Introduction

Conserving environmental resources while increasing agricultural production for a continually growing global population is a multifaceted challenge (German et al., 2017; Tscharntke et al., 2012). Agriculture constitutes one of the largest drivers of global environmental change but is imperative to future global food security (Rockström et al., 2017). However, the agricultural sector faces the greatest ramifications from the environmental changes it creates (Rockström et al., 2017; Walthall et al., 2012) with "food security require[ing] as much attention to increasing environmental sustainability as to raising productivity" (Garnett et al., 2013, p. 33). Agriculture benefits from multiple facets of environmental sustainability including soil health, water quality and supply, and climate resistance (Brodt et al., 2011). Likewise, sustainable agriculture benefits numerous ecosystems, such as wildlife-friendly farming that promotes biodiversity (Pywell et al., 2012) and prescribed livestock grazing to prevent wildfires (Lovreglio et al., 2014). Achieving mutual benefits between fields requires communication and cooperation between environmentalists and agriculturalists (Banks, 2004). Thus, management and communication strategies that promote sufficient food production while maintaining productive, environmentally healthy land are needed (De Fraiture & Wichelns, 2010).

Unfortunately, individuals, commodity groups, lobbyists, and other diverse stakeholders who are supportive of agriculture are often at odds with similar individuals who strive for environmental protection (Banks, 2004; Sanford, 2006; Scasta et al., 2018). The polarization between environmentalists and agriculturalists is surface-level and ignores the similarities between the groups that integrate food production and conservation (Banks, 2004). Scasta et al. (2018) found proactive communication for agricultural and environmental stakeholders may increase awareness of common values between the groups and ultimately benefit future issues. Similarly, Horton et al. (2017) explored the conservation identity of agriculturalists and found respondents who identified as conservationists discussed the "inextricable link" between conservation and production, providing an insight into the future of sustainable agriculture (p. 609). Moreover, Chappell and LaValle (2011) found biodiversity loss and food insecurity need to be addressed together, possibly with alternative sustainable agricultural practices emphasized. Therefore, integrated sustainable agriculture and environmental protection efforts benefit both the farmer and the environment suggesting holistic approaches are needed (Banks, 2004). If research and associated science communication about agriculture and the environment was a product of their common values and holistic approaches, it would better address the future of environmental sustainability and food insecurity.

Historically, one goal of land-grant universities (LGUs) was to teach science- and evidence-based agriculture to ordinary citizens in the United States (U.S.; Parr et al., 2007). A shift towards sustainability in the late 1990s emphasized the importance of human health and the environment, integrating sustainable agriculture into LGUs (Parr et al., 2007). Today, many LGUs have expanded the traditional college of agriculture name to label them as colleges of agricultural and environmental sciences, natural resources, or life sciences that provide teaching, research, and extension across both disciplines (Croft, 2019; National Research Council, 1995). The research conducted by LGUs is communicated back to the public through Extension professionals and agricultural communicators. Extension outreach encompasses not only communicating the latest research to farmers, but seeks to better the lives of community members by educating the public about sustainability practices in daily lives (Croft, 2019). Research conducted by colleges of agricultural and environmental sciences is responsible for data-driven advancements in the agricultural industry that also protect natural resources and human health (Fitzgerald et al., 2016). For example, Gold et al. (2013) evaluated the degradation of agricultural watersheds that endangers global food security and determined strategic, interdisciplinary research produced by LGUs is imperative to the future of agricultural sustainability. Ejeta (2009) asserted modern complex challenges facing agriculture, such as climate change and the global energy supply, can be addressed using the LGU research, teaching, and extension model.

LGUs are tasked with sharing their research to members of the public and engaging with members of their community through evidence-based education and science communication (Fitzgerald et al., 2016). Centers for interdisciplinary research exist at LGUs to solve agricultural challenges that require collaborative efforts from multifaceted teams (McLeod-Morin et al., 2020). Directors at those centers believe scientists are "the best communicators of science" and prioritize public interest as a goal of science communication (McLeod-Morin et al., 2020, p. 10). However, to address the future of environmental sustainability and food insecurity, the knowledge produced must be a holistic product of both agriculture and environmental science (De Leon et al., 2016; Scown et al., 2019). A limited number of studies have determined the collaborative efforts between agriculture and environmental science research programs to determine if institutional change within the LGU system is needed to increase the collaborations required to communicate agricultural and environmental findings.

