, 2021; Campbell and King, 2022).

The third ranking question asked which tool or information was the most necessary for the operation to adopt and/or further improve sustainability practices (Table 4). The Elanco survey asked producers to select all items they needed instead of ranking the importance, with "understanding the financial benefits of implementing sustainability practices," "research to identify sustainability solutions to reduce the beef sector's environmental footprint that are also viable," and "standardized expectations/measures of feedlot sustainability" the most prevalent choices (Elanco, 2023). This Alabama producer sample's results are similar to the Elanco study. A total of 82.5% of respondents ranked "understanding of the financial benefits of implementing sustainability practices" among their top three priorities. The second need most identified was "research to identify sustainability solutions to reduce their beef sector's environmental footprint that are also financially viable," and the third most needed was "'how-to' information on practices that will improve their operations' sustainability." Baumgart-Getz et al. (2012) found that the access to and quality of information has possibly the largest impact on the adoption of best management practices. The financial aspect is obviously very important to producers when considering sustainability practices, and this is also seen in the study by Smith et al. (2024) where they found that many producers state the importance of making a profit and giving the next generation the choice and ability to also raise cattle. A study mentioned in Briske et al. (2020) said that about 44% of their sample stated that their investment in sustainable practices depended on the likelihood of earning equivalent returns or would require cost-sharing, but 23% claimed they were unable to afford the implementation of adaptation practices altogether.

The importance of their operations' environmental impact on different stakeholders subscale is a 7-item 5-point Likert-type scale ranging from 1 (*not at all important*) to 5 (*very*

important) that demonstrated good reliability (Cronbach's α = .86) (Table 5). From most to least important based on the means, these Alabama producers considered their environmental impact on the reputation of the beef industry as a whole, the United States, their immediate neighbors, the global community, their state, their local community or town, and lastly their employees. The reputation of the beef industry is the only item that scored above a 4, or "important," while the others were within hundredths of each other between "moderately important" and "important." Producers ranked each one of these stakeholders at the top and bottom of the scale, and 10.0% or less of the sample stated that these stakeholders were "not at all important." These results are similar to the Elanco study with the reputation of the beef industry ranking as the most important followed by their immediate neighbors and town, and the scores were also close together (Elanco, 2023). Alabama producers are cognizant of how their operations reflect on the beef industry, but they have varying opinions on the importance of other stakeholders.

Climate-Smart Programs

Two "Climate-Smart Beef" questions asked producers about their awareness and interest in the program (n = 78). A total of 74.4% of producers were not aware of any programs, and another 16.7% stated they were unsure. When asked if they would be interested in participating in an approved "Climate-Smart Beef" labeling program that offered a marketing incentive, 25.6% said yes, 19.2% said no, and 55.1% indicated they would need more information. This echoes the previous ranking question stating they want more research or "how-to" information into this topic. Producers need more information on these practices and programs if there is going to be an increase in adoption (Baumgart-Getz et al., 2012). These results echo a Drovers survey in their annual State of the Beef Industry Report where 82% of respondents stated they were not aware of Climate-Smart Grant programs, and of those 18% that were aware, only 20% were currently enrolled in such a program (Speer, 2024). As of January 24, 2025, producers and

landowners in Alabama could enroll in 29 federally funded projects covering 48 commodities and 113 climate-smart practices (USDA, 2025). Filtering for projects that support beef, there are 8 projects lead by companies and universities such as University of Tennessee, American Farmland Trust, and Farm Journal. The USDA dashboard offers information and contact for interested producers to learn more and enroll. This resource can provide Alabama producers with the information on these projects and keep them up to date with future opportunities.

Resource Usage and Emissions

A 6-item 5-point Likert-type scale with adequate reliability (Cronbach's $\alpha = .58$), ranging from 1 (*not at all important*) to 5 (*very important*) asked producers to state how important it was for mitigating pollutants, preserving resources, increasing efficiency and yield, and protecting their employees and animals (Table 6). Animal health and wellbeing were the most important, followed by increasing efficiency and yield, which was closely followed by preserving land resources. This question is similar to the forced ranking question (Table 3) and could be seen as redundant, but the items are intended to act as an introduction to the last section of the survey which draws from the USRSB metrics (USRSB, 2019). The results of this section are similar even with the slight variation of choices, and even with the previous questions showing the financial incentives being important to these producers, the health and wellbeing of their animals remained the most important. Beef producers continue to increasingly focus on the wellbeing of their animals (NCBA, 2017).

In the questions pertaining to water and land resources ($n = 77$), 61 producers (79.2%) state they have a grazing management plan. Grazing management is any technique that a producer employs to control the grazing behavior of cattle in pursuit of specific goals, such as improving or protecting forage production, efficient forage utilization, maximizing animal efficiency, and maintaining pasture and soil health and resilience (Sollenberger et al., 2020).

Wang et al. (2018) found that multi-paddock grazing increases the long-term economic performance of operations compared to those that allow their animals to continuously graze. Of those 61 producers, 68.9% reported that their grazing management plan intentionally improves water resources, and 95.1% said it intentionally improves land resources. Table 7 shows grazing management techniques these producers use. Those that stated grazing techniques other than the listed options shared that they use dry lots or utilize stockpiled forage.

Manure management was not a very utilized technique, with only 32.5% stating they do have some sort of manure management. Manure management is sometimes thought to be more applicable to feedyards where manure can be highly concentrated in smaller areas, but it is applicable for cow-calf and other grazing operations. Manure in pastures usually doesn't require additional handling than what the cattle distribute themselves, but areas around feeders, waters, and shade might need more maintenance (Lemenager et al., 2011). The goals of a management system include keeping facilities clean and reducing odors and dust, insect control, and complying with any regulations (Lemenager et al., 2011). Manure and nutrient management are also important for the health of the soil and waterways. No examples were given for this questions, so possibly with more of an explanation of manure management, the data could reflect a higher implementation.

In the questions pertaining to air and greenhouse gas emissions (n = 76), 40.8% of producers would consider exploring alternative energy sources like solar panels or windmills to power their facilities, and 36.8% said they would need more information before they decided. A total of 51% of the producers stated that they were not at all aware of any commercial or retail items on the market that lower methane output in cattle. Only 9.2% of the producers stated that they employ carbon sequestration practices, with another 39.5% stating that they do not know if they do or not. When asked if they would consider exploring carbon management assessment

services or carbon credits (n = 75), 25.3% said yes and 54.7% indicated they would need more information before deciding, further giving credence to the need for research and information sharing in this area. A total of 20% of producers stated they would not consider exploring these services. With the data in Table 3 showing greenhouse gas emissions ranked the least important but with 80% of the sample stating an interest or the possibility of interest in carbon management, this is an area of sustainability that could be further explored by producers.

Animal Health and Wellbeing

The social pillar in sustainability emphasizes employee and animal safety, so equipping all employees in contact with live animals with the knowledge of how cattle behave and react to stimuli can greatly increase workplace safety (NCBA BQA, 2019). Furthermore, there is a relationship between the safety and health of a workplace and its profitability, so keeping people, animals, and machinery safe is also of financial importance (Lemenager et al., 2011). A total of 77.8% of producers have completed Beef Quality Assurance (BQA) training, and 38.9% of producers require their employees to be trained in stockmanship and training. A total of 59 producers (80.8%) stated they implement the principles of BQA or a similar program in the management of the operation (n = 73). This training program was created in the mid-1980's to improve food safety and quality issues, and it continued to evolve to include more animal welfare and handling information (NCBA BQA, 2019). Furthermore, 62 producers (81.6%) have attended Extension events or workshops (n = 76), and a total of 70 producers (92.1%) have an established relationship with their veterinarian (n = 76). A veterinarian-client-patient relationship is important for ensuring herd health. Alabama producers interacting with Extension programming allows them access to research and information from the university and research levels.

Efficiency and Yield

Increasing feed efficiency and growth metrics has a positive effect on economic and environmental sustainability, and the use of growth-promoting technologies have enhanced sustainability in the United States (Capper and Hayes, 2012). When asked about hormones implant use in cattle (n = 76), 44.7% of the producers considered using hormones a sustainable practice and 23.7% were unsure. A total of 42.1% of producers indicated that they use hormones on their cattle. Hormone implants are available for various ages and stages of production, and they increase muscle protein synthesis, which in turn can increase average daily gain by 10-30% and carcass weights are 5% heavier when used in the feedlot (Preston, 1999; Duckett and Pratt, 2014; Strydom, 2016).

Producers were then asked to select any and all of the feed additives that they use to increase growth and efficiency. Table 8 shows their responses, and those who selected "other" said they used cotton seed, minerals and tubs, and monensin, which is an ionophore. Alabama producers are utilizing a variety of these growth promotants. A total of 34 producers stated they do not use any growth promotants, and none of the producers use essential oils. Antibiotics that are considered medically important in human medicine are no longer allowed to be used for the sole purpose of promoting growth, but responsibly utilizing antibiotics for herd health can have positive effects on herd efficiency (NCBA, 2017). Ionophores are a class of antibiotics, but they were separated in this question because their primary use is to improve feed efficiency and are not medically important to humans. There is some research into using essential oils as antimicrobial alternatives to antibiotics, but the results showed to be highly variable and inconsistent (Strydom, 2016).

Feed costs and use are also important efficiency aspects to consider, so when asked about what hay feeder they use, a variety of options were listed (Table 9). The style of feeder can affect

the feed wastage. Those who selected "other" noted that they use a raised feeder with a roof and have hay on the ground. Hay rings were the most popular among these producers, and their popularity stems from being lightweight and convenient (Lalman, 2022). Hay rings and cones also have low wastage (6.1% and 3.5%, respectively) (Lemenager et al., 2011). Bales that are unprotected and unrolled tend to see the most wastage, and not many producers are providing hay to their cattle in this fashion.

When asked about their reproduction and calving management (n = 76), 27.6% of the producers use artificial insemination, and 25.0% use an estrous synchronization protocol. The calving seasons for these producers varied, with 26.3% of producers having a spring calving season, 40.8% calve in the fall, 6.6% of them calve in the winter, and 26.3% of them have year-round calving and/or leave the bull out. Defined breeding seasons can better utilize nutritional resources and labor and can result in more economic success (Mullenix et al., 2020). Every labor and resource situation varies between operations, so a year-round calving may work best with these producers' situations, but the majority of this sample does have a defined calving season.

Free Response

These producers were invited to leave comments at the end of the survey, and of the 105 producers, there were six responses. Two producers noted that they felt that the survey instrument was not applicable to themselves as smaller operations that are direct to consumers. These two producers, along with a third, also mentioned their interest and use in "chemical free" or natural cattle. Conventional operations using growth-promoting technologies, natural systems, and grass- fed operations all fit into a sustainable beef model, as one system does not improve all sustainability metrics (Capper, 2012). This presents an opportunity to introduce producers to sustainable practices that align with their operational goals, as some may not be interested in using these growth-promoting technologies but could benefit from information about practices

that work within their natural production.

Another producer said that while they can appreciate no-till practices and rotational grazing, climate change is not a concern of theirs. One producer expressed concern for crop and grazing land loss due to the increase in urban sprawl and areas used for solar farms and wind turbines. Another producer stated an interest in more information for controlling emissions in finishing cattle. This feedback offers insight into the producers' feelings toward this survey and its content and could provide guidance for improvements for future survey instruments.

Extension and Research Response

With the increase in interest and research into sustainable practices in the livestock industry, it is important to consider the opinions of livestock producers. It was a recurring theme in these results and the literature that the financial risk and return needs to be favorable in order for producers to be interested in certain sustainable practices, so this could be a starting point for Extension to create new programming or get producers connected with economists or other financial professionals. Another common sentiment was the need for more research to identify sustainable solutions and "how-to" information on introducing those practices onto their operations. Keeping in mind that different regions of the country require different production techniques, results of this survey can serve as a guide for Extension to better tailor its programming and resources on sustainable practices to cater to regional needs. Producers demonstrate a willingness to interact with and engage with the topic of sustainability, so further research or surveys could be valuable to further an understanding of beef producers' needs and priorities and how to best serve those needs.

APPLICATIONS

The purpose of this survey was to better understand the implementation of sustainable practices and opinions of beef producers in the state of Alabama. Results indicated that many

producers are already using practices to increase efficiency and optimize resource management, and there is a need for more information on Climate-Smart programs and the financial implications of implementing more sustainable practices on the operational level. These results could be expanded upon to target specific areas of sustainability and practice implementation to best inform beef producers in Alabama and the Southeastern region on the potential environmental and financial benefits to their operations.

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Table 1.

