USDA-NIFA Climate Portfolio:
Climate Professional Survey Report

Prepared November 2018:
Jackie M. Getson[1], Anders E. Sjöstrand[1], Brennan G. Radulski[1], Sarah P. Church[1], Jerry L. Hatfield[2], Linda S. Prokopy[1]

[1]Natural Resources Social Science Lab
Department of Forestry and Natural Resources
Purdue University

[2]National Laboratory for Agriculture and the Environment
Agricultural Research Service
United States Department of Agriculture

Acknowledgements:

This project has been funded (award number 2016-67003-24895) by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA). The contents of this document do not necessarily reflect the views and policies of the USDA-NIFA, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. The authors would like to thank Ian Gesell for his work on this project.

Recommended Citation:

Getson, J.M., Sjostrand A.E., Radulski, B.G., Church, S.P., Hatfield, J.L, and Prokopy, L. S. (2018). *USDA-NIFA Climate Portfolio: Climate Professional Survey Report*. West Lafayette: Purdue University.

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1 Introduction

In 2016, the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) contracted Purdue University and the USDA Agriculture Research Service (ARS) to conduct an assessment on the Climate Change and Agroecosystems project portfolio (henceforth referred to as the Climate Portfolio). These projects were identified by NIFA and the project directors (PDs) were surveyed between November 2016 and January 2017 (Getson et al., 2018). During the development of the PD survey, this project team determined that an additional survey to assess the perspective of climate scientists within the portfolio on project outcomes would provide a unique perspective to the portfolio assessment. Additionally, due to the polarization of climate change issues in the political arena at the end of 2016, the project team identified a knowledge gap relating to climate scientists' perspectives regarding the climate change discussion in the public forum (Steel et al., 2004; Stoutenborough et al., 2015). It was determined that there would be added value in evaluating climate scientists' views on climate change issues and their relationship with specific agroecosystem stakeholders. To gather a broader perspective from portfolio climate scientists, we included government agency scientists in our target audience. The following report presents the descriptive results of the Climate Professional Survey (CPS) deployed in the spring of 2017.

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2 Methods

The following sections provide details about the survey development, target audience, distribution, and analysis of the CPS.

2.1 Questionnaire development

The CPS questionnaire was designed to evaluate the respondents' current views on climate science and evaluate their relationship with specific agricultural stakeholders. The following categories formed the survey (the full questionnaire is presented in Appendix A):

- Portfolio project outcomes, contributions, knowledge gaps from the perspective of the portfolio project climate scientist,
- Key areas to focus climate and agroecosystem research,
- Climate and agroecosystem science,
- Climate scientist responsibility,
- Communication training,
- Climate science framing,
- Attitudes of stakeholders towards climate change, and
- Demographics.

Purdue University and USDA ARS project staff developed the initial survey. A pilot test was conducted with the project's Advisory Group who provided feedback, which was incorporated into the final survey.

The questionnaire included five sections, commencing with the portfolio only section which evaluated completed or ongoing NIFA Climate Portfolio projects. Future tense was utilized in questions regarding ongoing projects, whereas future and past tense (indicated with a forward slash in the question, e.g., "have/will") were utilized in questions about concluded projects.

The questionnaire evaluated the respondents' perspectives relative to five stakeholder groups: agribusinesses, crop advisors, crop and/or livestock producers, general public, and policymakers. Identical five question blocks were developed per stakeholder that were modified only for the stakeholder name. Only respondents that reported they have experience working with stakeholders were allowed to respond to that stakeholder-specific block of questions. To streamline the questionnaire for respondents, if participants indicated experience with numerous stakeholders, the questionnaire asked which stakeholder was their main priority and provided that stakeholder question block, then provided the opportunity to answer the same block of questions for other stakeholders, if they had interest.

2.2 Questionnaire recipients

Participants targeted were those scientists who were identified through the PD Survey (Getson et al., 2018) as a climate scientist that worked on projects within the Climate Portfolio (n=301). Additionally, an internet search was conducted to identify personnel at relevant government agencies that manage or conduct work related to climate issues. Personnel at the following organizations were contacted to complete the survey: American Association of State Climatologists (AASC), Environmental Protection Agency (EPA) Agriculture Center, Landscape Conservation Cooperative (LCC), National Oceanic and Atmospheric Administration (NOAA) Regional Climate Centers, USDA Climate Hubs and Forest Service of Sustainability and Climate Change, and United States Geological Survey (USGS) Climate Science Centers. Since this survey focused on communication and outreach, all job roles were included from relevant office staff (i.e., coordinators, research scientists, communicators) to directors and research leaders (n=339). Therefore, the recipients of this survey are not necessarily all climate scientists, but rather individuals that work on climate related projects.

2.3 Questionnaire distribution

The survey was generated and distributed through Qualtrics an online survey software (Qualtrics, Provo, UT). The NIFA National Program Leader for Agroclimatology announced the survey on March 28, 2017 via email.

The initial invitation was sent March 30, 2017; a total of three reminders were sent to those that had not responded prior to closing on June 2, 2017. Invitations with unique survey links were distributed to participants through Qualtrics emails.

2.4 Questionnaire analysis

The questionnaire consisted of closed (single and multiple response), Likert (i.e., scaler), numeric, and open question types. General descriptive statistics (i.e., percentages, means, standard deviations [sd]) were calculated based on question types. Two types of bar plots are presented in this report:

- Multiple choice closed questions, which includes an inset table to indicate the frequency of categories selected by respondents, and
- Bipolar ranking questions; which includes the percentage of respondents and the mean Likert score.

Qualitative analysis was used for open ended questions. One researcher coded a portion of the responses to develop the initial codebook. Two other researchers used the codebook to independently code each of the previously coded open responses. The research team discussed coding discrepancies, and then resolved them accordingly. Open answer question responses are presented in frequency tables, which provides at least one example quote per code unless all responses are necessary due to the nuance of the question. Text from responses was redacted where necessary to ensure respondent confidentiality. For the stakeholder specific blocks with identical questions, the coding was developed across all blocks for identical codes.

The report references the corresponding questions by section respective to the CPS found in Appendix A (e.g., the first question is referenced as “project_Q1”). Survey data was analyzed with R Statistical Software (version 3.2.3; R Core Team 2015).

3 Results

3.1 Response rate

A total of 273 surveys were completed. Bad addresses were removed from the eligible respondent total, which included email addresses that bounced as well as respondents that indicated "No" to project_Q1. The final response rate for 627 eligible recipients was 43.5% (number of responses per eligible recipients by 100 [Vaske 2008]). Since the target audience was comprised of climate scientists identified through the PD survey via the Climate Portfolio as well as government agencies, response rates were calculated by recipient group (Table 1). Not all respondents answered questions; therefore, response rates vary by question.

Table 1. Response Rate

Recipient group	Completed (n)	Eligible (n)	Response Rate (%)
Government	113	339	33.3
Portfolio	160	288	55.6
Total	273	627	43.5

3.2 Portfolio outcomes and knowledge gaps

The majority (66.3%; total n=160; project_Q2) of projects were ongoing at the time of the survey. Out of the 24 pre-defined outcomes, the top three outcomes that were or will be achieved through the project are: 1) "agricultural science to optimize sustainable management of natural resources under a changing climate" (53.7%), 2) "agricultural production method(s)/strategy(-ies) that can adapt to climate change" (52.4%), 3) "climate change impacts assessment data and/or method(s)/strategy(-ies)" (51.0%; Figure 1). A total of 50 respondents (Table 2) supplied an additional outcome beyond the 24 outcomes provided in project_Q3. The projects' largest contribution most frequently mentioned were "quantification" (n=65) and "development" (n=35; Table 3). Remaining knowledge gaps were identified based on project findings (Table 4). The majority of additional comments (project_Q7) provided information about their project (Table 5).

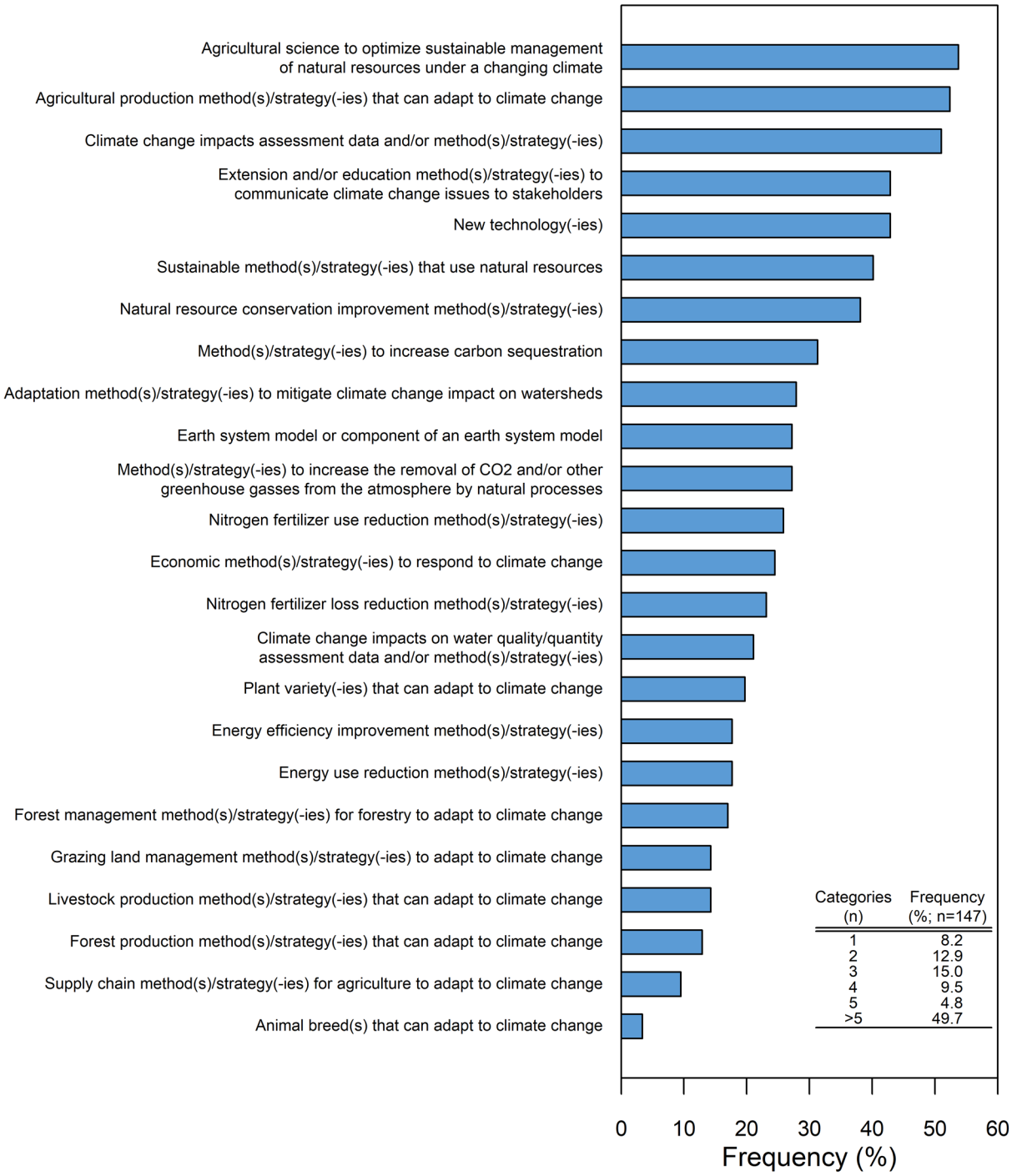

Figure 1. Project outcomes achieved
Corresponds to closed project_Q3: "Have/Will the following outcomes been/be achieved or not?" Inset table indicates the frequency of respondents to select ≥1 value.

Table 2. Additional project outcomes

Corresponds to open project_Q4: "If not listed above, what outcomes *have been/will be* developed through this project?" All responses included due to small number of responses (n=50).

