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UNDERSTANDING CONSERVATION SPECIALISTS' ROLE IN THE ADOPTION OF PRECISION AGRICULTURE IN NEBRASKA

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By

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There is a complex issue by the need for strategic development of agricultural lands to ensure we can feed a growing world, while simultaneously reducing impacts on our natural resources such as water pollution from runoff, soil degradation, and habitat fragmentation. To address these growing concerns, researchers are looking for ways to optimize both agricultural production and natural resource conservation. Precision conservation was developed to ensure sustainable ecosystems for future generations. Our research evaluates conservation specialists' ability to clearly articulate how precision conservation can help agricultural producers feed a growing world while simultaneously reducing impacts on our natural resources, I convened a panel of 20 conservation specialists to examine the current diverse perspectives on the progression and integration of precision agriculture in conservation management prescriptions through the Delphi Method research approach. Through the evaluation of the Delphi Method through a systematic review, I highlight the areas of agreeance in the field of natural resources, but also note the areas of concern moving forward for researchers looking to apply in their own research. We used the E-Delphi method to gather data through a series of three

surveys to test the hypothesis that the use of precision agriculture is becoming increasingly prevalent in the field of conservation.

Our results support the hypotheses, suggesting that conservation specialists are, in fact, using precision agriculture practices in their conservation positions, but with noticeable variance in the confinements of which practices were utilized. Furthermore, the results highlight the need to provide a united message when delivering precision agriculture across varying agency and organizational platforms.

Tags: Human Dimensions, Precision Agriculture, Delphi Method, Conservation, Private Landowners

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CHAPTER 1: A Systematic Review of Applications of The Delphi Method in Natural Resources

Abstract

The Delphi Method is used throughout a wide range of scientific disciplines for collecting abundant amounts of qualitative data about topics of interest. However, the structure and process can be vague and variable. When researchers seek to use this methodological approach, it is often coupled with hesitancy and confusion. Therefore, to address these issues, we conducted a systematic review of articles that used the Delphi Method in peer-reviewed literature to collect information about specific study design, characteristics, and themes that can provide an outline that is transferable and applicable of this methodology to other disciplines, specifically, the field of natural resources. Within 81 peer-reviewed scientific journals, we identified 115 publications addressing the use of the Delphi Method in the fields of natural resources, fisheries, wildlife, and conservation. In greater than 70% of publications, the number of survey rounds, panel size, and questionnaire analysis were the most commonly documented components of the Delphi Method. In less than 30% of publications, time commitments, inclusion of reminders, and feedback to panel members were the least commonly documented components of the Delphi Method. My research showed that the Delphi method can provide insight into a wide range of natural resources topics when reported and explained in the methodological structure. We identified the greater weakness in reporting rather than the Delphi method itself. Evaluating the inclusion and documentation of each articles' individual approach to the Delphi Method highlight the areas of agreeance in this

field, but also note the areas of concern moving forward for researchers looking to apply in their own research.

Introduction

The Delphi method was founded on a concept of 'pooled intelligence' from individual's perspectives and judgements into a consensus opinion by a group of experts (Shariff 2015). Using collective knowledge and expertise provides the benefit of aggregating ideas, opinions, and potential solutions to better understand complex questions from many experts. Multiple individuals can provide multiple perspectives on topics that may have little previously supported research (Thangaratinam and Redman 2005). The Delphi method uses a series of questionnaires, commonly referred to as rounds (Hasson et al 2008), to identify a consensus of understanding of a problem. Developed in 1963 by Norman Dalkey (1963), the Delphi method was designed specifically to collect information from a group military defense experts to forecast an atomic bomb attack. (Dalkey 1969, Shariff 2015). Since then, this approach is recognized as a tool to approaching in an exploratory manner of complex topics that need direction for future and in-depth research (Frewer et al 2011). The ability for identified experts on the panel to each contribute towards the topic at hand gives insight into the full range of perspectives, while specifically moving forward to pinpoint the most prominent responses through the narrowing down in rounds to consensus. The Delphi Method is recognized by several characteristics, including anonymity of participants, controlled feedback, the use of an expert panel, iteration of rounds, and the attempts towards consensus (Boberg et al 1992, Goodman 1987, Mullen 2003, Shariff 2015, Sourani and Sohail 2015).

The Delphi Method has been increasingly adopted to use collective knowledge to address complex problems, but still lacks widespread adoption (Padel and Midmore 2005). The lack of adoption has been attributed to limited awareness of the method, the lack of clear guidance in relation to its structure, procedures, reproducibility, as well as the variations in its application delivery as detailed below (Sourani and Sohail 2015). In particular, the Delphi methodology has become more frequently used in business, technology, management, education, medicine, nursing, health, and family therapy (Kalaian and Kasim 2012). The Delphi Method has been used to establish the perceived ranking orders of variables, design guidelines for new groups or practices, and list out key indicators of a major problem that has been identified. For example, Hess and King (2002) identified key species indicators of focal species, the ranking of research priorities in the healthcare system (Smith et al 2020) or establishing mental health first aid guidelines for elderly patience (Kingston et al 2009).

Boberg et al. (1992) detailed the advantages pertaining to the Delphi method, specifically noting the unique depth of exploration and elicitation during each round, which allows participants to provide equal consideration of feedback and input on topics of concern. The anonymity and individualized nature of the process helps minimize biases associated with group pressure, status, and dominancy of powerful personalities (Kalaian and Kasim 2012). Colton (1994) emphasized the importance of facilitating communication and sharing of information among panelists throughout the Delphi process. Another important benefit of the Delphi method is that it promotes a personal stake in the research for panelists through the direct inclusion of their responses in the process toward establishing consensus, often resulting in greater response rates (Gupta

and Clark 1996). Lastly, the Delphi Method has been updated several times (e.g., modified, e-Delphi, policy, etc.) with different approaches to collecting the information from the panelists that add a great amount of flexibility for many scenarios.

While many of the benefits of the Delphi correspond to the flexibility of the approach, the flexibility can also have its disadvantages. These disadvantages include limited quantitative statistical tests, large time commitments for both the panelists and researchers guiding the process, extensive qualitative data threat requires processing and coding, panelist falloff due to lack of interest or scheduling conflicts (Fink-Hafner et al 2019). Additionally, it can be difficult to define and determine consensus among the panelists as well as the point when consensus on a topic is reached (Donohoe and Needham 2009). Furthermore, the flexibility in the approach can make it difficult to assess what approach is the most scientifically valid given a certain scenario (Keeny et al 2011, Hasson et al 2008). For example, what qualifies an expert on an issue? The educational background, research record, years of experience, can vary considerably (or are even undefined) across studies (Adler and Ziglio 1996).

There are two primary considerations that must be made when using the Delphi Method: 1) who will be included as an expert panelist, and 2) what methodology will be used to collect information from the panelists. Perhaps most foundational to the validity of the Delphi Method is the establishment of the expert panel. Experts should be individuals at the top of the field of study with demonstrable expertise, knowledge, and skill; demonstrate interest and willingness to collaborate and engage in discussion of a topic; and be interested in creating solutions to complex and messy problems (Lilja et al 1992). Research has recommended up to 15 experts but the range tends to fluctuate

frequently (Linstone and Turoff 1975). The flexibility of the size of the panel is partly due to the limit of identified 'experts' for the researchers. Experts can be recruited through many pathways including personal connections, online recruitment, and professional events. One common approach is to use the snowball method, which uses recommendations of experts from other individuals that were previously identified (Helms et al 2016).

Once the expert panel is established, researchers must determine the appropriate methodology to elicit feedback on their question of interest. The original Delphi method format was designed with four rounds of anonymous inquiry administered through mailed questionnaires, with each round seeking increased refinement and specificity (Cookson 1986). Questionnaires during each round are composed of open-ended questions that collect information the next corresponding survey round. Depending on how the questions are initially asked, a researcher can direct the focus of the survey responses or allow the first-round opinions to shape what the research focus is for the remainder of the study (Skulmoski et al 2007). For example, Hess and King (2002) directed their research towards finding focal species for open spaces of wildlife in their region, which allowed feedback of panelists specifically within the confinements of the project's specific focus determined by the researchers. In contrast, Orsi et al. (2009) compiled a list of criteria and related indicators surrounding ecological restoration of forest ecosystems and utilized the first survey's findings to narrow down the feasibility and need of this list amongst panelists to develop the direction that the following surveys would focus on moving forward. Multiple rounds of the questionnaires typically provides a summarization of themes from the previous round with the intention to narrow down

ideas toward a common consensus. Consensus is loosely described as the panel reaching a majority agreement on a topic, often determined to be a two-thirds majority of agreeance (McMillan et al. 2016). However, there is no set requirement for the number of rounds needed to reach consensus

Variations on the original methodology make the Delphi Method very flexible in a wide range of contexts (Keeny et al. 2011). Major renditions include Modified Delphi method, the Policy Delphi method, and the E-Delphi method (Mead 1991, Keeny et al. 2011). The Modified Delphi method involves holding in-person interviews or focus groups rather than using a questionnaire during the first round of surveys (Hartman and Baldwin 1995). The Policy Delphi method uses the opinions of the panel to collect opinion and consensus which is understood to directly result in the implementation of a policy decision (Meyrick 2003). The E-Delphi method is like the original methodology but with the caveat that all surveying is done electronically via email or web survey (Toronto 2017). The Delphi method is recognized independently by its characteristics, which include anonymity, controlled feedback, expert panel, iteration of rounds, and the attempt towards consensus (Boberg et al 1992, Goodman 1987, Mullen 2003, Shariff 2015, Sourani and Sohail 2015).

There have been several reviews of the Delphi Method in various scientific disciplines (Boberg et al 1992, Sourani and Sohail 2015). However, few have addressed the application of this methodology in natural resources sciences and management. Therefore, we sought to identify, compile, and systematically assess the use of the Delphi Method in natural resources. The Delphi Method has been used in natural resources to develop habitat models, understand water resource issues, and eco-tourism evaluation

(Crance 1987, Taylor et al. 2003, Taylor and Ludd 1989). Further, the Delphi Method has been used as an important methodology in conservation planning, which identified focal species moving forward for the researchers and professionals in the United States (Hess and King 2002). By being able to narrow down to key species, managers can concentrate their efforts and more effectively manage species and habitats of concern.

Objectives

We systematically reviewed the use of the Delphi Method in natural resources, wildlife, fisheries, and forestry to compile information tied to several of the key characteristics of the Delphi Method. In Boolean terms, the search included “Delphi Method” AND “natural resources" OR “wildlife” OR “fisheries” OR “forestry”. Specifically, we assessed who was included in the expert panel, the number of panelists, number of rounds, and the level of consensus to be obtained from peer reviewed published studies (Hasson and Keeny 2000, Keeny and Hasson 2005). My objectives were to 1): compile research articles that address the Delphi Method in the field of Natural Resources; and 2) summarize attributes of the research to address common trends and patterns in the field of Natural Resources.

Methods

Article Selection

Peer reviewed literature was collected using Web of Science provided by the University of Nebraska-Lincoln library system. I confined to key search terms to included “Delphi Method” and any of the following terms: “Natural Resources,” “Conservation,” “Fisheries,” or “Wildlife.” These four terms were used to obtain the greatest scope of articles pertaining to Natural Resources management. Our initial search generated 263

articles published between 1992 and 2022. I individually evaluated each search result to identify their direct relevance to the Delphi Method, which was 115. Of those excluded, 148 articles (78%) were primarily due to articles not directly tied to natural resources management. Further, we excluded any manuscripts (20%) that used the Fuzzy Delphi method (Ishikawa et al 1993). Lastly, a few articles (2%) were not included due to the inability to obtain access to the original manuscript. We classified each article into categories that included "Natural Resources" or "Conservation" or "Fisheries" or "Wildlife" based on subject matter. Articles using the Delphi method discussed program evaluation in conservation, wetland effects on fisheries, fighting wildlife diseases, and strategies for sustainable management for natural resources (Hanisch et al 2012, Curzon and Kontoleon 2016, Naskar et al. 2018, Chen and Chen 2021).

Article Evaluation

We examined each article for three characteristics: questionnaire methodology, determination of expert panelist, and result analysis. To evaluate the questionnaire methodology component, we broke down eight factors that described the Delphi method. These factors include summarizing the: (1) number of survey rounds, (2) delivery method, (3) duration of entire process, (4) the variance of survey structure between each round, (5) length of survey availability for each round, (6) geographic range of distribution, (7) reminders sent for surveys, and (8) question structure. We noted specified the number of rounds from each article whereas indicated a yes or no whether the information for additional seven criteria were mentioned in the article (Table 1).

From each article, we collected information on the Expert Panelists through two criteria: Diversity in Stakeholders and Reported Panelist Characteristics (Table 1). We noted if

the job title or research affiliation was summarized for the panels in the 115 articles, and categorized this under the name, “Diversity in Stakeholders.” Characteristics outside of job title or research affiliation was included in the Reported Panelists Characteristics. Which included characteristics such as descriptions that helped researchers better understand the panel such as, personal connection to the topic, age, geographical location, or other socio-demographic questions.