Categorization of beef farm or operation

Type	Number of selections (*n*=148)
Cow-calf	94
Stocker	10
Seedstock	22
Backgrounder	4
Finisher	9
Bull developer	9

Table 2.

Producers' perception of consumer ranking of sustainability priorities (n = 92)

	1 (Most important)	2	3	4	5	6 (Least important)	Mean
Greenhouse gas emissions	9 (9.8%)	6 (6.5%)	6 (6.5%)	17 (18.5%)	8 (8.7%)	46 (50.0%)	4.60
Land resource usage	8 (8.7%)	6 (6.5%)	9 (9.8%)	23 (25.0%)	33 (35.9%)	13 (12.4%)	4.15
Water resource usage	5 (5.4%)	7 (7.6%)	11 (12.0%)	27 (29.3%)	30 (32.6%)	12 (13.0%)	4.15
Animal welfare	17 (18.5%)	34 (37.0%)	26 (28.3%)	8 (8.7%)	7 (7.6%)	0 (0.0%)	2.50
Animal wellness	10 (10.9%)	28 (30.4%)	28 (30.4%)	11 (10.5%)	10 (10.9%)	5 (5.4%)	2.98
Affordability or availability	43 (46.7%)	11 (12.0%)	12 (13.0%)	6 (6.5%)	4 (4.3%)	16 (17.4%)	2.62

Note: Percentages may not equal 100% due to rounding

Table 3.

Producers' ranking of sustainability priorities

	1 (Most important)	2	3	4	5	6 (Least important)	Mean
Greenhouse gas emissions	3 (3.2%)	2 (2.2%)	2 (2.2%)	2 (2.2%)	6 (6.5%)	78 (83.9%)	5.58
Land resource usage	22 (23.7%)	15 (16.1%)	21 (22.6%)	21 (22.6%)	14 (15.1%)	0 (0.0%)	2.89
Water resource usage	3 (3.2%)	19 (20.4%)	18 (19.4%)	27 (29.0%)	24 (25.8%)	2 (2.2%)	3.60
Animal welfare	23 (24.7%)	24 (25.8%)	25 (26.9%)	11 (11.8%)	8 (8.6%)	2 (2.2%)	2.60
Animal wellness	18 (19.4%)	24 (25.8%)	11 (11.8%)	21 (22.6%)	16 (17.2%)	3 (3.2%)	3.02
Affordability or availability	24 (25.8%)	9 (9.7%)	16 (17.2%)	11 (11.8%)	25 (26.9%)	8 (8.6%)	3.30

Note: Percentages may not equal 100% due to rounding

Table 4.

Operational needs for adopting and advancing sustainability practices (n = 80)

	1 (Most needed)	2	3	4	5	6	7 (Least needed)	Mean
Understand the financials[1]	33 (41.3%)	20 (25.0%)	13 (16.3%)	7 (8.8%)	6 (7.5%)	1 (1.3%)	0 (0.0%)	2.20
Research[2]	8 (10.0%)	25 (31.3%)	16 (20.0%)	11 (13.8%)	16 (20.0%)	1 (1.3%)	3 (3.8%)	3.21
Expectations and measures[3]	4 (5.0%)	8 (10.0%)	18 (22.5%)	13 (16.3%)	11 (13.8%)	15 (18.8%)	11 (13.8%)	4.35
More capital investment[4]	13 (16.3%)	5 (6.3%)	12 (15.0%)	11 (13.8%)	14 (17.5%)	17 (21.3%)	8 (10.0%)	4.14
"How-to" measure[5]	2 (2.5%)	3 (3.8%)	10 (12.5%)	18 (22.5%)	20 (25.0%)	18 (22.5%)	9 (11.3%)	4.76
"How-to" practice[6]	11 (13.8%)	13 (16.3%)	7 (8.8%)	16 (20.0%)	7 (8.8%)	19 (23.8%)	7 (8.8%)	4.00
Background[7]	9 (11.3%)	6 (7.5%)	4 (5.0%)	4 (5.0%)	6 (7.5%)	9 (11.3%)	42 (52.5%)	5.34

Notes: Percentages may not equal 100% due to rounding

[1] "understand the financial benefits of implementing sustainability practices"

[2] "research to identify sustainability solutions to reduce my beef sector's environmental footprint that are financially viable"

[3] "standardized expectations/measures of my beef sector's sustainability"

[4] "more capital investment to resource progress in my sector's sustainability"

[5] ""how-to" information on measuring on-farm sustainability, including collecting data and reporting"

[6] ""how-to" information on practices that will improve my operation's sustainability"

[7] "background on what sustainability is and why it is important"

Table 5.

Importance of operation's environmental impact on stakeholders

	Not Important	Slightly Important	Moderately Important	Important	Very Important	*N*	Mean
Your employees	8 (10.0%)	7 (8.8%)	21 (26.3%)	19 (23.8%)	25 (31.3%)	80	3.58
Your immediate neighbors	3 (3.7%)	10 (12.3%)	17 (21.0%)	27 (33.3%)	24 (29.6%)	81	3.73
Your local town or community	3 (3.7%)	13 (16.0%)	18 (22.2%)	25 (30.5%)	22 (21.0%)	81	3.62
Your state	3 (3.7%)	11 (13.6%)	20 (24.7%)	26 (32.1%)	21 (25.9%)	81	3.63
The reputation of the beef industry as a whole	2 (2.5%)	3 (3.7%)	4 (4.9%)	19 (23.5%)	53 (50.5%)	81	4.46
United States	3 (3.7%)	5 (6.2%)	13 (16.0%)	29 (35.8%)	31 (38.3%)	81	3.99
Global community	6 (7.4%)	11 (13.6%)	16 (19.8%)	21 (25.9%)	27 (33.3%)	81	3.64

Note: Percentages may not equal 100% due to rounding

Table 6.

Importance of protecting resources and mitigating pollutants (n=77)

	Not Important	Slightly Important	Moderately Important	Important	Very Important	Mean
Preserving water resources on your land or operation	1 (1.3%)	3 (3.9%)	4 (5.2%)	13 (16.9%)	56 (72.7%)	4.56
Preserving land resources on your operation	0 (0.0%)	1 (1.3%)	1 (1.3%)	13 (16.9%)	62 (80.5%)	4.77
Mitigating pollutants and greenhouse gas emissions	13 (16.9%)	14 (18.2%)	23 (29.9%)	17 (22.1%)	10 (13.0%)	2.96
Increasing efficiency and yield	0 (0.0%)	0 (0.0%)	2 (2.6%)	13 (16.9%)	62 (80.5%)	4.78
Animal health and wellbeing	0 (0.0%)	0 (0.0%)	2 (2.6%)	3 (3.9%)	72 (93.5%)	4.91
Employee health and wellbeing	1 (1.3%)	1 (1.3%)	4 (5.2%)	23 (29.9%)	48 (62.3%)	4.51

Note: Percentages may not equal 100% due to rounding

Table 7.

Grazing management techniques employed by operations

Grazing Technique	Number of selections (n = 109)
Continuous grazing	21
Rotational grazing	61
Intensive rotational grazing	5
Creep grazing	18
First-last (follow the leader)	1
Other*	3

*"Other" responses include stockpiled forage and dry lot

Table 8.

Feed additives used for growth and efficiency

Feed Additive	Number of selections (n = 89)
Antibiotics (CTC, Tylosin, etc.)*	17
Ionophores	16
Pre- and probiotics	11
Essential oils	0
Enzymes	5
None	34
Other	6

Table 9.

Hay feeder style

Hay Feeder	Number of selections (n = 76)
Hay ring	48
Cone hay ring	2
Hay wagon	10
Hay unroller	9
Bale on the ground	5
Other	2

Figure 1.

Survey participant distribution by county (n = 105)

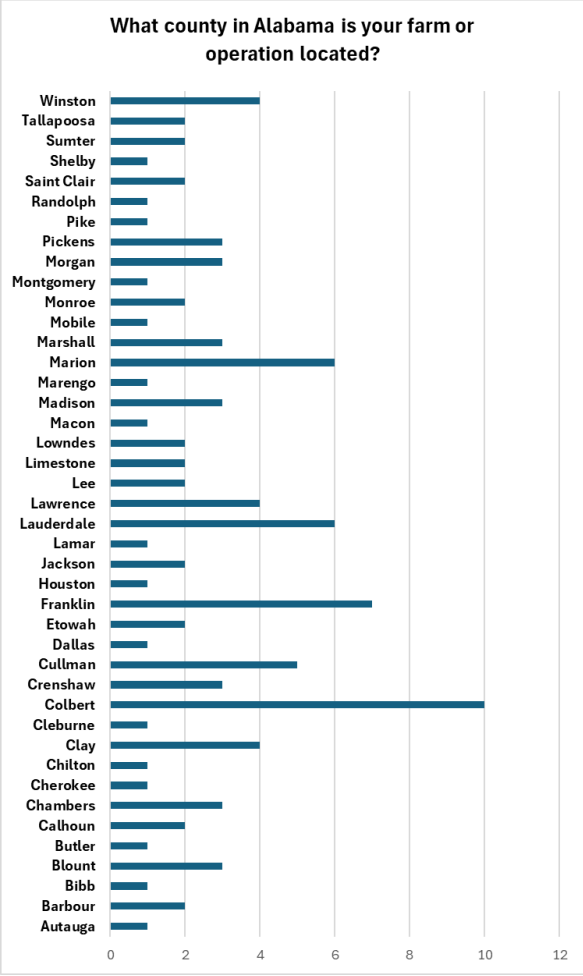
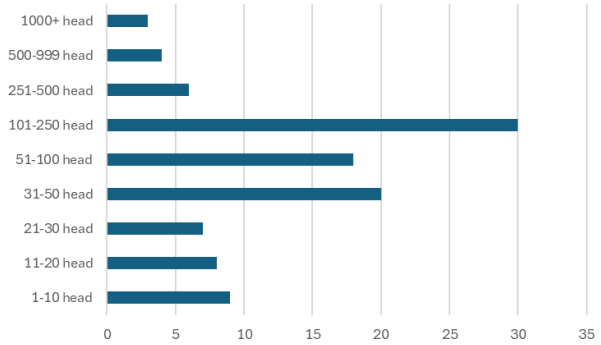


Figure 2.

Head of beef cattle, including calves, on operation (n = 105)



Chapter III

Exploring the Use of Infographics to Alter Consumer Opinions and Perceptions of Sustainability within the U.S. Beef Industry

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Abstract

The meat industry faces increasing scrutiny over its environmental impact, animal welfare practices, and role in sustainable food systems, often fueled by misinformation and lack of consumer understanding. The purpose of this research was to better understand opinions on sustainable beef production and the effectiveness of using infographics to change negative or misinformed opinions about the beef industry. Effective science communication strategies, such as evidence-based infographics, offer a promising approach to conveying complex agricultural topics in a visually engaging and accessible manner. These communication devices are effective in visually informing audiences and simplifying the messages; however, there is not a large body of literature on infographic use in agricultural education. A survey was conducted to gather participants' subjective and objective knowledge about resource usage, their prioritization of sustainability issues to address, and their beef shopping habits. Participants then rated their agreement with statements about sustainability, grass-fed and conventional cattle, and hormone use. After viewing three infographics, they were reassessed on the same questions to determine any changes in opinions or knowledge. Results showed a significant increase in self-reported knowledge ($p < .001$) and positive increases in opinions and agreement on statements about sustainability in the beef industry ($p < .001$). Participants expressed lingering doubt about the hormone information and the over- or underinflation of statistics represented. Further research could include more specific infographics focusing on fewer topics to decrease information load and integrating more interactive elements into the infographics to increase participation and interaction.

Introduction

Less than 2% of Americans are directly involved in agriculture, and this lack of involvement with food production may lead consumers to hold inaccurate perceptions about the agriculture industry and production practices (Yang et al., 2020; USDA ERS, 2023). Consumers also have difficulty defining sustainability and tend to focus on the environmental aspect only; however, they do not know how to estimate the environmental impact of their food choices (van Bussel et al., 2022; Elanco Animal Health, 2023). Despite this disconnect, there is a growing consumer interest in food production and how it affects animal welfare, environmental sustainability, safety, and social equity (Wilson & Lusk, 2020). While the beef industry actively works to mitigate its environmental impact and showcase the efforts of researchers and producers to reach sustainable goals, these efforts may go unnoticed in the media landscape. As more consumers turn to the internet and social media for information, it can be difficult for them to parse through the information overload to find reliable information about their food choices (Burnett et al., 2019; Sutherland et al., 2020). Multiple industry, university, and non-profit resources on sustainability initiatives are widely available, but many are tailored more toward internal users and industry partners. Agricultural communications research is investigating ways to address these concerns and disseminate information to non-agricultural audiences. Understanding consumer perceptions and opinions of food systems is important so the industry and producers have more information to make production, marketing, and lobbying decisions (Schroeder et al., 2023). This also serves as an opportunity for agricultural communicators to more effectively reach segments of the public who may be uninformed about food production and sustainable agriculture.