Outcomes by Funding Type
Capacity
"Benchmark data which future cc data can be compared."
"Better understanding of the context of regulatory means to control air pollution. That is, how much of the air quality problems of the state of California is 'controllable' via local regulations, vs. how much is coming from other 'non-controllable' sources."
"Better understanding of the epidemiology of soybean diseases. These diseases change with the changing climate. As a result, plant diseases are moving north from where they were first found. Part of my research was to access disease resistance in soybean cultivars and help identify resistance genes that can be used to control these diseases."
"Biofuel production and acceptability."
"Crop traits for better performance under drought. "
"Disease vector estimates"
"Dissemination: Our project got the attention of FEMA federal officials and we were one of three projects that presented to a national audience on the [date and time][title] webinar, sponsored by FEMA as part of its National African American Heritage Month celebrations. We believe that program was of interest to FEMA because it targeted a hard to reach, previously unreached stakeholder group for education on climate change and disaster preparedness: the Latino migrant and seasonal farmworker population."
"Ecological Indicators from Satellite Remote Sensing Data that allow monitoring of dryland productivity and assessment of the impacts of livestock on this productivity. "
"Effect of changing climate on components of the boreal forest ecosystem. Effect of soil moisture dynamics that will occur in future climates on boreal forest growth. Effect of thinning on boreal forest growth. Effect of fertilization on boreal forest growth."
"Forest fires cause large emissions of C (carbon), N (nitrogen) and Hg (mercury) to the atmosphere and thus have important implications for global warming (e.g., via CO2 and N2O emissions), anthropogenic fertilization of natural ecosystems (e.g., via N deposition), and bioaccumulation of harmful metals in aquatic and terrestrial systems (e.g., via Hg deposition). Research indicates that fires are becoming more severe over much of North America, thus increasing element emissions during fire. However, there has been little research relating forest floor and mineral soil losses of C, N and Hg to on-the-ground indices of fire severity that enable scaling up those losses for larger-scale accounting of fire-level emissions. We investigated the relationships between forest floor and mineral soil elemental pools across a range of soil-level fire severities following the 2011[wildfire location]. We were able to statistically differentiate losses of forest floor C, N and Hg among a five-class-level fire severity classification system. We estimate that 468 000MgC, 11 000 Mg of N and over 122 g of g were emitted from the forest floor during the burning of the 28 310 ha upland area of the Pagami Creek fire. Spatially explicit modeling of recovering forest structure within two years following wildfire disturbance has not been attempted, yet such knowledge is critical for determining successional pathways. We used remote sensing and field data, along with digital climate and terrain data, to model and map early-seral aspen structure and vegetation species richness following wildfire. Effects of pre-fire aspen density and fire severity on post-fire aspen recovery, structure and vegetation richness were analyzed. Post-fire recovery attributes were not significantly related to fire severity, while all but percent cover and richness were sensitive to pre-fire aspen density. This remote mapping capability enables improvement in the prediction of future forest composition and structure, and associated carbon stocks, which is critical given extant climate change pressures."
"I have been retired for more than a year and so am unaware to what has and will be developed."
"Monitoring of basic pollutant flux into many environments."
"New ecologically-based pest management tools and strategies that small- and mid-scale producers can implement at their farms, non-insecticidal approaches to pest management, identification of resilient native plants that bring beneficial arthropods for increased pollination and biological pest control, evaluation of sheep and goats for their potential in weed management within blueberry orchards, integration of farming practices to reduce inputs. Short-term outcomes: increased awareness and knowledge about the above by producers; mid-term outcomes: adoption of ecologically-based pest management tools and strategies."

Outcomes by Funding Type
"Nitrous oxide reduction methods."
"Our work will result in an orally delivered anticoccidial poultry vaccines."
"Recommendations concerning community-based management of noxious weeds."
"Recommendations for designing more effective forecast-based decision support tools in agriculture."
"The project investigates how exposure to nature influences family health and well-being. Data may be used to inform educational resources and programs that promote spending time in nature."
"This is a blanket, synthetic project that I was forced to write up, as part of our funding comes from Hatch money, but I actually did not get any money from the project. It just describes what I do with separate funding, mostly from NSF."
"This project was based on model plants like Arabidopsis and Medicago truncatula."
"Understanding how drought and crowding contribute to tree mortality."
"Use of bioreactor technology to produce clean plant material for the industry; use of alternative micronutrient solution that reduces the amount of nitrogen needed for plant production; production of hybrids of jatropha to be used as biofuel feedstock."
Competitive
"Expanded tools to envision and adapt to medium term model forecast outcomes, e.g., compare a range of forecast outcomes for phenological models that predict pest arrival and crop harvest dates for numerous species."
"Identified plant gene regulatory pathways for making photosynthesis and water use efficiency more stable to environmental stresses of water deficiency (drought) and high temperatures. In recent years high night time temperature has become critical for yield and quality of C3 cereal crops such as rice and wheat. The genes and pathways discovered in this project are valuable genetic markers for classical breeding of these crops, in addition to transforming them with specific constructs to improve their stress tolerance."
"Integrated approach to controlling smutgrass, with the possibility of decreasing herbicide application rate."
"None. It is a training grant."
"Our work will result in an orally delivered anticoccidial poultry vaccines."
"Reduction of catastrophic forest fires by forest thinning."
"Rural Health Mate improves the health outcome of rural seniors by respectfully monitoring their health-related activities and prompts or instructs them on things they can do to stay healthy when a deviation from an established baseline is detected. Specific areas of support include medication management, fall prevention, sleep quality and elopement detection."
"Solar Heating use for agriculture."
"The project has helped to identify sheep grazing as a method to control weeds, increase nutrient cycling, sequester carbon, and reduce greenhouse gas emissions compared with tillage and herbicide application of weed control."
"The project outcome was a large conference from western states that highlighted techniques and approaches that are working or may work in the near future to assist in the management of western water resources when facing long-term drought and climate uncertainty. Most of the focus of the conference (and therefore the project) was on the identification of management strategies...."

Table 3. Largest contribution of project
Corresponds to open project_Q5: "In your opinion, what is the largest contribution of your project relative to climate change and agroecosystems?" Codes ordered by frequency (n=138).

Code	Frequency (n)	Description	Examples
Quantification	65	Quantified, identified, clarified, documented	*"Defining better approaches for the spatial placement of Payment for Ecosystem Service investments to enhance connectivity for biodiversity."* *"Sheep grazing increased nutrient cycling, enhanced soil carbon sequestration, and sustained crop yield and quality compared with tillage and herbicide application of weed control."* *"Understanding the actual mechanisms that cause trees to die in both drier and wetter years."* *"Water quality at a watershed scale and uncertainty in effects."*
Development	35	Developed technology/ method/element/tool	*"We have developed a new energy technology that generates electricity from atmospheric thermal energy. The potential energy benefit is tremendous!"* *"New multiple stress tolerant corn germplasm."* *"Development of sustainable management practices and improved quality and yield."*
Application	13	Provided to stakeholders or field, that can or has been applied	*"Recycling of nutrients on farm, thereby reducing fuel consumption and reducing nutrient losses to environment."* *"Increased resilience of small farms and natural resources on them."* *"The largest contribution of this project is to improve C storage and nutrient cycling in soils that help maintain or improve their productivity. This then significantly contributes to improved sustainability of agricultural production such as maximizing profitability while minimizing production inputs."*
Better understanding	10	Insight, increased understanding	*"Advance our understanding of plant and microbial feedbacks to climate change in agroecosystems."* *"Improved knowledge of agricultural water quality BMPs."* *"Improved understanding of how land-atmosphere interaction processes affect our understanding of how agricultural and other land management practices affect weather and climate."*
Non-agriculture and/or climate change	8	Project unrelated to portfolio	*"I don't focus at all on agroecosystems."* *"The project I am on doesn't focus entirely on climate change but climate change (weather related) can impact the study."*
Discovery	5	Implication of new finding	*"That planting types in rangelands are more robust to climate variability than we previously thought."* *"Nanoparticle can increase yield in stressed plants."*

Code	Frequency (n)	Description	Examples
Implementation	5	Initiated/started/established element	*"The Rural Health Mate system is green, via the careful selection of low power components and sub systems that are integrated into the Rural Health Mate system."* *"The inclusion of forestry economics into a biophysical study of forest and forest sector response to climate change."*
Stakeholder engagement	5	Outreach, worked with stakeholders	*"Providing guidance to growers for how they can mitigate for annual changes in weather patterns."* *"Largest intended contribution is to help the [name] Tribe understand what the projected climate means for their forest (e.g., increasing fire hazard, potential loss of culturally important species)."*
Confirmation	4	Confirmed, proved validated, illustrated, demonstrated	*"Demonstrating the use of nonlinear mixed effects models to capture a broad range of plant phenological responses to environmental variability and to highlight the underlying drivers of climate adaptation."* *"Proof of concept for converting weather and climate forecasts and outlooks into crop management and yield information."*
Ongoing	4	Too early to determine	*"Too soon to quantify (just finished year 1)."* *"Work from the project is still ongoing, although not funded."*
Advancement	3	Improved/advanced element	*"Improving economic efficient and energy recover from biofuel process through producing biochar based activated carbon."* *"My project focuses on enhancement of oyster aquaculture and restoration to improve coastal and estuarine water quality, increase commercially and economically important aquatic species because of the oyster habitat created and remove excess nutrients in water and provide sustainable and safe and healthy food source for the citizens."*
Awareness	3	Highlighted issue/element, brought to attention	*"Indirectly through promotion of local agriculture and better waste management/recycling."* *"Broadening of issues, and awareness."*
Database	3	Dataset created	*"Constructing easily accessible and usable weather data for various researchers and agencies for their analysis."* *"Development of a comprehensive database detailing the contributions of genes conferring improved local adaptation."*
None	3	Nothing	*"This project was aimed at how climate variability influences emergence patterns of weedy and invasive species. Unfortunately, early in the project, a key investigator dropped out of the project and therefore the project was never completed as intended. Another project member agreed to analyze data and compile results, but to my knowledge this has never been done."* *"We wrote a proposal that was unfunded."*
Education	2	Trained/taught/mentored students/post-docs	*"Training."* *"More than 50 PhD students specialized in plant breeding and trained to address the agricultural challenges of climate change."*

Code	Frequency (n)	Description	Examples
Collaboration	1	Good working team, interdisciplinary team, established team	*"This project was successful at connecting researchers and others with expertise in multiple disciplines critically relevant to both advancing the scientific understanding of climate and pests -and- fostering more effective bi-directional communications between researchers in various disciplines and stakeholders. So, establishing connections that had not existed prior to the forum was, from my perspective as a climate scientist, a significant contribution relevant to climate change and agroecosystems."*
Foundational	1	Baseline/foundational data/knowledge	*"This project provided baseline data on soil carbons sequestration and provided a better understanding of the potential for no-till to sequester carbon."*
Miscellaneous	1	Miscellaneous contribution	*"Decreased use of biocides."*
Not coded	7	Unclear, vague, irrelevant	*"N/A"* *"The research project occurred during a period of drought and higher than average temperatures, which led to an outbreak of bark beetle-caused tree mortality of unprecedented scale."*

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Table 4. Remaining knowledge gaps

Corresponds to open project_Q6: "Based on your project findings, what do you believe to be the remaining knowledge gaps?" All responses included due to specificity of responses (n=131).

Remaining Knowledge Gaps by Funding Type
Capacity
"Adaptation methods and rate of need for adaptation."
"Adequate modeling of carbon stores in soils under various climate change scenarios."
"Although our data suggest that in the short term carbon could be sequestered we still lack information on the long-term sequestration potential as well as the dynamics of the soil carbon."
"Animal adaptation to heat stress over long periods of time."
"Application of nanotechnology is still in early stage. Addition research is needed."
"Best methods for use of heat energy produced by aerated static pile composting with heat recovery. As a low-grade heat resource (up to 150F), the energy must be used locally for space heating, water heating, greenhouse heating, etc. The efficiency of heat recovery is directly related to the simultaneous use of the available heat resource."
"Better understanding of mechanisms of tree mortality in unmanaged (or lightly managed) ecosystems."
"Chemistry of by-product and soil C that increases soil C stability."
"Concept from stakeholders in climate prediction, since the lack of which hinders information dissemination."
"Conducting field studies in crops of agronomic importance and imposing stress treatments during the crop stage that are most vulnerable to yield losses."
"Continuation towards the development of jatropha as a major biofuel crop, which can contribute to alternative energy production at the local level through use of biodiesel in school and city buses, county machinery, farmer equipment, etc.; as well as in commercial and private aviation."
"Continued measurement of impact and identification of varieties for adaptation to climate change."
"Controls on deep soil organic matter."
"Development of large scale markets to displace fossil derived resins."
"DOM is such a dynamic variable and mixtures and it is difficult to determine its exact sources and quantify the export."
"Economic targets are constantly on the move as technologies mature and new discoveries are made. The largest knowledge gaps now exist in the engineering of processing systems to further reduce cost to encourage investment in more sustainable energy."
"Effects of climate change on biological interactions and range expansion of pests."
"Everything we originally suggested since the project was not funded and we weren't able to follow through on hardly any proposed research plans."
"Genes that contribute to the stress tolerance."
"Higher throughput remote sensing measurement algorithms for phenotypic and selection of adaptive traits for trait integration and mapping of critical genetic loci."
"How far can we go? Top herds are producing more than 30,000 lbs milk per cow per year with maximal feed efficiencies and minimal health problems. The very top cows can produce twice that. More milk with fewer cows minimizes environmental impact. But the national average is still around 20000 lbs per cow. How can we continue to increase?"
"How has grassland destabilizes active dunes in the Great Plains in the past? It has obviously happened many times in the Holocene, but the temporal and spatial pattern of recovery is unclear."
"How to get farmers to use less water with the cost of water in most locations not high enough for them to invest in technology and the resistance of farmers to change the way they manage water. If water cost more they would conserve more or do what they are doing in New Mexico switch from low value crops to high value crops."
"How to tweak the carbon budget so that the producer still has a profitable operation."
"Impact of cc and marsh restoration on fishery production and duck habitats."
"Incomplete assessment of natural plant resources for urban use."
"Influences on efficiency of diet utilization by goats of likely future changes in the diets such as lower forage quality and increased prevalence of invasive plant species as well as increasing consumption of brackish and saline water sources."
"It is not clear if this question only relates to the question just above (climate change), or includes other project findings concerning risk management. If it relates only to the question above, then the major knowledge gap is how to better extend new drought-forecasting tools and information to the ranching community. If the question also relates to broader issues beyond climate change, effective management of noxious weeds such as Medusahead still requires science-based, cost-effective control packages that remain lacking."