Literature Review

Historically, there has been little collaboration and communication between agricultural and environmental research in the U.S., although researchers recognized the benefits of integrating the two fields as early as the mid-19th century (Banks, 2004). Environmentalists often viewed the term agriculture with images of pesticides, destroyed landscapes, and other activities that threaten the natural world. Agriculturalists, on the other hand, believed environmentalists had unrealistic expectations of environmental protection that forgoes economics and human livelihoods (Banks, 2004). The disconnect was further exacerbated as few researchers in the 20th century "explicitly focused on the incorporation of non-farmland resources into croplands" (Banks, 2004, p. 537), straying from a holistic perspective. In addition, government agencies in the U.S. treated conservation as a means for agriculture, such as minimizing farmland erosion, rather than a way to preserve biodiversity. Similarly, environmentalists have ignored the importance of agricultural landscapes in their research endeavors and policy formation activities (Banks, 2004). The historical disconnect between agriculture and the environment in the U.S. is largely problematic as increased agricultural intensification without regard for natural ecosystems will limit both agricultural systems and the environment moving forward (Butler et al., 2007).

Fortunately, there was a strong shift at the start of the 21st century towards creative and innovative approaches for integrated agricultural and environmental partnerships, communication, and research (Banks, 2004). For example, Isaacs et al. (2009) investigated the impact of integrating native plants on agricultural landscapes in order to increase survival and reproduction of beneficial arthropods, which benefits agriculture via crop pollination and pest control and benefits the environment via habitat creation and increased native biodiversity. In order to promote successful reintegration of native plants that benefits both the farmer and environment, multidisciplinary teams of researchers, educators, and native plant experts must work together (Isaacs et al., 2009). Prokopy et al. (2015) evaluated the role of Extension educators for disseminating information to farmers about climate change as well as the need to balance crop production and environmental protection and found farmers trust Extension agents, who therefore should continue to share information with farmers about climate change. However, better training for Extension agents about the nexus between climate change and agriculture is needed, specifically with help from university researchers (Prokopy et al., 2015). Telg et al. (2018) studied the barriers Extension agents who work with cattle producers face in communicating climate change. The study found Extension agents were hesitant to discuss politically divisive issues like climate change unless they had established relationships with producers and recommended training in communication practices. Continuing to foster research partnerships between agriculturalists and environmentalists through Extension education and science communication may play a vital role in the future of food security.

While there has been remarkable progress in integrating agricultural and environmental partnerships in research, the simplistic stereotypes still remain and additional communication and cooperation between the fields is needed (Banks, 2004; Scasta et al., 2018). Strategic communication may assist agriculturalists and environmentalists reach mutual goals through deliberate and purposeful communication (Holtzhausen, 2014). For example, communication about the nexus between agriculturalists and environmentalists needs to capitalize on commonalities between the two groups (Cox Callister, 2013). According to Scasta et al. (2018),

> Informed communication strategies can play a role in bridging the divide between agriculture and environmentalism/conservation [...] by facilitating the finding of common ground to guide co-management which has been suggested to be the future of natural resource [...] conservation and sustainable agriculture. (p. 762)

LGUs have the opportunity to facilitate strategic communication to a diverse set of stakeholders about interdisciplinary and multi-scale approaches for agricultural and environmental management that emphasizes their commonalities, ultimately benefiting the future of global food security. Given such, the research conducted by LGUs must be an interdisciplinary product of both agriculture and environmental science.

Purpose and Research Objective

The purpose of this study was to determine if research within a college of agricultural and environmental sciences at an LGU takes an interdisciplinary approach in addressing both agricultural and environmental issues. The following research objective was used to achieve this purpose: Determine where environmentally focused and agriculturally focused research publications overlap within a college of agricultural and environmental sciences at a LGU.