Consumer Perceptions of Sustainability and Food Choices

Multiple studies have investigated how consumers view the food supply chain, the meat and

beef industries, and sustainability within agriculture. A survey study by Peano et al. (2019) found that when asked the definition of "sustainable," most people stated it was the preservation of natural resources, and the most answered "cluster" of definitions was called "man-nature balance." This included protecting the ecosystems and minimizing the human footprint on the quality and quantity of available water, soil, and air. Respondents in this survey also stated that greenhouse gas (GHG) emissions were a top environmental concern (Peano et al., 2019). A study by Oesterreicher et al. (2018) surveyed millennials about their perceptions of the beef industry. These authors found that millennials were worried about the environment, specifically with climate change, global warming, and methane production.

This attention to environmental sustainability is further supported by a systematic literature review by van Bussel et al. (2022) that investigated studies on consumers' perceptions of sustainability in the food supply chain. They found that consumers most often associate environmental impact, local or organic food, and ethical production (slaughter, working conditions and wages, etc.) with a sustainable supply chain. It is interesting that these environmental or social elements are mentioned so frequently, yet they don't appear to follow through into their purchasing behaviors, as van Bussel et al. (2022) further states that consumers don't believe that sustainability influences their food purchasing decisions. Other factors such as price, taste, and health are considered more influential than sustainability (van Bussel et al., 2022).

A study by Lassoued et al. (2023) further supports these results, as these authors found that price and nutrition were by far the most important factors influencing their decisions. When specifically purchasing beef, Schroeder et al. (2023) found that consumers ranked product freshness, food safety, price, and eating experience qualities (flavor, juiciness, tenderness) the highest. Middle importance was animal welfare, hormone and antibiotic use, supporting local

farms, and nutrition content; ranked lowest was beef produced with lower GHG emissions or "low carbon" beef (Schroeder et al., 2023). O'Brien et al. (2023) also found that freshness, price, and taste were the most important when purchasing beef, followed by how and where it was raised, appearance, and health benefits. It appears that consumers are aware of the sustainability attributes of beef, but other factors tend to carry more importance.

Consumer Knowledge Gaps and Sources of Information

To address the knowledge gaps that consumers may have about animal agriculture, it is important to understand how consumers form their perceptions of the industry in the first place. Dr. Rebecca Walker Reczek, a Professor of Marketing at The Ohio State University, mentioned in her talk titled "Consumer Knowledge Gaps and Biases about Food, Health, and Sustainability" that consumer judgements about food is often based on lay theories that may not be objectively correct (Walker Reczek, 2023). Walker Reczek talked about how a scientist would use scientific theories or proven information to solve a problem or explain how something works, but an average consumer might not have that scientific knowledge or any firsthand experience with food production, so they rely on other inputs like word of mouth or their own personal experience (Walker Reczek, 2023). In an interview from Neuroscience News, Dr. Uma Karmarkar from University of California San Diego detailed her research on examining factors the both consciously and unconsciously influence people's decision making and purchasing behaviors like prices, brand recognition, and the experience of shopping online versus in-person (Clark, 2024). According to Dr. Karmarkar, "brands can offer familiarity and confidence in situations where we're not so sure about which product to buy, and that confidence is rewarding at the level of the brain" (Clark, 2024).

Web-based sources, specifically social media, are popular information sources for these consumers for a multitude of reasons. It is easily accessible and isn't behind a paywall like some

scientific publications or journals; however, these sources of easily accessible information very often lack credibility and there is a certain level of distrust (Sutherland et al., 2020; Lassoued et al., 2023). This contradicts an earlier study of 300 university students by Howard et al. (2017) where they found that students perceived Facebook and Twitter to be trustworthy sources of information. This shift in opinion on social media credibility could be due to the increase in "fake news" and misinformation that has seen peaks during the recent presidential elections and the COVID-19 pandemic (Beauvais, 2022)

Information from outside the industry is often polarizing or conflicting and can be a cause of confusion for consumers when making purchasing decisions (O'Brien et al., 2023). Social media personalities who have large followings that have critical or false views on agriculture pose a concern for this lack of credibility (Sutherland et al., 2020). If information presented through social media is the only source of information or news for consumers, then it could be assumed that consumers do not know what to believe about animal agriculture and food production (Sutherland et al., 2020). This offers an opportunity for agricultural communicators to harness the popularity of social media and disseminate information on various platforms to target non-agricultural audiences (Locke et al., 2023; Bennett et al., 2024).

Infographics

There are a variety of visual and persuasive media tools that marketing and education initiatives have used to facilitate information sharing and learning for their target audience. Infographics are a communication device that utilizes images, words, and other interactive elements to increase focus, information retention, cognitive processing, future recollection, and subsequently drives behavioral change (Traboco et al., 2022; Bhat & Alyahya, 2023). They combine textual information with visual aids that are visually and aesthetically pleasing to communicate information or messages that increase comprehension (Traboco et al., 2022).

Infographics present information in ways that decrease the cognitive load on viewers, which is necessary for information to "stick" (Schnotz & Kürschner, 2007; Traboco et al., 2022). These communication devices are effective in visually informing audiences and simplifying the messages, thus making the information more accessible to wider audiences (Traboco et al., 2022). Infographics are useful in instructional technology and design because they efficiently transmit information, knowledge, and conclusions to the media and public (Le & Pole, 2023). With social media being as popular as it is, using infographics to disseminate information on these platforms may achieve more exposure and traction (Traboco et al., 2022).

There has been an increase in the use of infographics in medical and educational studies, and this increased popularity could be attributed to the rise of social media and the fact humans process visual content faster than text (Smith, 2016). The COVID-19 pandemic saw an increase in "flatten the curve" infographics, which served as a public health tool to educate and influence behaviors on social distancing (Li & Molder, 2021). Infographics were also used to help people distinguish between false information about vaccines (Domgaard & Park, 2021).

Despite the amount of research and use of infographics in these sectors, there is not a large body of literature on infographic use in the agricultural industries and agricultural education (Fischer et al., 2023; Gibbs et al., 2023). There is a need for agricultural communicators and educators to better inform the non-agriculture public about the beef industry and its practices, and there is particularly a knowledge gap about infographic use in specifically beef production and sustainability. Because infographics can lead to higher comprehension and retention, they could be a good tool to increase agricultural literacy (Fischer et al., 2023).

When designing infographics, it is important to focus on visual simplicity, information load, and colors (Li & Molder, 2021; Traboco et al., 2022). Fischer et al. (2023) found that including pictographs over bar charts or pie charts were more effective in information

recognition and recall. When it comes to color palettes, it is important to know that colors often convey implicit and explicit message (Zak, 2023). In a study comparing pro- and anti-vaccine infographics and websites, it was found that pro-vaccine content used blue, green, teal, and gray as primary colors (Zak, 2023). These cool colors are often used in medical media or hospital settings. Blue tends to convey knowledge, security, and trust (Blake, 2014). Besides the visual appeal, it is also beneficial for citations and sources to be clearly displayed to give participants information on the journals or organizations to aid them in forming opinions (Royse, 2019; O'Brien et al., 2023).

Theoretical Framework

The Elaboration Likelihood Model (ELM) is a persuasion theory that says that attitude change uses two routes of elaboration processing: peripheral and central (Petty & Cacioppo, 1986). Attitudes are the general evaluations that people hold regarding their view on people (including themselves), objects, and issues (Petty & Cacioppo, 1986). Bainbridge Frymier (2021) defines persuasion in the context of a "receiver response" with its involvement in the symbolic communication between two persons with the intent to change, reinforce, or shape attitudes, beliefs, or change the behavior of the receiver. Petty & Cacioppo use "persuasion" to refer to a change in attitude after exposure to certain communication or information. Elaboration is defined as the amount of effort that someone is willing to use to process, evaluate, and remember a message, and then decide to accept or reject it (Petty & Cacioppo, 1986; Nickerson, 2023).

The central route occurs due to a person's thorough consideration of the information presented, and it is likely to create long-term change (Petty & Cacioppo, 1986). This route uses data and facts to persuade and support an argument or stance (Nickerson, 2023). This processing route requires more effort than the peripheral route. The peripheral route is an indirect route with

a lower level of elaboration; it doesn't require a lot of scrutiny like the central route but still induces change (Petty & Cacioppo, 1986). When motivation or ability to process information is low or absent, then the peripheral processing route is more likely to be used. Processing through the central processing route is more likely for an attitude change to occur (Petty & Cacioppo, 1986).

ELM has been used in health and agricultural communications, including infographic research (Lazard & Atkinson, 2015; Burnett et al., 2019; Lam et al., 2022). Lam et al. (2022) applied ELM to study elaboration in visual communication, and they found that infographics had better image appeal and respondents had greater elaboration. Lazard and Atkinson (2015) used ELM to show that people engage with infographics more than messaging that just uses text or illustrations. Burnett et al. (2019) found that using interactive elements in infographics causes respondents to exhibit higher elaboration, which increases attitude and cognition.

Purpose and Research Questions

The purpose of this study is to gather data on opinions on beef production and beef sustainability and the effectiveness of using infographics to educate and change negative or misinformed opinions about the beef industry.

RQ1: Will exposure to infographics increase participants' subjective knowledge about sustainability metrics and efforts in the beef industry?

RQ2: Will exposure to infographics improve negative opinions of the beef industry?

RQ3: Will exposure to infographics alter incorrect perceptions of the beef industry?

RQ4: Does exposure to the infographics increase participants' self-reported likelihood of engaging in specific behaviors related to the beef industry (e.g., supporting or communicating about the industry)?

Methodology

This research study was approved by the Auburn University Office of Human Research, Protocol #24-885 EX 2405 in May 2024. The survey instrument was created using Qualtrics. The survey instrument was modeled after previously published survey instruments and used information from peer-reviewed and industry resources on beef sustainability and facts and statistics of the beef industry (Ellison et al., 2017; Wilson and Lusk, 2020; Klopatek & Oltjen, 2022; Elanco Animal Health, 2023; Lassoued et al., 2023; Schroeder et al., 2023; NCBA, 2024). This instrument was reviewed by three professors at Auburn University and a pilot study of college-aged participants was performed for editing purposes. Once editing both the questions and the infographics, the final survey was distributed through Prolific (Prolific Academic Ltd., London, England), a company that provides survey respondents for online research studies.

Links and QR codes were provided to access the survey. When the respondents first accessed the survey, the opening screen contained a full information letter clearly stating who is invited to complete the survey and why, what is involved, if there were any risks, discomforts, or costs, the possibility of compensation, and how their data will be utilized. If they chose to participate, they were directed to click an arrow in the bottom right corner to continue.

Qualifying demographic information included a text box to enter the respondent's age. If they typed anything less than 18 and clicked the next arrow, they were brought to the exit screen. The other demographic questions of gender, educational level, and race are commonly used in surveys to understand the sample population of the respondents (University of Pennsylvania, 2022). Prolific can curate specific sample groups to match certain demographics; this study wanted a representative sample of the U.S. population.

After the demographics, the survey was divided into four sections. The first included questions about diet and shopping habits. They were asked if they consume beef and how often.

This served as an attention check. If they stated they do not eat beef, then they should answer the frequency question as "never" consuming beef. The next question asked if they were the primary grocery shopper of their household, and if yes, if they purchase beef. If they stated they do purchase beef, they were then given a list of 13 beef characteristics to rank from most to least important when it comes to their beef purchasing decisions: freshness, quality, cut or type of beef, USDA grade, fat content or leanness, brand, production labels, animal welfare label, organic or natural label, price, sustainability labels, animal diet, and hormone or antibiotic free (Ellison et al., 2017; Elanco, 2023; Lassoued et al., 2023; Schroeder et al., 2023). Finn and Louviere (1992) said this ranking system forces respondents to "make trade-offs" when they rank items or qualities by their importance, and this has been used extensively in agricultural economic and consumer research (Lusk & Briggeman, 2009; Ellison et al., 2017). The use of the drag-and-drop format for ranking style questions results in better response times, more complete responses, and is user friendly (Blasius, 2012, as cited in Schroeder et al., 2023). If they answered "no" to being the primary shopper or if they purchase beef, they skipped the preceding questions and went straight the last question of the block about where they get most of their information or knowledge about beef and agriculture.