Table 1. The characteristics of data collected from peer-reviewed articles discussing Natural Resources using the Delphi method from Web of Science between 04 April 2022 and 05 May 2022. The data was compiled on 06 May 2022.

Questionnaire Methodology		
Number of survey rounds	The number of times did panelist provide feedback.	Continuous
Delivery method	For example: Classic, Modified, E-Delphi	Yes or no
Duration	Time frame from start to finish.	Yes or no
Duration of each round	How long each round was made available to panelists.	

Geographic range	The range of locations at which data was collected (i.e., international, state-wide, company-specific).	Yes or no
Reminder	Was there indication of a reminder sent during survey collection?	Yes or no
Question structure	The articled specified the type of questions used: Multiple Choice, Likert Scale, Ranking, or Open-Ended.	Yes or no
	Determination of Expert Panelists	
Defined experts	The number of individuals comprised of the panel.	Yes or no
Panel size	Provided clear guidelines to the inclusion and exclusion of potential panelists.	Continuous
Criteria for selection of panel	The inclusion of socio-demographic questions to evaluate bias or external influences on panelists' responses.	Yes or no

Reported panelist Characteristics	The mention of who was comprised within the panel (i.e., what role they held, their representation).	Yes or no
Diversity in stakeholders	Was an analysis for concluding results reported?	Yes or no
	Results and Analyses	
How are the questionnaires evaluated?	How researchers analyzed their data collected (i.e., Analytic Hierarchy Process)	Yes or no
Consensus	The stated level of consensus determined by the researchers.	Yes or no
Response rate	Level of response across survey rounds.	Yes or no
Feedback to panelist	Reports, Meetings, Nothing at All	Yes or no

We identified four key components to evaluate the analysis of resulting data with Delphi Method from the articles pertaining to Natural Resources (Table 1). These four components included: (1) how the questions were evaluated, (2) how consensus was generated, (3) the inclusion of response rate, and (4) if there was mention of feedback provided to the panelists amongst the conclusion of the surveys.

Consensus can be reached by an average of responses falling above the researcher-selected threshold, majority agreement amongst panelists, or to use a statistical ranking and weighting system to evaluate the outcome (example: analytic hierarchy process). The recognized variation in analysis leads to the heightened need to address the process that each study decides to adopt as there is little room for assumptions. We evaluate the recognition of clear dictations of the agreed upon consensus rate as well as the distinguishment between the original sample size and the final response rate that was received. Delphi ranges in sample sizes from as little as 5 individuals to 1000+ individuals, with the majority favoring the smaller collective groups, meaning that non-response rates can quickly impact a articles' depth and statistical significance. Lastly, for the collaborative and relational format of this methodology over a span of multiple surveys, the investment of each participant builds a unique interest in the results of the study. The study explores if an expectation or a precedent is typically included in articles to reach out post-research with result summaries and explanations.

Analyses of Article characteristics

We summarized our findings using descriptive statistics (percentage, median, mean, standard deviation as appropriate) from the 115 articles included in the review. All descriptive statistics were calculated using R (R Core Team 2022). The results ultimately dictate the interpretation of the study, and we take measures to see how this is being evaluated in natural resources. For the analysis side, the results often range from simplistic and straightforward reporting such as averages, lower and upper quartiles, or ratios, venturing as far difficult as evaluating the coefficients of variation or utilizing the analytical hierarchy process to run tests for common themes and correlations.

Results

Of these 115 articles, we categorized 22% as natural resources, 65% in conservation, 10% in fisheries, 7% in wildlife, and 3% in forestry. Most of the articles (89%) using the Delphi Method have been published since 2012. The number of questionnaire rounds used was documented in 77% (n=89) of the articles. Of those articles, the number ranged from one to four rounds, with the median overall being 2 rounds (n=44), with a range from 1 to 4. The documentation of the chosen delivery method was reported 50% (n=58) of the time. The duration, or length of the entire survey process, was noted in 28% (n= 32) of the articles, whilst the duration of each specific survey round was reported at an even lower rate of 21% (n = 24). The geographical range of the panel experts was noted 51% (n=59) of the time. The use of reminders was noted in only 5% (n=6) of the articles. Lastly, we took note of question structure, for example Likert-scale, free response, ranking, etc. to address the ideas and data in the first rounds of the survey process. In natural resources we found 64% (n=74) of individuals noted this characteristic of their methodological process. Approximately 48% (n=55) of the time articles denoted where

they referenced the definition of expert from in past literature or denoted their own unique definition. There were 79% (n=91) articles that specified the panel sizes, with a range from 4 to 1,273 individuals. Overall, the average panel size was found to be 51 individuals (SD = 143 individuals). Only 50% (n=57) of the articles clarified their selection process for their panelists. Whereas 63% (n=72) described the diversity of roles or occupations that encompass the group. Fewer (33%; n=38) included the socio-economic characteristics of the panel.

Table 2: The article evaluations for the Natural Resources systematic review of the Delphi method is listed below including the corresponding results reported for the presence of these attributes in all 115 articles.

Category	Criteria	Result
Questionnaire Methodology	How Many Rounds?	77% (n= 89)
	Delivery Method	50% (n = 58)
	Duration	28% (n = 32)
	Duration of Each Round	
	Geographic Range	51% (n = 59)
	Reminder	5% (n = 6)
	Question Structure	64% (n = 74)
Determination of Expert Panelists	How is an Expert Defined?	48% (n = 55)
	Panel Size	79% (n = 55) Mean= 51 individuals Standard Deviation= 143 individuals
	Criteria for Selection of Panel	50% (n = 57)
	Reported Panelist Characteristics	33% (n = 38)
	Diversity in Stakeholders	63% (n = 72)
Results Analysis	How are the questionnaires evaluated?	77% (n = 89)
	Consensus	49% (n = 56)

Response Rate	37% (n = 43)
Feedback to Panelist	9% (n = 10)

The analytical methods were specified in 77% (n=89) of the articles assessed. Specifically, the description of consensus was reported in 49% (n=56) and the response rate was reported 37% (n=43) of the articles. The response rate from the originally reported panel size recruited was documented. Lastly, we evaluated the reported documentation of feedback to panelists when the consensus is reached for final objections or just for informational purposes. This was found to be a rather uncommon practice, reported at 9% (n=10).

Discussion

The results of our systematic review of the Delphi Method in Natural Resources highlighted the variability reported in the articles that have also been previously described in other reviews (Boulkedid et al. 2011, Varndell 2021). The variability in methodology and the level of detail reported in the peer-reviewed literature may be connected to some of the confusion surrounding the methodology (Linstone and Turoff 1975, Keene et al .2011). The number of rounds, panel size, and questionnaire analysis was found to have the greatest level of documentation, found in more than 70% of our articles. The least described characteristics that we assessed were time commitments, inclusion of reminders, and feedback to panel members - all described in less than 30% of the articles. Overall, it is important to note that no article that documented all characteristics that we examined in our analysis. Perhaps to aid in the greater adoption of

the Delphi Method as a useful tool to address complex problems, proper, and complete documentation of the methodology used should be described or assessed. At a minimum, we suggest a core of these characteristics that would help improve the consistency on how the Delphi Method is described in the natural resources.

Our systematic review found some consistent and highly variable characteristics among the articles in Natural Resources. Consistent with Dalkey's (1964) original framework, the average of two to three rounds has been commonly adopted in the Natural Resources. The size of the panel was variable among the articles we examined. The number of individuals on a panel in natural resources had a considerable range from a few individuals to several hundred, resulting in an average panel size of 51 individuals. However, other disciplines have had panels much smaller (healthcare: 8 individuals, Shinners et al 2021; and construction management: 16 individuals, Kermanshachi et al. 2019). We suggest that researchers clearly articulate panel size requirements to illustrate the need for panels with few individuals to many individuals.

Our intentions of this review of the Delphi method would be to provide insight to the importance of including the key aspects of the research approach for others to use as a guideline and thus strengthen the integrity of its reputation in the field of natural resources. The attributes listed in our review of literature can be used as consideration for a baseline of constructive characteristics that future researchers can include to bring consistency and clarity to the Delphi method. The mention of surveyors including the incorporation of reminders in their cycles of surveys was the lowest reported of all the characteristics considered. Ludwig 1994 recognized that the weakness in the gap of time that falls between initial delivery of the survey and the close can slow down the process

and quickly elude participants minds. To be designed as a repetitive and sequential process, it seems only necessary to design the method on the foundation of consistent communication and strategic tactics to keep individuals continually involved in the standings of the project (Hsu and Sandford 2007). Often response rate is drastically variable and difficult to predict, making the continuous and consistency of communication efforts essential (Hsu and Sandford 2007). The incorporation of consistent and necessary reminders could aid in overall success in feedback as well as serve as a simple way to boost morale for a project once its initial copy is received (Geist 2010).

When collecting exploratory data as within the Delphi method, the results include information that is on a topic where researchers convened the specialist of that field to provide feedback on. Thus, the information that comes from the results typically directly applies to the interest or focus of the individual's life. The Delphi method is designed to summarize findings and report back to the panelists to continue the collective nature of the technique (Linstone and Turoff 2005). Our review found low documentation of the feedback delivery, raising the concern of this key collaborative opportunity.

The e-Delphi process appears to hold a lot of promise in the natural resources. Natural Resource Agencies that have limited financial resources may be better able to incorporate technology into the delivery of surveys (Avery et al. 2005) and also create a space for exploratory information gathering without the financial constraints of paper survey costs and postage or travel needed for in-person interviews. Our findings revealed only 50% of researchers indicated their specific approach. With each variance from the original Delphi method, there could be attributes or characteristics that are purposely left out or left void

of mention. In the era of developing reproducible science, this finding is concerning and needs to be addressed by developing a clear rationale for readers to review and be able to replicate.

To fully evaluate the impact individual's experiences, careers, and socio-demographic factors have on study results is complementary, making the criteria set for who is on the panel vital (Keeney et al 2006). Finding where expert opinion falls in the overall scheme, the characteristics to be averagely reported perceives the continual lack of requirement for Delphi's data sources to be structured and justifiable (Linstone and Turoff 1975, Welty 1971). We suggest in particular the statistical analysis, the panelist descriptions and diversity, and feedback to panelists due to the literature illustrating the need for clarity often in these topics matched with our results surrounding their current reportings in natural resources. Welty (2017) focused his research on the need for expression of variances in panelist's degrees of expertise which could influence results of a study. The need to detail statistical analysis is supported by Landeta (2006) when detailing a weakness in the inability to check the researcher's methodological accuracy.

Feedback to the panelists can arguably, the most impactful by providing information to the individuals most influenced and impacted by the research findings. Oftentimes, it is discovered in the feedback process that many individuals recognize the new ideas, thoughts, or solutions discovered by other comments that they otherwise would have never considered (Lilja et al 2011). We suggest that heightened consideration of who is being surveyed and the potential factors that can be evaluated such: as gender, physical location, financial status, extracurricular involvement, and such

forth. Including potentially influential factors and how it is dictating the responses received, providing an environment for more avenues to explore in future research.

It is clear not just through previous literature but through our findings in this survey, that the Delphi method could benefit from more extensive reporting. With regards to the major implications that can come from lack of reporting, there is a need to point out, the problem is easily remedied. When individuals argue the weakness within the methodology, we argue the weakness is more so in the expectations of reporting. As stated above, there was not a single criterion that was not addressed at some point within our review.

The information is out there, but the struggle to find it becomes the issue and inconvenience. The 115 articles reviewed successfully displayed the ability to answer complex questions in the field of natural resources while utilizing the Delphi method. There is a recognition that the field of natural resources will only continue to face more complex problems as the increase in stakeholders and external factors continue to develop (Dewulf et al. 2005).

References

Adler, M., and Ziglio, E. (1996). Gazing into the oracle: The Delphi method and its application to social policy and public health. Jessica Kingsley Publishers.

Avery, A., Savelyich, B., Sheikh, A., Cantrill, J., Morris, C., Fernando, B., Bainbridge, M., Horsfield, P., & Teasdale, S. (2005). Identifying and establishing consensus on the most important safety features of GP computer systems: E-Delphi study. Journal of Innovation in Health Informatics, 13(1), 3–11.

Boberg, A. L., & Morris-Khoo, S. A. (1992). The Delphi method: A review of methodology and an application in the evaluation of a higher education program. The Canadian Journal of Program Evaluation, 7(1), 27–39.