Materials and Methods

This research was part of a larger study to provide data for informing science communication of a LGU by determining the interdisciplinary research publications of the University of Georgia's College of Agricultural and Environmental Sciences. The data were initially analyzed using a thematic analysis by a lead coder. Subsequently, categories of overlap between agricultural and environmental themes were sorted using a meta-synthesis approach by a secondary coder.

Data selection

The data analyzed for this study were acquired from the University of Georgia's Elements (Symplectic, London, United Kingdom) database, a web-based system where the university's research is collected. Faculty members, postdoctoral researchers, and graduate students are required to verify their automatically captured publications in the University of Georgia Elements system. Examples of publications included peer-reviewed publications, farming or gardening guides, and books authored or coauthored by the college. In order to determine the nature of the research reported, publication titles from 2016, 2017, and 2018 assigned to faculty, postdoctoral researchers, and graduate students in the College of Agricultural and Environmental Science at the University of Georgia were collected.

Data analysis

Thematic analysis, or examining and reporting reoccurring themes within the data, was used in this study to group data for the meta-synthesis (Braun & Clarke, 2006; Vaismoradi et al., 2016). Throughout the study, a theme was identified as "something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set" (Braun & Clarke, 2006, p. 82). Thematic analysis utilizes a multi-step process where statements were coded into categories that were later added to larger themes (Boyatzis, 1998). MAXQDA (VERBI software GmbH, Berlin, Germany), a data analysis software, was used for the thematic analysis in this study.

The thematic analysis involved a single, lead coder who manually coded all of the research publications. The publication's abstract or summary was examined for codes if a publication title was not descriptive enough to be assigned a code. For example, one publication title contained only the scientific name of a plant; thus, additional information was needed to code the publication. First, the lead coder immersed themselves in the data in order to gain a deeper understanding of the content (Braun & Clarke, 2006; Castleberry & Nolen, 2018). Next, the lead coder generated initial codes from the raw data by identifying similar ideas and constructs (Braun & Clarke, 2006; Castleberry & Nolen, 2018). These codes were then sorted into groups with similar patterns or characteristics, and emerging themes developed from the recurring patterns (Braun & Clarke, 2006; Castleberry & Nolen, 2018). One limitation of thematic analysis is coding with preconceived codes or themes that do not encompass the themes or patterns in the data set (Braun & Clarke, 2006). Therefore, an emergent coding approach was used by the lead coder to allow codes and themes to develop naturally throughout the process (Castleberry & Nolen, 2018). Throughout the thematic coding process, the lead coder revisited the codes to review and reanalyze themes (Braun & Clarke, 2006; Castleberry & Nolen, 2018; Vaismoradi et al., 2016).

The lead coder created a reflexive journal with perceptions of codes and a code index to further reflect on the meaning of themes (Vaismoradi et al., 2016). The lead coder used peer debriefing throughout the analysis to establish credibility and improve reliability in the study (Barber & Walczak, 2009). Two faculty members with expertise in social science research methods at the University of Georgia, a science communication faculty member, and the

Associate Dean for Research, who also serves as the Georgia Agricultural Experiment Station Director, were used as peer debriefers for the thematic analysis. The face-to-face peer debriefing meetings involved the lead coder and faculty members sharing their perspectives on the emerging thematic codes and thoroughly discussing the description of each code. Having face-to-face peer debriefing meetings helped avoid any misinterpretation of the data (Barber & Walczak, 2009). Throughout the peer debriefing process, reflexivity was used to assist with interpreting the multiple perspectives from faculty and the lead coder presented during the meetings (Barber & Walczak, 2009).

For the purpose of this manuscript, a second coder conducted a meta-synthesis to provide a comprehensive view of the findings from the research publications (Leary & Walker, 2018; Paterson et al., 2001). A meta-synthesis enables a researcher to review and interpret studies together rather than in isolation (Leary & Walker, 2018; Paterson et al., 2001). Meta-synthesis findings facilitate the advancement of knowledge and theory as new perspectives develop from the data collected (Leary & Walker, 2018). Healthcare studies commonly use meta-syntheses to analyze large quantities of data but the approach is fairly uncommon in the field of social science (Carlson & Palmer, 2016). Esteves et al. (2021) conducted a meta-synthesis to determine regulatory requirements for organic foods in Brazil, the U.S., and the European community and found there is not an equivalent organic certification between the three markets. Prior to conducting the meta-synthesis, the second coder reviewed the coded publication titles from the lead coder's initial thematic analysis and established reliability by checking for data that supported each theme (Hodson, 1999).