The next section asked respondents about their opinions and perceptions of the beef industry. Respondents were first asked to rank six topics in beef sustainability in order of most to least concerned: GHG emissions, land usage, water usage, animal welfare, animal wellness, and affordability or availability of beef products (USRSB, 2019; NCBA, 2024). Animal welfare listed examples like physical treatment and living conditions, while animal wellness listed usage of antibiotics and diet to give respondents a distinction between the two (NCBA, 2024). Then using subjective and objective methodology similar to Wilson and Lusk's (2020) study on consumer knowledge of redundant labels, they were given a Likert scale matrix asking them to

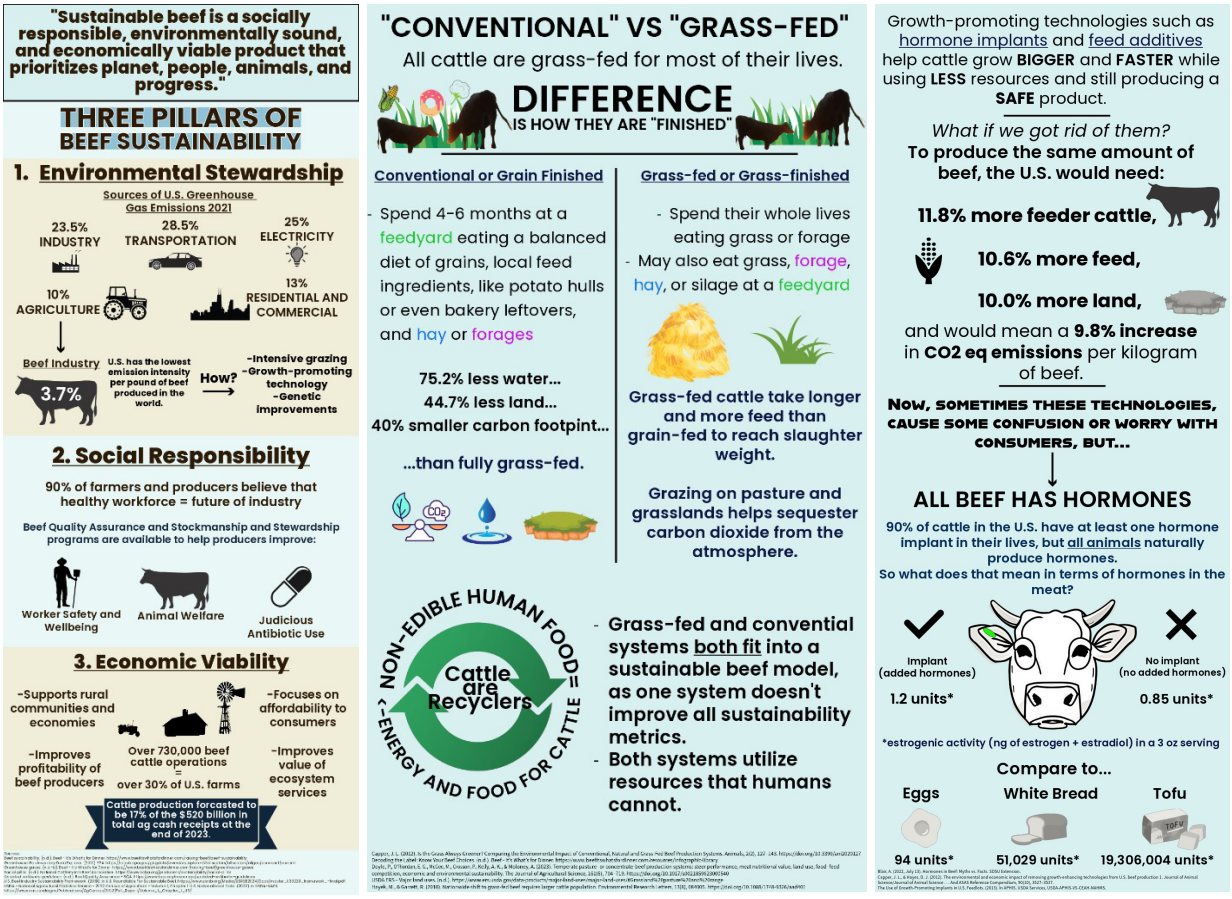
rank how knowledgeable they consider themselves to be on the topics of the beef industry's GHG emissions, water usage, land usage, growth or efficiency promoting technologies, and sustainability efforts in the industry. These responses were then compared to their *objective* knowledge in a series of multiple-choice questions about facts about the U.S. beef industry's resource usage and other statistics (Capper, 2012; Capper & Hayes, 2012; EPA, 2021; Klopatek & Oltjen, 2022; Rotz, 2023). Following this multiple-choice section, they were given two Likert scale matrices with internal consistency determined by Cronbach's α asking to rate their agreement with statements pertaining to sustainability in the beef industry on a 5-point scale (Pallant, 2020; Sheposh, 2024).

After completing this section, respondents viewed three infographics, which were created on Adobe Express using Adobe Stock photos and figures. Research has shown that pictographs are more effective with information recognition and design recall than other visuals, such as bar charts and pie charts (Fischer et al., 2023). For this reason, a pictograph was utilized to visualize the GHG emissions data. The color schemes and other information presentations were also modeled after the previously mentioned studies.

The first infographic contained a definition and overview of the three-pillar model (NCBA n.d.a; NCBA, n.d.b.; EPA, 2021; Beef Quality Assurance, n.d.; USRSB, 2019; USDA NASS, 2022.) The second infographic compared grass-fed to conventionally raised beef (NCBA, 2022; Capper, 2012; Hayek & Garrett, 2018; Doyle et al., 2023; USDA ERS, n.d.) The third infographic explained growth-promoting technologies, specifically hormones and visualized the estrogenic activity of different foods (Blair, 2022; Capper & Hayes, 2012; USDA APHIS, 2013). Each infographic had references with descriptive titles at the bottom of the page.

Figure 1.

Three infographics on beef cattle facts and sustainability



After viewing the three infographics, in which all were on the same page and there was no time limit for them to move to the next section, respondents were given the same Likert matrices about their knowledge and their level of agreement with the statements to see if their answers changed after viewing (Li & Molder, 2021). There were then given three recall questions about a specific piece of information from each infographic. Respondents then were given the opportunity to view each infographic again and click the area of each one they found the most influential, which would produce a 'heat map' to visualize the areas of interest. This is an interactive element of the infographic to increase elaboration as stated in Burnett et al. (2019).

Finally, in order to ascertain if the infographics and information provided were influential or persuasive enough to change or influence behaviors, they were asked if they were more likely to support the industry, if they would be more likely to engage in conversations about the industry, and if they are interested in learning more about the beef industry. The other questions in this section asked if they felt more comfortable conversing with others about the industry, if they had an increased understanding, if they learned something about the industry, and if they are overall satisfied with the industry. The final questions invited respondents to state if there were any topics or statistics on the infographics that they disagreed with, and they could also leave other miscellaneous comments in a text box before exiting the survey.

The data collected on Qualtrics was exported to Excel and SPSS and analyzed using paired *t*-test analysis, descriptive statistics, and frequencies. Significance was set at $p < .05$. The open-ended comments were exported to ATLAS.ti (ATLAS.ti Scientific Software Development, Berlin, Germany) for organization, coding, and thematic analysis.

Results

Demographics, Diet, and Shopping Habits

The survey collected 1,053 total responses on September 19, 2024. After data clean-up, which included removing any responses that left full pre- or post-Likert matrices unanswered, failed the attention check question or finished the survey in less than five minutes, there were 961 responses. The average time to complete the survey was 14.87 minutes. The demographics are organized in Table 1.

Table 1.

Demographic data (N = 961)

Characteristic	Mean	Frequency (*n*)	Frequency percent (%)
Age	45.93		
Gender			
Female		489	50.9
Male		452	47.0
Other		14	1.5
Prefer not to say		6	0.6
Racial Identity			
White		716	
Black or African American		150	
American Indian or Alaskan Native		29	
Asian		89	
Native Hawaiian or Pacific Islander		5	
Prefer not to say		36	
Education			
High school or less		127	13.2
Some college, associate degree, or vocational training		334	34.8
Bachelor's degree		365	38.0
Master's degree		101	10.5
Doctoral/professional degree		34	3.5
Urban-rural Classification			
Rural		202	21.0
Suburban		528	54.9
Urban		231	24.0
Eat Beef			
No		46	4.8
Yes		913	95.0
Missing response		2	0.2
How often do you consume beef?			
Never		46	4.8
A few times per year/special occasion		46	4.8
Once or twice a month		147	15.3
Once a week		263	27.4
More than twice a week		404	42.0
Daily		55	5.7
Primary Grocery Shopper			
Yes		841	87.5
No		120	12.5

Characteristic	Mean	Frequency (*n*)	Frequency percent (%)
Do you ever purchase beef?			
Yes		804	95.6
No		37	4.4

Note: due to rounding, frequencies may not equal 100%

People from rural areas eat beef more frequently than those from urban and suburban areas ($p = .007$; $p = .011$). Participants that do not eat beef and shared in the open response stated they avoid it for ethical or environmental reasons or for health implications. Of the participants that do purchase beef ($n = 804$), some indicated that they do not consume it, but as the primary grocery shopper they do purchase for the household. Participants in this sample ranked freshness, quality, and cut or type of beef as the top three important characteristics when purchasing beef products. The least important were the presence of animal welfare labels, the animal's diet (if it was grass-fed or grain-fed), and the presence of sustainability labels. Table 2 shows the average ranking of each attribute, with the lower the score, the higher the ranking.

Table 2.

Rank of importance of qualities or attributes of beef when purchasing

Quality or Attribute	Mean (In Rank Order)
Freshness	2.49
Quality	3.02
Cut or type of beef	4.60
Price	4.82
Fat content/leanness	5.77
USDA grade	6.03
Production location labels (locally grown/raised)	8.53
Hormone or antibiotic free	8.78
Brand	8.83
Organic or natural labels	8.99
Animal welfare labels	9.10

Perceptions of the Industry

News stations or televised news programs ($n = 232$), social media ($n = 196$), and internet searches ($n = 149$) were the most popular sources of news about beef and agriculture, followed

by word of mouth (n = 116) and food labels (n = 112). Respondents were given the option to type in an "other" answer (n = 41), with two respondents saying they get their information from local farmers or their friend who raises beef cattle; 11 people said some variation of online news stories or news sites; two said documentaries and four mentioned NPR or the radio. Two people said they do their own personal research, while eight said they do not see or search for news on agriculture or the beef industry. The remaining were some variation of "not applicable" or listing the allotted choices.

Table 3 shows the frequencies and percentage of respondents ranking what is the most important to address when it comes to sustainability in the beef industry.

Table 3.

Rank of importance of items to address in beef industry sustainability (n = 958)

	1 (Most important)	2	3	4	5	6 (Least important)	Mean
Animal welfare	290 (30.3%)	225 (23.5%)	165 (17.2%)	102 (10.6%)	114 (11.9%)	62 (6.5%)	2.70
Animal wellness	118 (12.3%)	355 (37.1%)	180 (18.8%)	96 (10.0%)	136 (14.2%)	73 (7.6%)	3.00
Affordability or availability	285 (29.7%)	77 (8.0%)	167 (17.4%)	60 (6.3%)	69 (7.2%)	300 (31.3%)	3.47
GHG emissions	157 (16.4%)	96 (10.0%)	149 (15.5%)	203 (21.2%)	90 (9.4%)	263 (27.5%)	3.80
Land resource usage	49 (5.1%)	91 (9.5%)	156 (16.3%)	259 (27.0%)	304 (31.7%)	99 (10.3%)	4.02
Water resource usage	59 (6.2%)	114 (11.9%)	141 (14.7%)	238 (24.8%)	245 (25.6%)	161 (16.8%)	4.02

Note: due to rounding, frequencies may not equal 100%

The lower the mean score, the higher the importance, with animal welfare, animal

wellness, and affordability or availability of beef ranked the highest, and GHG emissions and land and water resource usage ranked the lowest. Each item was ranked both the lowest and highest of importance, showing a variety of opinions from this sample.