Remaining Knowledge Gaps by Funding Type
"Large -scale validation on commercial farms."
"Links to reproduction and/or population-level outcomes."
"Long term impacts and implications."
"Long-run impacts that account for adaptation."
"Majority of our gap is mainly policy oriented and support. Unfortunately, amount of benefits and contribution oyster (in general shellfish) aquaculture provides is so under-estimated and hardly any support system to this industry in many states. Such important agricultural operation that is ecologically and economically important is underestimated and more often ignored by the legislatures. People are given cheaper choices of the imported products over the domestic products that are raised and processed in the country safe and has high nutrient quality. In the case of oyster aquaculture, we are not only culturing this product with high nutrient and protein content, we allow oysters to remove excess nutrients and clean up our coastal waters once they used to do."
"Many, since these are big questions that we can make progress on but are a long way from fully answering."
"More detailed farm assessments of uncertainty."
"More research is needed for 1. Improving technoeconomic feasibility of drop-in biofuels 2. Analysis of agri-business and their supply chain sustainability and resilience in the face of climate variability, and decision models that incorporate these risks in business decisions."
"Novel anti-fungal therapies and better diagnostic methods."
"One major challenge is to build the direct linkages between the microbes and process rates contributing to the climate change as influenced by human activities."
"Our knowledge is now pretty good. More depth in the agronomic performance database would be helpful."
"Our knowledge of nutrient cycling processes throughout the growing season is still very limited because of the difficulty of monitoring nutrient level changes on a continuous basis. Currently we can determine nutrient changes at points in time throughout the growing season but it is difficult to measure them on a continuous basis. This ultimately results in weaknesses in prediction models because the models' predictions are speculative based on information from points in time rather than information based on continuous data."
"Poor integration of policy mechanisms among competing government agencies."
"Regardless of the outcomes of this project, I think that there are significant knowledge gaps regarding how climate change will impact the distribution and spread of weedy and invasive plant species. We also need tools to help farmers to adapt to changes in weed behavior driven by climate change."
"Relating large scale weather patterns to disease development and where diseases occur."
"Short- and long-term chemistry and bioavailability of nutrients, potentially toxic inorganic trace elements, and pharmaceuticals and personal care products (trace organics) (note some of these are emerging concerns) in residuals, reclaimed water, and amended soils in order to assess the environmental and health risk-based effects of their application at a watershed scale. Evaluate impact of changing climate on the uses and associated agronomic and environmental benefits for residuals in agricultural, urban as well as other systems (such as mine reclamation)."
"Since current work has been restricted to a local area given budget constraints, it would be important to confirm whether our findings are more broadly applicable to the region."
"Social cost of carbon, better estimates of projected changes."
"Social science work on producer adoption of improved practices and utilizing climate and outlook information in decision-making. Better understanding of specific ag-climate impact information in the next few decades (rainfall rates, humidity, ET). Better modeling in climate outlooks."
"The major gap is the need to estimate below ground biomass and productivity at local to national scales."
"The need to evaluate the impacts of climate and land use changes on multiple agroecosystem services especially those that are cultural in nature."
"The precise way that weather physiologically induces the formation of reproductive buds."
"The vertical motions (i.e., mixing) in the atmosphere around the complex topography of California are not well understood at all, especially the stagnation that occurs over the San Joaquin Valley."
"There are a large number of knowledge gaps. How will changes to seasonal precipitation quantities effect the typical successional and carbon dynamics of the North American boreal forest? Will repeated disturbances totally change the vegetation structure? What role will increases in the growing season play in the systems moisture dynamics?"

Remaining Knowledge Gaps by Funding Type
"There are many, but the most important is the development of multi-scale approaches to phenological data collection for different plant species so that model inferences can be made from sub-field to regional scales, spanning variation in soil series, climate and landscape features."
"There is great uncertainty in the nature of future spring precipitation in the Midwest. More intense precipitation may make using cover crops more important but less frequent precipitation may make the use more risky in terms of competition with the cash crop."
"There needs to be increased understanding of exactly how deciduous trees respond to winter chilling and spring heat. We have made some inroads but more thorough understanding and prediction of tree behavior is needed."
"To use the knowledge learned in our system to integrate into a biofuel system."
"Tree-specific uptake of excess nitrogen and how much denitrification is happening in bottomland forested systems."
"True impact of high moisture and or heat extremes. Impact of climate change on systems, rather than individual crops taken in isolation. No crop is produced in isolation. True carbon footprint of organic systems that rely heavily on manure addition for N and P supply. Potential of landscape design to manage risks in general, not only the impact of climate change but agricultural pollution."
"Underlying genes that control the stable production. Ability to select new cultivars on these underlying traits."
"Understanding biological process."
"Understanding the role of root traits and their interactions on crop performance under multiple stresses, GxE interactions, and the value of plasticity."
"Unknown are (1) the extent to plants depend on nitrate versus ammonium as nitrogen sources, (2) the variation in ammonium tolerance among species and among genotypes within a species, and (3) the relative amounts of nitrate that is converted into protein in roots and shoots."
"We capture flow of pollutants out of the atmosphere. If there is some pollutant/compound that we could measure for that would help with this effort, we are certainly willing to consider monitoring for this pollutant, or sharing samples for others to look for these compounds."
"We have conducted a review of the existing literature but results from the fieldwork are yet to be fully analyzed. Based on the current status of the project, we consider the following to be important knowledge gaps in the broader literature on climate change; 1) Inadequate theoretical understanding of transitions toward more resilient social-ecological systems 2) Inadequate methodological tools for understanding and assessing such transitions 3) Challenges in bridging current gaps between science and decision-making on climate-related issues."
"We have yet to determine the rates of C transfer from standing, fire-killed forest to ground-level C pools in the form of coarse woody debris. Also, it is too soon to be able to quantify potential long-term effects of elevated fire frequency on especially sensitive, lowland conifers, such as black spruce and northern white cedar."
"We lack enough large experimental manipulations to gain both applied and basic science knowledge about forest ecosystems (managed) are responding to drought, risk of fire, and warming."
"We learned the limitations in the current CERT training system to access to migrant and seasonal farmworkers require adopting the training program to the conditions on the ground and the life of farmworkers. Our biggest challenge was recruitment of farmworkers into the program because we structured the 20 hours of CERT training required into a 3 day training program, because that is what our trainer could do and had done in the past. But we need to experiment with different training models to determine what makes the training more efficient for both the farmworkers and the trainers. We need to test if using a bilingual CERT trainers to deliver the training, what factors matter in training delivery: group size, training location, training structure (experiment with 3 and 4 hour training increments over a longer period of time than just 3 days produces), etc., to determine what works best for this population."
"What crops respond to climate stressors and do nanoparticle reduced the damage."
"Where are the dry-season refuges likely to be in the future? What small areas 'bioislands' might be able to be cleared of tsetse? How can land use change enhance tsetse removal without harming rangelands?"
"Whether this extends to other species / whether this extends beyond current generation, i.e., is it a heritable trait."
Competitive
"1) Most of the climate adaptation efforts considered only cropping systems germane to the study region, as opposed to novel crops/systems. Might there be opportunities to improve agricultural productivity/sustainability of lands by incorporating geographically novel crops/systems to the region? 2) How will weeds and pests factor into crop production estimates under climate change?"

Remaining Knowledge Gaps by Funding Type
"1) Complete impact of changing patterns on plants- how bad will higher nighttime temperatures be. We see it's pretty scary, but we've only looked in 'ideal' conditions, with well-watered plants with excellent management. What will this look like for less than ideal conditions? 2) Mechanisms of how plants are affected - so changing patterns of temperature and water are bad for plants. What can we do to help plants adapt- what are the targets?"
"1. We still need to evaluate additional management practices and their impact on greenhouse gas emissions. 2. Need time to extend the information gained from research to the agricultural community."
"1. Need continued work on attachment methods to reduce system overhead by using larger nitinol rods. 2. Need to improve operating pressure of the hydraulic system. 3. Need to develop low cost methods of building hydraulic systems. 4. Need to improve biodegradable hydraulic oils. Current ones degrade in UV light. 5. Need to develop coatings to improve surface area for better heat transfer. 6. Need to improve graphene growth capabilities to optimize heat transfer in/out of the nitinol. 7. Need to improve thermal conductivity of nitinol. 8. Need to continue to optimize efficiency of nitinol."
"A knowledge gap still remains in the area of discovering a motivator to help rural seniors make healthy decisions (including diet, exercise and medication adherence) because it is best for them. Current research suggests that the motivations are pain avoidance based (such as avoidance of conflicts with friends and relatives, threats of losing privileges and needing to relocate)."
"A more comprehensive and mechanistic understanding of processing involved."
"Again, work is ongoing. See point 1 above."
"An understanding of the value of forest heterogeneity as a hedge against climate-change induced and other stressors is broadening among managers. Heterogeneity was historically produced in large part by frequent low- to moderate-severity fire. It is unclear how well such heterogeneity can be sustained in forests where the fire regime is manipulated through fire suppression. What frequency of fire is necessary?"
"Animal performance, welfare, and health are modified by the internal and external environment. Adjustments to improve the negative impacts can add cost to animal production. Some forward planning and economic analyses considering animal production systems and facilities engineering is needed."
"At present the findings can be adapted for use in cereal crops such as rice and wheat, more information has to be gathered for applications in other crops."
"Characterizing forest health risks (current and future) related to extreme events and/or disturbances."
"Cloning the genes underlying the chromosome regions affecting water and nitrogen use efficiency identified in our mapping studies."
"Deployment of technologies by growers and consultants."
"Does the technology work offshore or can it be adapted to work there?"
"Extension of methods and technology to seasonal forecasting through ensembles of global climate model output or seasonal outlooks."
"Given the disagreement among studies, it is clear that a better understanding of what drives the different responses among climate models is needed. For one, the influence of model biases needs more scrutiny. A second need is to better constrain the response of vegetation, in terms of photosynthesis and water use, to increased C02, and to what degree this may offset the impacts of more extreme meteorological droughts."
"Growers recognize the importance of reduced tillage and carbon amendments for maintaining soil water-holding capacity and productivity, but a critical gap is: how much/what type of physical disturbance can be applied to soils without causing net organic matter oxidation and biological disruption (fungal networks and cooperative nutrient exchanges)? Another gap: how to deliver needed amounts of inorganic N when crops need it from existing organic matter and manures/cover crop residues. Another way to describe this: Need to figure out how to provide the right amount of 'organically derived available N' at the right time. Sustainable intensification will require figuring out how to balance electron donor availability to soil microbes with microbial release of inorganic N to crops."
"How to handle the high flux of N associated with high flow periods of the year and during cool weather when biological processes are low."
"How to improve seasonal forecasts to make them useful for crop management decisions."
"How to move from validating/calibrating crop-growth models at plot scales to regional and global Earth System modeling."

Remaining Knowledge Gaps by Funding Type
"I could easily list a half dozen knowledge gaps. There is still so much that we don't know, that we haven't analyzed. Basic questions about the vulnerability of western U. S. forests to climate change are only beginning to be asked and answered. What are the forest management strategies that minimize climate stress? How effective might forest thinning be - or is the climate stress coming down the pipe of such great magnitude that we should be thinking about planting new species (and if so, which species where)? Can we identify refugia on the landscape where pockets of resilience can be predicted for a given species? How does climate sensitivity vary with tree size - such that we can think about managing the size distribution of trees on the landscape for maximal resistance or resilience to climate stress? How do patterns of climate sensitivity scale up from diameter growth within a single tree to whole-tree biomass to stand-level biomass? Are there different strategies with respect to maximizing a) resistance/resilience to climate stress vs. b) maximizing stand-level carbon sequestration of forests? I could go on."
"Identifying the specific genetic loci which control the integration of multiple environmental stresses experienced concurrently."
"Impact of rainfall on herbicide efficacy."
"Instead of classifying production systems in a binary manner as conventional or organic, a metric that integrates the social/environmental impacts of net GHG emissions (including soil carbon stock changes and on farm energy use), pesticide use, NH3/NOx emissions, nitrate runoff/leaching, etc. is needed."
"Knowledge gaps exist in the service of rural businesses wishing to deploy advanced technologies and training of skilled mechatronic workforces for rural industries."
"Knowledge gaps include molecular mechanisms underlying drought response."
"Many knowledge gaps! That is why we do research!"
"N/A" (n=2)
"New methods for control of nitrification when fertilizers are applied pre-plant."
"Nothing to submit."
"Pest always adjust to changes and further research is need to address how to manage pests when they adjust to new environment."
"Physics based modeling and data science incorporating NAIP data at high resolution and including biophysical and biogeochemical processes."
"Refining the formulation, precise application timing and environmental impact."
"Relate to animal welfare science, not climate change."
"Scale up and energy balance for activation."
"Since the study was conducted for only five years, there are still lots of uncertainty about the effect of sheep grazing on soil carbon sequestration and net greenhouse gas emissions. Processes, such as carbon sequestration, take long time to obtain reliable results. Therefore, long-term studies, preferably for more than five years, are needed to effectively evaluate the effect of sheep grazing on soil carbon sequestration, net greenhouse gas emissions, crop yields, and weed control."
"Stacking agricultural water quality BMPs. Which BMP or BMPs to apply and performance knowledge."
"State regulatory environment to allow alternative practices on farm."