A total of 2,740 research publications produced by the University of Georgia's College of Agricultural and Environmental Sciences during the years 2016, 2017, and 2018 were thematically analyzed by the lead coder. The publication titles were coded into agriculturally and environmentally focused themes. To provide a comprehensive analysis of publication themes, many of the publications received more than one code and fell into multiple thematic categories. The lead coder assigned 4,235 thematic codes to the research publications. Using the established thematic codes, the secondary coder then sorted publications into meta-synthesis categories based on their specific overlap between agricultural and environmental science thematic codes (Leary & Walker, 2018; Paterson et al., 2001). Just as the lead coder, the secondary coder created a reflexive journal to gain a deeper understanding of their thinking process and to peer debrief their interpretation of grouped codes and themes, constructing a "dynamic and iterative process of thinking, interpreting, creating, theorizing, and reflecting" (Paterson et al., 2001, p. 112). Perspective on the analysis technique and textual descriptions was provided (Table 1).

Table 1
Reoccurring Terms

Terms	Definitions
Meta-synthesis categories	Categories with overlap between agricultural and environmental science codes and themes (Leary & Walker, 2018; Paterson et al., 2001)
Theme	Patterned responses or reoccurring ideas that are important for representing meaning in the dataset (Braun & Clarke, 2006)
Code	Words that share meaning and unify ideas based on their commonalities (Vaismoradi, et al. 2016)

Subjectivity Statement

It is necessary for the researchers who interpreted the data in this study to identify any points of bias. The coders were all graduate students within a LGU when the research was conducted but did not contribute to any of the research publications examined throughout this study. The lead coder, second coder, and lead author on the manuscript were pursuing degrees in the University of Georgia's College of Agricultural and Environmental Sciences and had backgrounds in environmental sciences and agriculture. The lead coder had knowledge of environmental and agricultural practices from growing up in rural Georgia. The second coder had an undergraduate degree in agricultural communication from the University of Georgia's College of Agricultural and Environmental Sciences and professional experience in the Georgia agriculture industry. The manuscript lead author had previous job experience in environmental science and education. The lead coder initially established codes and themes that may reflect these biases. However, they were later compared via peer debriefing and by the second coder to capture the essence of the themes and codes as seen by all researchers in this study.

Meta-Synthesis Findings

Seven environmentally focused themes emerged from the codes in the thematic analysis of the University of Georgia's College of Agricultural and Environmental Sciences research publications. These themes included: (1) *climate studies*, (2) *soil science*, (3*) water management*, (4) *farm/land management*, (5) *sustainable food systems*, (6) *environmental policy*, and (7) *environmental learning*. Publications that fell into primarily environmental themes received 390 individual codes, representing approximately 9.2% of the initial 4,235 codes identified by the lead coder.

In the meta-synthesis of the data, 155 publications received codes that fit into themes that were exclusively environmental in nature, representing 5.7% of the initial 2,740 publications coded. Environmental-only publications were coded for one or more of the environmental themes listed above but were not coded for any primary agricultural themes. The remaining environmentally focused publications received codes for both environmental and agricultural themes. The primary agricultural themes, identified in the lead coder's initial analysis, were (1) *advances in animal sciences*, (2) *advances in plant sciences*, (3) *society's role in agricultural and environmental sciences*, and (4) *advances in food science and safety*. Some publications received codes for multiple environmentally and agriculturally focused themes to provide a comprehensive view of the interdisciplinary nature of the work. The meta-synthesis (Table 2) revealed 212 codes that overlapped agricultural and environmental themes representative of approximately 5% of the total 4,235 codes revealed in the lead coder's initial thematic analysis. Because publications may have received more than one code, the number of total publications is less than the total number of codes.