Boulkedid, R., Abdoul, H., Loustau, M., Sibony, O., & Alberti, C. (2011). Using and Reporting the Delphi Method for Selecting Healthcare Quality Indicators: A Systematic Review. PLOS ONE, 6(6), e20476. https://doi.org/10.1371/journal.pone.0020476

Chen, D.-C., & Chen, T.-W. (2021). Research on Sustainable Management Strategies for the Machine Tool Industry during the COVID-19 Pandemic in Taiwan. SUSTAINABILITY, 13(23). https://doi.org/10.3390/su132313449

Colton, S., & Hatcher, T. (2004). The Web-Based Delphi Research Technique as a Method for Content Validation in HRD and Adult Education Research. Online Submission.

Cookson, P. S. (1986). Charting the unknown: Delphi and Policy Delphi strategies for international co-operation. International Journal of Lifelong Education, 5(1), 3–13.

Crance, J. H. (1987). Guidelines for using the Delphi technique to develop habitat suitability index curves. National Ecology Center, Division of Wildlife and Contaminant Research, Fish ….

Curzon, H. F., & Kontoleon, A. (2016). From ignorance to evidence? The use of programme evaluation in conservation: Evidence from a Delphi survey of conservation experts. Journal of Environmental Management, 180, 466–475. https://doi.org/10.1016/j.jenvman.2016.05.062

Dalkey, N. C. (1969). The Delphi method: An experimental study of group opinion. RAND Corp Santa Monica Calif.

Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. Management Science, 9(3), 458–467.

de Meyrick, J. (2003). The Delphi method and health research. Health Education.

Dewulf, A., Craps, M., Bouwen, R., Taillieu, T., & Pahl-Wostl, C. (2005). Integrated management of natural resources: Dealing with ambiguous issues, multiple actors and diverging frames. Water Science and Technology, 52(6), 115–124.

Donohoe, H. M., & Needham, R. D. (2009). Moving best practice forward: Delphi characteristics, advantages, potential problems, and solutions. International Journal of Tourism Research, 11(5), 415–437.

Fink-Hafner, D., Dagen, T., Doušak, M., Novak, M., & Hafner-Fink, M. (2019). Delphi method: Strengths and weaknesses. Advances in Methodology and Statistics, 16(2), 1–19.

Frewer, L. J., Fischer, A. R. H., Wentholt, M. T. A., Marvin, H. J. P., Ooms, B. W., Coles, D., & Rowe, G. (2011). The use of Delphi methodology in agrifood policy development: Some lessons learned. Technological Forecasting and Social Change, 78(9), 1514–1525.

Geist, M. R. (2010). Using the Delphi method to engage stakeholders: A comparison of two studies. Evaluation and Program Planning, 33(2), 147–154. https://doi.org/10.1016/j.evalprogplan.2009.06.006

Goodman, C. M. (1987). The Delphi technique: A critique. Journal of Advanced Nursing, 12(6), 729–734. https://doi.org/10.1111/j.1365-2648.1987.tb01376.x

Gupta, U. G., & Clarke, R. E. (1996). Theory and applications of the Delphi technique: A bibliography (1975–1994). Technological Forecasting and Social Change, 53(2), 185–211. https://doi.org/10.1016/S0040-1625(96)00094-7

Hanisch, S. L., Riley, S. J., & Nelson, M. P. (2012). Promoting Wildlife Health or Fighting Wildlife Disease: Insights From History, Philosophy, and Science. Wildlife Society Bulletin, 36(3), 477–482. https://doi.org/10.1002/wsb.163

Hartman, F. T., & Baldwin, A. (1995). Using technology to improve Delphi method. Journal of Computing in Civil Engineering, 9(4), 244–249.

Hasson, F., Keeney, S., & McKenna, H. (2000). Research guidelines for the Delphi survey technique. Journal of Advanced Nursing, 32(4), 1008–1015.

Helms, C., Gardner, A., & McInnes, E. (2017). Consensus on an Australian nurse practitioner specialty framework using Delphi methodology: Results from the CLLEVER 2 study. Journal of Advanced Nursing, 73(2), 433–447.

Hess, G. R., & King, T. J. (2002). Planning open spaces for wildlife: I. Selecting focal species using a Delphi survey approach. Landscape and Urban Planning, 58(1), 25–40.

Hsu, C.-C., & Sandford, B. A. (2007). Minimizing non-response in the Delphi process: How to respond to non-response. Practical Assessment, Research, and Evaluation, 12(1), 17.

Kalaian, S. A., & Kasim, R. M. (2012). Terminating Sequential Delphi Survey Data Collection. Practical Assessment, Research & Evaluation, 17(5). https://eric.ed.gov/?id=EJ977579

Keeney, S., Hasson, F., & McKenna, H. (2006). Consulting the oracle: Ten lessons from using the Delphi technique in nursing research. Journal of Advanced Nursing, 53(2), 205–212. https://doi.org/10.1111/j.1365-2648.2006.03716.x

Keeney, S., McKenna, H., & Hasson, F. (2011). The Delphi technique in nursing and health research. John Wiley & Sons.

Kenney, D. S., McAllister, S. T., Caile, W. H., & Peckham, J. S. (2000). The new watershed source book: A directory and review of watershed initiatives in the western United States.

Kermanshachi, S., Rouhanizadeh, B., & Dao, B. (2020). Application of Delphi method in identifying, ranking, and weighting project complexity indicators for construction projects. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 12(1), 04519033.

Kingston, A. H., Jorm, A. F., Kitchener, B. A., Hides, L., Kelly, C. M., Morgan, A. J., Hart, L. M., & Lubman, D. I. (2009). Helping someone with problem drinking: Mental health first aid guidelines-a Delphi expert consensus study. BMC Psychiatry, 9(1), 1–7.

Landeta, J. (2006). Current validity of the Delphi method in social sciences. Technological Forecasting and Social Change, 73(5), 467–482.

Lilja, K. K., Laakso, K., & Palomäki, J. (2011). Using the Delphi method. 2011 Proceedings of PICMET'11: Technology Management in the Energy Smart World (PICMET), 1–10.

Linstone, H. A., & Turoff, M. (1975). The delphi method. Addison-Wesley Reading, MA.

Ludwig, B. G. (1994). Internationalizing Extension: An exploration of the characteristics evident in a state university Extension system that achieves internationalization [PhD Thesis]. The Ohio State University.

McConnell, M. D. (2019). Bridging the gap between conservation delivery and economics with precision agriculture. Wildlife Society Bulletin, 43(3), 391–397.

McMillan, S. S., King, M., & Tully, M. P. (2016). How to use the nominal group and Delphi techniques. International Journal of Clinical Pharmacy, 38(3), 655–662.

Mead, D., & Mosely, L. (2001). The use of the Delphi as a research approach. Nurse Researcher, 8(4), 4–23.

Mullen, P. M. (2003). Delphi: Myths and reality. Journal of Health Organization and Management.

Naskar, M., Roy, K., Karnatak, G., Nandy, S. K., & Roy, A. (2018). Quantifying climate change induced threats to wetland fisheries: A stakeholder-driven approach. ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY, 20(6), 2811–2830. https://doi.org/10.1007/s10668-017-0018-6

Orsi, F., Geneletti, D., & Newton, A. C. (2011). Towards a common set of criteria and indicators to identify forest restoration priorities: An expert panel-based approach. Ecological Indicators, 11(2), 337–347.

Padel, S., & Midmore, P. (2005). The development of the European market for organic products: Insights from a Delphi study. British Food Journal.

R: The R Project for Statistical Computing. (n.d.). Retrieved June 18, 2022, from https://www.r-project.org/

Shariff, N. (2015). Utilizing the Delphi survey approach: A review. J Nurs Care, 4(3), 246.

Shinners, L., Aggar, C., Grace, S., & Smith, S. (2021). Exploring healthcare professionals' perceptions of artificial intelligence: Validating a questionnaire using the e-Delphi method. DIGITAL HEALTH, 7, 20552076211003430. https://doi.org/10.1177/20552076211003433

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. Journal of Information Technology Education: Research, 6(1), 1–21.

Smith, G. E., Long, J., Wallace, T., Carradice, D., & Chetter, I. C. (2021). Identifying the research priorities of healthcare professionals in UK vascular surgery: Modified Delphi approach. BJS Open, 5(2), zraa025.

Sourani, A., & Sohail, M. (2015). The Delphi method: Review and use in construction management research. International Journal of Construction Education and Research, 11(1), 54–76.

Taylor, J., & Ryder, S. (2003). Use of the Delphi method in resolving complex water resources issues. JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION, 39(1), 183–189. https://doi.org/10.1111/j.1752-1688.2003.tb01570.x

Thangaratinam, S., & Redman, C. W. (2005). The delphi technique. The Obstetrician & Gynaecologist, 7(2), 120–125.

Toronto, C. (2017). Considerations when conducting e-Delphi research: A case study. Nurse Researcher, 25(1).

Varndell, W., Fry, M., Lutze, M., & Elliott, D. (2021). Use of the Delphi method to generate guidance in emergency nursing practice: A systematic review. International Emergency Nursing, 56, 100867. https://doi.org/10.1016/j.ienj.2020.100867

Welty, G. (1972). Problems of selecting experts for Delphi exercises. In Academy of Management Journal (Vol. 15, Issue 1, pp. 121–124). Academy of Management Briarcliff Manor, NY 10510.

CHAPTER 2: HOW DO WE IMPROVE PRECISION CONSERVATION ADOPTION? AN APPLICATION OF THE DELPHI METHOD

Abstract

By 2050, the world's human population is expected to increase to >9.7 billion people, resulting in increased pressures on food production and urbanization of rural lands. The increased pressure will require strategic development of agricultural lands to ensure we can feed a growing world, while simultaneously reducing impacts on our natural resources such as water pollution from runoff, soil degradation, and habitat fragmentation. To address these growing concerns to optimize both agricultural production and natural resource conservation, precision conservation was developed to ensure sustainable ecosystems for future generations. Precision conservation leverages various precision agricultural tools like yield monitor data, Geographic Information Systems (GIS), etc. to identify areas in fields that can be diversified to optimize financial return on investment while benefiting conservation. Unfortunately, the role conservation specialists play and their influence on the implementation and adoption of emerging precision agricultural practices remains in question. To ensure conservation specialists can clearly articulate how precision conservation can help agricultural producers feed a growing world, while simultaneously reducing impacts on our natural resources, we convened a panel of 20 conservation specialists to examine the current diverse perspectives on the progression and integration of precision agriculture in conservation management prescriptions. We used the E-Delphi method to gather data through a series of three surveys to test the hypothesis that the use of precision agriculture is becoming

increasingly prevalent in the field of conservation. Our results support the hypotheses, suggesting that conservation specialists are, in fact, using precision agriculture practices in their conservation prescriptions but with noticeable variance in the confinements of which practices were utilized. Furthermore, the results highlight the need to provide a united message when delivering precision agriculture across varying agency and organizational platforms.

Tags: Human Dimensions, Precision Agriculture, Conservation, Private Landowners

Introduction

Continued of population growth worldwide has led to increased pressure for food production and urbanization of rural lands, amplifying the role of agriculture. As such, there is a strong need for intensive agricultural practices such as monoculture landscapes (e.g., transition from multi-crop to single crop) and large-scale operations across the United States to maximize production and optimize profits, often at the expense of environmental health (Berry et al 2003, McConnell 2019). Agriculture has been linked to many contributing natural resources issues, such as water pollution from runoff, soil degradation, and reduced habitat connectivity (Boutin and Jobin 1998, Moss 2008, Alam 2014). To maximize agricultural production and natural resource conservation, the development of precision conservation has arisen to mitigate these concerns (Bongiovanni 2004). Precision conservation, akin to precision agriculture, is defined as the use of technologies and procedures linked to mapped spatial-temporal characteristics

used to implement conservation management practices such as conservation tillage, cover crops, and field-edge vegetation buffers across natural, or land characterized by human activities, and agricultural systems (Berry et al. 2003). The continued development and refinement of spatial technologies in agriculture and conservation provides an important opportunity to develop sustainable ecosystems while meeting production and profitability demands (Batte and Arnholt 2003).

With technological innovations in the agricultural sector, a new paradigm shift has occurred with the implementation of precision agricultural practices. For example, switching less productive and profitable portions of a field to a lower input management option, such as perennial vegetation funded by a conservation program, could increase overall cropland profitability by 80% and reduce water pollution by 38% (Brandes et al. 2018). Targeted conservation adoption is essential to increase crop yields and optimize production acreage since most of the world's arable land is already being cultivated (Berry et al. 2003).

