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Using social media analytics as a tool to strengthen research and extension support for the adoption of pastured poultry and integrated cropping systems

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Using social media analytics as a tool to strengthen research and extension support for the adoption of pastured poultry and integrated cropping systems

By

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THESIS

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## Abstract

Pastured poultry and its integration into crop production is a farming system that has the potential to improve agricultural systems by leveraging mutually beneficial relationships between poultry, soil quality, and crop or pasture production. Despite the potential advantages of this farming system, its scale and popularity are relatively small. Our study uses social media analytics to characterize online conversations and public perceptions around pastured poultry and integrated cropping, with the objective to identify the challenges and drivers of this farming system, and guide strategies for science communication and public engagement so that more farmers can potentially benefit from this type of farming system. We obtained data from 2,399 English language posts about pastured poultry and integrated cropping scraped from online platforms including blogs, news sites, Reddit, Twitter and others, published between February 2019 and May 2021. Our methodology utilized machine learning tools and manual content analysis to identify prevalent trends in online platforms that individuals and organizations use to exchange knowledge and opinions, and to understand their sentiments around various attributes regarding pastured poultry and integrated cropping. We found that social media users largely vocalized the potential benefits of pastured poultry and integrated cropping systems more so than the potential drawbacks, with contributions to soil fertility as the most mentioned attribute. We found low volume of conversations regarding food safety risks as well as a largely absent mention of scientific studies in pastured poultry and integrated crop production, indicating a possible gap in science news consumption and an opportunity for additional extension and outreach. While online news sites returned the highest volume of posts pertaining to pastured poultry and integrated cropping and generated a moderate impact score, they have the lowest reach score in terms of how many people on average may have seen the post relative to other content types such as forums, blogs, and Twitter. We identified several online forums including Reddit as hotspots of conversations around our research topic, which present an opportunity for targeted engagement of future agricultural extension efforts.

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## I. Introduction

Producers and suppliers seeking to innovate and succeed in the future of agribusiness are keenly aware that sustainability-based purchasing is accelerating, and that more than ever, up-and-coming consumer segments such as millennials and gen Z are driven by the environmental impact, taste and quality of their grocery products (Greene et al., 2017; Rubin, 2019; Schroeder, 2019). As sustainability increasingly becomes a key differentiator for marketing agricultural products and costs of fertilizers and feed grow, there is increasing interest in integrating pastured poultry and crop farming. Pastured poultry in integrated cropping systems is an opportunity to produce a more diverse array of higher-value animal products such as egg, poultry meat and crops, which maximizes land-use efficiency while reducing producers' reliance on purchased inputs such as feed and fertilizer (Campbell, 2022; Nair & Bilenky, 2019; Ofuoku & Ekorhi-Robinson, 2020; Rothrock et al., 2019; Soares et al., 2022).

### **Pastured poultry and integrated cropping**

Grazing animals play an important ecological role in managing vegetation and cycling organic biomass and nutrients into the soil, which in turn sustains rich plant life and healthy ecosystems. Integrated crop-livestock systems utilize agricultural techniques such as rotational grazing—practiced historically and currently around the world—that leverage this beneficial relationship between animals, soils and plants (Sekaran et al., 2021).

Rotational grazing is practiced with many different types of livestock including cattle and pigs. In this study we refer specifically to pastured poultry as the rotational grazing of poultry. Rotational grazing is a management technique that entails containing poultry in one portion of the pasture and successively moving them to other portions of the pasture, or removing them from the pasture before they fully denude the vegetation in any given area (Pitesky, 2017). The grazed portion of the pasture is then given

time to regrow before animals are allowed to graze it again, while the poultry's brief visitation can ultimately benefit the quality of the soil and pasture in various ways. The term "chicken tractor", describing bottomless mobile chicken coops used for rotational poultry grazing, has emerged amongst proponents of alternative agricultural production systems as a notable technology specific to rotational pastured poultry systems (Soares et al., 2022). Proponents of pastured poultry claim that in contrast to conventional production systems, which contain poultry in stationary housing such as barns, pastured poultry can offer improved welfare conditions wherein poultry can experience more enriched surroundings and natural behaviors such as scratching the ground and catching insects (Entz & Thiessen Martens, 2009). Properly managed rotational grazing is additionally said to reduce disease pressure on the chickens compared to stationary-housed chickens given access to pasture. For instance, rotating poultry to a new patch of pasture avoids the buildup of excess manure, pathogens and parasites in the land (Entz & Thiessen Martens, 2009; Sossidou et al., 2011). Although poultry are not ruminants so for the most part cannot obtain calories from forages, forages and insects found in pasture allow them to supplement their diets with vitamins, minerals, protein and fiber (Spencer, 2013). Evidence is emerging that pastured poultry eggs and meat can contain better dietary value in terms of certain vitamins, fatty acids, and cholesterol (Sossidou et al., 2015; Spencer, 2013). Although nutritional benefits depend on the quality of the pasture (Soares et al., 2022), some studies have also shown comparable or higher yields from pastured or crop-integrated poultry compared with conventional systems (Chen et al., 2013; Miao et al., 2005; Skřivan et al., 2015).

Farmers may manage rotational grazing with the goal of maximizing the benefits of pasture for poultry production, or intentionally integrate rotational grazing with the goal of building a mutually beneficial relationship with crop production. While conventional systems produce animals and crops on separate farms, resulting in both soil nutrient depletion related to heavy reliance on costly soil amendments on one hand (Sekaran et al., 2021) and excessive manure pollution on the other (Maheshwari, 2013;

Ofuoku & Ekorhi-Robinson, 2020; Rothrock et al., 2019), integrated farming can create a more resource-efficient “closed loop” system wherein pastured poultry consume crop residue, and deposit manure to support crop production.

In addition to the benefits derived from pastured poultry alone, integrated cropping systems can purportedly also benefit from improved retention of soil nitrogen, a key nutrient for crops (Miao et al., 2005; Zhang et al., 2020) as well as other important soil quality indicators (Hilimire et al., 2013). As poultry forage outdoors, they can provide additional ecosystem services such as weed or insect pest control (Glatz et al., 2005; Rehman et al., 2017). These characteristics of pastured poultry contribute to higher crop yields and economic profit (Soares et al., 2022; Zhang et al., 2020). For vegetable producers interested in trialing integrated cropping, poultry requires lower entry costs relative to other livestock, lowering the barriers to development of small-businesses and additional innovation (Sossidou et al., 2011).

Despite the longtime existence and renewed interest in pastured poultry and integrated cropping, its scale and popularity are much smaller than that of conventional systems. Although promising examples exist regarding the benefits of integrated poultry-crop systems, research to substantiate the purported benefits remains sparse around certain features of these farming systems. For instance, although consumers commonly perceive that pastured poultry provides welfare benefits as compared to chickens raised conventionally indoors, there is a tradeoff since poultry raised outdoors experience higher mortality rate associated with potential exposure to extreme elements, predation and disease vectors, that may also result in reduced yield of meat and eggs (Delgadillo et al., 2021; Glatz et al., 2005; Sossidou et al., 2011; K. H. Wang et al., 2009). Risk of food-borne pathogen contamination is an important concern that is also not yet sufficiently studied in integrated cropping with pastured poultry (Gallant, 2013; Sossidou et al., 2015). Further research is still needed to fully evaluate the potential benefits and challenges. If significant potential to benefit from such farming systems exist, then

extensionists should help more agricultural producers gain awareness of it, and support them in overcoming challenges to successful implementation so that the integrated pastured poultry and cropping practices can be utilized at a larger scale to benefit more people. However, the degree of awareness or importance farmers and the public attribute to the benefits and drawbacks of such production systems has not yet been extensively studied. Additional research to gain understanding of the challenges or successes experienced by current practitioners of pastured poultry and integrated farming can help guide the production of scientific knowledge that will strengthen the value that agricultural extension services can bring to farming innovators.