Table 2

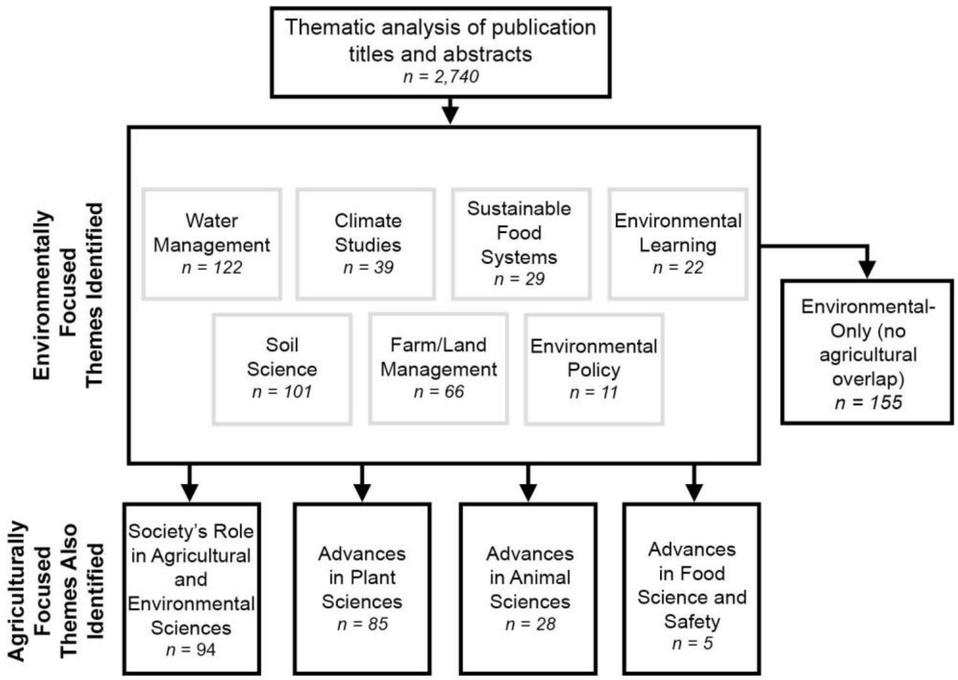
Overlap Between Agriculturally and Environmentally Focused Themes in Research Publications Based on Thematic Codes

Agriculturally Focused Themes	Climate Studies	Soil Science	Water Management	Farm/Land Management	Sustainable Food Systems	Environmental Policy	Environmental Learning	Total
Advances in Animal Sciences	3	5	6	14	0	0	0	28
Advances in Plant Sciences	13	28	27	12	3	2	0	85
Society's Role in Agricultural and Environmental Sciences	8	6	44	8	12	4	12	94
Advances in Food Science and Safety	0	0	3	1	1	0	0	5
Total	24	39	80	35	16	6	12	212

The second coder conducted an analysis of publication titles and theme overlap under each agricultural theme. Agriculturally and environmentally focused themes that shared 14 or more publications with overlapping codes were examined for similarities and detailed according to agricultural focus areas. Through peer debriefing, 14 emerged as the natural breakpoint in the data and was, therefore, selected as the level of acceptance. A visual representation of the second coder's process of determining overlap between environmentally focused and agriculturally focused publications is represented in Figure 1.

Figure 1

Meta-synthesis Process for Overlapping Research Publication Themes Based on Number of Publications



Note. n = number of publications; some publications were coded for multiple themes

Environmental Themes in Society's Role in Agricultural and Environmental Sciences

The largest overlap between agriculturally and environmentally focused themes occurred in the category *society's role in agricultural and environmental sciences* with 94 overlapping publications. The highest overlap occurred in the nexus between *water management* and *society's role in agricultural and environmental sciences*. It should be noted that the lead coder identified the themes *sustainable food systems*, *agricultural policy*, and *agricultural and environmental learning* and categorized them under the agricultural theme *society's role in agricultural and environmental sciences*. However, in the meta-synthesis, the second coder sorted through all publications in the initial categories to identify those specifically with environmental themes. Publications in the e*nvironmental policy*, *environmental learning*, and *sustainable food systems* themes were only coded for agricultural overlap if they were combined with at least one other secondary theme encompassed by *society's role in agricultural and* *environmental science* such as *agricultural economics, agricultural and rural technology, communicating agriculture*, *agricultural and rural social structure*, etc.