Although advances in precision agriculture have developed rapidly and become more readily available, adoption of these practices remains limited. For example, agricultural producers in the United States maintained only approximately 20% of the arable acres in corn, soybeans, and rice using precision agriculture technology (Hellerstein 2019). Thus, there is a strong need to disseminate the advancements to agricultural landowners to realize the full potential of new technologies and opportunities to balance conservation and production. The demand to disseminate and educate to agricultural landowners about emerging technologies becomes essential to carry out the full potential of new programs, such as the Conservation Reserve Program (CRP) or the

Environmental Quality Incentives Program (EQIP). However, there is a need to further develop our understanding of how landowners make decisions and what factors influence adoption of these practices (Adrian 2005, Aubert 2012, Selinske 2015, Gigliotti 2019). Ultimately, adoption motivation is influenced by farmer's characteristics (i.e., economic class, education level, or other socio-demographics), circumstances, as well as the current agricultural practices that are being used (Greiner et al. 2009). Understanding the decision-making processes and the factors mediating those processes of landowners will be foundational for greater adoption of precision conservation practices (Selinske et al 2015).

Financial and economic risk are significant components of a farmer's decision-making process (Nowak 1987, Daberkow 2003, Pannell et al. 2006). The primary characteristic for precision farming implementations is ultimately determined on the justification of profitable motivations. However, the decision to adopt a new conservation practice is not solely made on one individual's motivation, but on factors such as on-farm experimentation, improved data of land characteristics for management decisions, and risk reduction (Batte and Arnholt 2003, Ryan et al 2003, Greiner and Gregg 2011, Lute et al 2018). Upon addressing financial components for adoption, the need to understand individuals' intrinsic motivations such as wildlife-orientation values, mental models, and pro-environmental behaviors help us evaluate the likelihood of adoption (Manfredo et al 2009, Pfrimmer et al 2017). Landowner decision-making has been attributed to reasons such as place attachment value, land and wildlife stewardship beliefs, and conventional resource production ownership objectives (Balukas et al 2019). Further, aesthetic preferences, information availability, parcel size, personal values, recreation activities,

and social factors are also highly influential on conservation decisions (Brook et al 2003). Gigliotti and Sweikert (2019) evaluated landowners' attitudes and motivations in the Upper Midwestern region of the United States and found that landowners were predominately utilitarian orientated, suggesting that individuals will be more prone to adoption when the outcome is perceived as useful for the majority.

A key component to increasing the knowledge and adoption of conservation practices is for effective conservation communication and education with a need to advocate the importance of conservation (Burger Jr. 2019, Jacobson et al 2006). Previous research has recognized the communication gap that impedes the success of conservation efforts nation-wide, thus placing a greater demand to uncover where exactly this gap occurs and its capacity of unknowns (Kamal et al 2015, Findlater et al 2019). Our research seeks to understand what conservation specialists understand about precision conservation and how they communicate with landowners about using the approach. Furthermore, we seek to how resources and research can better equip conservation specialists with the tools to confidently and effectively promote the adoption of precision agriculture with the purpose of benefitting conservation in intensive agricultural systems.

The Delphi method is increasingly being used to collect information to address complex social problems (Nelms and Porter 1985). Briefly, the Delphi method was founded on a concept of 'pooled intelligence' from individual's perspectives and judgements into a collective opinion by a group of experts (Shariff 2015). Dalkey (1969) used the phrase, "Two heads are better than one," to describe the benefits of using this approach to better understand complex questions by members of the group. Collecting information from multiple individuals obtains a combined perspective on topics that may have little to no

previously supported research, making opinions important to collect (Thangaratinam and Redman 2005). Generally, the Delphi method uses a series of questionnaires, commonly referred to as rounds (Hasson et al. 2000), to identify a consensus of understanding concerning a question or problem.

In a review of applications of the Delphi method in natural resources, Chapter 1 indicated the broad scope that the method has been used to address exploratory and complex research topics. While being used to address a wide range of issues, there was considerable disparity in the frequency of reporting among the 16 prominent Delphi Method components. The researchers identified that the number of rounds, the panel size, and questionnaire analysis were found to have the greatest level of documentation, found in more than 70% of our articles. The least described characteristics that we assessed were time commitments, inclusion of reminders, and feedback to panel members - all described in less than 30% of the articles. My research showed that the Delphi method can successfully provide insight into a wide range of natural resources topics when reported and explained in the methodological structure. We identified the greater weakness in reporting rather than the Delphi method itself. Evaluating the inclusion and documentation of each articles' individual approach to the Delphi Method highlighted the areas of agreeance in this field, but also note the areas of concern moving forward for researchers looking to apply in their own research. Overall, it is important to note that there was no article that documented all the components that we assessed. Furthermore, all the characteristics that we assessed were found in at least one peer-reviewed article. The authors suggest that there is a need for increasing the transparency of the

methodology used in hopes to strengthen the validity and application of the results to natural resources issues.

Given the findings from Chapter 1, we sought to use the Delphi Method to better address potential communication and knowledge gaps that impedes the success of conservation and sustainability efforts as farmers continue to meet the production demands from a growing world population. Specifically, we sought to 1) highlight the role conservation specialists play in contributing towards the adoption of precision agriculture practices on the landscape, and the efficiency of their current communication strategies and 2) identify informational gaps and misunderstandings in the current emergent field of targeted conservation and precision agriculture. By addressing these two objectives, we seek to establish a baseline understanding to move forward in Nebraska's communication efforts for targeted conservation delivery and implementation of precision agriculture across the state.

Methods

Study System

Nebraska is part of the Great Plains region of central United States. The trend towards increased private-land ownership continues to redirect conservation efforts and their targeted audience. Private land ownership continues to direct conservation efforts and their targeted audience, with the state of Nebraska being no exception (Cortes Capano et al 2019). Nebraska is approximately 97% privately owned, with 92% being utilized for agricultural resources (Bishop et al. 2011). Nebraska has 181.7 billion m^2 utilized in farmland and ranchland, with nearly 128.7 million m of rivers and streams, suggesting abundant opportunities for targeted conservation approaches. Additionally,

Nebraska sits atop the Ogallala Aquifer, which spans 704.2 million m^2 of the United States (NRCS-USDA 2021). In 2018, row crop production in Nebraska was estimated at $10 billion (USDA-NASS 2018). Nebraska has several conservation programs, agencies, and organizations that serve private landowners and farmers, which provides the need to understand the willingness of adoption throughout the region more in-depth.

Approach

We used an e-Delphi method, which uses an online or web-based approach to collect information from a geographically dispersed group of individuals for input (Toronto 2017). We used this method to better understand precision conservation across a geographically distant population. We developed a series of open-ended questions to elicit information on conservation specialist responses to current approaches and application of targeted conservation practices in precision agriculture (Appendix A). All interview instruments and processes were approved by the University of Nebraska-Lincoln Institutional Review Board (IRB) (#20210720881EX) prior to the beginning of the research. The initial contact with panelists occurred via email correspondence and included a cover letter (Appendix B), and the reminder message (Appendix C).

Panelist selection

When selecting specialists for our panel, we identified primary objectives to determine who would be asked to join. This inherently justifies the confinement of our conservation considerations. We used the "reputation approach" (Hess and King 2001) to identify potential panelists in the state of Nebraska and offered them the opportunity to recommend other individuals to join the panel (i.e., naturalistic snowball effect; Helms et

al. 2017). We compiled and evaluated specialists who brought knowledge, authority, and insight to conservation and precision agriculture (Gupta and Clark 1996). Specifically, we sought individuals that met the following criteria: 1) employed with an established conservation organization (i.e., federal, state, NGO) in Nebraska; 2) currently employed in that organization; 3) the panelist's role in conservation (e.g., biologists, administrator, field consultant); and 4) whether the panelist interacts directly with landowners.

Survey methodology

Panelists were contacted via email with instructions, summary of the intended research, concluded with an invitation to join the survey at a set time and date. Consent was received via a consent document located on each survey's landing page with the required step to select the option of granting consent. Once consent was obtained, participants were provided access to the survey, which they could complete over a two-week window.

We adapted the approach described in Sourani and Sohail (2015) to conduct our research (Figure 1). To begin the survey process, we sent an email to each participant that described the process of the project and the purpose of our research so that our panel could make an informed decision whether they wanted to participate in the project. Consent to participate in the survey was collected on the landing page for the survey, after clicking the link in the invitation email. Consent to participate in the research was obtained at the start of the three rounds. The three rounds of the survey occurred over a duration of 16 weeks (July 26th, 2021-November 16th, 2021).

The first survey was composed of three sections: Socio-Demographic, Precision Agriculture, and Communication (see survey questions in Appendix A). The socio-demographic section focused on background of the individuals from the panel that provided feedback, such as workplace past and present involvement, years of experience in conservation, and private land ownership. The Precision Agriculture section collected panelist's knowledge of questions pertaining to the definition, inclusive practices, influences of adoption, and barriers conservation specialists face. The Communication section was the third component of the survey and sought to understand how specialists communicated precision agriculture practices to farmers and farmland owners, alongside purposely obtaining insight on the resources that are needed to assist in the improvement of future communications. The survey was composed of 24 questions structured as open-ended, short answer format, with socio-demographic questions being multiple choice (Appendix A). The expected time of completion for the first round was approximately 15 minutes.

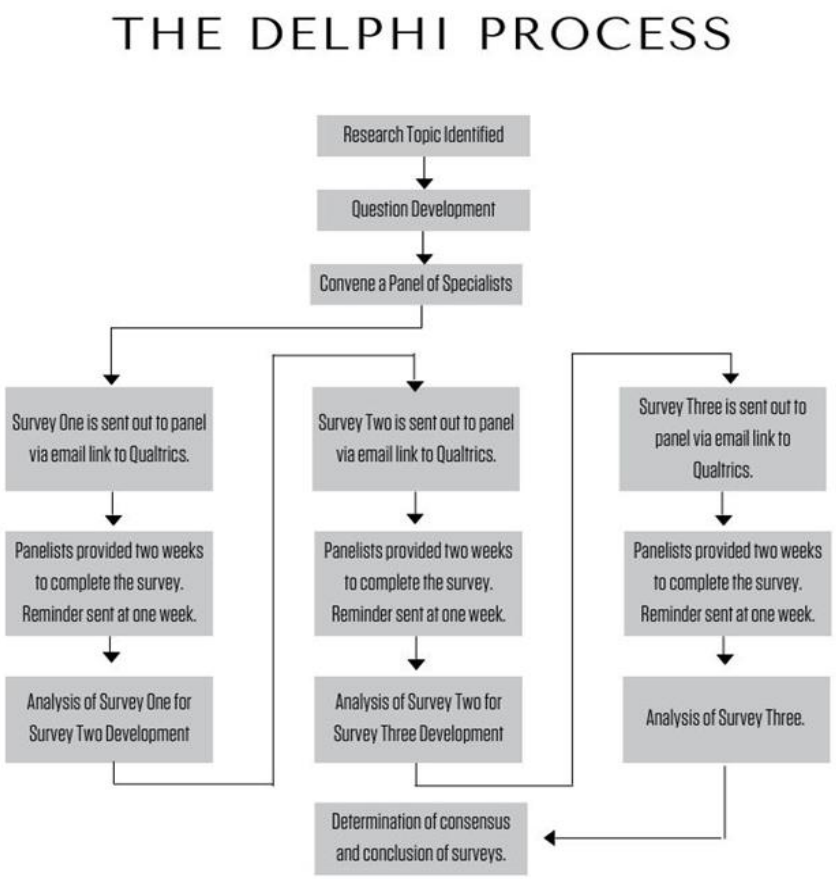

Figure 1: Conceptualization of the Delphi process.

The first survey's responses were summarized and analyzed for major themes. Then, the summaries were provided to the panelists for further comments, prioritization, and approval in a second round of surveys. In survey one, we collected definitions of precision agriculture from each individual to produce a collective working definition. To obtain consensus in following surveys, five researchers from the University of Nebraska-Lincoln collectively categorized themes of our initial responses based on discussion and separation of reoccurring ideas. The second round of surveys provided opportunities to highlight further consensus amongst the group. An additional section on communication was added during the second survey round. The additional section included eight open

ended questions seeking to inform researchers about what communication avenues conservation specialists are using currently to interact with farmers and farmland owners and the struggles they perceive to hinder their success at encouraging adoption of precision agriculture. The last survey round sent out to the panelists collected information on final consensus of questions in surveys one and two as well as providing an opportunity for panelists to note any additional comments they may want to share based on the survey process or topics brought up throughout.

We targeted the primary components of precision agriculture including defining jargon, clarifying practices that fall into these categories, and how professionals are communicating with farmers and farmland audiences. The panelists can contribute realistic insight into how the dissemination of information pertaining to precision agriculture is being delivered throughout Nebraska. Online survey communications were deployed via email correspondence, including links to survey questions and communications to address issues that arise. After the two-week mark was reached on survey two, the survey response rate stood at six out of twenty, leading us to add additional call participants to provide any assistance or field any questions that may not have been otherwise recognized. Previous research suggested routes such as this to reduce non-response in subsequent rounds (Hsu and Sandford 2007).