Remaining Knowledge Gaps by Funding Type
"Stratospheric ozone is one of the main absorbers of the ultraviolet (UV) portion of the solar spectrum. The depletion of stratospheric ozone, initially discovered in 1985 over the Antarctic, led to a series of global efforts to reduce the impact of harmful ozone depleting substances. In recent years, the discovery of intermittent losses of columnar ozone above the Artic support the concern over potential harmful effects of increasing levels of UV-B on agriculture, ecosystems, and humans. Moreover, the complicated interactions between changing climate and UV-B levels on Earth's surface may result in enhanced detrimental effects, especially on agricultural production. To date, uncertainties within ground solar UV measurements dominate in the observed trends of solar UV levels, thus longer time series of records are needed. Furthermore, complex interactions between clouds, aerosols and solar radiation are not yet fully understood, and changes in land use may affect the surface albedo and thus the overall UV levels. Although global monitoring is now available through satellite measurements, their low temporal availability and high uncertainties in UV are still imposed limitations. Furthermore, satellite retrieval algorithms need to be validated and/or further improved using ground-based measurements. On the other hand, higher spatial coverage is difficult to achieve using ground monitoring stations due to costs and required technical support. Thus satellite- and ground-based data are of equal importance for global monitoring. [Climate-Crop Modeling] 1. To model crops within different regions, appropriate cultures or management practices for crop production are not known enough in the scale of nation-wide. 2. Surface albedo is a crucial parameter in crop modeling, but current land surface albedo models are over-simplified and/or contain substantial biases from observations, and consequently cause serious uncertainties in modeling climate-crop interactions. 3. The respective components of the crop growth models in predicting the soil thermal and hydrological processes are much less comprehensive, where the formulations are generally empirical and especially lack full interactions with atmospheric dynamics, and thus limit the model performance. 4. Irrigation water demands remain large uncertainties under future climate change as warmer air temperature and precipitation pattern shifts are projected."
"The BFB densification technology will be proven for economical transport of forest slash for energy production. The remaining knowledge gap is to reduce the dense logs into required size and feed into different kinds of reactors used for bio-fuel and bio-power production. [Name] is developing an innovative method for size reduction and feeding of BFB logs into different kind of reactors used for bio-fuel and power production."
"The Congress fails to understand that funding substantially more forest thinning projects will drastically reduce money needed to fight fire. Only 10 or 20% of the expenses in fighting forest fires will do the job."
"The point at which the total market and non-market benefits of prairie strips overcome the cost of their implementation on different soil types."
"The project is still in progress, so it is unclear what the knowledge gaps will be upon completion."
"The project was unfunded."
"The project will uncover potential involvement of genetic networks on drought tolerance, however, it will test experimentally whether specific networks are responsible for increased drought tolerance. This needs to be tested in future research."
"The remaining knowledge gaps center on the lack of understanding of how climate change actually impacts the day-to-day decision making in agricultural production. In an agroecosystem, climate change can be subtle and sometimes contradictory. For instance, climate change in some areas may reveal itself with a higher volatility in temperature or precipitation extremes. Without some historical context, volatility may be interpreted as an atmosphere becoming more unpredictable and therefore not warranting any remediation. However, volatility if understood may be a key piece of knowledge for changing production practices."
*"The remaining knowledge gaps included: what properties of biochars impact N availability; *can biochars be designed with characteristics that balance plant N availability without losses via denitrification."*
"The solar curtain system demonstrated in [project name] needs to be tested on a large scale at a commercial poultry house with a commercial ready system. The solar performance needs to be tested at the USDA Beltsville test site using different curtain orientations (southeast, southwest, etc.) to match the varied sun angles found on commercial poultry houses. In addition, the testing of the east facing curtain needs to be accompanied with a more precise solar monitoring station than those available from the USDA stations at the Beltsville test site."
"There is increased recognition in scientific literature that land management (wood harvest, irrigation, fertilization, tilling, species selection, crop rotation, shifting cultivation) is an important forcing of the earth system, in addition to land cover change (e.g., deforestation). To date, the emphasis of most research has been on the impact of land cover change. It remains highly uncertain what aspects of land management are critical for weather, climate, and the carbon cycle."
"This project is still ongoing."
"Too soon to quantify (just finished year 1)."
"Training."
"We are in proof-of-concept phases, so there are many gaps in terms of bringing these technologies to market."

Remaining Knowledge Gaps by Funding Type
"We have considered only surface air temperature as the climatic condition, but other climatic factors, especially water vapor in the atmosphere, should be integrated to quantify the climate impacts on agroecosystems."
"We have not yet addressed ag-tech options (new crops, new species), and these may be more realistic (yes, more realistic) than some of the conjunctive use options being considered so far."
"We need to start to scale up studies at individual sites to larger regions."
"We still have a gap between short term (1-10 days) and extended-term (1 month to 7 months) forecast intervals. This is essentially a transition from weather forecasts into climate forecasts. The gap involves both our technical (data) needs, and the need to explain the differences to stakeholders."
"We still have some work to do connecting different parts of the production system. We connected feed to manure storage, feed to land application, and processing to land application, but not all three (feed, manure storage/processing, land application). This is an important data set for model evolution. Additionally, we would need to measure other fluxes of N, other than N2O, such as nitrate to make sure the full effects of the system are analyzed. This would be an excellent test of the robustness of models and LCA."
"We still need a better understanding of the impact of the different components of digestor effluent on the process of nitrification and the subsequent effect on greenhouse gas formation. We need more information on the resilience of the soil nitrifier microbial communities to adapt to the high N loads of the digestor effluent and its impact on greenhouse gas production."
"We still need to determine if the miRNA from milk are absorbed and are active in the body of whom consume the milk (i.e., horizontal transfer)."

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Table 5. Project only additional comments

Corresponds to open project_Q7: "Please use the space below for any additional comments regarding this project." Codes ordered by frequency (n=35).

Code	Frequency (n)	Description	Examples
Project factoid	26	Detail regarding project	*"I believe that our extension work is very important for helping forest and range owners to adapt to climate change."* *"In 2017, JSWC will publish a special issue/section as an outcome of a symposium/conference that was partially funded by this project."* *"In addition to superior alleles of drought genes, this project will identify small molecular signals that may be directly applied to crops if commercially feasible."* *"In addition to university-based investigators, the team includes investigators at the National Center for Atmospheric Research who are an integral part of the project. The project is funded jointly by the National Science Foundation and by the US Department of Agriculture. Research jointly develops integrated agricultural and urban models necessary to examine hydroclimatic impacts and economic and social benefits/tradeoffs associated with agricultural and urban land use/cover changes accompanying localization of food production within cities."* *"In my opinion, this work has the potential to impact several aspects of regional climate prediction and air pollution regulation efficiency."* *"It will revolutionize the U.S. [mussel] industry."* *"Lots of scientists from various disciplines have been involved in this project. As a result, it is difficult to coordinate the research as everybody has their own interest. It is difficult to collect the data as one scientist has proposed, which is not favored by other scientists. Probably, a fewer scientists with similar disciplines, might work out better for designing the experiment, collecting data, and presenting and publishing them in the meetings and journals."* *"One of the ways this project succeeded was in getting the information to land managers and the public through field tours and the media. Three major events that shaped are still shaping the ecology of forests in the Sierra Nevada and put a focus on our research here were: wildfire, drought, and unprecedented tree mortality. The Rim Fire, at 257,000 acres, was one of the largest fires in the modern history of the Sierra Nevada, and burned to within 5 miles of the study area through forests similar to those in our study. The media and the public became increasingly interested in how past management has shaped our forests and treatments that would improve resilience to future wildfires. This created a great deal of interest in our USDA-NIFA funded research. Our project also coincided with a severe drought, lasting from 2012 through 2016, which generated interest in water issues and how forests influence the water supply. One of the areas of emphasis in our USDA-NIFA funded work was to understand how canopy structural heterogeneity influences snow accumulation and melt out, putting us in the right place at the right time. However, the drought (and particularly the unusually warm temperatures accompanying the drought) also hampered the data collection for some of the variables we were most interested in. An average to above average snow pack did not accumulate in any of the study years. The final winter of the project (2017) was wetter than normal and we continued snow surveys past the grant end date with other sources of funding, using the infrastructure installed as part of the grant. During the latter two years of the drought (and the study), a major bark beetle outbreak resulted in the death of over 102 million trees in the Sierra Nevada. This presented a new opportunity not envisioned when we wrote the grant proposal - to evaluate how treatments influenced stand resilience to drought and bark beetle attack."*

Code	Frequency (n)	Description	Examples
			"Our NIFA project will terminate in 2017. We accomplished much collaborative research using CHARnet as our umbrella program." *"Propane and fuel oil heating costs are the largest variable costs for most poultry growers. A significant portion of the money spent on the propane or fuel oil goes out of the local farm economy to outside suppliers. By using the solar energy that is available to be captured from a solar curtain system on the side of the poultry house, propane/fuel oil use and grower expenses are reduced and the money stays within the local farm economy."* *"The application of the genes identified, HYR and downstream regulated pathways, can presently be applied using transgenes, which are not acceptable in these crops that are directly consumed as food; and being self-pollinated are not as easy to protect (and be commercially profitable) as self-pollinated varieties in contrast to as hybrids which have better returns to investment for breeding companies."* *"The iPiPE has been deliberately designed to be global. Accordingly, it is able to collect, store, and process crop, pest, and weather data from anywhere in the world. Since climate change will likely manifest itself first on a continental or global scale, the iPiPE is ideally suited to respond to those scales with the appropriate products."* *"The project essentially failed as no funding was ever garnered to do anything substantial."* *"The project is highly successful in defining critical adaptive traits while also serving as a vehicle of support and inquiry to graduate 24 PhD and MS students from my program who are now professors and key personnel in major agribusiness."* *"The project provided an invaluable coordination among the activities of all wheat and barley public breeding programs, trained the next generation of plant breeders and developed the genomics and genetics tools to accelerate the breeding cycles in wheat and barley breeding."* *"The replacement of Phenol/Formaldehyde resins with lignin and furfural resins is a significant improvement in worker and user safety and health profiles."* *"This conference has resulted in increased collaboration of the Western Region Multistate Coordinating Committee on Water Resources (WERA 1020) and the Western Committee on Management and Policy Challenges in a Water-Scarce World (W3190). Third, the conference resulted in concrete recommendations including: 1) identification of tools and approaches that are 'working'; 2) ideas on how to expand application of these tools and approaches to other basins or user groups; and 3) identification of gaps in knowledge and research needs."* *"This project dealt with several aspects of risk management. These included: (1) drought management (both in general and in terms of the adoption of drought management innovations by ranchers); (2) noxious weed management (focus on Medusahead); (3) rancher attitudes about climate change; and (4) risks of intensified beef production on private land."* *"This project has resulted in novel, non-insecticidal and grower-friendly IPM methods for organic management of important insect pests such as cucumber beetles (in cucurbit crops) and Japanese beetles (in fruit orchards) in Missouri, and new science-based information on integrated management of livestock, fruit orchard, composting, native plants, and biomass."* *"This project is a seed grant with the intent to build expertise and technical knowledge for further research in this area."*

Code	Frequency (n)	Description	Examples
			"This project is winding up its two year Phase II SBIR grant with section 8.6 of the USDA. This section is focused on exploring how researchers could improve the lives of individuals in rural America. Commercialization plans have been completed and are now being implemented. Relationships with strategic partners are being forged for a nation-wide deployment of the business-to-business model. The target B2B customers are private duty nursing/personal service agencies; rural rehab agencies and rural short-term and long term facilities." *"This was a planning project and it was unfunded."* *"We are addressing the need to develop an intervention to improve our education/extension methods to educate migrant and seasonal farmworkers residing in upstream locations where there are limited bilingual resources, as compared to the level of bilingual resources in sending communities. Our demonstration project shows that the MSFW population can be successfully targeted for disaster preparedness training, even in upstream locations. If an intervention to train farmworkers in disaster preparedness is proposed, the key is having a bilingual CERT trainer that is flexible to accommodate the training to the reality of the farmworkers on the ground. Additional experiments are necessary to figure out what training would work best. Whether Extension, County Emergency Managers, or a nonprofit organization is in a best position to deliver the actual training may also depend on the conditions in the receiving community."* *"We spend a lot of time on measurement and mitigation. The adaptation came through smaller side-projects and modeling work."* *"While my project was not specifically focused on climate change, it has improved our understanding of the role of weather in disease development which can be used to anticipate the effects of climate change."* *"While the current study does not explicitly focus specifically on climate change resilience, we hope to be able to move in that direction to address some of the knowledge gaps in subsequent phases of the study."*
Suggestion	4	Suggestion about program to NIFA	*"The future climate data from climate models have been improving temporally and spatially, so the higher resolution datasets from the different models should be applied to estimate the uncertainty using the ensemble climate data."* "*There is also a need for social science research to learn how to incentivize farmers to implement best management practices and to educate consumers that it is the net environmental impact of different cropping systems that matters most."* *"Unfortunately, seafood consumption is far less in the country than it should be. Considering ongoing issues with the wild fisheries population decline and habitat lost, shellfish aquaculture should have been promoted far more advanced than it is now. This type of operation not only provides food sources but also creates other food sources and enhances fisheries stocks along with their environmental benefits (i.e., improving water quality)."* *"Users have found the data sets quite useful. However, the set of users would be broadened substantially if the R data sets could be web accessible."*
None	3	Nothing	*"No additional comments."*
PD factoid	1	Detail regarding PD	*"I was a [name] project member for many years, but because I was located at a university that did not redistribute the Hatch funds from these projects, I was doing the research without any funds. This was unsustainable for me, and I discontinued my participation in the group."*
Funding	1	Monetary support	*"Federal support for assessment and development of horticulturally valuable natural plant resources is almost entirely lacking."*

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3.3 Climate change and agroecosystem

All respondents were asked their level of agreement (Likert scale from 1-5; 1="strongly disagree," 5="strongly agree;" climate_change_Q1) with statements to assess their views on climate change. The statements of greatest agreement (Likert mean 4.7) were "Climate change is happening" and "Human activities are contributing to climate change." The statement with greatest disagreement (Likert mean 1.4) was "Earth's climate conditions occur at random with no cycles or trends" (Figure 2).