The largest overlap occurred between *society's role in agricultural and environmental sciences* and the *water management* environmental theme with a total of 44 overlapping publications, accounting for 47% of all overlap in this agricultural theme. Nineteen publications overlapping in *water management* and *society's role in agricultural and environmental sciences* focused on influencing public opinion and actions surrounding water conservation. Examples include "Diffusing Water Conservation and Treatment Technologies to Nursery and Greenhouse Growers" (Lamm et al., 2017) and "Influence of Source Credibility on Agricultural Water Use Communication" (Lamm et al., 2016). Additionally, publications highlighted water conservation communication through LGU extension programming such as "Enhancing Extension Programs by Discussing Water Conservation Technology Adoption with Growers" (Lamm et al., 2017).

The second coder's analysis of publication titles revealed that 17 publications within *society's role in agricultural and environmental sciences* dealt with matters of *agricultural and rural technology* in relation to *water management*. Implementing water conservation with smartphone technologies was a common theme across six of these publications. Examples include "Development and Assessment of a Smartphone Application for Irrigation Scheduling in Cotton" (Vellidis et al., 2016) and "Comparing a Smartphone Irrigation Scheduling Application With Water Balance and Soil Moisture-Based Irrigation Methods: Part II-Plasticulture-Grown Watermelon" (Miller et al., 2018). Overlap in these publications revealed that researchers were taking advantage of advances in agricultural technology to increase water conservation efforts in their irrigation practices.

Environmental Themes in Advances in Plant Sciences

The second coder identified 85 publications containing environmental themes within *advances in plant sciences*. This was the second largest amount of overlap within the four primary agricultural themes. Of all the environmental themes, *soil science* and *water management* shared the most overlap with the primary agricultural themes. *Advances in plant sciences* overlapped with *soil science* in 28 publications. The most overlap occurred in publications exploring crop management, plant growth and growing, plant breeding and genetics, and specialty crops.

Eleven of the publications coded for both *soil science* and *advances in plant science* were focused on various aspects of soil health in the management and growth of commodity crops such as alfalfa, peanuts, cotton, and corn. Yang et al. (2016) explored the impact of soil potassium deficiency on the fiber of cotton, a commodity crop, in "Soil Potassium Deficiency Reduces Cotton Fiber Strength by Accelerating and Shortening Fiber Development." Conversely, five of the overlapping publications focused on *soil science* in specialty crops such as blueberries, tomatoes, pecans, and watermelons in studies like, "Soil pH and Mineral Nutrients Strongly Influence Truffles and Other Ectomycorrhizal Fungi Associated with Commercial Pecans (*Carya Illinoinensis*)" (Ge et al., 2017). Lee et al. (2018) discussed the effects of beef cattle manure compost and mixed oilseed cakes on soil health for organic onion yield. Studies of this nature explored improving soil health for specialty crops and even overlapped with animal agriculture production. However, the majority of *soil science* and *advances in plant sciences* overlapping publications were not as interdisciplinary and did not overlap with other environmental or agricultural themes.

Water management was also crucial to plant health and overlapped with 27 publications in *advances in plant sciences*. The largest contributors to this overlap were publications focused on plant growth, specialty crops, and crop management. Nine publications shared overlap between *water management* and *plant growth and growing*. Research ranged from irrigation methods such as "Impacts and Limits of Irrigation Water Management on Wheat Yield and Quality" (Torrion & Stougaard, 2017) to the effect of wastewater bacteria on plant growth like "Evaluation of Bacteria Isolated from Textile Wastewater and Rhizosphere to Simultaneously Degrade Azo Dyes and Promote Plant Growth" (Shafqat et al., 2017). Nine publications overlapped between *water management* and *specialty crops,* primarily concerned with irrigation research for these specialty crops like "Evaluation of Shallow Subsurface Drip Irrigation for the Production of Acorn Squash" (Coolong, 2016). Finally, six publications shared overlap in *water management* and *crop management* in publications that explored the water use in different types of crops such as "Water Use Efficiency in Living Mulch and Annual Cover Crop Corn Production Systems" (Sanders et al., 2018).