Our research project is designed to allow input from panelists, condense responses, and lastly gather thoughts on how the group came to the conclusions and consensus that they did. Lastly, we provide initial results of farmers/farmland owners' surveys for comments alongside the panelist responses to provide any insight that may benefit participants in the future. This will be provided at the conclusion of the project

and does not serve a role in the data collection portion of the research, but rather a response to the results. The process allows for the involvement of individuals to receive answers to questions that our research was primarily intended to address. The entirety of the project was comprised of qualitative data; therefore, the analysis led with the intention to gain consensus. We a priori sought to obtain consensus at ≥75% agreement; 50% is deemed acceptable (Hasson et al 2000; Chapter 1).

Findings that reached the desired level of consensus were then restructured into questions for the subsequent rounds in a closed question format to either narrow down further or gain group agreement on the condensed results. In addition to determining consensus around ideas of precision conservation and agriculture, we also quantified relationships and frequency of occurrence of certain topics (Shariff 2015). The topics addressed were perceived encouragers and discouragers of farmer's adoption, educational resources needed by specialists to communicate more efficiently, and the current modes utilized for connecting with farmers and farmland owners.

Results

I had an overall response rate of 55% across all three surveys (survey round one: 60%, survey round two: 50%, survey round three: 60%). Our conservation panel was characterized by 20 individuals representing eleven different state, federal, or non-governmental agencies and organizations in Nebraska. Time commitment for survey completion ranged from 2 minutes and 30 seconds to an hour and 34 minutes. Our project schedule concluded with a sum of 16 weeks (July 26th, 2021-November 16th, 2021)

Socio-demographics

Our conservation panel was identified based on the position title given upon their recruitment into the panel. However, whenever asked of the individual's current employment, we found additional self-recognized titles of Farmer, Rancher, and University association (i.e., extension, academic professor). To understand our respondents background, we asked for respondents past employment if applicable. As a collective, our panelists provided input based upon a collective 232 years working in the field of conservation. The average reported years of experience was 21 years, with a range of 5 years to 50 years.

To identify if respondents had connections to precision agriculture from a landowner perspective, we asked if each individual had private lands of their own. If so, they were directed to a series of four additional questions. Of the 11 respondents who answered the question, six panelists identified as owning private lands. The following four questions for those six panelists found that their land is utilized recreationally (n=1), agriculturally (n=5), and as a home site (n=1). The properties ranged in size with one individual reporting less than ten acres, while the remaining five individuals reporting greater than 100 acres. Five out of the six individuals responded that they pursue conservation practices on their land. Lastly, we provided the opportunity for the private landowners in our panel to describe how they implement precision agriculture practices to their properties. Responses included: no till, leaving stubble, crop rotation, use of soil moisture probes, planting of wind blocks, variable rate application, use of livestock, cover crops, grass water ways, buffer strips, soil sampling, implement seeding back poor productive acres, and auto-steer.

Surveys

In survey one, there was final completion from 12 individuals. The survey provided 12 statements to seek foundational input for the collective definition of precision agriculture researchers were working to establish. At the end of the round, we had collected 23 practices from the agreement of the pre-identified list along with the addition of respondent's submitted practices. All other questions were responded to in a free response fashion garnering an abundant source of data to build survey two. Socio-demographic questions were collected and are summarized above. In Survey Two, our survey was accessed by 18 individuals with final completion from 10 full responses and 1 partial response. Survey two allowed consensus of the precision agriculture to be reached with 80% (n = 8) agreement. After narrowing down the initial 23 practices due to combining similar terminology, we found 18 precision agriculture practices were accepted within the panel's definition of precision agriculture.

The frequencies of each practice were also identified with soil erosion management used most frequently, and skip row planting, drone, and auto-steer used least frequently (see Chapter 3 for more details). Lastly, ranking occurred on survey one's previous question of primary influences for the adoption of precision agriculture, where cost ranked the highest priority and need for consistency ranked the lowest. In the second part of survey two, respondents were asked about communication efforts they utilize, which resulted in three major themes arising: postcards, word-of-mouth, and in-person meetings.

In Survey Three, our survey was accessed by 13 individuals with 12 full responses and 1 partial response. Respondents found no consensus on the primary influences of farmer and farmland owner adoption of precision agriculture, with an

agreeance rate of 67% (n = 8). Each individual (n = 12) provided feedback by means of free response on the biggest concerns for specialists moving forward promoting the adoption of precision agriculture. Respondents were given the option to provide any additional feedback for the researchers where six individuals shared miscellaneous input of comments pertaining to previous topics or questions.

Precision Agriculture

With 80% agreement, we received consensus on a collaborative definition of Precision Agriculture as "The use of targeted technology and practices with the intent to improve agricultural profits and minimize environmental impacts." The definition selected by panelists included both the economic and environmental pieces provided in the definition in comparison to the other possibilities that included either one or the other. We sought to understand what specialists considered to fall within the framework of this definition by collecting a list of practices that are associated with their working definition. Through three rounds of surveys, we identified 18 practices from the collective group. The list of practices is as such: Variable Rate Application, Satellite Imagery, Drone, Auto Steer, Soil Sampling, Equipment Selection, Yield Monitoring, GPS Spray Equipment, and Alternative Crops in Locations, Plant Cover Crops, No Till, Grassed Waterways, Crop Rotation, Integrate Livestock, Planting and Fertilizer Application, Enrolling in Conservation Programs, Soil Erosion Management, and Artificial Intelligence. Once the list was compiled, researchers reintroduced the entire list to the panelists and found that none of the practices were identified as outside of their working definition of Precision Agriculture. This solidified the 18 practices that we addressed moving forward. Panelists reported their frequency of use of Skip Row

Planting, Artificial Intelligence, Drone, Auto-Steer, and GPS Spray Equipment in their conservation recommendations to be the least, at 22% (n=2). While Soil Erosion Management was reported most frequently used at 78% (n=7).

In the first survey, panelists provided a list of primary influences of land tenant's decisions towards adoption of precision agriculture on the landscape from their point of view. In consequent rounds, the influences were ranked determining the following as the most important factors they consider (from highest importance to lowest importance): Cost, Return on Investment, Knowledge, Confidence, Neighbors Influence, Term of Lease, Cultural Norms, Support, and Need for Consistency. Although this list is reflective of the panelist ranks provided,wWhen presented in the last round of surveys, only 67% agreed on the ranking results. We decided to move forward with lack of complete consensus noting the feedback for disagreement was four completely different opinions of the rearrangement of one influence that they uniquely recognize as more important. Examples of feedback of disagreement, "Lease needs to be 3rd or 4th," or "I think Neighbor Influence should be higher - not the top but higher than it is..."

Table 1: Survey participants provided the attributes they considered to encourage and discourage Nebraska farmers' receptiveness to adopt precision agricultural practices on their lands

Farmers' Receptiveness to Adoption	
Encouragers	**Discouragers**

-Cost (1)	-Cost (7)
-Seeing it work on land parcels like their own (3)	-Seeing it work on land parcels similar/neighbors' example (2)
-potential to increase profits/ROI (7)	-Inability to understand/use technology (3)
-less time/energy spent (1)	-Unreliability of technology (1)
-used equipment w/technology already on it (1)	-Complexity (2)
-Pressure from neighbors (1)	-Peer pressure (1)
-Conservation Incentive (3)	-Crop consultant opinions (1)
-Crop consultant opinions (1)	-Short-term profit reductions (1)
-Education (1)	-Perception that “it’s a gimmick” (1)
-Early Adopters (1)	-Political divides/beliefs (1)
-Incentives (2)	-Lack of trust (1)
-Providing hard, evidence-based proof (1)	-Fear of risk (1)
-Changing the measuring stick of success from average yield-per-acre to net-profit-per-acre (1)	-Resistance to change (3)
-Ease of use (1)	-Data sharing concerns (1)
-Privacy protection (1)	

The feedback for the panel's perspectives on farmers' receptiveness to adoption can be found displayed in the Table 1 above. Noted encouragements for adoption included increase in profits and return on investments, seeing it work on similar parcels of land, and conservation incentives. Discouragers for adoptions included cost, resistance to change, and the inability to understand and use technology. Based on Nebraska's current knowledge of precision agriculture, panelists reported they were unsure or did not feel as though farmers and farmland owners have the adequate resources to adopt these practices in their operations. Additionally, from their perspective, 75% of respondents (n=9) expect less than 50% of Nebraska farmers to use precision agricultural practices in their operations.

Communication

The panel was selected on the basis that specialists directly interacted with landowners. To clearly understand how panelists reached out to farmers and farmland owners to discuss conservation enrollment, we asked panelists to identify the best ways to contact farmers and private landowners. Three themes emerged from our research: postcards (n=3), word-of-mouth/referral (n=3), and face-to-face interactions (n=5). All respondents noted utilizing the resources and collaboration of other conservation agencies or organizations in Nebraska. The majority (n=7) collaborates with another entity on a weekly or more basis. Of nine responses, only two recognized the incorporation of an agency or organization communication evaluation mechanism in place for their outreach to private landowners and farmers. However, no one disagreed when asked if they believed their agency should have an established mechanism to evaluate their communication methods to the public.

Discussion

Conservation specialists play a pivotal role in the communication of conservation across privately owned landscapes (Lutter et al 2018). With Nebraska largely being privately owned and agriculture dominated, conservation decisions are a collaborative front between the farmers and farmland owners and specialists who communicate the resources and opportunities that decision-makers can choose from. Our results indicate that precision agriculture is being incorporated into the discussion with stakeholders across the state of Nebraska from the conservation specialists, but not without its difficulties of adoption, similar to many reports across the world (Cook et al 2000, Popp and Giffin 2000, Zhang et al 2002). Our first objective was to highlight the role conservation specialists play in contributing to the communication and adoption of targeted conservation across Nebraska's landscape; results from our study indicated that conservation specialists are familiar with precision agricultural practices. However, their comfortability and frequency does not reflect this knowledge. Panelists provided a collective definition and list of practices and technologies that fall within their working knowledge of precision agriculture that reflected their skillsets to communicate precision agriculture, but when asked their expertise on the topic, none indicated a perception as such that they could effectively inform farmers and farmland owners.

Our second objective identified the key facilitators and constraints conservation specialists observed or faced when assisting with the new precision practices and technologies; results from our study found that conservation specialists perceived cost, return on investment, and economic factors as the top factor in the adoption of precision agriculture. This finding is well supported in literature as the largest obstacle and

consideration when making decisions in the farming industry (Shruthi et al. 2017, McConnell 2019, Pathak et al. 2019). Panelists also noted important factors being knowledge of precision agriculture, confidence to implement new practices, and neighbor influence to dictate the decision to adopt, while highlighting those discouragements to adopt included the need for consistency, resistance to change, and the need for support to learn the new technology. Cultural norms and the resistance to change was noted as a hindrance frequently reflective of the research that emphasizes the need for a shift in landholders' perception that these new practices will enhance the achievement of their personal goals (Pannell et al 2006).

Our final objective identified the informational gaps and misunderstandings for conservation specialists when communicating precision agriculture to farmers and farmland owners; our results in this study found that conservation specialists in Nebraska have a competent understanding of the foundational components encompassing precision agriculture. We evaluated competency by collecting the definition and practices that individual came to a consensus on and comparing to commonly cited research in the precision agricultural field. Additionally, we found the barriers to adoptions and the perception of precision agriculture adoption to be highly supported in literature. We utilize the findings noted above and the needs provided by panelists to provide insight into how to move forward with improving the communication of precision agriculture in the context of conservation in the future.

The self-efficacy of the conservation specialists, the perception that precision agriculture can be implemented across Nebraska’s landscape, is notably small in our results. When asked if farmers and farmland owners have adequate resources to adopt

precision agriculture in their operations, the majority reported without confidence. Research shows that one of the major contributors to new adoption sources from the recommendation or the influence of a trusted professional (Wright and Shindler 2001). If the individuals working directly with farmers and farmland owners are not confident in sharing this information, we cannot expect conservation recommendations to reflect the encouragement of adoption moving forward. As one respondent noted, “I don't feel like I have a great read on what producers need regarding precision Ag…. I work in conservation and my organization works with landowners, but we don't have a great understanding of agriculture and the reasons why producers do or don't implement conservation into their operation.” Kwok and Gao detail the importance of an individual to share information is directly linked to one’s own perception of their capabilities (2005). Our focus must shift to encouraging positive knowledge sharing behaviors and strengthening the self-efficacy of our specialists to equip them with the know-how to share these new practices to decision-makers (Yang and Chen 2007, Maddux 1995).

In order for precision agriculture to be incorporated into Nebraska’s conservation efforts, our study suggests that it may begin with providing attention first within the educational and training resources provided to the conservation specialists. Finding ways to boost morale and confidence within the specialists such as field days with hands on experience, courses, and access to emerging research in the topic could lead to an increase in adoption from a top-down effect (Heiniger et al. 2002). The understanding of why conservation specialists do not feel equipped plays a key role in our research as the panel effectively communicated precision agriculture throughout the surveys. For example, Schellberg and researchers recognized precision agriculture as,

"An innovative, integrated and internationally standardized approach aiming to increase the efficiency of resource use and to reduce the uncertainty of decisions required to control variation on farms (2008)." Pierce and Nowak defined precision agriculture as,

"The application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality (1999)."