### **Data mining and social media analysis**

For agricultural research and extension to meet the knowledge demands of producers in adopting innovations in rotationally grazed poultry and integrated cropping, as well as to promote awareness of these sustainable production alternatives, it is imperative to incorporate producers' perceptions into research generation and science communication. The significance of studying social media and other online user-generated content is two-fold. First, as a means of knowledge dissemination: it has been demonstrated that for farmers with access to online technologies such as smartphones, the use of social media platforms as an agricultural extension tool improves adoption of sustainable agricultural technologies (Gao et al., 2020). In fact, the important role of social networks in enhancing adoption of sustainable technologies or natural resource management practices is an established topic of research (G. Wang et al., 2020; Ward & Pede, 2015; Weyori et al., 2018; Wossen et al., 2013) and online platforms can facilitate this. Second, as prevalent forms of communication evolve, and the global population increasingly seek out online media and online platforms for community and knowledge exchange, online conversations present a unique opportunity for researchers to understand current perceptions of the benefits, challenges, and other motivators around the agricultural innovations in question (Appel et al., 2020). This study underlines the importance of understanding social media as



platforms for social learning, and ultimately as channels for more productive exchange and understanding between farmers and extension service.

Already, corporations and market researchers are targeting social media and other online user-generated content as an essential part of their strategy to understand how people converse about certain products or brands (Appel et al., 2020; Asur & Huberman, 2010). Companies use social media data to understand consumer sentiments on product features, and look to these platforms to gain an advantage in advertising products and disseminating information to the public (Asur & Huberman, 2010; Rutsaert et al., 2013; Tourani, 2022). In the new age of social media, it is no longer sufficient to reach the public through traditional means that mostly seeks a passive audience, but rather to capture a continuous and active relationship of consumer engagement (Hanna et al., 2011). Since 72 percent of US adults utilize social media (“Social Media Fact Sheet,” 2021), conversations gathered from these online platforms can represent a larger proportion of individuals in the population than would be feasible with traditional survey tools (Hanna et al., 2011). Sometimes, associated metadata scraped from the social media posts also allow researchers to analyze geographic (Peters, 2013; Vaughan et al., 2017) and temporal trends (Houghton et al., 2019) to understand where posts originate, and how online discourse is evolving over time. From a science communication perspective, the auto amplification effects of social networks which allow certain information to “go viral” online, present an opportunity for new practices and technologies to reach an audience with low excess costs (Weyori et al., 2018).

In addition to allowing sampling of a greater portion of the population, researchers are also applying machine learning methods for targeted marketing of specific consumer segments. For instance, Wang et al.’s work presents an approach to customer segmentation by using machine learning models to identify “Sentiment Communities”, defined as “a group of users who are closely connected and highly consistent in their sentiments about one product/service”(D. Wang et al., 2017). Following segmentation into different customer clusters, targeted marketing can conserve significant costs by

communicating product information to the most relevant audience in the most effective way (Berry & Linoff, 2004; D. Wang et al., 2017). Outside of corporate marketing, data from social media has also been mined and analyzed to understand public opinions around government development initiatives (Chandra et al., 2020), monitor public response to disease outbreaks (Gendreau et al., 2022), and advance food safety risk communication (Rutsaert et al., 2013; Tiozzo et al., 2020). Ding and Zhang (2010) compared the volume of posts from social media platforms used by government agencies and citizens for risk communication during the swine flu epidemics to identify what prevalent platforms are used, and performed a text analysis to understand the types/function of their communications—allowing them to chronicle how publicly valuable information is effectively disseminated online amongst different groups and entities.

Thus far, there has been sparse application of this opportunity to understand the adoption of improved agricultural practices. Ofori and El-Gayar (2019, 2021) present the sole example we were able to find of this particular application. Their research employed machine-learning algorithms for sentiment analysis and topic analysis of social media posts. They quantified emotions as well as categorized text into various groupings that reflect prevalent drivers and challenges expressed in social media discourse pertaining to “Smart Agriculture” and “Precision Agriculture.” They found that according to social media discourse, the public perceived that most prevalent drivers of adoption for these farming approaches were their potential to generate jobs in agricultural technology industries, and the creation of supportive public policies, and that the biggest barriers to adoption were related to the cost and complexity of the technology. Their findings can help precision agriculture technology providers better address concerns regarding the innovations, as well as leverage the key drivers of adoption in their technology promotion efforts.

The present research was conducted to address the gaps in understanding of how producers and consumers perceive the benefits and drawbacks of pastured poultry and integrated cropping, as well as

to exploit the emerging technologies in consumer analytics of social media data, which has thus far not been extensively used for supporting the adoption of agricultural practices and technologies.

## **Research Questions**

This study aimed to characterize online conversations around pastured poultry in integrated cropping systems with the objective of finding insights that can ultimately help researchers and agricultural extensionists better target their research priorities, science communication, and public engagement strategies. The specific questions as well as the associated findings we aimed to uncover with the data are:

1. Understanding overall content sources and trends in social media sites around pastured poultry and integrated cropping.
  - Which social media platforms, websites and content sources are the most prevalent for expressing information or opinions around these topics? And how have content sources changed in relevance over time?
2. Identifying challenges and drivers in social media discussions around pastured poultry and integrated crop production.
  - What are the predominant benefits or challenges most often attributed to the production system of interest?
  - What are the main motivations and incentives for pursuing the production system of interest?

By analyzing the topics and sentiments emerging from our dataset of online social media content, we gain the opportunity to understand possible gaps in information and identify research and extension needs that could help to support producers interested in integrated pastured poultry.

## II. Methods

### Data Collection

Using the same consumer intelligence platform "Brandwatch"<sup>1</sup> as Ofori and El-Gayar ( 2019, 2021) we collected online posts related to pastured poultry and integrated crop-poultry production. The service employs web crawlers—internet bots that aggregate big data from a variety of top social media Application Program Interfaces (APIs) of major social media sites—giving access to data from 100 million online sources and over 1.4 trillion posts (*Brandwatch Consumer Research*, n.d.).

In this paper, the data sources consisted of user-generated public content from sources of the following social media content types:

- Blogs: webpages where individuals or organizations can post regular content and readers can leave comments.
- Twitter: Sometimes referred to as a type of microblog, users can post short content of up to 280 characters in addition to links. Users can interact by resharing posts and posting replies to others' posts, and these interactions are easily viewable by the public in a thread.
- Forums: These are online platforms that host discussion threads based on defined topic(s) or communities of interest. Users are able to post anonymously. Popular examples include 4Chan.com, quora.com and stackoverflow.com.
- Reddit: A mega forum hosting site that is home to over a hundred thousand active interest groups known as "sub-Reddits" where users can post discussion threads anonymously.