The objective knowledge section consisting of four multiple choice questions that mirror the information in the infographic showed that more than half of respondents answered the questions correctly, with two out of the four subjective vs objective questions showing that respondents overstated their knowledge. A total of 36.3% claimed to be knowledgeable about the U.S. beef industry's GHG emissions, 25.9% claimed to be knowledgeable about water usage, 30.3% claimed to be knowledgeable about land usage, and 34.7% of respondents claimed to be knowledgeable about growth-promoting technologies. Compared to the objective knowledge questions, 40.0% of respondents correctly answered that 3.7% of the U.S. GHG emissions is from the beef industry (EPA, 2021), and 34.6% correctly answered that it takes approximately 273 gallons of water to produce one pound of boneless beef (Klopatek & Oltjen, 2022; this number was converted from the 2,275 liters of blue water per kilogram of boneless beef reported, as the United States does not use the metric system and gal/lb would be more understood by this audience). In contrast, 25.9% and 31.2% of respondents correctly answered that conventionally raised beef uses 44.7% less land than fully grass-fed beef and that it would take 385,000 more animals to produce the same amount of beef if the U.S. removed growth-promoting technologies (Capper & Hayes, 2012).

RQ1: Will exposure to infographics increase participants' subjective knowledge about sustainability metrics and efforts in the beef industry?

A paired samples *t*-test was performed to evaluate whether there was a difference between the pre-infographic viewing self-assessed knowledge and the post-infographic viewing self-assessed knowledge (Table 4). The self-assessed knowledge subscale is a 5-item 5-point

Likert-type scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) that demonstrated excellent reliability (Cronbach's α pre-knowledge = .90; Cronbach's α post-knowledge = .91).

Table 4.

Mean response to level of self-assessed knowledge before and after viewing infographics

"I am knowledgeable about…"	Before infographic	After infographic	*N*	Difference
"…the U.S. beef industry's GHG emissions."	2.84	3.53	961	-.70***
"…the U.S. beef industry's water usage."	2.63	3.43	957	-.80***
"…the U.S. beef industry's land usage."	2.72	3.49	954	-.77***
"…the technologies used to improve beef cattle efficiency."	2.86	3.54	960	-.68***
"…sustainability efforts in the beef industry."	2.68	3.56	953	-.89***

***$p < .001$

There was a statistically significant increase in self-assessed knowledge after viewing the infographics in all five topics described in the study ($p < .001$). Males reported a higher pre-viewing self-assessed knowledge than females on GHG emissions, water usage, and land usage ($p < .001$). There were no differences between rural, urban, and suburban respondents in all the specified areas except urban respondents claiming a higher level of knowledge in the beef industry's water usage and sustainability efforts than the suburban respondents ($p < .001$; $p = .014$, respectively). Previous studies have shown that rural-residing people tend to be more knowledgeable about agriculture than suburban and urban people, so it interesting that this sample of rural respondents did not consider themselves significantly more knowledgeable than their counterparts (Frick et al., 1995; Harmon & Maretzki, 2006; Dale et al., 2017; as cited by Wilson & Lusk, 2020).

RQ2 and RQ3: Will exposure to infographics improve negative opinions of the beef industry? Will exposure to infographics alter incorrect perceptions of the beef industry?

A paired samples *t*-test was performed to evaluate whether there was a difference between the pre- and post-infographic viewing agreement with statements about beef's environmental footprint and growth-promoting technologies (Table 5). These were separate 4-item 5-point Likert-type scales, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) with both demonstrating adequate reliability (Cronbach's α pre- and post-environmental footprint = .62 and .66, respectively; Cronbach's α pre- and post-growth-promoting technologies = .71 and .80, respectively). Three of the statements' pre- and post-viewing differences refer to RQ2: "I believe that the U.S. beef industry is sustainable; I am not worried about added hormones in beef; and growth-enhancing technologies are safe to use on animals intended for human consumption." These statements were worded to be opinionated statements for the participants to rate their agreement or disagreement. The remaining statements in Table 5 refer to RQ3 and changing incorrect perceptions of facts about the beef industry and production.

Table 5.

Mean response to level of agreement to statements before and after viewing infographics

Statement	Before infographic	After infographic	*N*	Difference
"I believe that the U.S. beef industry is sustainable."	3.11	3.59	961	-.49***
"The beef industry has a relatively small contribution to GHG emissions compared to other industries in this country."	3.03	3.74	959	-.72***
"Conventionally raised beef uses fewer natural resources than 100% grass-fed beef."	3.25	3.79	957	-.54***

Statement	Before infographic	After infographic	*N*	Difference
"Conventionally raised cattle spend the majority of their lives eating grass or forages."	2.88	3.25	956	-.37***
"I am not worried about added hormones in beef."	2.39	2.93	960	-.54***
"If someone is worried about hormones in food, beef is a low-hormone food choice."	2.64	3.37	960	-.73***
"If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable."	3.01	3.57	960	-.56***
"Growth-enhancing technologies are safe to use on animals intended for human consumption."	2.66	3.24	960	-.57***

***p<.001

There was a statistically significant increase in agreement with all the statements about the beef industry's environmental footprint and growth-promoting technologies ($p < .001$). The largest changes in agreement were seen in the statements "the beef industry has a relatively small contribution to GHG emissions compared to other industries in this country," and "if someone is worried about hormones in food, beef is a low-hormone food choice."

In the pre-infographic Likert questions, rural respondents and urban respondents believe that the industry is more sustainable than the suburban respondents ($p = .002$; $p = .017$). Rural respondents agreed more than the suburban and urban respondents that the beef industry has a small GHG contribution compared to other industries ($p < .001$; $p = .026$). Urban respondents had a higher agreement than rural and suburban respondents that conventionally raised cattle spend the majority of their lives eating grass or forages ($p < .001$; $p < .001$) and also had a higher

agreement that growth-enhancing technologies are safe to use on animals intended for human consumption ($p = .003$; $p = .002$). Urban respondents are less worried about added hormones in beef than suburban respondents ($p = .026$), and urban respondents agree more than suburban respondents with the statement that eliminating those technologies would lessen the environmental sustainability of the industry ($p = .015$). Urban respondents agreed more than rural respondents with the statement that conventionally raised cattle use fewer natural resources than 100% grass-fed beef ($p = .036$). From these results, urban respondents tended to have a more positive opinion on the beef industry and rate themselves more knowledgeable. Furthermore, females tended to have a lower post-exposure agreement with these statements, particularly those that focus on hormones in beef ($p < .001$).

Extrapolating only the non-beef consumers, there was a difference in the significance in the pre- and post-viewing opinions. Exposure to the infographics still resulted in an increase in agreement with all the statements, but they tended to have a lower pre-viewing opinion than the overall sample except in the question about the safety of growth-promoting technologies, and their post-viewing opinions were still negative toward the industry.

There were three statements that the non-beef consumers did increase their agreement passed the middle of the scale. Despite this portion of the sample having more negative views on the beef industry, exposure to the infographics and the information was persuasive enough to statistically increase their perceptions and opinions.

Table 6.

Mean response of non-beef consumers to level of agreement to statements before and after viewing infographics (n = 46)

Statement	Before infographic	After infographic	Difference
"I believe that the U.S. beef industry is sustainable."	1.91	2.41	-.50***
"The beef industry has a relatively small contribution to GHG emissions compared to other industries in this country."	2.20	2.98	-.78***
"Conventionally raised beef uses fewer natural resources than 100% grass-fed beef."	2.85	3.50	-.65***
"Conventionally raised cattle spend the majority of their lives eating grass or forages."	2.07	3.04	-.97***
"I am not worried about added hormones in beef."	2.30	2.57	-.27
"If someone is worried about hormones in food, beef is a low-hormone food choice."	2.20	2.98	-.78***
"If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable."	3.00	3.37	-.37*
"Growth-enhancing technologies are safe to use on animals intended for human consumption."	2.28	2.70	-.42**

*$p < .05$, **$p < .01$, ***$p < .001$

The recall questions asked respondents to recall a piece of information from each infographic. A total of 48.9% of respondents correctly recalled that transportation is the main source of GHG emission in the U.S.; 59.3% correctly recalled that tofu has the highest estrogenic activity of the foods mentioned, and 42.7% correctly recalled that conventionally raised beef uses 75.2% less water than grass-fed beef.

RQ4: Does exposure to the infographics increase participants' self-reported likelihood of engaging in specific behaviors related to the beef industry (e.g., support, communicating about the industry)?

The behavior section wanted to investigate if the respondents were more likely to engage in certain behaviors after viewing the infographics (Table 7). This was a 7-item 5-point Likert-type scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) demonstrating good reliability (Cronbach's $\alpha = .87$). Table 7 shows that the majority of respondents agreed or strongly agreed with the statements relating to their likelihood to change or modify behaviors after viewing the infographics, and the majority also agreed or strongly agreed that they felt like they learned something and are interested in learning more about sustainability in the beef industry. Respondents most strongly agreed that they had a better understanding of sustainability in the beef industry after participating in this survey, with 92.5% of respondents agreeing or strongly agreeing. It is also encouraging that 72.8% agreed or strongly agreed that they felt more comfortable conversing about these topics after participating in the study. For every statement, 20% or less of the sample disagreed or strongly disagreed. This coupled with the percentage of participants that showed agreement toward engaging in supportive behaviors or becoming more knowledgeable indicates a generally positive reception to the information presented and highlights this research's potential to influence behavior and knowledge.

Table 7.

Post-test behavior modifications and interest

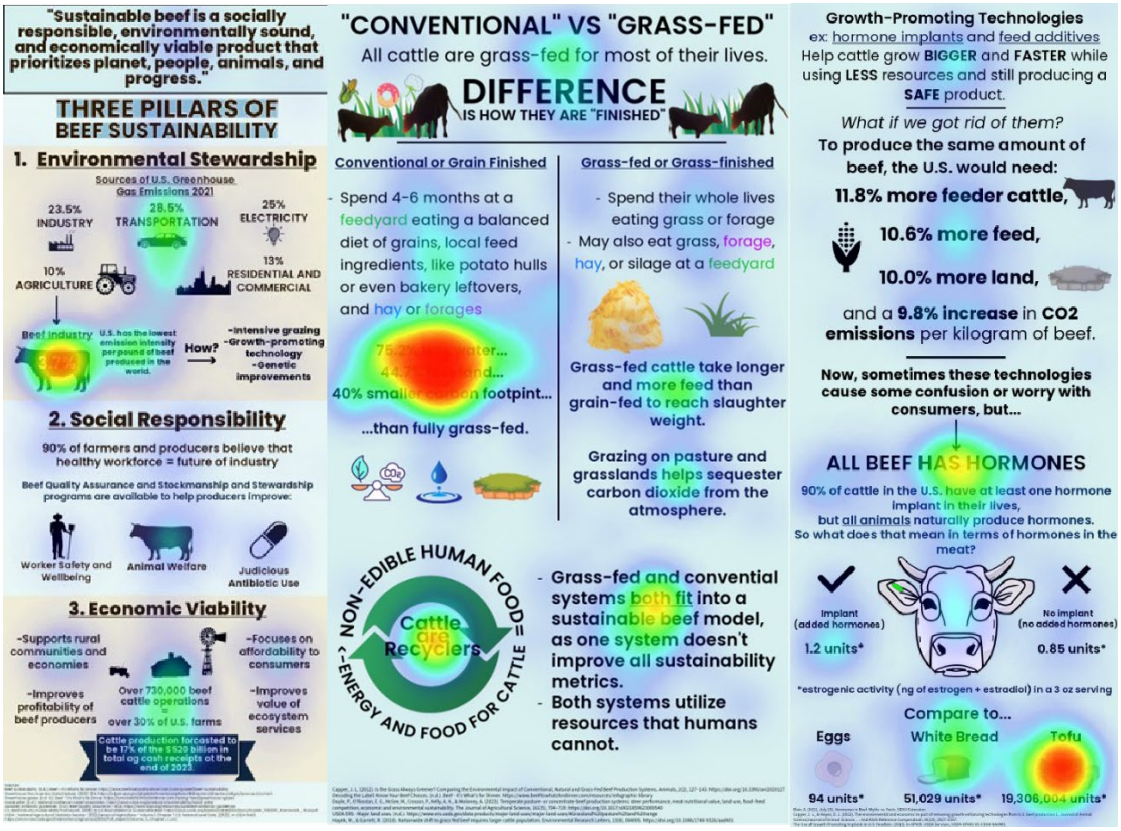
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N	Mean
"I am more likely to support the beef industry."	41 (4.3%)	91 (9.5%)	258 (27.1%)	426 (44.7%)	137 (14.4%)	953	3.55
"I am more comfortable having a conversation with others about the beef industry."	21 (2.2%)	73 (7.7%)	165 (17.3%)	567 (59.6%)	126 (13.2%)	952	3.74
"I am more likely to engage in conversations with others about the beef industry."	44 (4.6%)	143 (15.0%)	267 (28.0%)	397 (41.7%)	101 (10.6%)	952	3.39
"I have a better understanding of sustainability in the beef industry."	16 (1.7%)	35 (3.7%)	112 (11.8%)	598 (62.9%)	190 (20.0%)	951	3.96
"I learned something about the beef industry."	5 (0.5%)	12 (1.3%)	55 (5.8%)	524 (55.2%)	354 (37.3%)	950	4.27
"I am interested in learning more about the beef industry."	38 (4.0%)	115 (12.1%)	230 (24.2%)	432 (45.5%)	135 (14.2%)	950	3.54
"Overall, I am satisfied with the U.S. beef industry."	49 (5.2%)	96 (10.1%)	240 (25.3%)	421 (44.5%)	141 (14.9%)	947	3.54

Note: due to rounding, frequencies may not equal 100%

Three heat map questions, one for each infographic, asked respondents to choose one area of each infographic that they considered the most impactful. Areas with more interaction or clicks appear "hotter" or redder, and areas with fewer interactions displayed colors on the other end of the color spectrum (Qualtrics, 2024). Figure 1 shows that almost every section or piece of information on each infographic was considered "impactful" by respondents, as these areas are showing at least a blue or purple hue.