Our final definition resulted as such,

"The use of targeted technology and practices with the intent to improve agricultural profits and minimize environmental impacts."

We see right away that the definition constructed by the panel reflects the key aspects denoted in both of the commonly cited definitions surrounding precision agriculture. Some research may reflect a definition that is more focused on the technology-driven aspect of precision agriculture, but the panel noted this while maintaining the focus on the purpose behind why the emerging technology is needed- sustainable and biologically rooted, which is oftentimes lacking in consideration (Stafford 2000).

Precision agriculture practices and technologies are recognized in research as including GPS, GIS, yield monitors, crop scouting, remote scouting, variable rate application, guidance, and navigation practices and technologies (Aubert et al. 2012). When comparing the eighteen practices identified in our surveys, we find that there are a few practices that do not fall within the limitations of those listed above. These practices include soil sampling, plant cover crops, no till, grassed waterways, integrate livestock,

and enrolling in conservation programs. Oftentimes best management practices, or practices that are implemented with the specific purpose to improve land health and production, can be grouped into the same as precision agriculture (Schimmelpfennig 2018). Although these practices may continue to contribute towards a sustainable and conservation-minded goal alike precision agriculture, it is important to clearly communicate what is uniquely within the confinements to stay consistent in communication efforts and when assessing the progress of its implementation across the state.

Our results indicated that all respondents collaborated with other conservation organizations or agencies more than once a month. Aligned with the need for clear communication of precision agriculture mentioned above, the need for the conservation community to have a cohesive message across different entities will be essential for long-lasting impacts (Jacobson 1999). Specialist reach farmers and farmland owners through face-to-face meetings, word-of-mouth, and postcards. Past research extension reports have suggested that some landowners prefer newsletters, publications, and field tours for their educational delivery methods (Radhakrishna et al 2003). Considering the diversity in demographics that a conservation specialist may communicate with, a mixed mode approach to reaching new populations could be efficient and effective moving forward (Dillman 2014).

Respondents, when prompted, responded with the needs and resources that could be provided for better communication efforts on their behalf. Responses included, "More experience with equipment operation/setting/troubleshooting".

Another stated,

“Face-to-face time. Ag day events are a great way to interact with producers.”

Additionally,

“The right sales pitch - our agency is not an "ag agency" and isn't perceived as having an "ag voice," so this is a tough arena for us to get into.”

The responses showed the need for more hands on time with the practices and technology that they are encouraged to incorporate for targeted conservation. The experience directly recognizes the need for heightened confidence in each specialist individually, as previously discussed. The panelists also requested incorporating marketing techniques, such as a sales pitch into communication needs. Natural resources has long recommended the usefulness in message framing, incorporating this same strategy into specialist’s training for communication would only strengthen the message of an agency or organization as a whole (Davis 1995, Kolandai-Matchett and Armoudian 2020).

From the perspective of the panel, two questions were directed to evaluate the informational gaps and misunderstandings for conservation specialists when communicating precision agriculture to farmers and farmland owners. The most important factors they consider (from highest importance to lowest importance): cost, return on investment, knowledge, confidence, neighbors influence, term of lease, cultural norms, support, and need for consistency. The encouragements for adoption included increase in profits and return on investments, seeing it work on similar parcels of land, and conservation incentives. Discouragers for adoptions included cost, resistance to

change, and the inability to understand and use technology (Table 1). When asked why these barriers exist, respondents stated reasons such as,

"Done it this way for a long time."

Or many comments eluded similarly as,

"Resistance to change - we have always farmed this way - we are going to keep farming this way."

But ultimately the most noted reason was,

"Up-front implementation costs. Not convinced it will help the bottom line."

In response to what information they have found could be helpful to provide to landowners, every single one mentioned the economic concern. For example,

"They need to know the economic returns, ecosystem processes and how this decision impacts the ecosystem processes and function. How to trouble shoot the outcomes of practices."

Providing conservation specialists with as much knowledge and resources about conservation practice economics can leverage a discussion with landowners to get past the biggest hurdles and allow consideration to occur. Resources could include access to Conservation Reserve Program (CRP) funding, Environmental Quality Incentives Program (EQIP), or other state and federally funded opportunities (Barnes et al. 2020).

Additionally, considerations found noted by conservation specialists included issues such as multiple decision-makers, such as non-operating landowners, that contribute to overall adoption (Dell 2020). For example,

"I do not do the farming - it is done by my nephew. We do keep certain areas in grass production vs. row crop production due to steep slopes, soils, etc. but those decisions are very broad without the use of detailed technology to define what and where."

The role of neighbor influence and word-of-mouth spreads quickly throughout the rural landscape (Zeng et al 2022). Research shows that maintaining and keeping trust can ultimately be one of the biggest hurdles that a conservation specialist faces in the adoption process (Stern and Coleman 2015, Jayashankar et al 2018). Additionally, with many different conservation entities included within this project, we recognize that it is a collaborative effort. If a community has negative perceptions from one experience with a particular outside organization, evaluating who potentially could reach these groups and recruiting their help will be essential moving forward. As one responder put it,

"There is no information that will change their minds if they have a preexisting bias against government programs. Perhaps the messenger is more important than the message in some cases."

Or as another respondent stated,

"The few landowners who have a negative experience (real or perceived loss of income and/or slow and unpleasant experience working with government programs/agencies/employees) will influence others not to participate, even though most experiences will be positive." The primary objective of this project is to identify key components hindering the adoption process of targeted conservation implementation. We utilized our resources of conservation specialist input, as well as outreach opportunities

towards farmers and farmland owners to collect unique perspectives of the adoption process. For future research, a comparison of the collected input of conservation specialists in Nebraska with perspectives from agricultural professionals and farmers and farmland owners themselves would be valuable

Our results found the Delphi method was an effective choice in addressing the research questions we sought to gain insight on. The Delphi method successfully provided a collective definition and list of associated practices and techniques, as well as provided copious amounts of justification and insight into the struggles and successes these individuals are facing when working with farmers and farmland owners. Due to the prior lack of documented empirical data on a complex issue, such as the conservation specialist's perspective on precision agriculture, our project will serve as a catalyst and guideline for future research and management decisions based on the feedback collected (Rixon et al. 2007). Our first objective was to highlight the structure and major characteristics of the Delphi method in regard to our project specifically. The results found strength in the methodological approach through ease of using the e-Delphi survey, effective accumulation of qualitative input from a large group of specialists, and the ability to structure our Delphi method akin to the structural characteristics addressed in Chapter 1. Our second objective identified the conclusions gathered by researchers for the effectiveness and ability of the Delphi method to address research questions in the field of natural resources. Our project addresses an example of appropriate circumstances where the Delphi method is helpful in integrating individuals with relevant expertise together from geographically diverse regions to receive foresight to a large and relatively vague area of interest (Linstone and Turoff 2002).

The Delphi method has been recognized in literature as a flexible research technique on topics that are currently incomplete or vague (Skulmoski et al 2007). To the researcher's knowledge there is no current published research addressing the role conservation specialists specifically play in the influence of adoption of precision agriculture across Nebraska. More so, there evaluation of how they perceive their abilities to communicate these options to the farmers and farmland owners. Research addressing precision agriculture, the adoption consideration for landowners, and how to apply implement these new practices are available (Zhang et al 2002, Pierpaoli et al 2013, Cisternas et al 2020); however, the mode with which they can be received and taught can become difficult to locate. The Delphi method allowsresearch to be conducted in situations where the process and responses are never a ‘one size fits all’ concept (Rixon et al 2007). Our research recognizes from previous literature that there are many components that effect the decision-making process for adoption, such as up-front costs, the resistance to change, ans accessibility to resources (Daberkow et al 2003). Therefore, when addressing our over-arching research questions for the project, the Delphi method was able to capture all of these factors from the collective wisdom of specialists (Shariff 2015).

Timeliness of this methodology was also a concern. The original plan for the surveys included an 8-week schedule with two weeks for each survey to be open to participants and one week between each subsequent survey until the completion of the third survey. The entire project ended up taking 12 weeks and therefore a month longer than originally planned.

With the second-round's low initial response, the questions quickly arose of the original sample size of twenty participants. Sample size discrepancies in literature are a point of contingency that needs clearer confinement within this methodology. Many weigh sample size decisions by funding capabilities, analysis capacity limits, and the potential cost inefficiencies related to time, product and the iteration process that can come with a large sample size (Needham and de Loë 1990). Weidman et al. (2011) argue that literature has not specified the number of experts needed for a Delphi Study thus far. While others provide specific recommendations such as a minimum of 8-10 individuals and most studies included 8-16 individuals, with some noting panels as small as 4 individuals to more than 600 (Needham and de Loë 1990, Hallowell and Gambatese 2010, Keeney et al 2011).

The success of our qualitative approach with the Delphi method was recognizable from the first open-ended survey and the abundance of responses provided. However, notably this participation did not reflect a significant drop through the exhaustion of the rounds as expected. Survey three included a response box for any additional comments to be added, and we received many in-depth, unique perspectives provided that weren't necessarily required. Additionally, through the surveys we were able to retrieve consensus through controlled feedback on topics as well as collect additional matching questions to extract the 'whys' of our panelists (Sourani and Sohail 2015).

When evaluating the flexibility of the Delphi method, one decision discussed included the decision upon statistical analysis of our survey data, as research has reiterated that there is no preferential method (Schmidt 1997, Hasson et al 2000). Shariff noted the process can be utilized qualitative analysis computer packages or done

manually (2015). Ultimately, we wanted to provide our data as straightforward and simply as possible to eliminate any additional question of methodological biases or manipulation. Therefore, we were able to present our data with descriptive statistical analysis with our variable's mean, standard deviation, mode, and range.

One major consideration of all projects addressing the Delphi method must recognize the panel that provides the data received. One of the largest takeaways from the project was the vast knowledge this project collected over the series of 16 weeks that summarized experience and opinions of over 230 years of cumulative experience in the field of conservation amongst panelists. Sourani and Sohail (2015) noted the advantage of controlled feedback for panelists as it all but eliminates common barriers in diverse groups, such as concern of the opinion of others in the panel, domineering voices steering the conversation, or the ease of one individual to avoid providing their opinion. With a panel of eleven different state, federal, or non-governmental agencies and organizations, as well as a wide range of time spent in the professional field of conservation, the Delphi method gained feedback from all individuals.

The conclusion of this project was the recognition as a viable solution to addressing natural resource topics in an exploratory fashion. Taking time to address the decisions and unique adjustments a researcher specifically designs their approach to the Delphi method towards advocates for the strength and reliability of the Delphi method. Allowing insight into the use of the Delphi method from our project pertaining to precision agriculture application in the field of conservation will demonstrate the versatility of the methodology for other projects in the future. In regard to the research questions for our project, findings concluded that conservation specialists are, in fact,

aware of the foundational knowledge pertaining to precision agriculture. However, we found a lack the confidence or ability to implement the practices at a rate to which is needed or desired. In the future, research should be directed to prioritizing training opportunities that will familiarize conservation specialists with precision agriculture practices and technologies. Additionally, taking the feedback on barriers and problems the specialists are facing in the adoption process can help direct the discussion around precision agriculture and facilitate in directing where management decisions are made moving forward.

Conclusion

Based upon the findings from this project, I conclude that there are three major takeaways from this research. The use of the Delphi Method in future studies pertaining to the field of natural resources will be useful in addressing complex and unnavigated topics. Recognizing the importance of not only using past approaches for the Delphi Method is pertinent; however, my project highlights the need for clear and consistent reporting of future methodological approaches to build on the reliability and strength of the methodology moving forward.

Specifically, my research addressed the unique perspectives of conservation specialists and their role in implementing precision agricultural practices across the Nebraska landscape. The results indicated that conservation specialists do, in fact, have a foundational knowledge of precision agriculture through their determination of a collaborative definition and list of practices included within their working understanding of the topic. The final takeaway from the project recognized a potential area to pursue in future research. Conservation specialist commonly reported that they did not feel knowledgeable about precision agriculture. More so, their responses found that majority of participants also did not feel as though there were the resources and knowledge in Nebraska to implement the adoption of precision agricultural practices to farmers and farm landowner's current operations.

In future studies, it will be valuable for researchers to continue to seek input from these conservation specialists, to learn how to increase the communication strategies and confidence these individuals relay to farmers and farmland owners when working on their

properties in the future. A solution provided for the conservation specialists and the confidence they need in promoting precision agriculture adoption could serve as a major boost in overall adoption throughout the state of Nebraska. Although the research study area was limited to Nebraska, the similar landscape, agricultural activity, and predominantly privately-owned states that encompass the Midwest suggest that this research could be applicable and potential significant to consider throughout the entire region.