Codes and subcodes were developed for the key areas to focus climate and agroecosystem research in the next decade (climate_change_Q2). Codes provide the larger system or topic that the response addresses (Table 6). Subcodes (Table 7) articulate any further specificity provided about how or what issue to study within the broader code. Codes and subcodes are unique relative to each other. The most common codes were crop systems (n=112) and models (n=95). Methods (n=104) and management (n=37) were the most frequently identified subcodes. Combining the code and subcodes, the top key area to focus climate change and agroecosystem research in the next five years was "models" with no subcode specified (Table 8).

Spatial scales (climate_change_Q3) were coded on a 5-point scale to indicate size where:

- 1 corresponds to field, hectares, individuals, laboratory, plant, plot, and site;
- 2 corresponds to city, county, ecosystem, farm, HUC12, irrigation district, landscape, local, and watershed;
- 3 corresponds to aquifer, biome, ecoregion, mesoscale, region, and state-level;
- 4 corresponds to continent, international, nation, and transnational; and
- 5 corresponds to global.

If a hierarchal approach was called for, these scales were indicated with a hyphen. Examples of the spatial scale coding is provided in Table 9. Respondents indicated that a 3 (i.e., "aquifer/biome/ecoregion/mesoscale/ region/state-level") approach would be the most appropriate scale (n=252); additionally, respondents indicated a range of hierarchical scales would be ideal (n=224; Table 9).

A wide range of responses were identified for the length of funding cycles but half (50.0%; climate_change_Q4) of all respondents indicated that funding cycles should be 5 years long. On average, 9.6 years was the suggested length of funding cycles to research climate change (Table 10).

Respondents were asked their level of agreement (Likert scale from 1-5; 1="strongly disagree," 5="strongly agree;" climate_change_Q5) with a series of questions pertaining to climate change and agroecosystem science. The highest level of agreement (Likert mean 4.5) was "policymakers need comprehensible scientific input to inform their decision making." The greatest disagreement (Likert mean 1.8) was "climate model projections should not be used to inform mitigation and/or adaptation strategies" (Figure 3).

Respondents were asked their level of agreement (Likert scale from 1-5; 1="strongly disagree," 5="strongly agree;" climate_change_Q6) to a series of questions pertaining to scientists' obligations towards climate change and agroecosystem science. There was general agreement (Likert mean 3.2-4.5) for all statements. The greatest agreement (Likert mean 4.5) were for statements "scientists have a responsibility to society to provide scientific input to policymakers" and "scientists have a responsibility to society to provide scientific input to the public" (Figure 4).

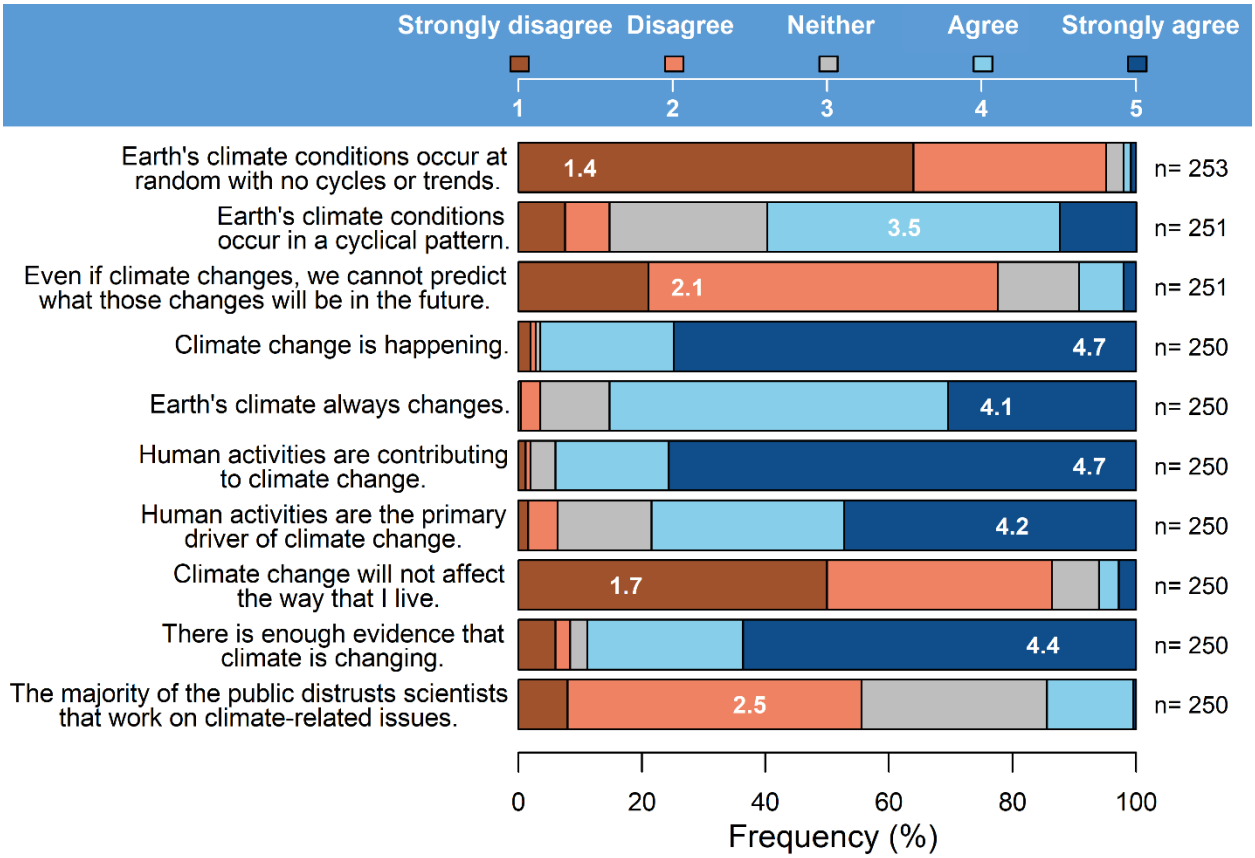

Figure 2. Climate professionals' views on climate change
Corresponds to Likert climate_change_Q1: "Please indicate your level of agreement with the following statements."

Table 6. Key areas to focus climate and agroecosystem research code descriptions
Corresponds to open climate_change_Q2 (n=218): "In your opinion, what are up to 5 key areas to focus climate and agroecosystem research in the next decade?"

Code	Frequency (n)	Description
Crop systems	112	Plant systems grown for agricultural purposes
Models	95	Models, projections, predictions, forecasts or any other means of predicting future conditions
Hydrologic systems	79	Water processes excluding precipitation
Adaptation	65	Broad/general adaptation, lacking specificity for other more nuanced code
Extreme weather	62	Any deviation from expected weather, including events such as droughts, heavy precipitation, floods, etc.
Soil systems	54	Soil functions and processes, including nutrient loading, erosion, fertilization, cover crops, etc.
Impacts	41	Broad/general evaluations of climate change impacts/responses
Ecosystems	40	Non-agricultural landscapes and/or wildlife
Mitigation	37	Broad/general mitigation, lacking specificity for other more nuanced code
Livestock systems	36	Commercial production of animals for consumptive use including grazing and rangeland
Resilience	36	Ability of an ecosystem to recover from outside shocks or stressors
Production systems	33	Any form of production not specified as crops, forest, fisheries, or livestock
Energy	26	Production and/or usage of different energy sources
Human dimensions	25	Motivations for decision-making, behavior, and management
Emissions	24	Anthropogenic atmospheric pollutants
Atmospheric systems	23	Climate variables including temperature, precipitation, circulation
Carbon sequestration	22	Storage or removal of carbon dioxide from the atmosphere
Pests	20	Pests affecting any system
Sustainability	20	Using resources today without compromising their future availability for environmental and social ends
Forest systems	19	Natural processes and productive uses of trees
Policy	18	Institutional action
Diseases	14	Diseases affecting any system
Education	14	Public education
Project/funding suggestion	14	Proposition to allocate funding, resources, or attention to a specified project
Communication	11	Identifying and improving ways of relaying information between different stakeholders
Invasive/unwanted species	11	Non-native or undesirable plants
Ocean dynamics	11	Ocean processes including circulation, sea-level rise, and/or coastal areas
Decision support	10	Methods of improving decision making/support
Land use change	10	Anthropogenic induced alterations in land use/cover
Resource use efficiency	8	Ability of a plant to use resources efficiently
Outreach	7	Direct assistance to stakeholders
Coupled systems	5	Human and natural system connection
Carbon cycle	3	Carbon cycle system as a whole
Pollinators	3	Pollinating species
Fisheries	2	Commercial production of fish
Miscellaneous	4	Miscellaneous topic that did not have at least three instances
Not coded	8	Vague, unclear, or irrelevant

Table 7. Key areas to focus climate and agroecosystem research subcode descriptions
Corresponds to open climate_change_Q2 (n=218): "In your opinion, what are up to 5 key areas to focus climate and agroecosystem research in the next decade?"

Subcode	Frequency (n)	Description
Methods	104	Techniques or approaches, particularly in research
Management	37	Process of coordinating, directing, or planning in a direct manner
Feedbacks	35	Linkages, interactions
Plant breeding	26	Process of breeding plants to select for optimal traits
Strategies	24	Calling for a specific action, using demand language
Economics	22	Factors involving finances or the exchange of finances, such as markets, trading, or off-sets
Monitoring	22	Monitoring including measuring or quantifying
Technology	21	Technology development and/or advancement, including infrastructure
Conservation	19	Preservation or protection of existing natural resources, e.g., water, ecosystems, wildlife
Genetics	19	Improving plants through their genetics
Alternatives	17	Possible choices outside of the existing paradigm, e.g., energy sources, materials, resources
Food security	16	Ability of individuals or groups to have sufficient access to food and/or water
Vulnerable populations	12	Humans or other species particularly affected by climate change
Variability	11	Lack of consistency in weather
Ecosystem services	9	Quantification of the services that ecosystems provide
Public health	8	Aggregate health of a population, including welfare
Diversity	7	Array or variety of something, such as biodiversity or crops
Tool development	7	Designing tools to help with stakeholder goals
Phenology	6	Impacts of shifting phenology
Risk	6	Likelihood of an unwanted event to happen
Fire	5	Causes or impacts of fire
Interdisciplinary	5	Involving multiple disciplines or areas of knowledge
Acceptance	3	Willingness of individuals or broader groups to accept climate change or the repercussions of it
Global security	3	Global political, economic, and social stability of the world
Urban	2	Relates to areas of high population density, such as cities, and also the process of urbanization
Restoration	1	Process of returning an ecosystem or natural resource back to its original state
Miscellaneous	2	Miscellaneous detail that did not have at least two other mentions

Table 8. Key areas to focus climate change and agroecosystem most frequent code and subcodes combinations
Corresponds to open climate_change_Q2 (n=218): "In your opinion, what are up to 5 key areas to focus climate and agroecosystem research in the next decade?" Table is ordered by code and subcode combination frequency for combinations that have ≥ 10 occurrences (n=229).

Code	Subcode	Frequency (n)	Examples
Models	NA	68	*"Near-term predictions/projections of weather/climate - 2 to 10 years out."* *"Enhance climate prediction at the seasonal and decadal levels."* *"Spatial modeling of temperature change as it relates to threshold temperature impact on physiological properties and yields for key crops."* *"Improving monthly forecasts of climate."*
Crop systems	NA	39	*"Climate change impacts on cropland."* *"Changing climate space for crops and agro techniques."* *"Migration of crops and associated supply chains in response to ensuing and projected climate change."*
Hydrologic systems	NA	37	*"Water quality and quantity."* *"Water availability."* *"Water."*
Extreme weather	NA	36	*"Dealing with climate extremes like droughts and floods."* *"Enhanced occurrence of severe storms in the lower 48."* *"The impact of heavy rain events on flooding, water quality, nutrient loss, etc."*
Soil systems	NA	27	*"Soil Health."* *"Increasing soil water storage."* *"Reducing erosion."*
Adaptation	NA	26	*"Changing climate suitability for different crops."* *"Climate will change even if we are able to mitigate these changes by reducing emissions, so we need to develop new research approaches to adapt to these irreversible changes."* *"Adaptation to fairly rapidly changing climate change, especially large variability and serious disruptions to global ecosystems and economy/business, by investing in resilient systems."*
Impacts	NA	19	*"Impacts of changes in the growing season - temperature and precipitation."* *"How agroecosystems respond to a trend of increased temperature."* *"Individual organism and species response to conditions wrought by changes in climate."*
Livestock systems	NA	19	*"Improving and evaluating livestock systems - both grazing as well as CAFOs."* *"Heat stress in livestock."* *"Livestock production systems."*
Ecosystems	NA	16	*"Vegetation change in managed and unmanaged ecosystems."* *"Ecological Indicators of Climate Change."* *"Increased understanding of the climate related impacts on the ecosystems of the earth."*