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<sup>1</sup> Brandwatch is an online consumer intelligence and analytics service that claims to be the number one consumer intelligence platform used by many of the world's biggest brands. <https://www.brandwatch.com/>

- News sites: news articles produced by journalism outlets that allow readers to consume the materials online. This ranges from more traditional news companies that originated in print media such as Farm Progress.com or the New Yorker to more recent news companies that mainly focus on web distribution such as Politico or MSN.
- YouTube: a video hosting site where users can anonymously upload video content. The platform enables public discussion amongst viewers and creators in the comments section of each video.
- Reviews: Product or service review platforms (such as Yelp.com or Tripadvisor.com)

The following English-language Boolean string search was set up to extract online posts between February 28, through 2019 May 2, 2021.

```
(pastur* OR pasture-raised OR rotationally-grazed OR "rotational grazing" OR "Rotational grazing" OR "rotationally grazed" OR "rotational systems" OR "rotational system" OR "Rotational system" OR "Rotational systems" OR "pasture raised" OR "Pasture raised" OR "chicken tractor" OR "Chicken tractor" OR "Chicken tractors" OR "chicken tractors")
AND (poultry OR chicken*)
AND (crop* OR garden* OR vegetable* OR "vegetable production" OR "Vegetable production")
NOT (recipe OR bake OR fry OR cook OR roast* OR fried OR omelet OR saute OR recipes OR site:("food.com" OR "allrecipes.com" OR "tumblr.com"))
NOT (flu OR AI OR "avian influenza" OR euthaniz* OR cull*)
NOT ("Ancient Nutrition")
```

The farming system in question is not strictly defined by its own unique term—it is rather a set of various practices that different producers may choose to combine together in distinct ways, making it more challenging to capture the relevant data (as compared to a distinct product or a brand name). The search string was developed through an iterative process of first identifying core terms and associated pseudonyms that describe the concept of rotational grazing, combined with the terms chicken or poultry, as well as the term “chicken tractor” which specifically describes a type of mobile housing for poultry. Then, a group of terms describing crop production was added. Finally, based on a review of the results returned, additional terms were identified to exclude noise from the posts. We did this by reviewing posts from the highest-ranking websites as well as key topics detected by Brandwatch’s

machine learning classifier. We determined that certain websites or topics were generating high volumes of irrelevant posts –these included posts focused on sharing recipes, or those that were primarily focused on the avian influenza outbreaks, which was a trending topic at the time. We eliminated these posts by excluding terms like “recipe” or “flu” or entire web domains such as “food.com” that turned up in our search. By excluding the term “Ancient Nutrition” a popular brand of dietary supplements, we were able to eliminate hundreds of irrelevant posts that advertised their product. While it is possible that some exclusion terms, particularly those referring to the disease outbreak, could result in the loss of some relevant conversations, it was necessary to reduce the large volume of unrelated posts that would otherwise have cluttered the dataset. Through an iterative process, the final Boolean string provided a set of results that did not include obviously irrelevant webpages or key topics.

## **Analysis**

We used a hybrid approach by first applying machine learning tools to analyze the full dataset, before applying traditional content analysis methodology (Bengtsson, 2016) to conduct a detailed manual review of a subset of the data originating only from Twitter, Reddit and online forums.

Pertaining to the first research question, we performed descriptive statistics of the posts based on the relative volume of posts generated from various content sources, as well as changes in the post volume over time. To gain a more complex understanding of which platforms are most strategic for potential public engagement and social listening pertaining to the research topic, we further considered the Impact and Reach scores of these posts. Reach Estimate is a score calculated by Brandwatch to estimate how many individuals may have seen a piece of content using regression models on various post metadata (for instance, average number of “likes” for similar posts). It is calculated differently for different post types to account for the different metrics attached to different post types, so that the

score is comparable relative to various content types (Siegel, 2019). Impact is a Brandwatch metric to measure the impact of a post based on numerous industry metrics that indicate *potential* views and shares. It is designed to gauge how likely an author, site or post will gain or influence public attention (so that for instance, a social media manager can quickly respond to a critical remark about a brand). It is scored on a logarithmic scale between 0-100 normalized (Jaume, 2013).

#### *Natural language processing analysis of online text*

Pertaining to the second research question, we conducted an exploratory topic analysis of the online conversations by utilizing Brandwatch's natural language processing (NLP) technology, which utilizes a supervised machine learning classifier to identify prevalent topics in the text body of the posts. For the full 26-month span of the study (Feb 27, 2019 to May 02, 2021), the algorithm provided the prevalence of key phrases and locations emerging from the text corpuses of all conversations. We were also able to identify prevalence of singular keywords for a 24-month span within the timeframe of the study (March 01, 2019 to March 14, 2021).

#### *Manual analysis of online text*

We then took a deeper dive on the dataset by narrowing our focus to a manual review of posts from three selected content types: Twitter, Forums and Reddit. Although news and blog sources generated a high volume of relevant posts, they were not prioritized for manual review since they take longer to review and additionally seemed to be declining in popularity based on a preliminary look at the post volume data. Due to the high volume of non-functional URLs and links, missing post body text, and/or irrelevant posts generated by the web scraper, we were unable to include posts from Youtube.com in the manual text analysis. Additionally, since blogs and news sites seemed to be decreasing in popularity based on post volume comparisons over time, they were deemed less strategic when considering future agriculture and research extension efforts (Figure 2). We also further limited our query to only posts that originate from the three major English-speaking poultry producer countries: USA, Great Britain, and

Canada (which accordingly, returned the highest volume of relevant posts). We reviewed all 1,042 posts from the resulting subset of data and manually-coded the text of these posts by defining variables of interest relevant to our research questions. Just as it is useful to analyze consumer sentiment around the features of a product (for instance the battery life and camera quality rather than just overall impression of a phone), the categories selected included specific “features” of pastured poultry and integrated crop production (such as vegetation impacts, animal welfare, or soil fertility impacts) perceived by the users. Our selection of the categories was guided by the trends uncovered by the machine learning classifier and the researchers’ preliminary review of the posts. We also included some categories that were not necessarily direct impacts of any production system per se, but which reflected broader values expressed by the users (such as self-sufficiency, or sustainability). Lastly, some categories were added based on the interest of research and extension practitioners working on the relevant production systems. The directionality of user sentiment attributed towards these features were defined by a positive or a negative 1. Posts indicating both negative and positive attributes of integrated poultry-crop production were counted twice, otherwise, volumes do not reflect multiple mentions or a particular attribute in one post. The full list of categories is defined in the codebook in Appendix 1.

The criteria for each category was defined in a codebook which was used during the coding and coder training process to avoid subjectivity and ensure consistency in coding. Coders were trained in hands on-session totaling over 10 hours over the course of a month during which coders regularly met to assess inter-coder reliability. Early on, coders frequently discussed and refined the codebook and eventually decided on 22 categories to code. Before coding the dataset independently, coders collectively coded a randomly-extracted training dataset, which contained no less than 20% of each content source type, until they reached over 90% agreement on the coding. Three coders were used in total with each source type reviewed by at minimum two coders.



We used Microsoft Excel (v16) in the data analysis to preform descriptive statistics and generate figures and tables. We also used Brandwatch to generate tables and conduct natural language processing.

### III. Results

A total of 2399 posts from 1089 unique authors (determined based on the metadata) were retrieved and downloaded with 56 columns of data and metadata related to the posts. Relevant metadata included author, date, country, web URL, partial post text, and others. The posts retrieved were automatically categorized by Brandwatch into content source types based on the web domains: News, Twitter, Blog, YouTube, Review, Forum, and Reddit. We note that while Reddit is technically a type of online Forum, it is disaggregated into its own category due to the singular prominence of this platform and its community of users.

Table 1: Sites with highest volume of relevant posts					
	Site	Vol	Impact	Reach	Type
1	backyardchickens.com	275	30	386	Forum
2	reddit.com	200	N/A	N/A	Reddit
3	twitter.com	185	13	2265	Twitter
4	youtube.com	113	N/A	N/A	YouTube
5	4channel.org	87	N/A	N/A	Forum
6	farmprogress.com	21	N/A	N/A	News
7	uberpeople.net	18	29	274	Forum
8	survivalistboards.com	17	N/A	N/A	Forum
9	beginningfarmers.org	15	15	12	Blog
10	helpfulgardener.com	15	23	55	Forum

Table 1. Top sites listed based on volume of relevant posts with the associated impact score, reach score, and typology

Of the total 2399 posts retrieved between February 28, 2019 and May 2, 2021, 40% of the posts were news articles, 27% Forums, 12% were blogs, 8% Reddit posts, 6% Tweets, followed by YouTube at 5%. We disregarded the review posts which made up less than 1% of the total

and were determined to be noise upon review. The top ten sites with the highest volume of posts are indicated in Table 1. We note that the majority of the top sites are online discussion forums.