Tangible steps for Nebraska moving forward can include integrating more agricultural extension research and educational programs which targets equipping conservation specialist with the agricultural knowledge and skillsets to directly teach the farmers they work with on a daily basis. The recommendation to include more agricultural coursework into natural resources curriculum at the university level will serve as a potential bridge to the comfortability conservation specialists feel as they move into industry jobs post-graduation and begin directly working with farmers and farmland owners. My research not only highlights the need for research and educational programming to be developed in the years to come for conservation specialists, but also encourages the collaboration and overlap between the field of conservation and agriculture at an institutional level as well as professionally across the state. Utilizing the help and increasing the frequency of interactions between both parties will provide a cohesive message and unified mission to efficiently produced agricultural products while mitigating the conservation needs of the future generations.

References

Adrian, A. M., Norwood, S. H., & Mask, P. L. (2005). Producers' perceptions and attitudes toward precision agriculture technologies. Computers and Electronics in Agriculture, 48(3), 256–271. https://doi.org/10.1016/j.compag.2005.04.004

Alam, A. (2014). Soil Degradation: A Challenge to Sustainable Agriculture. International Journal of Scientific Research in Agricultural Sciences, 1, 50–55. https://doi.org/10.12983/ijsras-2014-p0050-0055

Aubert, B. A., Schroeder, A., & Grimaudo, J. (2012). IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. Decision Support Systems, 54(1), 510–520.

Balukas, J. A., Bell, K. P., & Bauer, D. M. (2019). Classifying private landowners to improve understanding of management decisions and conservation opportunities in urbanizing forested landscapes. Journal of Environmental Management, 232, 751–758.

Barnes, J. C., Sketch, M., Gramza, A. R., Sorice, M. G., Iovanna, R., & Dayer, A. A. (2020). Land use decisions after the Conservation Reserve Program: Re-enrollment, reversion, and persistence in the southern Great Plains. Conservation Science and Practice, 2(9), e254.

Batte, M. T., & Arnholt, M. W. (2003). Precision farming adoption and use in Ohio: Case studies of six leading-edge adopters. Computers and Electronics in Agriculture, 38(2), 125–139.

Berry, J. K., Detgado, J. A., Khosla, R., & Pierce, F. J. (2003). Precision conservation for environmental sustainability. Journal of Soil and Water Conservation, 58(6), 332–339.

Bishop, A., Barenberg, A., Volpe, N., & Grosse, R. (2011). Nebraska land cover development. Rainwater Basin Joint Venture Report, Grand Island, NE.

Bongiovanni, R., & Lowenberg-DeBoer, J. (2004). Precision agriculture and sustainability. Precision Agriculture, 5(4), 359–387.

Boutin, C., & Jobin, B. (1998). Intensity of agricultural practices and effects on adjacent habitats. Ecological Applications, 8(2), 544–557.

Brandes, E., Plastina, A., & Heaton, E. A. (2018). Where can switchgrass production be more profitable than corn and soybean? An integrated subfield assessment in Iowa, USA. GCB Bioenergy, 10(7), 473–488.

Brook, A., Zint, M., & De Young, R. (2003). Landowners' responses to an Endangered Species Act listing and implications for encouraging conservation. Conservation Biology, 17(6), 1638–1649.

Burger Jr, L. W., Evans, K. O., McConnell, M. D., & Burger, L. M. (2019). Private lands conservation: A vision for the future. Wildlife Society Bulletin, 43(3), 398–407.

Cisternas, I., Velásquez, I., Caro, A., & Rodríguez, A. (2020). Systematic literature review of implementations of precision agriculture. Computers and Electronics in Agriculture, 176, 105626.

Cook, S. E., Adams, M. L., & Bramley, R. G. V. (2000). What is obstructing the wider adoption of precision agriculture technology. Proceedings of the 5th International Conference on Precision Agriculture, Bloomington, Minnesota, USA, 16-19 July, 2000, 1–7.

Cortés Capano, G., Toivonen, T., Soutullo, A., & Di Minin, E. (2019). The emergence of private land conservation in scientific literature: A review. Biological Conservation, 237, 191–199. https://doi.org/10.1016/j.biocon.2019.07.010

Daberkow, S. G., & McBride, W. D. (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. Precision Agriculture, 4(2), 163–177.

Dalkey, N. C. (1969). The Delphi method: An experimental study of group opinion. RAND Corp Santa Monica Calif.

Davis, J. J. (1995). The effects of message framing on response to environmental communications. Journalism & Mass Communication Quarterly, 72(2), 285–299.

Dell, R. (2020). Non-operating landowners and conservation on rented farmland. The Nature Conservancy.

Dillman, D. A. (1991). The Design and Administration of Mail Surveys. Annual Review of Sociology, 17(1), 225–249. https://doi.org/10.1146/annurev.so.17.080191.001301

Findlater, K. M., Kandlikar, M., & Satterfield, T. (2019). Misunderstanding conservation agriculture: Challenges in promoting, monitoring and evaluating sustainable farming. Environmental Science & Policy, 100, 47–54.

Gigliotti, L. M., & Sweikert, L. A. (2019). Wildlife value orientation of landowners from five states in the upper midwest, USA. Human Dimensions of Wildlife, 24(5), 433–445.

Greiner, R., & Gregg, D. (2011). Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia. Land Use Policy, 28(1), 257–265.

Gupta, U. G., & Clarke, R. E. (1996). Theory and applications of the Delphi technique: A bibliography (1975–1994). Technological Forecasting and Social Change, 53(2), 185–211. https://doi.org/10.1016/S0040-1625(96)00094-7

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative research: Application of the Delphi method to CEM research. Journal of Construction Engineering and Management, 136(1), 99–107.

Hasson, F., Keeney, S., & McKenna, H. (2000). Research guidelines for the Delphi survey technique. Journal of Advanced Nursing, 32(4), 1008–1015.

Heiniger, R. W., Havlin, J. L., Crouse, D. A., Kvien, C., & Knowles, T. (2002). Seeing is believing: The role of field days and tours in precision agriculture education. Precision Agriculture, 3(4), 309–318.

Hellerstein, D., & Vilorio, D. (2019). Agricultural Resources and Environmental Indicators, 2019 (No. 1476-2019–1679). AgEcon Search. https://doi.org/10.22004/ag.econ.288293

Helms, C., Gardner, A., & McInnes, E. (2017). Consensus on an Australian nurse practitioner specialty framework using Delphi methodology: Results from the CLLEVER 2 study. Journal of Advanced Nursing, 73(2), 433–447.

Hess, G. R., & King, T. J. (2002). Planning open spaces for wildlife: I. Selecting focal species using a Delphi survey approach. Landscape and Urban Planning, 58(1), 25–40.

Hsu, C.-C., & Sandford, B. A. (2007). Minimizing non-response in the Delphi process: How to respond to non-response. Practical Assessment, Research, and Evaluation, 12(1), 17.

Jacobson, S. K. (1999). Communication skills for conservation professionals. ERIC.

Jacobson, S. K., Morris, J. K., Sanders, J. S., Wiley, E. N., Brooks, M., Bennetts, R. E., Percival, H. F., & Marynowski, S. (2006). Understanding barriers to implementation of an adaptive land management program. Conservation Biology, 20(5), 1516–1527.

Jayashankar, P., Nilakanta, S., Johnston, W. J., Gill, P., & Burres, R. (2018). IoT adoption in agriculture: The role of trust, perceived value and risk. Journal of Business & Industrial Marketing, 33(6), 804–821. https://doi.org/10.1108/JBIM-01-2018-0023

Kamal, S., Kocór, M., & Grodzińska-Jurczak, M. (2015). Conservation opportunity in biodiversity conservation on regulated private lands: Factors influencing landowners' attitude. Environmental Science & Policy, 54, 287–296.

Keeney, S., McKenna, H., & Hasson, F. (2011). The Delphi technique in nursing and health research. John Wiley & Sons.

Kolandai-Matchett, K., & Armoudian, M. (2020). Message framing strategies for effective marine conservation communication. Aquatic Conservation: Marine and Freshwater Ecosystems, 30(12), 2441–2463.

Kwok, S. H., & Gao, S. (2005). Attitude towards knowledge sharing behavior. Journal of Computer Information Systems, 46(2), 45–51.

Linstone, H. A., & Turoff, M. (1975). The delphi method. Addison-Wesley Reading, MA.

Lute, M. L., Gillespie, C. R., Martin, D. R., & Fontaine, J. J. (2018). Landowner and practitioner perspectives on private land conservation programs. Society & Natural Resources, 31(2), 218–231.

Lutter, S. H., Dayer, A. A., Heggenstaller, E., & Larkin, J. L. (2018). Effects of biological monitoring and results outreach on private landowner conservation management. PloS One, 13(4), e0194740.

Maddux, J. E. (1995). Self-Efficacy Theory. In J. E. Maddux (Ed.), Self-Efficacy, Adaptation, and Adjustment: Theory, Research, and Application (pp. 3–33). Springer US. https://doi.org/10.1007/978-1-4419-6868-5_1

Manfredo, M. J., Teel, T. L., & Henry, K. L. (2009). Linking society and environment: A multilevel model of shifting wildlife value orientations in the western United States. Social Science Quarterly, 90(2), 407–427.

McConnell, M. D. (2019). Bridging the gap between conservation delivery and economics with precision agriculture. Wildlife Society Bulletin, 43(3), 391–397.

Moss, B. (2008). Water pollution by agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 659–666.

Needham, R. D., & de Loë, R. C. (1990). The policy Delphi: Purpose, structure, and application. Canadian Geographer/Le Géographe Canadien, 34(2), 133–142.

Nowak, P. J. (1987). The Adoption of Agricultural Conservation Technologies: Economic and Diffusion Explanations. Rural Sociology, 52(2), 208–220.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. Australian Journal of Experimental Agriculture, 46(11), 1407–1424.

Pathak, H. S., Brown, P., & Best, T. (2019). A systematic literature review of the factors affecting the precision agriculture adoption process. Precision Agriculture, 20(6), 1292–1316.

Pfrimmer, J., Gigliotti, L., Stafford, J., Schumann, D., & Bertrand, K. (2017). Motivations for enrollment into the conservation reserve enhancement program in the James River Basin of South Dakota. Human Dimensions of Wildlife, 22(4), 382–389.

Pierce, F. J., & Nowak, P. (1999). Aspects of Precision Agriculture. In D. L. Sparks (Ed.), Advances in Agronomy (Vol. 67, pp. 1–85). Academic Press. https://doi.org/10.1016/S0065-2113(08)60513-1

Pierpaoli, E., Carli, G., Pignatti, E., & Canavari, M. (2013). Drivers of precision agriculture technologies adoption: A literature review. Procedia Technology, 8, 61–69.

Popp, J., & Griffin, T. (2000). Adoption trends of early adopters of precision farming in Arkansas. Proceedings of the 5th International Conference on Precision Agriculture, Bloomington, Minnesota, USA, 16-19 July, 2000, 1–10.

Radhakrishna, R. B., Nelson, L., Franklin, R., & Kessler, G. (2003). Information sources and extension delivery methods used by private longleaf pine landowners. Partnership, 15(6.8).

Rixon, A., Smith, T. F., McKenzie, B., Sample, R., Scott, P., & Burn, S. (2007). Perspectives on the art of facilitation: A Delphi study of natural resource management facilitators. Australasian Journal of Environmental Management, 14(3), 179–191.

Ryan, R. L., Erickson, D. L., & De Young, R. (2003). Farmers' motivations for adopting conservation practices along riparian zones in a mid-western agricultural watershed. Journal of Environmental Planning and Management, 46(1), 19–37.

Schellberg, J., Hill, M. J., Gerhards, R., Rothmund, M., & Braun, M. (2008). Precision agriculture on grassland: Applications, perspectives and constraints. European Journal of Agronomy, 29(2), 59–71. https://doi.org/10.1016/j.eja.2008.05.005

Schimmelpfennig, D. (2018). Crop production costs, profits, and ecosystem stewardship with precision agriculture. Journal of Agricultural and Applied Economics, 50(1), 81–103.

Schmidt, R. C. (1997). Managing Delphi surveys using nonparametric statistical techniques. Decision Sciences, 28(3), 763–774.

Selinske, M. J., Coetzee, J., Purnell, K., & Knight, A. T. (2015). Understanding the motivations, satisfaction, and retention of landowners in private land conservation programs. Conservation Letters, 8(4), 282–289.

Shariff, N. (2015). Utilizing the Delphi survey approach: A review. J Nurs Care, 4(3), 246.

Shruthi, K., Hiremath, G. M., & Joshi, A. T. (2017). Financial Feasibility of Precision Farming in Paddy-A Case Study. Current Agriculture Research Journal, 5(3), 318–324.

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. Journal of Information Technology Education: Research, 6(1), 1–21.