Figure 2.

Heat map results showing the most impactful components of each infographic



On the infographic explaining the three pillars of sustainability, the image of the cattle representing the industry's GHG emissions was the most interacted with. Other notable areas of interest were the transportation industry's GHG emissions and the economic pillar showing the amount of beef cattle operations in the U.S. The conventional-vs-grass fed infographic showed that respondents clicked the statistics comparing conventionally fed cattle's resource usage in comparison to grass fed. The graphic "cattle are recyclers" and its explanation was yellow-orange, showing another area of high interaction. The third infographic about growth-promoting technologies and hormones showed the bottom half of the image with the most clicks, with the information about tofu's estrogenic activity displaying very saturated red.

Open-Ended Responses

The last two questions had a textbox entry for open responses, and the data was exported to ATLAS.ti to create codes for sorting the responses. Because there were no guidelines or character limits, answers ranged from short statements to paragraphs in length. The first question asked, “Are there any topics from the infographics or statistics represented that you don't agree with? Leave blank if none.” There were 161 responses; however, over one-third said some variation of “none” or discussed something that was not presented in the content of the survey, such as genetically modified organisms or global GHG emissions. A few responses expressed vehement disagreement with the beef industry and eating animal products altogether. Eight respondents stated they would need to do more research before fully agreeing or disagreeing, with one person stating they “are not adequately knowledgeable about the beef industry to make an informed comment.” There were also 16 comments that stated some information felt misleading or misrepresented, with four of them stating it was propaganda. One respondent stated, “the information needs to be compiled by an outside source with no ties to the industry.”

The remaining responses mentioned disagreement with how the estrogen information was presented, the differences in grass and grain fed, and the pillars of sustainability. A total of 56 comments mentioned estrogen, phytoestrogen, or growth promotants. The most common sentiment was that they were unsure or disagreed with the use of growth hormones in beef cattle. Another common concern was the comparison of the hormones in tofu and meat, with one respondent calling it “disingenuous” and another saying it is an “absurd exaggeration.” A total of 7 responses disputed the differences in grass and grain fed cattle, with most sharing “I don’t believe conventional is more sustainable than grass fed.” In reflection, while the infographic does state that neither system fulfills each pillar of sustainability and that they both fit into a sustainable system (Cooprider et al., 2011), the sources used do favor conventional cattle with

feedlot systems and growth-promoting technologies more than grass fed or natural systems, so the argument of a perceived bias is valid.

The second free response question directed them to leave any feedback or comments, and it received 224 responses. Some comments from the previous question would have been more appropriate for this question, such as some of the visual and textual suggestions and general comments or disagreements about animal welfare issues in the industry. For example, someone stated that they didn't agree with "animal welfare taking a backseat to profitability." It was not meant to be implied that this is the case, as animal welfare is a top priority for beef producers (Edwards-Callaway & Calvo-Lorenzo, 2020; Smith et al., 2024). A total of 51 responses stated that they had no further feedback, and 61 people expressed thanks for the opportunity to participate or appreciated the information. One respondent shared, "My family is ranchers and have contributed to the beef industry for years. I never thought about how they are taken to farms to fatten them up. This survey gave me a lot of insight." Another respondent who found this survey insightful said, "This is interesting, and contradicts most of the things I've heard about the beef industry." Most of these comments were positive or neutral in tone or attitude, but there were a few responses that were aggressive and against the research altogether.

Discussion and Conclusions

These research results show that exposure to infographics can significantly increase subjective knowledge and positive opinions and perceptions of the beef industry. Respondents also reported an increase in the likelihood of engaging in behaviors that support the beef industry. These results are encouraging for the use of infographics in agricultural communications; however, it is important to look beyond the statistical significance and consider the practical implications of these results.

While Table 4 shows a positive increase in self-assessed knowledge, the average ranking

shifting from “disagreement” to “neither agree nor disagree.” Tables 5 and 6 also show positive increases in agreement with every statement, but the means still show a disagreement or neutral feelings toward the topic. For example, after viewing the infographics, respondents increased their agreement toward not being worried about hormones in beef, but the mean response was still below a 3, showing a general disagreement with the statement remaining after the treatment. Furthermore, these responses are hovering around the middle of the scale, which indicates an average neutral opinion toward the statements. The non-beef consumers had more negative opinions than the overall sample, and there were areas of sustainability that remained negative. Participants expressed lingering doubt specifically about the hormone information and possible over- or underinflation of statistics represented.

Expanding on the hormone doubt, it is interesting that the hormone infographic had the most feedback and interaction (see Figure 2), as the presence of hormone-free labels on beef did not rank very high in their importance of attributes when purchasing beef, which is similar to other studies. Lassoued et al. (2023) found that less than half of their sample claimed that hormone-free was an important label or attribute in their purchasing decisions. Howard et al. (2017) noted that university students are only “relatively concerned” with the use of growth hormones in cattle. Because animal welfare is important to consumers, the use of hormones might be a bigger concern than indicated, and it is possible that presence of hormone-free labels and discussions of growth promotants use in the media might increase consumer awareness (Sutherland et al., 2020). There are opposing viewpoints on the use of hormones in food animals, as the United States allows these technologies while many European Union countries do not (Evans et al., 2022). The Food and Drug Administration (FDA) requires rigorous testing and proof that hormones are present at appropriate levels in animal products. With some respondents’ argument of the difference between estrogen in beef and phytoestrogen in plants and the claim

that this study reported this information disingenuously, the facts show that mammalian estrogen and phytoestrogen are structurally and functionally similar, and the research on the possible benefits or concerns of phytoestrogen on the human body tend to contradict themselves (Patisaul & Jefferson, 2010). There may be a need for robust evidence to address this persistent distrust or misconception about hormone use in beef production, highlighting an opportunity for the beef industry to invest more in research and disseminate information accordingly.

Consumer Rankings of Beef Qualities and Sustainability Metrics

Comparing these results to previous studies, the rank of attributes of beef in Table 2 are similar to O'Brien et al. (2023), Schroeder et al. (2023), and Lassoued et al. (2023), however price did not rank in the top three as it did in these studies. Schroeder et al. (2023) sorted the beef attributes in their survey to fit into one of the three pillars of sustainability. Animal welfare and hormone/antibiotic free is the social pillar; low carbon beef is environmental, and price and supports local farmers is economic. Their remaining attributes (freshness, safety of food, nutritious content, and flavor/juicy/tender) were labeled as "general" (Schroeder et al., 2023). The attributes used in this research came from multiple survey instruments, so some are not included in Schroeder et al.'s study or the wording is slightly different. The presence of sustainability labels was ranked as the least important quality, consistent with findings from their study where "low- carbon beef" also ranked last. The top three attributes most similarly fit the "general" category, showing that while this sample did express concern for the environmental and social aspects of sustainability in other areas of the survey, sustainability ultimately isn't guiding their purchasing behaviors, as supported by van Bussel et al. (2022).

The ranking results in Table 3 show that resource usage and protection ranked lower than animal welfare considerations, which is interesting that the environmental aspects of sustainability rank the lowest in this survey, as Peano et al. (2019) found the opposite, with

consumers considering the environmental aspect the most important. Oesterreicher et al. (2018) also found that millennials consumers were most worried about the environment. Each item was ranked the highest and lowest on the importance scale, and some participants did consider the environmental aspects similarly to these studies' results, so this highlights that consumers' perspectives on the importance of different topics in sustainability are variable.

Future Research

Upon review and reflection of the infographic design, potentially decreasing the information on each infographic or choosing to focus on a specific area of sustainability may have been more impactful on results. Approximately 43-59% of respondents correctly recalled some of the information and statistics from the infographics. Fischer et al. (2023) didn't find significant differences in recall between pie charts, bar charts, or pictographs, so if this study were to be repeated, incorporating the other figures could create more interesting visuals. Future studies could possibly benefit from engaging the help of students or professionals in the graphic design field as members of the research team. With more professionally crafted infographics paired with continual beef sustainability research and information, infographic use in the beef industry could have positive results on consumer perceptions.

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Appendix A

Qualtrics Survey for Exploring Alabama Beef Producers' Opinions and Implementation of Sustainable Practices

Information Letter

Exploring Alabama Beef Producers' Opinions and Implementation of Sustainable Practices

If you are a beef cattle producer in the state of Alabama and are over the age of 18, you are invited to participate in a research study exploring beef producers' opinions and implementation of beef sustainability and sustainable practices. The study is being conducted by Donald Mulvaney, Associate Professor of Animal Sciences at Auburn University. You are being invited to participate because you are a beef producer in the state of Alabama and receiving an email from the Alabama Cooperative Extension Service (ACES) or Alabama Cattlemen's Association (ACA).

What will be involved in this survey? Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to complete an electronic survey consisting of questions regarding your opinions of beef sustainability and implementation of sustainable practices. Your total time commitment will be approximately 15 minutes.

Are there any risks or discomforts? This is a completely voluntary, anonymous study which can be exited at any time. There are no risks or discomfort associated with taking this survey and the subject matter should not cause any strong physical or emotional responses. At any time during the duration of the survey you may choose to stop completing the survey or may choose to skip any questions (besides required qualifying questions) that you may find uncomfortable to answer.

Are there any costs? If you decide to participate, there are no costs to you other than the estimated 15 minutes required to complete the survey.

Will you receive compensation for participating? If you choose to do so, a giveaway for three $100 and four $50 gift cards will be available for you to enter at the end of this survey. Entering the giveaway will require you to enter your email in order to be contacted if you are selected as a winner, however your email will not be associated with any of the answers you provide during the survey. However, there is no guarantee that you will receive any of the benefits described.

If you change your mind about participating, you can withdraw at any time by closing your window browser. Once you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University or the Department of Animal Sciences.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by maintaining all data on single password protected computers accessible only by study approved personnel. Information collected through your participation may be used for presentations at academic conferences or for publication in academic journals.

If you have questions about this study, please or contact Dr. Donald Mulvaney, Associate Professor in the Department of Animal Sciences at 334-844-1514 or at mulvadr@auburn.edu.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu. **Having read the information above, you must decide if you want to participate in this research project. If you decide to participate, please click on the arrow below. You may create a copy of this letter to keep**.

End of Block: Purpose and Consent

Start of Block: Demographics

Q1 Do you own or manage beef cattle in the state of Alabama?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Q1 = No

Q2 What is your age in years?

_____

Q3 What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to say (4)

Q4 How many years have you managed beef cattle and/or been involved in the beef cattle industry? Please use a whole number.

_____

Q5 What county in Alabama is your farm or operation located?

▼ Prefer not to respond (68) ... Winston County (67)

Q6 How would you categorize your beef cattle operation? You can pick more than one option.

- ☐ Cow-calf (1)
- ☐ Stocker (2)
- ☐ Backgrounder (3)
- ☐ Finisher (4)
- ☐ Seed stock (5)
- ☐ Bull development (6)

Q7 Approximately how many head of beef cattle (including calves) do you manage in your operation?

- ○ 1-10 head (4)
- ○ 11-20 head (5)
- ○ 21-30 head (6)
- ○ 31-50 head (7)
- ○ 51-100 head (8)
- ○ 101-250 head (9)
- ○ 251-500 head (10)
- ○ 500-999 head (11)
- ○ 1000+ head (12)

End of Block: Demographics

Start of Block: Sustainability Questionnaire

Sustainability Definition **Please read the following information about sustainability before continuing.** The USDA defines sustainable agriculture as "an integrated system of plant and animal production practices having a site-specific application that will over the long-term satisfy human food and fiber needs." With a growing population, the agriculture sector needs to adapt to meet this goal, and the beef industry definitely has a role in feeding and supplying the world. Sustainability has three pillars: social responsibility, economic viability, and environmental stewardship. For a production system to be fully sustainable, the industry should aim to satisfy each of these areas. The environmental pillar is very often the most recognized with heavy focus on beef's greenhouse gas emissions and water or land usage. Social responsibility includes focus on animal welfare improvements, worker safety, and satisfying consumers' demands. Economic viability refers to both the producer's ability to make a profit and keeping beef prices affordable for consumers to continue enjoying beef products as a part of a healthy diet.