Table 1 also displays the Impact and Reach scores for the top sites, with a similar breakdown by content type in Figure 1. Unfortunately, where the requisite metadata is not available, it was impossible to calculate impact and reach for posts from certain popular platforms such as Reddit, YouTube, 4Chan and others.

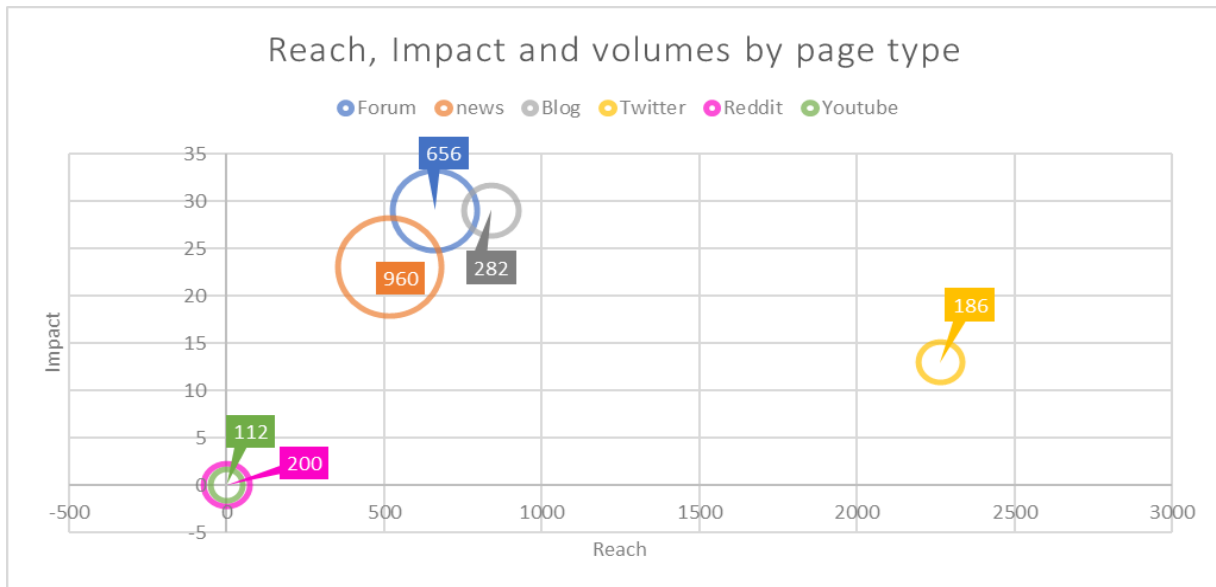


Figure 1. Comparison of reach, impact of different page types with post volume represented by bubble size. NOTE: Reach and impact data were not available for Reddit and YouTube and were therefore treated as zeros.

Temporally, the most recent year of the study (May 1, 2020 to May 1, 2021) shows an increased volume of relevant posts from Twitter, Reddit, and Forums (of 49%, 45% and 11% respectively), and a decreasing trend in post volume from YouTube, News and blog content sources (-88%, -4% and -4%) (Figure 2.). These insights should be considered in addition to post volume, reach, and impact when determining a public outreach and engagement strategy.

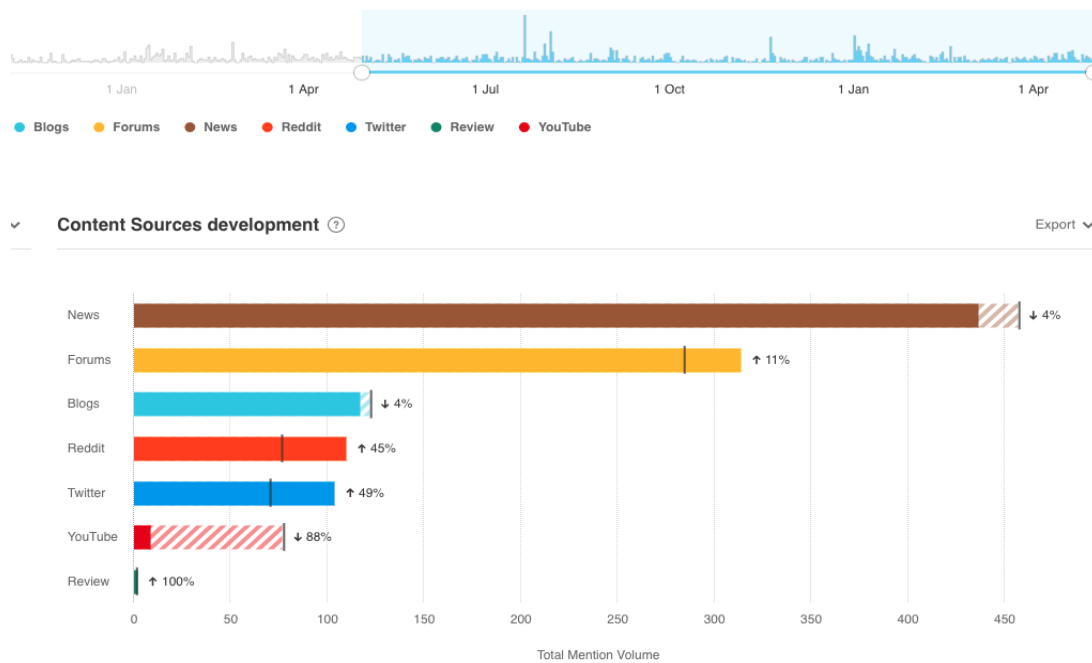


Figure 2. Temporal trend of content source volume in the second year of the study. News, Blogs and YouTube are shown to have decreased as relevant content sources, as compared to an increase in other source types.

## Machine-generated topic analysis

Using Brandwatch’s natural language processing (NLP) algorithms<sup>2</sup>, we were able to examine an array of machine learning-generated insights on topics discussed in the online posts we queried. They are represented in the topics wheel (Figure 3), with the outer circles representing subtopics associated with the main topics in the inner circle. The topics generated relate strongly to the concepts which we tried to capture in our query, featuring terms that describe concepts that we would expect to be discussed such as “pasture”, “vegetables”, and “garden”. The terms “cover crops”, “garden beds”, “mobile coop” and “soil” are relevant key terms that we didn’t explicitly define in our query, but were nevertheless

<sup>2</sup> Natural Language Processing (NLP) utilizes computational linguistics and machine learning to enable computers to processing meaning and sentiment expressed by human language.

captured from the conversations in our dataset. This finding helps us validate the reliability of the web

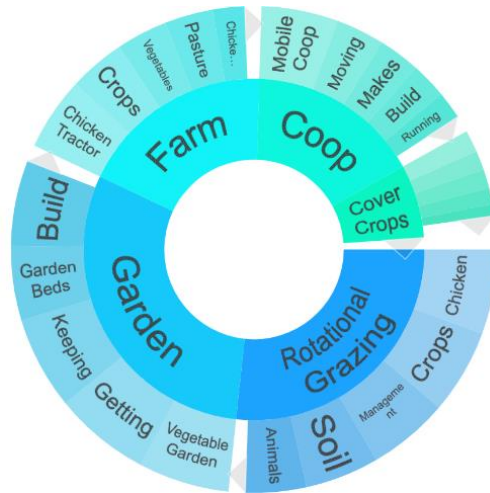


Figure 3. Topic wheel of significant terms from the texts of our dataset identified via NLP

crawlers used and the appropriateness of the query applied.