There was minimal overlap between the other environmental categories and *advances in plant science.* This agricultural theme overlapped with 13 studies within the *climate studies* theme and 12 publications with *farm/land management* themes. Overlap was minimal with the themes *sustainable food systems*, *environmental policy*, and *environmental learning* with no more than three publications in each category.

Environmental Themes in Advances in Animal Sciences

The lead coder identified 1,276 codes within *advances in animal sciences*, the second-largest area of research in the University of Georgia's College of Agricultural and Environmental Sciences. However, the second coder identified only 28 publications containing codes that intersected between *advances in animal sciences* and environmental themes.

The section of overlap that garnered the most attention in this area was between *farm/land management* and *advances in animal sciences*. Five publications related to avian studies largely addressed the nitrogen excretion from poultry litter. Examples include "Grazing Management and Buffer Strip Impact on Nitrogen Runoff from Pastures Fertilized with Poultry Litter" (Pilon et al., 2019) and "The Nitrogen Contained in Carbonized Poultry Litter is not Plant Available" (Steiner et al., 2018). Three publications coded for *mammal studies* dealt largely with different ideas for cattle management practices, including "Grazing Evaluation of Annual and Perennial Cool-Season Forage Systems for Stocker Production in the Lower Transition Zone" (McKee et al., 2017); "Spatial Distribution of Inorganic Nitrogen in Pastures as Affected by Management, Landscape, and Cattle Locus" (Dahal et al., 2018); and "Canola and Calves: An Integrated Crop-Livestock Farming System for Producing Canola and Stocker Cattle in the Southeast" (Ingram et al., 2018). *Animal nutrition also* received codes in three publications, but all three publications were also coded for in the *avian studies* and *mammal studies* (Chalova et al., 2016a; Chalova et al., 2016b; McKee et al., 2017). The other environmental themes had minimal overlap with *advances in animal sciences*.

Environmental Themes in Advances in Food Science and Safety

There were minimal areas of overlap between *advances in food science and safety* and environmental themes. Of the 396 codes identified by the lead coder in this primary agricultural theme, only five publications overlapped with environmental themes in the areas of *water management*, *sustainable food systems*, and *farm/land management*.

Discussion

Agricultural practices that further environmental protection and food production are needed to ensure the future of global food security (Garnett et al., 2013; Rockström et al., 2017); however, there are management challenges that must be addressed through research, and their associated science communication efforts, in order to promote collaborative efforts that benefit agriculture and the environment (Banks, 2004; De Fraiture & Wichelns, 2010). The purpose of this study was to determine where environmentally focused and agriculturally focused research overlapped within a college of agricultural and environmental sciences at a LGU.

Overlap between the agricultural category *society's role in agricultural and environmental sciences* and environmental themes were limited. The majority of overlap in this category was with *water management*. While the University of Georgia's College of Agricultural and Environmental Sciences has conducted research on the societal impacts of water management as they relate to irrigation technology and public influence, there is room for additional collaboration and communication outside of these spaces.

While environmental research should naturally coincide with *advances in plant sciences*, the overlap between the groups is minimal. By its nature, *soil science* overlapped with *advances in plant sciences* because of the importance of healthy soil in crop production. However, in the initial review of the publications, the lead coder identified *advances in plant sciences* as the largest primary theme with 1,624 codes. With only 85 research publications coded for both environmental and agricultural themes, there is much untapped potential for research and communication collaboration in the area of plant sciences. Previous studies recommended collaboration between plant sciences and the environment, such as Isaacs et al. (2009) who found promoting native plants that attract beneficial arthropods to help with crop pollination and pest control must be done with a multidisciplinary team, and LGUs must shift towards this approach. In addition, communicating about integrated approaches between plant sciences and the environment with diverse stakeholders may encourage future implementation.