Code	Subcode	Frequency (n)	Examples
Crop systems	Methods	15	*"Ways to increase yield."* *"Cultural/political change to accept facts of climate change and create will to adapt/counteract."* *"How to manage cover crops in the off season."*
Soil systems	Methods	15	*"Cover crops."* *"Soil Health- how to improve practices."* *"How to use biochar to increase the water holding capacity of soils."*
Emissions	NA	14	*"Reducing greenhouse gas emissions."* *"Greenhouse gas emissions."* *"Effect of increased CO2 on agriculture and nutrition."*
Pests	NA	14	*"Pest impacts...multiplication of life cycles within same year as a result of warmer temperatures."* *"Evaluating how changing climate affects pest persistence, expansion, and outbreaks."* *"Understand the changes in pest complexes that come with a changing environment."*
Production systems	NA	14	*"Impacts of climate change on agricultural industries."* *"Adapting existing production to changing climate conditions of warmer temperatures, less precipitation, more extreme hot/cold events (frosts, heat spikes)."* *"Climate change adaptation for agroecosystems that are most crucial for food production."*
Human dimensions	NA	13	*"Factors that influence beliefs about climate change."* *"Human Behaviors and climate change."* *"Factors that may influence change in knowledge, attitudes, and behaviors regarding science."*
Mitigation	NA	13	*"Explore climate mitigation options."* *"We should focus on agricultural products with no to minimal impacts on environment."* *"Certainly mitigation should be a priority. We should stop growing corn for fuel, as it does not help climate much. The land can be better used for other crops. "*
Resilience	NA	13	*"Resilience."* *"Drought stress."* *"Heat stress."*
Crop systems	Plant breeding	12	*"Development of new cultivars"* *"Focus on breeding crops adapted to climate change."* *"Crop breeding for increased heat tolerance and less moisture."*
Education	NA	12	*"Making the public aware that one consequence of climate change is the increase in 'extremes,' or great uncertainty."* *"Making the public aware that greater uncertainty costs money to deal with."* *"We need more young people trained in modern breeding techniques"*

Code	Subcode	Frequency (n)	Examples
Carbon sequestration	NA	11	*"C Sequestration."* *"Carbon sequestration."* *"Carbon sequestration."*
Energy	Alternatives	10	*"Develop new, clean, and non-fossil energy supplies."* *"Alternative heating. Within our buildings and commercial/agricultural processes, heating is the largest need for on-site energy."* *"Economical gas and liquid fuel production from agricultural resources."*
Hydrologic systems	Methods	10	*"Impact of increased precipitation intensity and amount on nutrient and ag chemical transport and subsequent effect on water quality. Research on practical strategies to reduce these impacts is very important in east and Midwest."* *"How long can aquifers buffer the impact of drought in different part of the irrigated agriculture sectors? If one plants almond trees or pecan trees how long can one deplete aquifer before the rainfall returns to fill it up again and start the wet dry cycle again?"* *"Understanding how changes in water availability (e.g., snowpack, changes in timing amount of streamflow, etc.) will affect availability of water for agriculture."*
Resilience	Plant breeding	10	*"We need to be ready to breed for increased crop tolerance to increased crop losses due to abiotic and biotic stress."* *"Develop more plant species better adapted to increased drought, salt tolerance, and heavy metal tolerance."* *"Development of hybrids that are tolerant of weather extremes."*

Table 9. Ideal spatial scale to perform climate and agroecosystem research
Corresponds to open climate_change_Q3 (n=210): "In your opinion, what is the ideal spatial scale to research the key areas you described above?"

Code[a]	Frequency (n)	Examples
1	109	*"What is the impact on individuals and families (why should the public care)?"* *"Ideally, the research would be done across the country at sites specific to pre-defined regions of relevance."* *"1-km scale."* *"Field-scale."* *"50 m."*
2	191	*"Farm and ranch scales so the results are directly applicable to managers."* *"County – level."* *"Watershed basins/subbasins depending on topic."* *"Local: hundreds of km^2."* *"Climate change is a multi-level phenomenon. Policies integrating mitigation and adaptation will need to be coordinated across multiple scales from the local to the global. Given the neglect of the local level in past mitigation and adaptation strategies, an increased emphasis on the local level is essential for ensuring equitable and sustainable adaptation policies."*
3	252	*"Regional (example: New England)."* *"Regional -- e.g., US Corn Belt, acknowledging that it's exact location might drift over time."* *"Ecosystem or biome scale."* *"Depends on the question - but I would suggest regional scales."* *"It depends on the issue (invasives, drought, hydrology). In general, a regional or ecoregion scale is most appropriate."*
4	55	*"National."* *"Probably the scale of climate zones, for example the temperate zone, moist subtropical, dry subtropical, arctic, etc."* *"These are projects that are better tackled at the National level with strong encouragement of international collaborations."* *"International."*
5	25	*"Spatial scale=earth?"* *"Global."* *"Global."*
1-1	7	*"From laboratory to small field plot scale."* *"Plot to field scale."*
1-2	51	*"Laboratory scale experiments are good, but experiments up to 100 acres are beneficial."* *"Mesoscale 10-100 km."* *"All scales from individuals to landscape."* *"Micro-scale to landscape-scale. All levels are important."*
1-3	36	*"A melding of plot-based (and greenhouse based) small scale studies on mechanisms to larger scale studies that uncover patterns to general regional models."* *"Hectares to regions (plot level combined with modeling and remote sensing)."* *"Need to conduct research at multiple scales, from field soils to watersheds to climatic regions."*
1-4	12	*"All scales, from soil structural unit to continental."* *"…needed from plot level to national and international scales."* *"The challenge is not to select a specific scale but to relate field/plot level science, observations, and practice up to larger scales, at which management and policy are designed."*

Code[a]	Frequency (n)	Examples
1-5	34	*"Given the broad range of climate change effects, research on all spatial scales from sub-cellular to global are necessary."* *"Most of my suggestions could be addressed on anything from a field- to a global- scale, or perhaps on any scale. Probably my key concern would be that the individual researcher is aware of the scale being investigated. (And it is the role of the program manager to ensure that projects fit the program goals - whether they be state, national of global)."* *"One of the key areas of research needed is finding ways to make predictions across scales, from the leaf scale to whole tree, to forest stand, landscape, and the global scale. We desperately need to develop tools to operate across these scales."*
2-2	8	*"Landscape to local."* *"Farm to watershed scale within a regional context."*
2-3	31	*"Landscape-scale -- HUC3 watersheds and larger to ecological regions."* *"Local to regional."* *"I think you need better integration at the field to landscape (watershed) scale integration. Cross comparatives between regions in the U.S. would be very helpful. Watershed and ecological boundaries are great but then it makes it tricky to study human behavior or policies, etc. because we don't organize ourselves on the basis of watersheds in terms of policy, etc."*
2-4	15	*"Hemispheric to local scales."* *"Multiple scales, from farm to national."* *"Ideally the work would be scaleable in order to deal with multiple scales - local to regional and national. Many state partners also prefer information at the state level."*
2-5	10	*"These need to be studied at the local, regional and global scales."* *"From local to global. This is nebulous because there IS no ideal scale."* *"Landscape to global. We need to be comparing US to Asia and Europe.*
3-3	3	*"State level to regional."*
3-4	10	*"At least state-wide to entire coastal areas."* *"Regional to national."*
3-5	8	*"Regional to global."* *"Large scale, from regional to national to global."*
4-4	0	*NA*
4-5	0	*NA*
Don't know	2	*"I'm not sure that there is an ideal spatial scale at which to conduct these studies. A scale of one field might be needed to developed tools and technologies, but a broader scale might be more appropriate for testing these developments. Also various phenomena associated with climate change may occur at various scales."* *"Not qualified to respond. I am not an expert in this field."*
No single scale	5	*"No single ideal scale, it is a multi-scale problem/solution."* *"There is no single ideal spatial scale, we need to invest in understanding, modeling and building resiliency at all scales."*
Not coded	57	*"5-7 years."* *"It depends, and some are systemic and national, while some (nutrient recapture) are local."* *"It can be a 20 year Manhattan Project type work which is doable by taxing fossil fuel users."*

[a]Spatial scales were coded on a 5-point scale to indicate size where:
1 = laboratory, plant, individuals, plot, hectares, field, and site;
2 = farm, watershed, county, ecosystem, landscape, irrigation district, local, HUC12, and city;
3 = region, state-level, ecoregion, biome, mesoscale, and aquifer;
4 = nation, international, continent, and transnational; and
5 = global.
If a hierarchal approach was called for, these scales were indicated with a hyphen.

Table 10. Recommended length of funding cycles
Corresponds to open climate_change_Q4: "In your opinion, how long (in years) should a funding cycle be to research climate change (please enter a numeric value)?"

Years	2	3	4	5	6	7	8	9	10	12	15	20	25	30	50	99	100	Mean
Respondents (n)	4	20	16	108	3	4	1	1	32	1	3	8	4	2	5	1	3	9.6

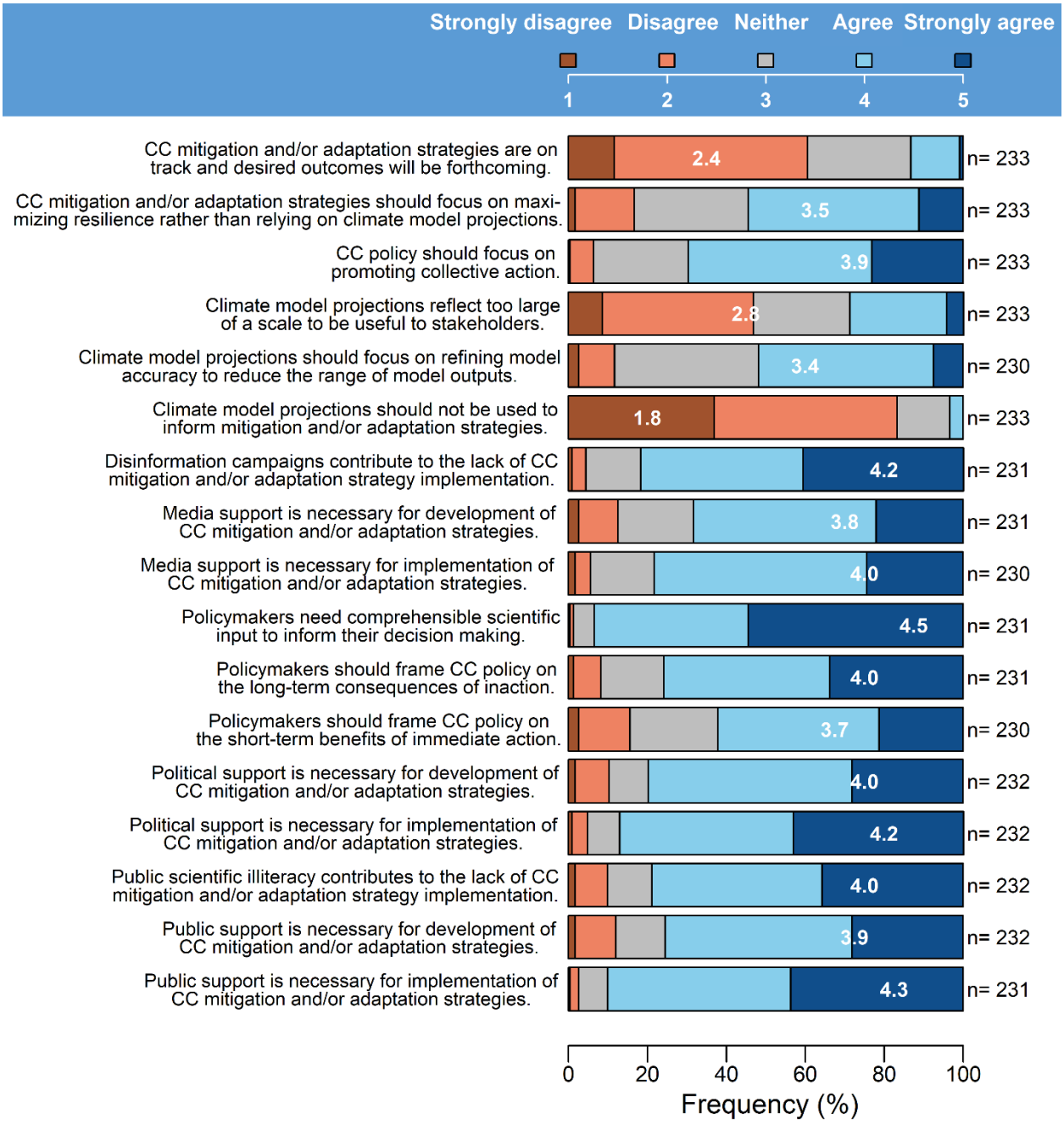

Figure 3. Climate professionals' views on climate change strategies
Corresponds to Likert climate_change_Q5: "Please indicate your level of agreement with the following statements in terms of climate change and agroecosystem science."