Sourani, A., & Sohail, M. (2015). The Delphi method: Review and use in construction management research. International Journal of Construction Education and Research, 11(1), 54–76.

Stafford, J. V. (2000). Implementing Precision Agriculture in the 21st Century. Journal of Agricultural Engineering Research, 76(3), 267–275. https://doi.org/10.1006/jaer.2000.0577

Stern, M. J., & Coleman, K. J. (2015). The Multidimensionality of Trust: Applications in Collaborative Natural Resource Management. Society & Natural Resources, 28(2), 117–132. https://doi.org/10.1080/08941920.2014.945062

Thangaratinam, S., & Redman, C. W. (2005). The delphi technique. The Obstetrician & Gynaecologist, 7(2), 120–125.

Toronto, C. (2017). Considerations when conducting e-Delphi research: A case study. Nurse Researcher, 25(1).

Weidman, J. E., Miller, K. R., Christofferson, J. P., & Newitt, J. S. (2011). Best practices for dealing with price volatility in commercial construction. International Journal of Construction Education and Research, 7(4), 276–293.

Wright, A. S., & Shindler, B. (2001). The role of information sources in watershed management. Fisheries, 26(11), 16–23.

Yang, C., & Chen, L.-C. (2007). Can organizational knowledge capabilities affect knowledge sharing behavior? Journal of Information Science, 33(1), 95–109.

Zeng, Y., Qiu, F., & Zhang, J. (2022). The impacts of observational learning and word-of-mouth learning on farmers' use of biogas in rural Hubei, China: Does interpersonal trust play a role? Energy, Sustainability and Society, 12(1), 1–16.

Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture—A worldwide overview. Computers and Electronics in Agriculture, 36(2), 113–132. https://doi.org/10.1016/S0168-1699(02)00096-0

APPENDICES

Appendix A. Survey Questions

Survey One

1. How would you define precision agriculture?
2. Select all of the practices listed below that you identify as associated with precision agriculture. (Select all that apply)
    a. No Till
    b. Variable Rate Nutrients
    c. Crop Rotation
    d. Integrate Livestock
    e. Plant Cover Crops
    f. Satellite Imagery
    g. Drone
    h. Auto-Steer
    i. Soil Sampling
    j. Grassed Waterways
3. List any additional practices associated with precision agriculture that were not listed above that you feel are important to note.

4. What do you believe encourages farmers' receptiveness to adopt precision agriculture?

5. What do you believe discourager's farmers' receptiveness to adopt precision agriculture?

6. From your perspective, what factors primarily influence land tenants' decisions to adopt precision agriculture practices? (Select all that apply)

    a. Knowledge

    b. Confidence

    c. Support

    d. Return on Investment

    e. Need for Consistency

    f. Cost

    g. Other: _____

7. Based on Nebraska's current knowledge of precision agriculture, do you feel farmers and farmland owners have the adequate resources to adopt these practices in their operations?

    a. Yes

    b. No

    c. Unsure

8. What percentage of Nebraska farmers would you estimate use precision agricultural practices in their operations?
    a. Less than 25%
    b. 25-50%
    c. 50-75%
    d. Greater than 75%
9. How do you incorporate precision agriculture into your conservation efforts on Nebraska operations?
10. Select all of the practices listed below that you identify as practices of conservation through precision agriculture.
    a. No Till
    b. Variable Rate Nutrients
    c. Crop Rotation
    d. Integrate Livestock
    e. Plant Cover Crops
    f. Satellite Imagery
    g. Drone
    h. Auto-Steer
    i. Soil Sampling

j. Grassed Waterways

11. List any additional conservation practices associated with precision agriculture that were not listed above that you feel are important to note?

12. List the biggest constraints that you face when implementing conservation practices on Nebraska operations?

13. Which of the following types of organizations are you currently employed with? (Select all that apply)

    a. Federal Government Agency

    b. State Agency

    c. Non-Governmental Organization (NGO)

    d. Non-Profit Organization

    e. Other:_____

14. Which of the following types of organizations have you been associated with in the past?

    a. Federal Government Agency

    b. State Agency

    c. Non-Governmental Organization (NGO)

    d. Non-Profit Organization

    e. Other:_____

15. How many total years of experience do you have in the field of conservation?

16. Do you own private land of your own?

    a. Yes

    b. No

        i. If yes,

            1. How would you characterize your land? (Select all that apply).

                a. Recreational

                b. Agricultural

                c. Urban

                d. Other:_____

            2. How many total acres do you own among all of your properties?

                a. 0-10 acres

                b. 11-25 acres

                c. 26-50 acres

                d. 51-100 acres

                e. 101-500 acres

                f. 500+ acres

3. Do you pursue conservation practices on your land?
4. Do you implement specific precision agriculture techniques on your property? If so, what?

Survey Two

1. Of the definitions provided below, please select which of the following encompasses "Precision Agriculture" most accurately to you.
    a. The use of targeted technology and practices with the intent to improve agricultural profits and minimize environmental impacts.
    b. The use of targeted technology with the intent to improve agricultural profits and minimize environmental impacts.
    c. The use of targeted practices with the intent to improve agricultural profits and minimize environmental impacts.
    d. The use of targeted technology with the intent to improve agricultural profits.
    e. The use of targeted practices with the intent to minimize environmental impacts.
    f. The use of targeted technology and practices with the intent to improve agricultural profits.

g. The use of targeted technology and practices with the intent to minimize environmental impacts.

2. How frequently do you apply each of the following Precision Agricultural practices to your conservation recommendations? (Likert Scale from 1 “Not At All to” -4 “Very Frequently”)

    a. Variable Rate Applications (Nutrient, Irrigation, Seeding)

    b. Satellite Imagery

    c. Drone

    d. Auto-Steer

    e. Soil-Sampling

    f. Equipment Selection

    g. Yield Monitoring

    h. GPS Spray Equipment

    i. Alternative Crops in Locations

    j. Plant Cover Crops

    k. No Till

    l. Grassed Waterways

    m. Crop Rotation

    n. Integrate Livestock

o. Planting and Fertilizer Application

p. Enrolling in Conservation Programs

q. Skip Row Planting

r. Soil Erosion Management

s. Artificial Intelligence

3. Of the list below, please indicate whether the following practices should be included within your definition of "Precision Agriculture"? (Selected for each: Yes, No, or Unsure)

    a. Variable Rate Applications (Nutrient, Irrigation, Seeding)

    b. Satellite Imagery

    c. Drone

    d. Auto-Steer

    e. Soil-Sampling

    f. Equipment Selection

    g. Yield Monitoring

    h. GPS Spray Equipment

    i. Alternative Crops in Locations

    j. Plant Cover Crops

    k. No Till

l. Grassed Waterways

m. Crop Rotation

n. Integrate Livestock

o. Planting and Fertilizer Application

p. Enrolling in Conservation Programs

q. Skip Row Planting

r. Soil Erosion Management

s. Artificial Intelligence

4. Of the factors listed below, please rank the top five that primarily influence land tenant's decisions towards adoption of precision agriculture on the landscape? (Rank Order)

    a. Knowledge

    b. Confidence

    c. Support

    d. Return On Investment

    e. Cost

    f. Neighbors Influence

    g. Need for Consistency

    h. Term of Lease

i. Cultural Norms

5. In reference to the question "List the biggest constraints to you face with conservation adoption?" which of these have you faced personally working with landowners?

    a. Lack of Confidence to Implement

    b. Up-Front Implementation Costs

    c. Resistance to Change (i.e. maintaining tradition)

    d. Policy

    e. Lack of Education

    f. Excessive Paperwork

    g. Risk

6. What have you found to be the best way to contact farmers/private landowners?

7. Does your agency/organization have an established mechanism to evaluate their communication methods to the public?

    a. Yes

    b. No

    c. Unsure

8. What training, knowledge, etc do you need in order to equip you to communicate more efficiently with farmers and farmland owners about incorporating precision agriculture on their landscapes?
9. From your experience, what information do private landowners need to make conservation decisions?
10. How often do you utilize the resource of other conservation agency/organization specialists in Nebraska?
    a. Daily
    b. Weekly
    c. Monthly
    d. Annually
    e. Never

Survey Three

1. How would you rate your level of expertise on incorporating precision agriculture for conservation in Nebraska?
    a. I do not consider myself an expert.
    b. I am in the process of becoming an expert.
    c. I am an expert.

d. I used to be an expert but no longer are.

2. Of the practices listed below, what is your knowledge level of each? (Likert Scale 1 “Not Knowledgeable – 5 “Extremely Knowledgeable”)

    a. Variable Rate Applications (Nutrient, Irrigation, Seeding)

    b. Satellite Imagery

    c. Drone

    d. Auto-Steer

    e. Soil-Sampling

    f. Equipment Selection

    g. Yield Monitoring

    h. GPS Spray Equipment

    i. Alternative Crops in Locations

    j. Plant Cover Crops

    k. No Till

    l. Grassed Waterways

    m. Crop Rotation

    n. Integrate Livestock

    o. Planting and Fertilizer Application

    p. Enrolling in Conservation Programs

q. Skip Row Planting

r. Soil Erosion Management

s. Artificial Intelligence

3. Do you believe your agency should have an established mechanism to evaluate their communication methods to the public?

    a. Yes

    b. No

    c. Maybe

4. Would you agree with the list below, ordered from highest to lowest importance, of primary influences of land tenant's decisions towards adoption of precision agriculture on the landscape?

Cost, Return on Investment, Knowledge, Confidence, Neighbors Influence, Term of Lease, Cultural Norms, Support, Need for Consistency

    a. Yes

    b. No

5. If you do not agree with the list above, what do you disagree with?

6. What is your biggest concern regarding promoting the adoption of new precision technologies or enrolling in a conservation/incentive program.

Please note any additional thoughts about precision agriculture and conservation in

Appendix B. Email Cover Letter for Web-Based Survey

The Nebraska Environmental Trust

University of Nebraska Lincoln

SCHOOL OF NATURAL RESOURCES

Nebraska Farmers and Farmland Owners Attitudes of Targeted Conservation

Dear participant,

You are invited to participate in a survey to provide your insight and comments on relevant targeted conservation practices and constraints pertaining to landowner adoption. Not much is known about landowner and professional constraints, and we want to know what your perspectives and experiences have been and apply your provided responses to our research. We in the School of Natural Resources at the University of Nebraska—Lincoln hopes our research will help provide new and better landowner interaction opportunities while continuing to protect our resources.

Participation in this study is completely voluntary. If you are 19 years of age or older, please take 20-30 minutes to participate in this research. To participate in the web survey through Qualtrics, please follow this link (link here). The link will be open for two weeks and close on /2021.

If you have any questions about this survey, contact Morgan Register (email mregister2@huskers.unl.edu), Andy Little (email: alittle6@unl.edu), and Christopher Chizinski (email: cchizinski2@unl.edu). If you have questions about your rights in this research, please contact the Research Compliance Services Office (email: irb@unl.edu, phone: (402) 472-6965.

We greatly appreciate you taking the time to help us with this important research.

Sincerely,

Morgan Register
School of Natural Resources
University of Nebraska-Lincoln

Appendix C. Reminder Note for Delphi Method

Dear Participant,

This message serves as a reminder that you were selected to participate in a survey that is currently open for input. The survey will be open until xx/xx/2021.

To complete survey, follow the link below:

XXXXXXXXXX

The University of Nebraska-Lincoln and the Nebraska Environmental Trust are working together to better understand the willingness of farmers and farmland owners to adoption targeted conservation practices. We are interested in gaining perspective from conservation specialist, like yourself, in Nebraska.

You are free to decline to participate. For more information about this study, please visit https://wildlifeecologylab.unl.edu/current-projects for further details. Dr. Andrew Little (Work Cell: 402-219-1913, Email: alittle6@unl.edu) and Morgan Register (Email: mregister2@huskers.unl.edu) will be available to answer any questions or concerns you may need. We look forward to speaking with you, and we are excited about the opportunity to collaborate

Sincerely,

Dr. Andrew Little & Morgan Register

University of Nebraska-Lincoln

Appendix D. Article Analysis Evaluation Form

Article

Title:

Citation:

Questionnaire Methodology

How many rounds?

Delivery Method? (e.g., basic, modified, e-delphi, etc)

Duration of the entire process: _____

Length of availability for each survey round: _____

Geographic Range for Survey? (e.g., local, state-wide, national, international, etc.)

Was a reminder sent?

Question structure? (e.g., multiple choice, Likert scale, open-ended, etc.)

Determination of Expert Panelists

How is an expert defined?

Panel size? (e.g., sample size)

Criteria for the selection of panel?

What was reported on each panelist's characteristics?

Diversity in Stakeholders?

Results Analysis

How are the questionnaires evaluated?

Level of consensus?

Response Rate-

Feedback to panelists? (Reports, meetings, none at all, etc.)