End of Block: Sustainability Questionnaire

Start of Block: Concerns about Sustainability

Q8 What do you believe **consumers** are the most concerned about when it comes to sustainability in the beef industry? Please drag the answers up or down to rank from most to least concerned.

_____ Greenhouse gas emissions (1)
_____ Land resource usage and pollution (2)
_____ Water resource usage and pollution (3)
_____ Animal welfare (physical treatment of animals, living conditions, slaughter, etc.) (4)
_____ Animal wellness (usage of antibiotics and medications, diet and feedstuffs, etc.) (5)
_____ Affordability of beef (6)

Q9 What are **you** most concerned about when it comes to sustainability in the beef industry? Please drag the answers up or down to rank from most to least concerned.

_____ Greenhouse gas emissions (1)
_____ Land resource usage and pollution (2)
_____ Water resource usage and pollution (3)
_____ Animal welfare (physical treatment of animals, living conditions, slaughter, etc.) (4)
_____ Animal wellness (usage of antibiotics and medications, diet and feedstuffs, etc.) (5)
_____ Affordability of beef (6)

Page Break

Q10 Using a scale of 1 to 5, with 1 being “Not at All Important" and 5 “Very Important,” when you think about your operation’s potential environmental impact (including air emissions) on the following stakeholders, how important is each stakeholder to consider?

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Important (4)	Very important (5)
Your employees (1)	○	○	○	○	○
Your immediate neighbors (2)	○	○	○	○	○
Your local community or town (3)	○	○	○	○	○
Your state (4)	○	○	○	○	○
The reputation of the beef industry as a whole (5)	○	○	○	○	○
United States (6)	○	○	○	○	○
Global community (7)	○	○	○	○	○

Q11 What does your operation need to be prepared to adopt and/or further improve sustainability practices? Rank from most needed to least.

_____ Understand financial benefits of implementing sustainability practices (1)

_____ Research to identify sustainability solutions to reduce my beef sector's environmental footprint that are financially viable (2)

_____ Standardized expectations/measures of my beef sector’s sustainability (3)

_____ More capital investment to resource progress in my sector’s sustainability (4)

_____ "How to" information on measuring on-farm sustainability, including collecting data and reporting (5)

_____ "How-to" information on practices that will improve my operation's sustainability (6)

_____ Background on what sustainability is and why it is important (7)

End of Block: Concerns about Sustainability

Start of Block: Climate Smart Beef

Carbon Environmental stewardship is often the most focused on of the three pillars. The USDA announced the Partnership for Climate-Smart Commodities in February 2022. USDA will finance partnerships to support the production and marketing of climate-smart commodities via a set of pilot projects lasting one to five years. USDA is investing $3.1 billion in 141 selected project so far. The goals include: Hundreds of expanded markets and revenue streams for farmers and ranchers and commodities across agriculture and forestry ranging from traditional corn to specialty crops. More than 60,000 farms reached, encompassing more than 25 million acres of working land engaged in climate-smart production practices, like cover crops, no-till and nutrient management, as well as pasture and forestry management. More than 60 million metric tons of carbon dioxide equivalent sequestered over the lives of the projects. This is equivalent to removing more than 12 million gasoline-powered passenger vehicles from the road for one year. Involvement of nearly 100 universities, including over 30 minority serving institutions. This will bring new ideas and innovative skills in monitoring and outreach. To name a few, projects related to beef in Alabama include: Climate-Smart Grasslands: The Root of Agricultural Carbon Markets Producer Led Collaborative Effort to Fundamentally Transition the U.S. Beef Supply Chain to Carbon Neutral Low Carbon Beef USDA Pilot Program: A Fully Integrated Lifecycle Approach to Reduce GHG Emissions from Beef Cattle at Commercial Scale. (for more information, visit USDA Climate Solutions)

Q12 Are you aware of any emerging marketing programs for 'Climate-Smart Beef'?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q13 If there was a program for an approved 'Climate-Smart Beef' label that offered marketing incentives, would you be interested in participating?

- ○ Yes (1)
- ○ No (2)
- ○ I would need more information (3)

End of Block: Climate Smart Beef

Start of Block: USRSB Indicators: Water, Land, GHG

Q14 The following section designations and content were determined from the USRSB sustainability indicators referenced in the Sustainability Assessment Guides.

Q15 The following question uses a scale of 1 to 5, with 1 being “Not Important" and 5 "Very Important." How would you rate the importance of:

	Not Important (1)	Slightly Important (2)	Moderately Important (3)	Important (4)	Very Important (5)
Preserving water resources on your land or operation (1)	○	○	○	○	○
Preserving land resources on your operation (2)	○	○	○	○	○
Mitigating pollutants and greenhouse gas emissions (3)	○	○	○	○	○
Increasing efficiency and yield (4)	○	○	○	○	○
Animal health and wellbeing (5)	○	○	○	○	○
Employee health and wellbeing (6)	○	○	○	○	○

Water and Land Resources

Q16 Do you have a grazing management plan in place?

- ○ Yes (1)
- ○ No (2)

Skip To: Q19 If Q16 = No

Q17 Does your grazing management plan intentionally seek to maintain or improve water resources?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q18 Does your grazing management plan intentionally seek to maintain or improve land resources?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q19 What grazing management techniques do you employ? Select all that apply

- [ ] Continuous grazing (1)
- [ ] Rotational grazing (2)
- [ ] Intensive rotational grazing (3)
- [ ] Creep grazing (4)
- [ ] First-last (follow the leader) grazing (5)
- [ ] Other (6) _____

Q20 Do you have any kind of manure management in place?

- ○ Yes (1)
- ○ No (2)

Page Break

Air and Greenhouse Gas (GHG emissions)

Q21 Would you consider exploring alternative energy sources (solar panels or windmills) to power your facilities, water pumps, etc.?

- ○ Yes (1)
- ○ No (2)
- ○ I would need more information (3)

Q22 On a scale of 1 to 5, with 1 being “Not at All Aware” and 5 being “Aware,” how would you rate your awareness of commercial or retail items on the market for lowering methane output in cattle?

- ○ 1 - Not at All Aware (1)
- ○ 2 - Slightly Aware (2)
- ○ 3 - Somewhat Aware (3)
- ○ 4 - Moderately Aware (4)
- ○ 5 - Aware (5)

Q23 Do you employ any carbon sequestration practices?

- ○ Yes (1)
- ○ No (2)
- ○ I do not know/I am not aware of carbon sequestration practices (3)

Q24 Would you consider exploring carbon management assessments services or carbon credits?

- ○ Yes (1)
- ○ No (2)
- ○ I would need more information (3)

Page Break

Animal Health and Well-Being

Q25 Have you ever completed Beef Quality Assurance (BQA) training?

- ○ Yes (1)
- ○ No (2)

Q26 Do you require your employees to be trained in stockmanship and safety, such as through BQA training or Extension animal handling courses?

- ○ Yes (1)
- ○ No (2)

Q27 Have you implemented principles from BQA (or similar program) into management of your operation?

- ○ Yes (1)
- ○ No (2)

Q28 Have you ever attended any Extension events or workshops (such as calving management workshops or the Beef Systems Short Course)?

- ○ Yes (1)
- ○ No (2)

Q29 Do you have an established relationship with a veterinarian?

- ○ Yes (1)
- ○ No (2)

End of Block: USRSB Indicators: Water, Land, GHG

Start of Block: Efficiency and Yield

Efficiency and Yield

Q30 Do you consider the use of hormone implants a sustainability practice?

- Yes (1)
- No (2)
- Unsure (3)

Q31 Do you use hormone implants in any of your cattle?

- Yes (1)
- No (2)

Q32 Please select any of the following feed additives that increase growth and efficiency that you use:

- ☐ Antibiotics (CTC, Tylosin, etc.) (1)
- ☐ Ionophores (2)
- ☐ Pre- and probiotics (3)
- ☐ Essential oils (4)
- ☐ Enzymes (5)
- ☐ None (6)
- ☐ Other (7) _____

Q33 Which of these hay feeders do you use to feed hay to your beef cattle?

- ○ Hay ring (1)
- ○ Cone hay ring (2)
- ○ Hay wagon (3)
- ○ Hay unroller (4)
- ○ Bale on the ground (5)
- ○ Other (6) _____

Q34 Do you have a determined /well-defined calving season?

- ○ Spring calving (1)
- ○ Fall calving (2)
- ○ Winter calving (3)
- ○ No, year-round calving/bull always out (4)

Q35 Do you ever use artificial insemination (AI)?

- ○ Yes (1)
- ○ No (2)

Q36 Do you utilize estrous synchronization such as CIDRs?

- ○ Yes (1)
- ○ No (2)

Page Break

Comments If you have any comments about the content of this survey, what you liked, disliked, etc. please feel free to leave them here.

_____

Thank you for your time completing this survey. **Click the arrow in the bottom right corner to submit this survey.** You will be redirected to another Qualtrics survey to enter your email address if you would like to participate in the random drawing for one of seven gift cards (valued at either $50 or $100). The researchers appreciate your contribution to this research.

End of Block: Efficiency and Yield

Appendix B

Qualtrics for Exploring the Use of Infographics to Alter Consumer Opinions and Perceptions of Sustainability

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Start of Block: Purpose and Informed Consent

Exploring the Use of Infographics to Alter Consumer Opinions and Perceptions of Sustainability within the U.S. Beef Industry

Researchers from the Department of Animal Sciences at Auburn University are looking to better understand opinions on beef production and sustainability and the effectiveness of using infographics to educate and change negative or misinformed opinions about the beef industry. If you are 18 years old and over, you are invited to participate in a research study exploring beef consumers' opinions and on beef sustainability and sustainable practices. You will be asked to answer demographic questions and then a series of multiple choice, rank order, and Likert scale questions. You will then be shown three infographics containing visuals and information about beef production. You will then answer the same set of Likert scale questions.

What will be involved in this survey? Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to complete an electronic survey consisting of questions regarding your opinions of beef sustainability. Your total time commitment will be no more than 20 minutes.

Are there any risks or discomforts? This is a completely voluntary, anonymous study which can be exited at any time. There are no risks or discomfort associated with taking this survey and the subject matter you as participant will questioned on should not cause any strong physical or emotional responses. At any time during the duration of the survey you may choose to stop completing the survey or may choose to skip any questions (besides required demographic or qualifying questions) that you may find uncomfortable to answer.

Are there any costs? If you decide to participate, there are no costs to you other than the estimated 20 minutes required to complete the survey. If you change your mind about participating, you can withdraw at any time by closing your window browser. Once you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University or the Department of Animal Sciences.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by maintaining all data on single password protected computers accessible only by study approved personnel. Information collected through your participation may be used for presentations at academic conferences or for publication in academic journals. **If you have questions about this study,** please or contact Dr. Donald Mulvaney, Associate Professor in the Department of Animal Sciences at 334-844-1514 or at

mulvadr@auburn.edu. If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.
Having read the information above, you must decide if you want to participate in this research project. If you decide to participate, please click on the arrow below. You may create a copy of this letter to keep.

End of Block: Purpose and Informed Consent

Start of Block: Demographic Information

*

Q1 Age What is your age? Enter as a whole number.

○ _____

Skip To: End of Survey If Condition: What is your age? Enter as ... Is Less Than 18. Skip To: End of Survey.

Q2 Gender What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to say (4)

Q3 Education What is your highest education level achieved?

- ○ High school or less (1)
- ○ Some college, associate degree, or vocational training (2)
- ○ Bachelor's degree (3)
- ○ Master's degree (4)
- ○ Doctoral/professional degree (5)

Q4 Grew up How would you describe the community setting you grew up in?

- ○ Rural (1)
- ○ Suburban (2)
- ○ Urban (3)

Q5 Race What is your racial identity? You can select more than one.

- ☐ White (1)
- ☐ Black or African American (2)
- ☐ American Indian or Alaska Native (3)
- ☐ Asian (4)
- ☐ Native Hawaiian or Pacific Islander (5)
- ☐ Prefer not to say (7)

End of Block: Demographic Information

Start of Block: Questions about diet and shopping habits

Q6 eat beef Do you eat beef?