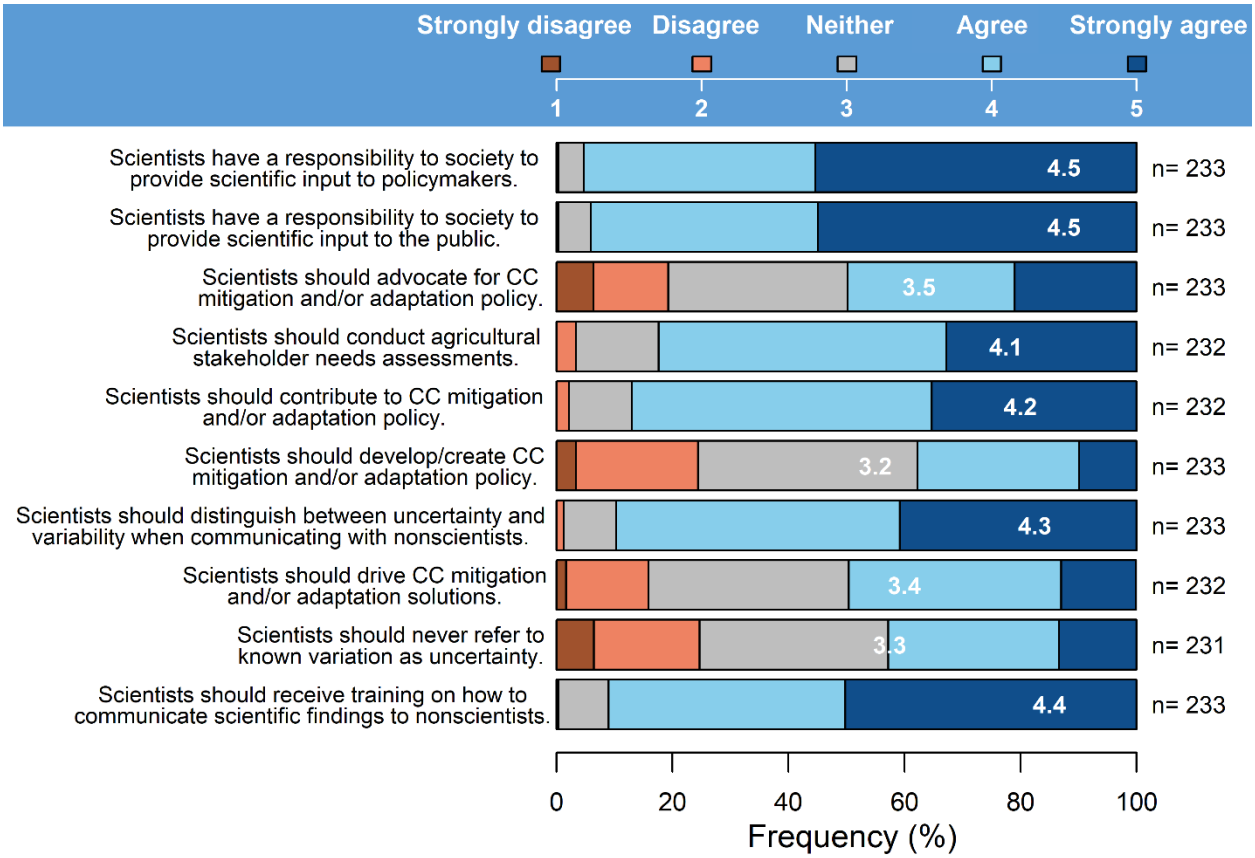

Figure 4. Scientists' obligations to climate change strategies
Corresponds to Likert climate_change_Q6: "Please indicate your level of agreement with the following statements."

3.4 Stakeholders

The majority (63.9%; total n=223; stakeholder_Q1) of respondents had not received formal training on how to communicate with stakeholders. Of those that had participated in some type of formal training, the training consisted mostly of "workshops" (n=28), "classes" (n=12), and "in-service" (n=11; Table 11). The majority of informal training consisted of "on-the-job training" (n=105) which included learning by doing and through experience (Table 12).

Most (85.9%; stakeholder_Q4) of the respondents have worked with the general public. The majority (86.8%; n=220) of respondents have worked with two or more stakeholder groups (Figure 5). Those respondents that replied that they worked with multiple stakeholders were asked which stakeholder was their main priority and most (89.4%) worked with "producers," "general public," or "policymakers" (Table 13).

Table 11. Formal training on how to communicate with stakeholders

Corresponds to open stakeholder_Q2: "Please describe the formal training you received on communicating with stakeholders." Codes ordered by frequency (n=79).

Code	Frequency (n)	Description	Examples
Workshops	28	Workshop attendance	*"I participated in a week-long workshop with reporters from major newspapers and networks on how to communicate to the public about science."* *"Multiple workshops from universities and non-profit organizations."* *"Through the NSTA (national science teachers association) and the NAS (national academy of sciences) workshops and publication."*
Classes	12	Graduate, undergrad, or not specified	*"In grad school I took classes in public participation in environmental policy, where we had to design a public process that achieved the desired level of input on appropriate decisions."* *"University coursework."* *"I graduated from a four-year degree program in development planning. Communicating information on the planning process to policy-makers and other stakeholders was an essential component of the training program."*
In-service	11	Formal training offered through place of employment	*"Over my 30 years I have had many opportunities for formal training as part of my extension specialist duties."* *"Internal agency training."* *"Through my university."*
Extension	6	Provided by Extension	*"I have attended a variety of short, 1-hour long, mini-training sessions offered by nearby University and Extension representatives."* *"Extension seminars and workshops."*
Online courses	6	Completed online courses	*"Alda center for communicating science."* *"Structured decision making and adaptive management training through National Conservation Training Center (NCTC)."*
Seminars	5	Seminar attendance	*"As a post doc and faculty member I received formal training in seminar courses and with NSF sponsored programs."* *"Seminar training (from a social scientist)."*
Short courses	5	Short course attendance	*"I took a science communication for the media training. It was led by media members from top publications and media outlets who were science reporters. It was also professionally facilitated with a structured agenda that engaged the attendees. The focus was very specific to communicating important science knowledge on conservation to the media and the public. This course helped me understand the need to create science messaging that is readily digestible by the public (or the media), but accurate and honest at the same time."* *"Plain language writing course."*
Programs	4	Participated in program	*"Stanford University's Leopold Leadership Program."* *"10 day American Meteorological Society's Summer Policy Program."*
Sessions	3	Attended sessions	*"1 day session on effective scientific communications with non-scientists."* *"ASA sessions."*

Code	Frequency (n)	Description	Examples
Webinars	3	Participated in webinars	*"Webinar from university on extension efforts to communicate climate science."* *"Webinars."*
Conferences	2	Conference attendance	*"I occasionally attend meetings of CapSciComm (The Capital Science Communicators, Sacramento, CA), some of which focus on engaging with stakeholders."* *"AGU Chapman Conference in Colorado a couple years ago."*
Graduate degree	2	Completed relevant degrees	*"Have a master's degree in environmental journalism."* *"I am a Social Science Analyst, with my degrees rooted in the social sciences utilizing quantitative and qualitative research methods with emphasis on evaluation research design, and adult education."*
None	1	None	*"None."*
Pitch practice	1	Practicing pitches	*"Pitch practices."*
Not coded	23	Vague or irrelevant	*"Management by network."* *"Executive development."* *"Training on types of stakeholders and messages to them."*

Table 12. Informal training on how to communicate with stakeholders
Corresponds to open stakeholder_Q2: "Please describe any informal training and/or research you have done to improve your ability to communicate with stakeholders." Codes ordered by frequency (n=168)

Code	Frequency (n)	Description	Examples
On-the-job	105	On-the-job, through experience, learning by doing	*"On-the-job-training."* *"I have completed numerous public speaking engagements where I have taken the time to talk to individual attendees after my presentations to hear the feelings, feedback, and suggestions on the topic I presented. By expressing my interest in their feelings, and not appearing that I'm there to talk about only my agenda and viewpoints, they are more open to discussion and sharing thoughts and feelings with me."* *"Practice."* *"Years of doing it."* *"Have gone to many meetings with farmers, ranchers and land managers. It is very helpful to understand your audience.*
Publications	33	Reading of any kind including scientific, websites, blogs	*"Guides such as produced by AGU. Social science research papers."* *"Keep informed on reports and media resources."* *"Online research about communication. Reading assessments of public's view of climate/change."*
Collaborator	19	Working with expert collaborator or Extension	*"We have hired a communications specialist for the science center. She reviews and translates things for us (i.e., for factsheets, newsletters, web, etc.). We have Office of communications people provide training on how to do live interviews. We often use moderators to assist in the meetings. We ask that our communications person attend stakeholder/researcher meetings to ensure that both are 'communicating' with each other (vs talking past each other). This is something that occurs all during the project (from proposal development, during the research activities, and while developing the final product/tool/model, etc.)."* *"Have attended tribal organization meetings which are very helpful in understanding science delivery needs. However, tribes/indigenous peoples should not be considered 'stakeholders.' They are co-collaborators."* *"Work with extension agents."*
Observation	15	Watching experts	*"Learn by watching others who are good at it and practice. Use common sense based on a life lived not simply interacting with other scientists. Constantly tweak approach. Listen to radio stories about communicating science. Know your audience."* *"Watching what good communicators do, then try to do that. Hang out with social scientists."* *"I have watched numerous online videos, tutorials, TED talks, etc. about communicating science effectively to stakeholders."*
None	8	None	*"None."* *"I've received none, but would love it if it were available."*

Code	Frequency (n)	Description	Examples
Expert	4	One-on-one conversations with an expert	*"Speaking to state climatologists on their experiences in speaking with public."* *"Guidance from NIFA Program Specialists ([name]) and reviewers on filling out NIFA (REEport) project reports."*
Miscellaneous	3	Miscellaneous training	*"I go to conferences outside science conferences and try to meet people and understand their perspectives (e.g., public safety, public health). I also seek out communities outside academia for one-on-one connections to understand broader impressions of what climatologists do."* *"I try to engage frequently with the public."*
Not coded	42	Vague or identified as formal training	*"Trainings on science communications."* *"A few communications sessions at various conferences or workshops."* *"Made presentations at conferences, but have no experience to speak in front of the public."*

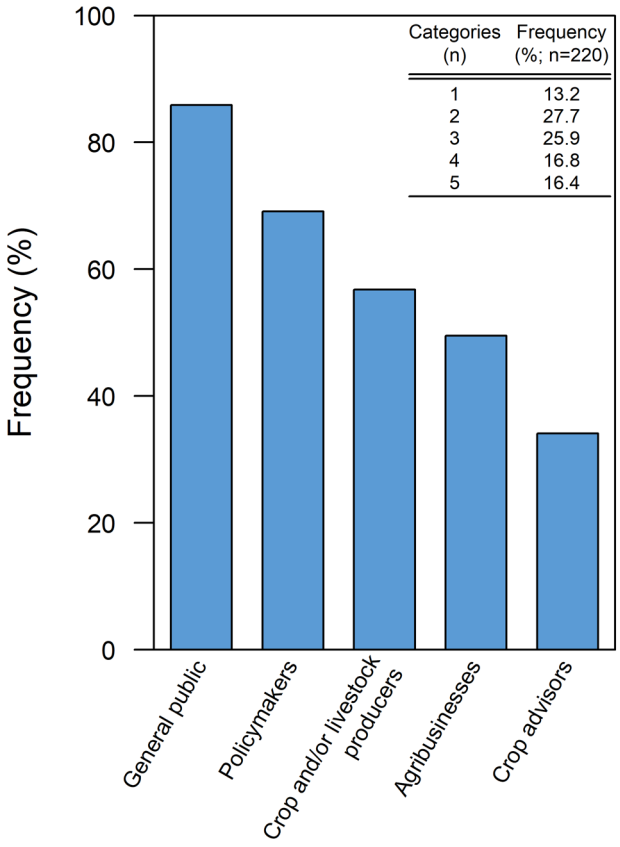

Figure 5. Stakeholders
Corresponds to closed stakeholder_Q4: "Please select the following stakeholders that you currently or previously worked with (check all that apply). If none, click the next arrow (>>) to skip." Inset table indicates the frequency of respondents to select ≥1 value.

Table 13. Main priority stakeholder
Corresponds to open stakeholder_Q5: "In the previous section you indicated that you worked with multiple stakeholders, in an attempt to shorten this survey we will ask you a series of questions regarding the stakeholder that is your main priority, which stakeholder is your main priority?"

Main priority stakeholders	Frequency (%; n=188)
Agribusinesses	7.4
Crop advisors	3.2
Crop and/or livestock producers	35.6
General public	24.5
Policymakers	29.3

3.4.1 Agribusinesses

Over one third (38.1%, total n=21; agribusiness_Q1) of respondents indicated that 10 years would be sufficient for modeling climate projections to maximize usefulness to agribusinesses. The mean value of years for model projections was 22.8 years (Table 14).

The challenges most frequently identified for communicating with agribusinesses were "timescale" (n=7), "uncertainty" (n=3), and "using layperson language" (n=3; Table 15).

Respondents were asked to indicate the likelihood (Likert scale from 1-5; 1="extremely unlikely," 5="extremely likely;" agribusiness_Q3) of using specific terms/phrases when talking to agribusiness about climate change. The term most likely (Likert mean 4.6) to be used by respondents was "sustainability." The least likely (Likert mean 2.4) term/phrase was "climate debate" (Figure 6).

Of the 14 respondents that reflected on terms/phrases they would avoid while talking to agribusiness (agribusiness_Q4), six respondents indicated there were no terms/phrases they would avoid, two were not sure, one said technical terms/jargon and the remainder supplied:

- global warming,
- must,
- tax driven behavior change,
- typical meteorological year, and
- urgency.

Additional comments included:

- "I have not encountered non-belief in climate change as of yet, so I haven't had to have this conversation."
- "I will argue that humans are increasingly becoming the important driver for climate change along with other naturally occurring processes. I avoid saying that climate change outcomes with respect to their impact on agriculture are known with certainty."

Respondents were asked to rate what they believed agribusinesses' level of agreement (Likert scale 1-5; 1="strongly disagree," 5="strongly agree;" agribusiness_Q5) with the statements regarding climate change. The greatest agreement (Likert mean 4.0) pertained to statements "climate change is happening" and "earth's climate always changes." The greatest disagreement (Likert mean 2.0) pertained to a statement directly relating to agribusiness: "climate change will not affect the way that agribusinesses operate" (Figure 7).

Table 14. Climate projections for agribusiness
Corresponds to numeric agribusiness_Q1 (n=21): "How far (in years) would you model climate projections to maximize usefulness to agribusinesses (please enter a numeric value)?"