The large number of peer-reviewed publications about *advances in animal sciences* and the minimal amount of overlap with environmental codes is disappointing. Collaboration and communication between animal agriculture and environmentalists have vast benefits, such as prescribed livestock grazing to prevent wildfires (Lovreglio et al., 2014). Considering animal agriculture is cited as one of the largest drivers of environmental issues (Clark & Tilman, 2017), especially climate change (Koneswaran & Nierenberg, 2008; Rojas-Downing et al., 2017), there may be surface-level polarizations between agriculturalists and environmentalists. Research should be conducted to determine if a surface-level polarization deters animal agriculturalists and environmentalists from working together, and, if so, what ways best unite the groups. Either way, the lack of overlap in this research area indicates the need for interdisciplinary research and in-depth communication in this subject matter area. Moreover, overlap between *advances in food science and safety* and environmental themes were limited. It is important researchers foster better communication to create agricultural systems that are both sustainable and safe, especially as reduction of food waste is a problem solved by both food scientists and environmentalists.

Limitations and Conclusion

There were several limitations that should be addressed before the findings are interpreted. One limitation was the lead coder assigned a code to only the section of the publication title that related to its corresponding theme. Therefore, the second coder had to sort through all environmentally focused codes to determine agricultural overlap using the lead coder's work as a guide rather than working directly from the lead coder's established codes. Additionally, code interpretation was based on each coder's perception of agricultural and environmental sciences including their experiences and current knowledge. Thus, it is possible codes were wrongly assigned or may have been assigned otherwise by a coder with different experiences and knowledge. Lastly, the publications were only examined based on their title and abstract, which may have caused misinterpretation as titles and abstracts cannot encompass everything the study finds. Similarly, the meta-synthesis examined themes via titles and abstracts in order to determine collaboration between agricultural and environmental sciences, which may have caused misinterpretation between group collaboration and simple connections between the groups within studies. Future studies should examine the full text of research publications in order to have a more detailed understanding of the collaboration between environmentally focused and agriculturally focused research.

Acknowledging these limitations, the results of the meta-synthesis revealed there was limited collaboration between environmentally focused and agriculturally focused research. Without collaborative research, agricultural communicators cannot develop science communication efforts that integrate evidence-based science from both groups. The findings are similar to Scasta et al. (2018) and Banks (2004) who found additional communication and cooperation strategies that bridge the divide between agriculture and environmentalism are needed, especially those that focus on their common ground. Moving forward, it is imperative that LGUs have an institutional shift towards a more collaborative research and communication platform that uses interdisciplinary approaches to integrate sustainable agriculture and environmental protection to warrant future food policy that will ensure food security (Banks, 2004).

Recommendations

While new challenges and competing objectives may emerge within interdisciplinary research teams, this approach is needed to address multifaceted, uncertain issues (Harris & Lyon, 2013) such as global food security. Moving forward, faculty members, researchers, and communicators must be made aware of this gap so that complex environmental and agricultural issues can be addressed from an interdisciplinary perspective. Agricultural communicators should facilitate conversations between faculty members and researchers directed at this gap and emphasize commonalities and the importance of interdisciplinary research teams (Scasta et al., 2018). In addition, agricultural communicators should assist in reducing potential misunderstandings due to scientific jargon or labels with more productive discourse (Scasta et al., 2018). Future studies could examine if there are key characteristics of successful interdisciplinary teams that may help others overcome the surface-level polarization between agricultural and environmental researchers, communicators, and stakeholders.

The public cannot become more literate and make informed science communication decisions if agricultural and environmental perspectives are not integrated. Since directors of centers for interdisciplinary agricultural research are invested in the importance of science communication (McLeod-Morin et al., 2020), agricultural communicators should partner with these centers as they conduct research on the power of interdisciplinary teams. Understanding key characteristics of successful interdisciplinary teams will provide an educational tool for agricultural communicators to share with faculty members and researchers. In addition, the collaborative research process could be beneficial to both agricultural communicators and center faculty.

Future research also should determine effective techniques for communicating the importance of interdisciplinary research to researchers and stakeholders to garner financial support for integrated projects. Agricultural communicators cannot develop science communication efforts that holistically integrate evidence-based science without collaborative research. Therefore, agricultural communicators must strive to encourage researchers to engage in interdisciplinary teams and stakeholders support of interdisciplinary research endeavors in order to effectively address and solve the wicked issues facing agriculture and the environment.

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