Table 2 contains a list of top 10 most frequently mentioned topics represented by keywords and phrases. Terms relating to

components and horticultural aspects of

integrated systems emerge, such as cover crops, garden beds, raised beds, vegetable garden, and fruit trees.

Table 2. Most mentioned topics by key phrases, locations and keywords						
	Phrase	mentions	Location	mentions	keyword	mentions
1	cover crops	252	California	157	farm	1091
2	chicken coop	229	Iowa	120	food	991
3	soil health	205	China	67	work	945
4	organic matter	165	Australia	64	years	918
5	garden beds	102	Missouri	58	small	902
6	Raised Beds	91	Texas Hill Country	36	people	896
7	vegetable garden	83	Pennsylvania	35	good	880
8	Fruit trees	82			soil	852
9	intensive rotation	59			day	849
10	meat chickens	58			water	821

Table 2. Most mentioned topics by key phrase, location, and keywords from online posts authored between 2019-2021

We also note that the phrase “meat chickens” was mentioned 58 times, compared to “egg-laying hens” which had 13 mentions. At the same time, there are 626 mentions of the keyword “eggs” compared to 600 mentions of the word “meat”.

Finally, the most mentioned locations in relation to discussions about pastured poultry and integrated cropping are also displayed in Table 2. Note that mentions of a location do not mean that the author made the post from that location.

### Manual content analysis of Twitter, Forums and Reddit data

Fig 4. Volume of perceived attributes of integrated poultry-crop production in social media

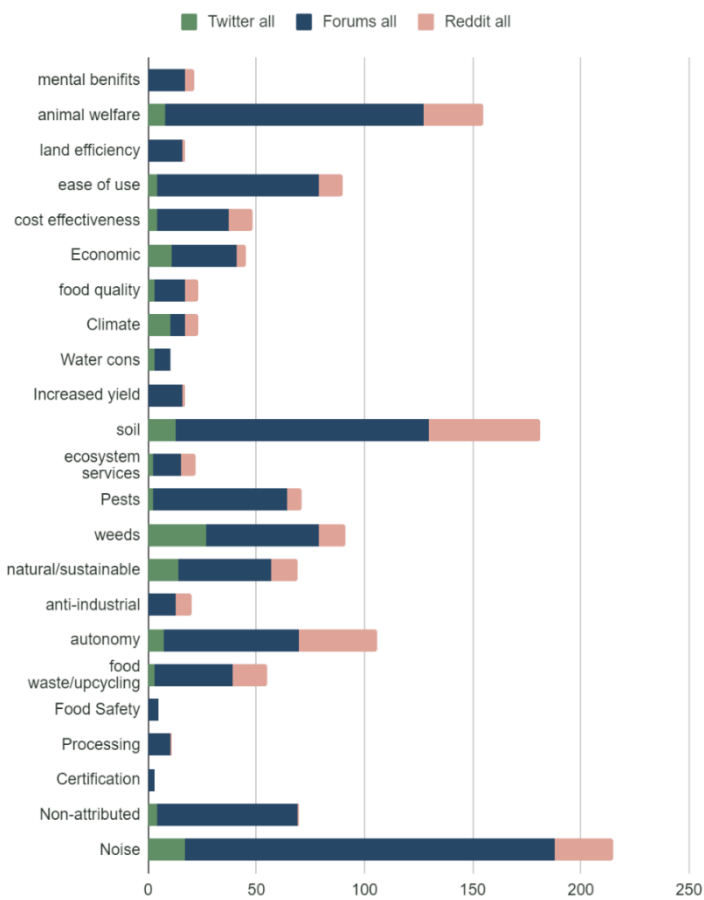


Fig 5. Volume of positive and negative sentiment expressed towards attributes of integrated poultry-crop production

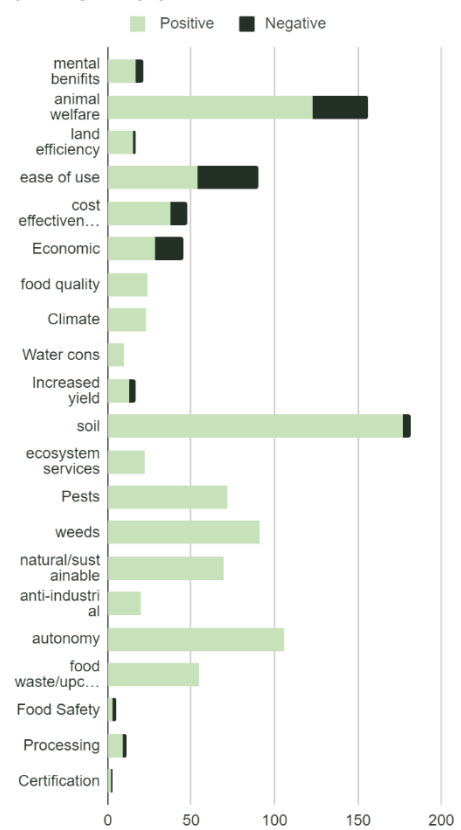


Figure 4. Volume of attributes identified via manual review of Twitter, Reddit and online forum posts, including the volume of non-attributed posts (for example, posts where the user mentions they practice integrated poultry-crop production but do not talk about any of the attributes), and noise posts (posts that are not relevant). Figure 5 shows the same attribute volumes as in figure 4, but displays the proportion of positive and negative sentiment associated with each attribute.

After using the key words and key phrases to help confirm the general relevance of the posts in our dataset, and to guide the identification of key topics for manual coding, we selected Twitter, Forums and Reddit for manual content analysis. Detailed manual review of the posts determined that 21% of the posts were irrelevant, but nevertheless picked up by our web scraper because they contained related terms or concepts (for instance, discussion of integrated systems but with cattle instead of poultry). 7% of posts mentioned our research topic generally and were deemed relevant, but did not specifically mention any attributes defined in our codebook (Figure 4). Figure 4 shows attributes regarding soil health, animal welfare, and autonomy are most mentioned in conversations on Twitter, Reddit and

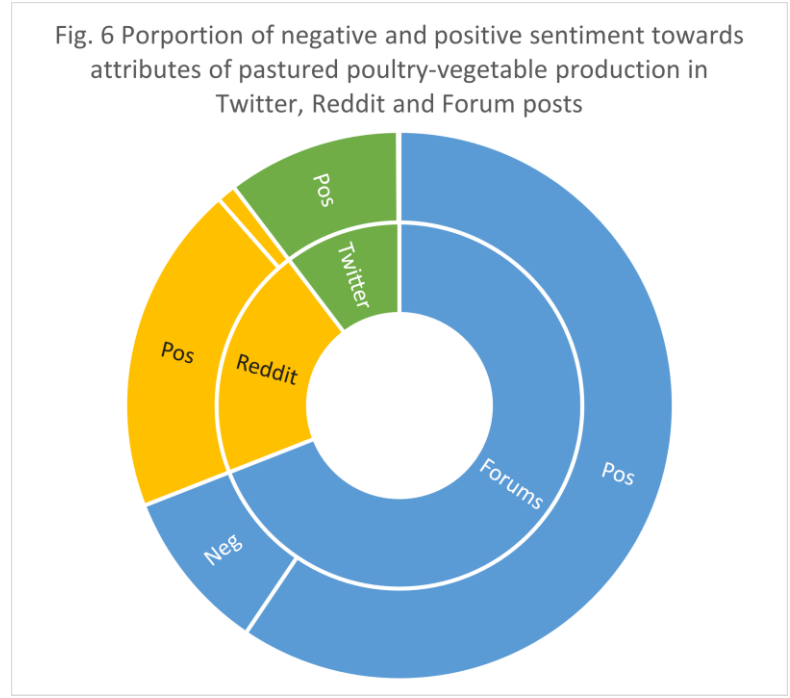


Figure 6. shows that online users mostly mentioned a attributes of pastured poultry-vegetable production with a positive sentiment. 15% of the attributes were mentioned with a negative sentiment in forum posts, and this percentage is 5% for Reddit posts, and 1% for Tweets.

forums, and Figure 5 shows for each of those attributes, sentiments were mostly positive overall, but ease of use, economic benefits and food safety had the greatest percentage of negative sentiment. Figure 6 shows a breakdown of negative and positive sentiments for each source type.