- ○ No (1)
- ○ Yes (2)

Q7 often consume How often do you consume beef food products?

- ○ Never (1)
- ○ A few times a year/only on special occasions (2)
- ○ Once or twice a month (3)
- ○ Once a week (4)
- ○ More than twice a week (5)
- ○ Daily (6)

Q8 primary shop Are you the primary grocery shopper?

- ○ No (1)
- ○ Yes (2)

Skip To: Q9 purchase If Q8 primary shop = Yes
Skip To: Q11 news source If Q8 primary shop = No

Page Break

Q9 purchase Do you ever purchase beef products?

- ○ Yes (1)
- ○ No (2)

Skip To: Q11 news source If Q9 purchase = No
Skip To: Q10 rank qualities If Q9 purchase = Yes

Page Break

Q10 rank qualities Please rank the following qualities from most important (1) to least important (10) when you are purchasing beef products.

_____ Freshness (1)
_____ Quality (2)
_____ Cut or type of beef (3)
_____ USDA Grade (4)
_____ Fat content/leanness (5)
_____ Brand (6)
_____ Production location labels (i.e. locally grown/raised) (7)
_____ Animal welfare labels (8)
_____ Organic or natural labels (9)
_____ Price (10)
_____ Sustainability labels (11)
_____ Animal diet: grass-fed or grain-fed (12)
_____ Hormone or antibiotic free (13)

Page Break

Q11 news source What source or platform do you get most of your news about beef and agriculture?

- ○ News stations or televised news programs (Fox News, NBC, etc.) (1)
- ○ Social media (Twitter, Instagram, Facebook, etc.) (2)
- ○ YouTube (13)
- ○ Podcasts (12)
- ○ Internet searches (3)
- ○ Blogs (4)
- ○ Professional or outreach publications such as from an agricultural trade organization like the Farm Bureau or Cattlemen's Association (5)
- ○ University Extension communication (6)
- ○ Federal government agency such as USDA (7)
- ○ Food labels (8)
- ○ Peer reviewed journals (9)
- ○ Word of mouth, conversationally (10)
- ○ Other: (11) _____

End of Block: Questions about diet and shopping habits

Start of Block: Perceptions and Opinions

Q12 rank sus. Please click and drag up or down to rank from most (1) to least important (6) in your opinion as a consumer what is the most important to address when it comes to sustainability in the beef industry?

_____ Greenhouse gas emissions (1)
_____ Land resource usage (2)
_____ Water resource usage (3)
_____ Animal welfare (physical treatment of animals, living conditions, slaughter, etc.) (4)
_____ Animal wellness (usage of antibiotics and medications, diet and feedstuffs, etc.) (5)
_____ Affordability and availability of beef products (6)

Q13 knowledge The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree" and 5 “Strongly Agree,” to indicate your self-described level of knowledge on the following topics. **I am knowledgeable about...**

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)
…the U.S. beef industry's greenhouse gas emissions. (1)	○	○	○	○	○
…the U.S. beef industry's water usage. (2)	○	○	○	○	○
...the U.S. beef industry's land usage. (5)	○	○	○	○	○
…the technologies used to improve beef cattle efficiency (growth hormones, feed additives, etc.). (3)	○	○	○	○	○
…sustainability efforts in the beef industry. (4)	○	○	○	○	○

Page Break

Animal Agriculture Knowledge and Perceptions Questionnaire This portion of the survey refers to general knowledge of the beef industry. Please answer the following questions to the best of your ability. Do not use outside references or sources as it is the objective of this evaluation to gather a baseline of your knowledge regarding the beef industry

Q14 ghg The U.S. beef industry contributes _____% of the national greenhouse gas emissions.

- 3.7% (1)
- 7.4% (2)
- 10% (3)

Q15 water How many gallons of water does is take to produce one pound of boneless beef?

- 273 gallons (1)
- 442 gallons (2)
- 546 gallons (3)

Q16 land Conventional beef (or grain-fed beef) uses _____% less land than grass-fed beef.

- 22.3% (2)
- 37.2% (4)
- 44.7% (3)

Q17 If the U.S. beef industry stopped using growth-promoting technologies, such as hormone implants or feed additives, how many more cattle would be required to produce the same amount of beef that is currently produced with these technologies?

- ○ 192,500 (1)
- ○ 295,000 (2)
- ○ 385,000 (3)

Page Break

Q18 The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree” and 5 “Strongly Agree,” to indicate your level of agreement with the following statements about the environmental footprint of the U.S. beef industry.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I believe that the U.S. beef industry is sustainable. (1)	○	○	○	○	○
The beef industry has a relatively small contribution to greenhouse gas emissions compared to other industries in this country. (2)	○	○	○	○	○
Conventionally raised beef uses fewer natural resources than 100% grass-fed beef. (3)	○	○	○	○	○
Conventionally raised cattle spend the majority of their lives eating grass or forages. (5)	○	○	○	○	○

Q19 The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree” and 5 “Strongly Agree,” to indicate your level of agreement with the following statements about animal welfare and technologies used in the U.S. beef industry.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I am not worried about added hormones in beef. (1)	○	○	○	○	○
If someone is worried about hormones in food, beef is a low-hormone food choice. (2)	○	○	○	○	○
If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable. (3)	○	○	○	○	○
Growth-enhancing technologies are safe to use on animals intended for human consumption. (4)	○	○	○	○	○

End of Block: Perceptions and Opinions

Start of Block: Info for viewing the infographics

The next section will show you three infographics in a random order with statistics and facts about the beef industry. Once contains information about the three pillars of sustainability, one

has the differences between conventional and grass-fed beef systems, and one has information about added hormones and hormone technology in implanted beef animals. After you are done viewing all three infographics, please continue onto the next section of questions.

End of Block: Info for viewing the infographics

Start of Block: Infographics

Infographic 1

Infographic 2

Infographic 3

End of Block: Infographics

Start of Block: After viewing infographics perceptions

Q20 knowledge #2 The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree" and 5 “Strongly Agree,” to indicate your self-described level of knowledge on the following topics after viewing the infographics. **I am knowledgeable about...**

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)
…the U.S. beef industry's greenhouse gas emissions. (1)	○	○	○	○	○
…the U.S. beef industry's water usage. (2)	○	○	○	○	○
...the U.S. beef industry's land usage. (5)	○	○	○	○	○
…the technologies used to improve beef cattle efficiency (growth hormones, feed additives, etc.). (3)	○	○	○	○	○
…sustainability efforts in the beef industry. (4)	○	○	○	○	○

Q21 The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree” and 5 “Strongly Agree,” to indicate your level of agreement with the following statements about the environmental footprint of the U.S. beef industry after viewing the infographics.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I believe that the U.S. beef industry is sustainable. (1)	○	○	○	○	○
The beef industry has a relatively small contribution to greenhouse gas emissions compared to other industries in this country. (2)	○	○	○	○	○
Conventionally raised beef uses fewer natural resources than 100% grass-fed beef. (3)	○	○	○	○	○
Conventionally raised cattle spend the majority of their lives eating grass or forages. (5)	○	○	○	○	○

Q22 GETS After The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree” and 5 “Strongly Agree,” to indicate your level of agreement with the following statements about animal welfare and technologies used in the U.S. beef industry after viewing the infographics.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I am not worried about added hormones in beef. (1)	○	○	○	○	○
If someone is worried about hormones in food, beef is a low-hormone food choice. (2)	○	○	○	○	○
If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable. (3)	○	○	○	○	○
Growth-enhancing technologies are safe to use on animals intended for human consumption. (4)	○	○	○	○	○

Page Break

End of Block: After viewing infographics perceptions

Start of Block: Heat map

Q23 recall gas These next few questions are going to ask you to recall some of the information you just learned about from the infographics. Out of the main sources of greenhouse gas emissions in the United States, which source contributes the most?

- Agriculture (1)
- Transportation (2)
- Industry (3)
- Electricity (4)
- Residential and Commercial (5)

Q24 recall hormone Which of these foods has the highest estrogenic activity (nanograms per a 3 oz serving)?

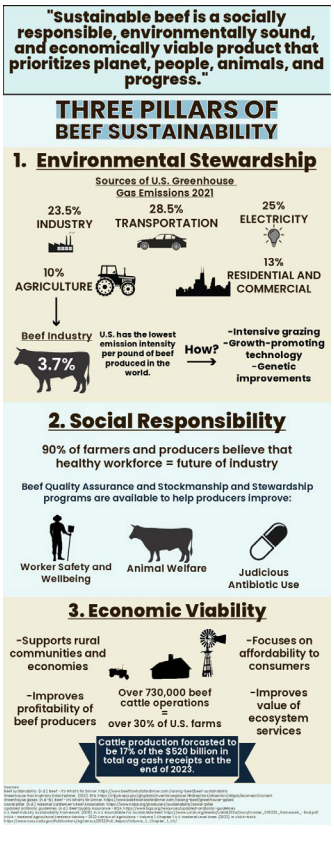
- Tofu (1)
- Beef (2)
- Eggs (4)
- White bread (3)

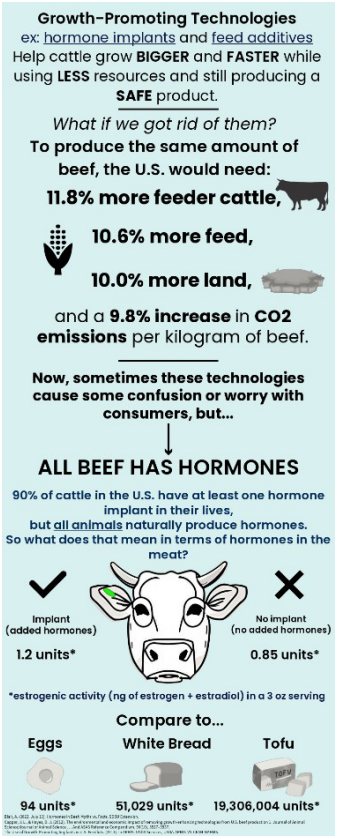
Q25 recall water How much less water does conventionally-raised beef used compared to grass-fed beef?

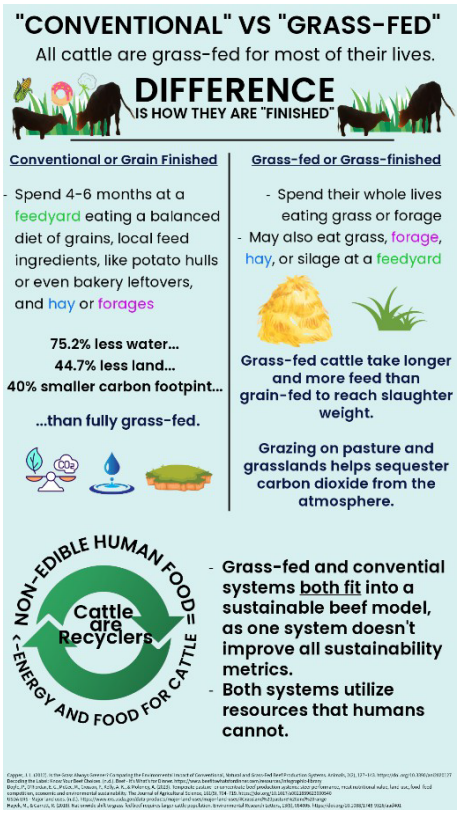
- ○ 75.2% (1)
- ○ 65.2% (2)
- ○ 85.2% (3)
- ○ 55.2% (4)

Page Break

Heat map Sus. Beef Thank you for taking the time to answer those questions. For the final part, the infographics are shown again below, and you can pick one part of each image that you found the most impactful. Simply hover over the part and click, and a dot will be added to the image. You can only put one dot on each image.







Q26 Behavior/Action The following section uses a scale of 1 to 5, with 1 being “Strongly Disagree” and 5 “Strongly Agree,” to indicate your level of agreement with the following "I" statements about your thoughts after participating in this survey. **After participating in this survey...**

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)
I am more likely to support the beef industry. (1)	○	○	○	○	○
I am more comfortable having a conversation with others about the beef industry. (2)	○	○	○	○	○
I am more likely to engage in conversations with others about the beef industry. (7)	○	○	○	○	○
I have a better understanding of sustainability in the beef industry. (3)	○	○	○	○	○
I learned something about the beef industry. (4)	○	○	○	○	○
I am interested in learning more about the beef industry. (8)	○	○	○	○	○
Overall, I am satisfied with the U.S. beef industry. (6)	○	○	○	○	○

Belief Are there any topics from the infographics or statistics represented that you don't agree with? Leave blank if none.

○ _____

Open Feedback Please feel free to leave any feedback or comments.

○ _____

End of Block: Heat map