Finally, we found that 1% or less of online posts mentioned food safety, certifications, processing or any

scientific studies in relation to our research topic.

### III. Discussion

#### **Prevalent Content Sources and Trends**

Online news sites returned the highest volume of posts (n=960, 40%) pertaining to pastured poultry and integrated cropping. It generated a moderate impact score, but has the lowest reach relative to other content types such as forums, blogs, and Twitter. The news posts are for the most part not centralized to any singular news platform, but rather dispersed across multiple news sites—with the exception of farmprogress.com, which generated 21 posts relevant to our research topic. When considering the potential for this type of content type to be effective for information dissemination, a strategy that ensures distribution of articles across many news outlets may be important for impact. Additionally, we should bear in mind that although analyzing the content of news articles can indicate what information people are consuming, this more formal platform may not fully reflect the sentiments of the broader public as compared to platforms such as forums that allow online users to interact in unstructured conversation. Outreach and engagement strategies should also consider that although over half of Americans in 2022 across all demographics get their news from news websites or apps, a greater percentage of Americans under 30 years old report a preference for and usage of social media as a news source. Overall, preference for news websites or apps has shown a slight decrease from 2020 to 2022 while preference for social media as a news source trends slightly up (Forman-Katz & Matsa, 2022). Post volume data from our study from 2020-2021 similarly showed a decreased trend of news websites versus increased volume of social media platforms as compared to the prior year (figure 2).

Although almost a quarter of American adults use Twitter, Twitter produced a relatively lower volume of relevant posts in our study (n=186, 6%) (Table 1). Research shows that Twitter users bias using it as a platform for political content (Mitchell, 2022), thus since poultry and vegetable production are not specifically politicized issues, it is possible that people are less inclined to tweet about it. Despite the low

post volume, Twitter posts generated an overwhelmingly high average reach score (2265). This finding is not entirely surprising given that 97% of all Tweets are produced by just 25% of users with a large following, while a majority of Twitter users “lurk” on the platform to see what others are saying instead of publishing content themselves (Mitchell, 2021). A closer examination of our data showed that almost 40% of the Twitter posts generated an estimated reach of zero, while the top three posts averaged an estimated reach score of over 17 thousand per post. Finally, considering the low impact score (13) of the Twitter posts collected by the commercial web scraper along with research showing that highly active Tweeters receive little engagement (retweets, likes or replies) from the broader Twitter audience (Mitchell, 2021), our data seems to suggest that, although ideas or content shared on Twitter may be seen by a large number of people, most posts may not have much influencing power on how overall opinions or conversations online will trend.

Blogs also have a relatively low volume of conversations (n=282, 12%). However, Blogs display the second highest reach score (840), and they are tied with Forums for the highest Impact score (29). Blogs are a type of online media that straddles the line between news outlets and social media. Like Twitter, blog content is produced by a small minority of online users who make up 9.6% of the US population, but blog posts are consumed daily by 77% of internet users (Carlson, 2018). Additionally, blogs generate considerable user engagement through user comments (world et al., 2021). The high impact and reach scores show that blogs are an effective medium for communication about our topic. As confirmed by other studies, blogs are important in a strategy for science communication and disseminating research (Fraumann & Colavizza, 2022; Ross-Hellauer et al., 2020) and marketing (Crestodina, 2022; world et al., 2021). Outreach and engagement strategies should however also consider the possibility that blogs may decline in relevance in the future due to lower readership from younger demographics (Chang, 2020), this is reflected in our findings that show a slight decrease in content from blogs in the second year of our data (Figure 2.) Another potential drawback is that effective blogs require a considerable investment



of time to produce—with success greatly depending on higher length, quality, and frequent publication of new posts (Chang, 2020; Crestodina, 2022). [beginningfarmers.org](http://beginningfarmers.org) is a blog site that generated 15 hits from our query, but we otherwise did not identify any other blogs that emerged as a leader in producing content around pastured poultry and integrated production, indicating both a possible gap and opportunity for communication and outreach.

Our data shows that online forums generate not only a high volume (n=656, 27%), but also high impact (661) and reach (29). Results displayed on Table 1 show that including Reddit, six of the top ten websites with the highest volume of relevant posts are online forums. Thus, we are able to identify these specific platforms as hotspots of conversations around our research topic, which present an opportunity for targeted extension engagement in the future. [backyardchickens.com](http://backyardchickens.com), a popular hobbyist poultry keeper forum, ranks #1 in sites with the highest volume of posts from a single site (n=275), highest impact score (30) and second highest impact score of any website. Other popular online forum sites are not poultry or agriculture specific. They include [Reddit.com](http://reddit.com), one of the leading content sharing online community platforms in the digital world (Rogers, 2017); [4channel.com](http://4channel.com), a similar discussion board platform commonly distinguished by its controversial counterculture communities and political movements such as Anonymous and the Alt-right; [uberpeople.net](http://uberpeople.net), an online community for Uber drivers; and finally, [survivalistboards.com](http://survivalistboards.com), a community of people who practice outdoor survival skills as a hobby.

Finally, although YouTube trails behind other content types in terms of volume (n=113, 5%), it still ranks 4<sup>th</sup> in terms of sites that produced relevant posts (table 1). Due to the high volume of non-functional URLs and links, missing post body text, and/or irrelevant posts generated by the web scraper, we were unable to include posts from [YouTube.com](http://YouTube.com) in the manual text analysis. Reach and impact data were also not available for us to give a more in-depth assessment of this platform. It is entirely possible that some relevant posts were not picked up since the Brandwatch web scraper captures text content rather

than video content. Although in the 2<sup>nd</sup> year of our study YouTube declined by over 80%, its relevance cannot be completely disregarded since overall usage of this platform has increased steadily in recent years to include 82% of US adults in 2022.

### **Main drivers of pastured poultry and integrated production**

Whereas social media platforms are sometimes known to skew towards promulgating negative opinions (Tsugawa & Ohsaki, 2015), this dynamic was not observed for the topic of pastured poultry and integrated production. Across all platforms, conversations tended to focus much more on the beneficial attributes rather than barriers related to the key attributes we identified. As shown in figure 4, soil health and animal welfare, autonomy topped the charts with over 150 mentions. Other attributes like autonomy, ease of use, weed control, and pest control were also frequently mentioned.

Overwhelmingly, the potential for pastured poultry to contribute to soil fertility and soil health is stated as a benefit or motivator for producers. The term “soil”, and related phrases such as “soil health” and “organic matter” topped the most mentioned charts (Table 2) and therefore unsurprisingly emerged as the most discussed attribute in manual review of social media posts. Animal welfare follows closely behind soil as the second most mentioned attribute. In most cases, online users state a belief that chickens are happy and healthy when allowed to forage and graze on pasture, and report their usage of mobile chicken coops as a way to allow pasture grazing while protecting flocks from predators.

There is also a frequent mention of using integrated poultry-vegetable production to control weeds. In the 91 posts we identified that brought up this attribute, (Figure 4) many online users described employing poultry to clear unwanted vegetation either at the end of a cropping season, or to start a new plot of land for cultivation. Online users also frequently mentioned chickens’ tendency to consume insects (quantified under the label “pests” in Figure 4), although sometimes they frame access to insects

on pasture as a benefit to chicken nutritional needs, while other times it is framed as an ecosystem service that chickens provide for removing pests from crops.

Our research also revealed some value-based drivers for poultry in integrated production systems. The benefit of autonomy was the 3<sup>rd</sup> most mentioned attribute (Figure 4): in many posts, people who discussed pastured poultry and/or poultry-crop integrations related their motivations to their desire to increase self-reliance in the face of supply chain disruptions, high food costs, and mistrust towards the food system. We were able to identify several of the platforms or accounts as belonging to the “homesteading”, “prepper”, or “survivalist” communities. This finding is somewhat unexpected as this aspect of pastured poultry and integrated cropping was mentioned only once in the literature we reviewed by Sossidou et al., who wrote “there are many social benefits of raising pastured poultry, such as family work ethics, community involvement and improving lifestyles. This alternative enterprise fits with the farmers desire to live on the farm and to be self-sufficient and self-directed” (Sossidou et al., 2011, p 55). Others expressed a value for integrated systems because they are perceived to be more natural or sustainable. At a small extent, some social media posts also expressed counter-industrial values, contrasting integrated production favorably in contrast to large-scale commercial production; and overall intrinsic value towards practicing such types of sustainable production (tagged for our analysis under “mental benefit”) from which they derive a sense of happiness, well-being, and satisfaction (Figure 4).

### **Challenges of pastured poultry and integrated production**

Overall, positive or neutral sentiment far outnumbered negative sentiments by a ratio of around 9:1. Of the negative sentiments expressed, ease of use, animal welfare, and economic viability of pastured poultry and integrated production were most frequently mentioned.

Negative sentiments related to ease of use predominantly occurred in online forums, which tells us that many people are trialing the systems and turning to discussion boards for troubleshooting. Users commonly discussed challenges around moving their poultry flocks around for rotational grazing. This often involved the heavy weight of the mobile chicken coops, which varied depending on the building design and material. Other complaints revolved around undesired labor, time or logistics involved in executing this type of production system.

Negative sentiments on the animal welfare topic often revolved around challenges related to predation, with users either having lost birds due to predation or expressing doubt that chickens can be adequately protected in an outdoor mobile chicken coop. Another concern was around exposure of chickens to the elements, with some users expressing that mobile coops were not sufficient to house chicken in the winter. A few users also mentioned lack of shade and crowding as a concern.

Doubts and concerns around the economic viability of pastured poultry and integrated production were captured solely from online forum posts, with some users arguing that such farming systems cannot be profitable as a source of income. A much smaller share of concerns was expressed around the expenses related to implementing the system. This may indicate that the economic challenges are perceived by many to lie in access to market or marketing rather than cost of entry. It was unclear in many cases whether the users were speaking from firsthand experience or merely for the sake of theoretical debate. It is possible to speculate that negative sentiments were absent from platforms like Twitter and Reddit because they are being used to promote pasture and integrated systems rather than to debate its efficacy.

Finally, although based on keyword identification through natural language processing, mentions of terms related to egg production and broiler production are roughly even, manual review of social networking content indicates that the number of posts discussing layer production is almost twice as

numerous as posts mentioning broiler production. This indicates that online users may be more interested in egg production, but that both are important since broiler production was also mentioned at a relatively high volume.

### **Differing conversations between source types**

Figure 5 allows us to compare the proportional breakdowns of the attributes mentioned in each source type. We found that across all three source types, attributes related to soil health rank amongst the top 3 most discussed topics, whereas the ratios of prevalent conversation around other topics differed across source types. For Reddit users, the larger share of conversations mentioned autonomy compared to other content types. Forums revolved at a relatively greater percentage around ease of use and animal welfare. Twitter users are mentioning climate change 3x more than users on the other sites. They are overwhelmingly positive and focus on the potential for using poultry to remove unwanted vegetation, and the improved sustainability and higher market value of integrated farming outputs.

### **Gaps in online discourse**

The findings also allow us to elucidate gaps in the discourse around certain topics related to pastured poultry and integrated cropping that we have identified as subjects of interest to producers. We found that discussions around relevant scientific research trials and findings, food safety, processing, and certification of goods produced through integrated pastured poultry production noticeably showed the lowest presence from social media discourse in our data set. This lack of awareness or interest may be due to bias among the social media user demographics towards people who are relatively new to this type of production system and may not be knowledgeable about certain challenges that they have yet to face. A low extent of practical experience in pastured poultry and integrated farming may also explain the low volume of perceived challenges and negative sentiment found in our data, in which case negative sentiment might be expected to increase in the future as producers confront more challenges

over time. Further research is required to better understand the backgrounds and experience of social media users around the topic of interest, however, we note that the several of the top sites, such as backyardchickens.com, survivalistboards.com, beginningfarmers.com, and helpfulgardener.com are targeted towards hobby producers and those with a lower level of experience. We may speculate that this demographic is unlikely to be trialing the production at such a scale as to be very concerned about certification or processing, or perhaps they simply see these topics as part of general considerations for poultry and crop production that are not uniquely associated with pastured poultry and integrated cropping.

Finally, the absence of relevant scientific findings and studies mentioned in the social media posts indicates an opportunity for researchers and extensionists to engage and promote the relevance of scientific findings for the benefit of producers.

## IV. Conclusion

Social data analytics technology is a tool that has thus far not been heavily utilized for agricultural extension research. This research mimics the powerful approach that researchers in other fields like corporate marketing have developed—leveraging online media data to understand their audience, improve product features based on public sentiment, and execute effective audience communication and engagement. In this study, analysis of English language online posts scraped from the web between February 28, 2019 and May 2, 2021 allowed us to access online platforms for the purpose of understanding public perceptions around pastured poultry and integrated cropping as well as to identify key spheres of influence for public engagement and science communication. Researchers and extensionists will also be able to curate content regarding integrated poultry-crop production based on drivers of adoption that producers are most interested in such as building soil health, animal welfare, gaining autonomy of their food supply, and controlling unwanted weeds. Based on the negative

sentiments social media users expressed, we can discern some challenges that they need support in, such as marketing products for a better profit, or engineering mobile chicken coop designs that optimizing ease of usability for rotational grazing.

Although blogs and online news platforms are already central to existing strategies for effective science communication (Fraumann & Colavizza, 2022), and were shown to achieve moderate to high impact and reach on our topic, blogs and news sites seemed to be decreasing in popularity, and could possibly be less strategic when considering future agriculture and research extension efforts. this study identified a vacuum of science content relevant to pastured poultry and integrated cropping in social media platforms. This presents an opportunity for science communication as a 2017 report by Pew showed that most Americans do not actively seek out or consume science news, but rather tend to get it by happenstance (Funk, 2017). That same study reports that a third of social media users in the US feel social media are an important way they get science news, while 44% are getting science news from social media that they would not have gotten elsewhere. These facts underline the advantage of engaging outside of general news outlets and blogs.

In addition to identifying the main drivers and challenges of pastured poultry and integrated cropping systems expressed by online users, this study allowed us to assess the strengths and drawbacks of various platforms that can serve to inform future science communication strategies, especially for social media outreach and engagement. Table 3 below presents a summary of key considerations around each source type analyzed in this study. The guidelines in this table will aid science communicators to determine, for instance, that Twitter may be the most strategic for reaching a large volume of online users with simple information, as it is concise and gets many potential viewers, however, forums and blogs may be better for communications that aim to generate engagement or to promote behavior change. Or that, rather than authoring tweets or blogs in a platform with low reach or impact, communication strategies may do better by leveraging the use of celebrity or influencer accounts that

already have a strong following. The data we collected allows us to identify these specific individuals and organizations that have such status and have shown interest in pastured poultry and integrated cropping in their past Tweets.

Table 3. key advantages and limitations for various media types for science communication on pastured poultry and integrated production.			
Media type	Advantages	Limitations	Demographic
News	-Moderate impact & reach	-high time cost	Used by majority of Americans across all demographics
Forums	-High reach and impact -clear target platforms	-Time cost is unclear	Diverse demographic that is platform-dependent
Reddit	-Has a large user base	-Time cost of engagement is unclear	Used by a much higher share of men than women. Leans towards people under 50. Slight lean towards higher education and income.
Blog	-high impact and reach -can amplify content from news articles.	-high time cost -requires consistency and high quality to gain readership and reach	77% internet users read blogs, but readership is flavored by older demographics (over 30)
Twitter	-low time cost -very high reach	- low impact/ typically low engagement rates -slow growth -bias towards political content	High usage rate amongst journalists (69%) and adults under 30.
YouTube	-growing user base	- time and production cost	Used by 80-95% of adults under 65. Usage is fairly evenly distributed across demographics

Table 3 Summary of assessment of key advantages and limitations of various media types for science communication on pastured poultry and integrated production (source: Author; Atske, 2021; Carlson, 2018; Chang, 2020; Jurkowitz & Gottfried, n.d.)

## Limitations

Although this study attempts to identify the most impactful online platform for scientists to engage with the public around rotational poultry and integrated production, we were unable to obtain reach and impact metrics for certain key platforms such as YouTube and Reddit. Due to Facebook’s stance on user privacy protections which limits researchers’ ability to access their APIs (Collins, 2017), we were unable to include data from their platform despite the fact that it ranks the biggest existing social network with 2.9 billion monthly active users in 2022 (*Biggest Social Media Platforms 2022*, 2022). Our text analysis approach also did not include any analysis of video and pictorial content, which are growing as predominant forms of social networks today in platforms like Instagram, Snapchat, and TikTok.



Furthermore, in the course of our review of online posts, we found some slang terms for chicken or poultry used online that were not included in our Boolean query. Although we included the colloquial term “chicken tractors” for mobile chicken coops in our search, we also observed some additional alternative terms that were not included, which could have potentially resulted in the omission of certain posts that used different terminology.

In this study, we could not distinguish whether people were only producing pastured poultry, or also integrating with crops. This is because online users sometimes chose to discuss just one aspect or issue, or did not clearly describe their full production system. Future analysis could include further semantic analysis to better understand the producers’ activities.

Although welfare disadvantages of pastured poultry highlighted in published literature such as concerns with exposure to harsh weather were mentioned in some posts, we noticed that concerns with increased risk of exposure to disease vectors such as wildlife were absent. This may be an important finding given the importance of educating poultry producers about disease, however, it is possible that relevant posts may have been excluded when we chose to eliminate posts that contained terms related to avian flu in our search query.

Finally, although a more complete set of insights could have been generated had we included certain key content sources like news and blogs in our manual review, we were limited in our ability to accomplish this due to the high time cost of manual coding and coder training. However, the manually coded dataset we have created thus far from Reddit, Forms, and Twitter content presents an opportunity for training models to perform accurate machine learning-based analysis of text data around perceptions of pastured poultry and integrated production for larger volumes of online posts in the future.

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## VI. Appendix—Codebook

- 1. Anti-industrial**
  - 1: expresses the comparative advantage of or preference for integrative poultry systems over industrialized ag production
  - 1: expresses that integrative poultry production is harmonious with or not preferred over industrialized ag production
- 2. Anarchist/survivalist/autonomy**
  - 1: expresses that integrating poultry benefits autonomy and food security (often will promote it for self-reliance or "homesteading")
  - 1: expresses that integrating poultry reduces autonomy or food security
- 3. Animal Welfare**
  - 1: beneficial to animal welfare (protects from predators, happy chickens etc.)
  - 1: detrimental to animal welfare (increase stress, exposure to disease vectors etc.)
- 4. beneficial insects/ecosystem services**
  - 1: expresses that integrating poultry supports the presence of beneficial insects like pollinators, or of wildlife habitat
  - 1: expresses that integrating poultry is detrimental to beneficial insects or wildlife habitat
- 5. Certification**
  - 1: ease of obtaining/maintaining certification
  - 1: difficulty of obtaining/maintaining certification
- 6. Integration**

What integrations with poultry are mentioned? (pasture? crops? permaculture systems? etc.) if no integration then put 0
- 7. Climate**
  - 1: Expresses that integrating poultry beneficial for the climate (reduces climate change impacts or improve the human/animal/crop ability to withstand climate change impacts)
  - 1: expresses that integrating poultry is detrimental to the climate
- 8. Cost effective**
  - 1: expresses that it is inexpensive to produce pastured poultry or other poultry integrations. (i.e. reduced expenditure on off-farm manure/or compost, reduced labor expenses)
  - 1: expresses that it is relatively too expensive to implement integrative systems (i.e. increased expenses)
- 9. Ease use**
  - 1: expresses that integrative systems/pastured poultry is easy to implement (e.g. saves labor,
  - 1: Lack of lack of labor or time to care for or market poultry, difficulties due to more complex farm management
- 10. Economic**
  - 1: expresses that meat or crops produced from integrated systems can earn additional income, or be marketed for a higher value than regular products
  - 1: express that farmers will earn less money or products cannot gain a marketing advantage compared to regular products (e.g. lack of a market for organic poultry)
- 11. Food quality**
  - 1: expresses that meat or crops produced via integrative poultry systems are more nutritious or delicious or healthy
  - 1: expresses that meat or crops from integrative systems are less nutritious, delicious, or healthy
- 12. mental benefit**
  - 1: expresses intrinsic value (enjoyment, enriching experience) of raising poultry in integrative systems
  - 1: stress or negative mental effect of raising poultry in integrative systems
- 13. Land efficiency**
  - 1: expresses that integrating poultry is a more efficient use of a limited amount of land
  - 1: expresses that integrating poultry is an inefficient use of limited amount of land
- 14. Natural/sustainable**
  - 1: describes integrating poultry as more natural and more sustainable
  - 1: describes integrating poultry as unnatural or unsustainable
- 15. Pest control**
  - 1: expresses that integrating poultry helps reduce pests (insect, animal or disease) in the agricultural system
  - 1: expresses that integrating poultry can attract pests into the ag system
- 16. Processing**
  - 1: mentions relative ease of processing the chickens (butchering) or crops with integrative systems
  - 1: attributes challenges with or concern with processing chickens or crops in integrative systems
- 17. Sci**



If post refers to scientific study, a publication or otherwise shares scientific information, indicate "1"

**18. Water cons**

1: expresses that integrating poultry can create more efficient water use in the agricultural system (oftentimes people will mention improved water retention ability of the land)

-1: expresses that integrating poultry may reduce the water quality or consume too much water

**19. Increased yield**

1: increased crop or meat yield (indicate crop or meat)

-1: decreased crop or meat yield (indicate crop or meat)

**20. Soil**

1: expresses that integrating poultry improves the soil/land

-1: expresses that it degrades the quality of the soil or land

**21. Weeds**

1: expresses that integrating poultry helps reduce weeds in the agricultural system

-1: expresses that integrating poultry can increase weeds in the ag system