Years	4	5	10	20	25	50	120	Mean
Respondents (n)	1	3	8	3	2	3	1	22.8

Table 15. Challenges to communication with agribusinesses

Corresponds to open agribusinesses_Q3: In your opinion, what is the fundamental challenge in communicating climate change issues to agribusiness?" Codes ordered by frequency (n=21).

Code	Frequency (n)	Description	Examples
Timescale	7	Long term impacts of climate change	*"Most large agribusinesses have a deep understanding of risk and uncertainty. However, the timescales that they are most comfortable with stretch to at most 1-2 years. Most climate change issues are developing on longer time scales. Getting them to understand that year-to-year variability, which they are comfortable with, is a moving target due to climate change and that decisions and actions now will have effects in out years can be challenging. Government policy can help cement these ideas and give actionable options for agribusinesses."* *"Agribusiness stakeholders (i.e., their stockholders) expect financial returns over both short- and long time scales, often with too much emphasis on short-term returns. Climate change will impact short term yields and profits, and therefore corporate strategy, but the long-term effects of climate change are far more severe. Persuading this industry to plan longer term strikes me as a substantial challenge."*
Uncertainty	3	Scientific uncertainty	*"Prediction of what, when and how much with certainty."* *"Uncertainties regarding model projections."*
Using layperson language	3	Accurate but not overly technical language; simple	*"To present findings in a layman language understandable to general public."* *"Presenting clearly data derived from studies."*
Culture	1	Not the stakeholders' norm	*"They see the challenges but are not necessarily interested in the more holistic way of understanding and solving them- they will choose applications with freedom to operate instead of making more thorough solutions of broad application."*
Economics	1	Economics, return on investment, cost	*"Return on investment must be 30% on any climate change reduction technology, (i.e., 3 year payback)."*
Making it personal	1	Specific to individual, stakeholder, and/or area	*"Communicate a tangible impact on their local business."*
None	1	None	*"I don't feel that communicating climate change issues is a challenge with my farmer stakeholders. Just because we can communicate about it doesn't mean that they are ABLE to choose to put more adaptation practices in place (which I would like to see them do), but they are aware, and we communicate well about it. Of course, that's not true for everyone, but I don't have the expectation that it would be."*
Politics	1	Politically driven	*"Disconnecting the issue from politics."*
Stakeholder knowledge	1	Lack of knowledge including scientific literacy	*"The fundamental issue is the lack of knowledge of climate in general and climate change in particular on the part of the audience."*
Miscellaneous	1	Miscellaneous challenge	*"Obtaining appropriate data to demonstrate how climate change will affect their 'bottom line' and the future viability of their operations."*
Not coded	1	Unclear	*"How can we help agribusiness to adapt effectively to climate change?"*

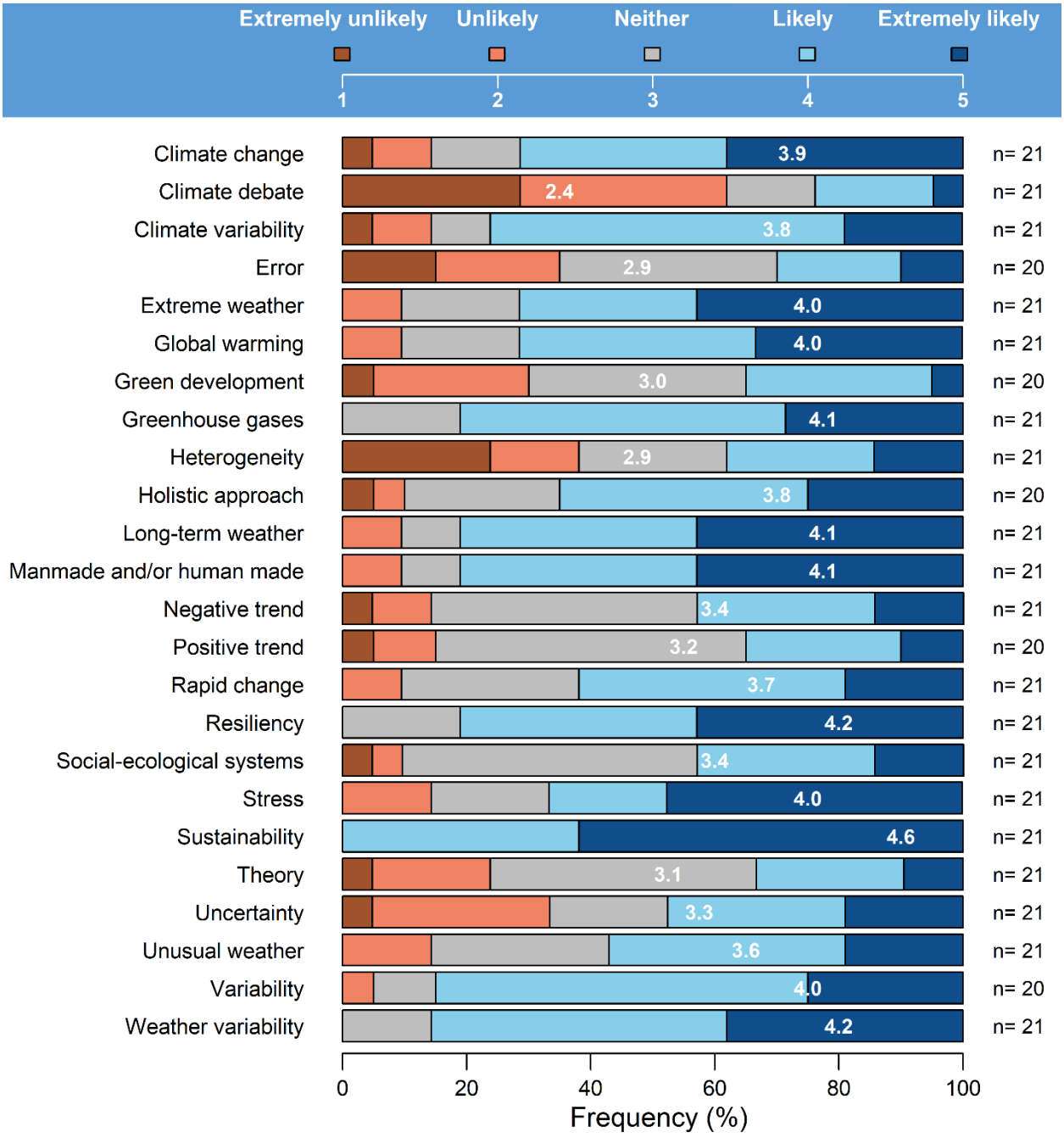

Figure 6. Terminology usage with agribusinesses
Corresponds to Likert agribusiness_Q3: "How likely are you to use the following terms/phrases when talking to agribusinesses about climate change?"

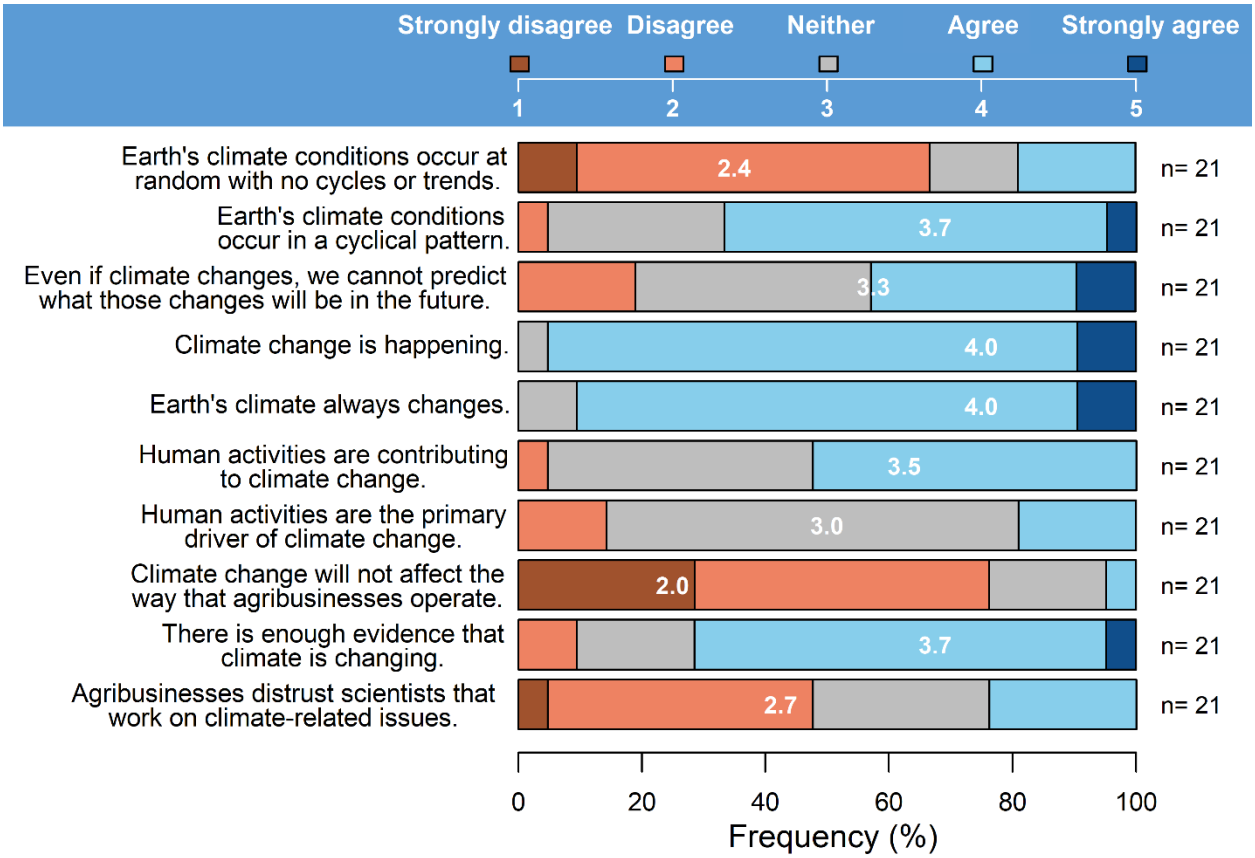

Figure 7. Perception of agribusinesses' views on climate change
Corresponds to Likert agribusiness_Q5: "In your opinion, what would the majority of agribusinesses' level of agreement be with the following statements?"

3.4.2 Crop advisors

One third (33.3%, total n=9; crop_advisors_Q1) of respondents indicated that 10 years would be sufficient for modeling climate projections to maximize usefulness to crop advisors. The mean value of years for model projections was 15.3 (Table 16).

The 10 respondents identified 10 different challenges for communicating with crop advisors (Table 17).

Respondents were asked to indicate the likelihood (Likert scale from 1-5; 1="extremely unlikely," 5= "extremely likely;" crop_advisors_Q3) of using a series of terms/phrases when talking to crop advisors about climate change. The phrases most likely to be used (Likert mean 4.5) were "extreme weather," "long-term weather," and "manmade and/or human made." The least likely term/phrase (Likert mean 2.5) was "heterogeneity" (Figure 8).

The seven respondents that reflected on terms/phrases they would avoid while talking to crop advisors (crop_advisors_Q4) supplied:

- climate change (n=2),
- democrats (n=2)
- global warming (n=2),
- republicans (n=2),
- conservative (n=1),
- green peace (n=1), and
- liberal (n=1).

An additional comment includes, "crop advisors may be more open to talking about groups that they perceive to be anti-agriculture than growers, but not much more open."

Respondents were asked to rate what they believed crop advisors' level of agreement (Likert scale 1-5; 1="strongly disagree," 5= "strongly agree;" crop_advisors_Q5) to the statements regarding climate. The greatest agreement (Likert mean 4.1) was "earth's climate always changes." The greatest disagreement (Likert mean 2.3) was with the statements "earth's climate conditions occur at random with no cycles or trends" and "climate change will not affect the way that crop advisors operate" (Figure 9).

Table 16. Climate projections for crop advisors
Corresponds to numeric crop_advisors_Q1 (n=9): "How far (in years) would you model climate projections to maximize usefulness to crop advisors (please enter a numeric value)?"

Years	0	1	2	10	25	30	50	Mean
Respondents (n)	1	1	1	3	1	1	1	15.3

Table 17. Challenges to communication with crop advisors

Corresponds to open crop_advisors_Q2: "In your opinion, what is the fundamental challenge in communicating climate change issues to crop advisors?" Codes ordered by frequency (n=10).

Code	Frequency (n)	Examples
Timescale	2	*"Getting them to think about long term changes in climate and how to adapt to them now."* *"How these longer term forecasts affect decision making today. Planning is a difficult poorly understood process."*
Credibility	1	*"Personal credibility."*
Economics	1	*"Economic loss."*
Overworked	1	*"Many crop advisors especially University Extension have limited time and resources and they are stretched too thin. Funding to support more extension personnel will allow them to engage with their stakeholders and have the time to learn the latest on climate change."*
Pathway	1	*"The methods of communication are difficult with extension agents using a variety of pathways that can be diverse. Some are very tech-savvy and rely in mobile phone communications and email. Others prefer to receive information face to face or in meetings. Meeting these demands can be challenging."*
Pipeline	1	*"Reaching the right people that can reach the greatest number of shareholders."*
Scientist knowledge	1	*"Do we know what the adaptation practices should be?"*
Stakeholder knowledge	1	*"Planning is a difficult poorly understood process."*
Uncertainty	1	*"Climate change signal estimation."*
Variability	1	*"Distinguishing between year to year variability and longer term trends."*

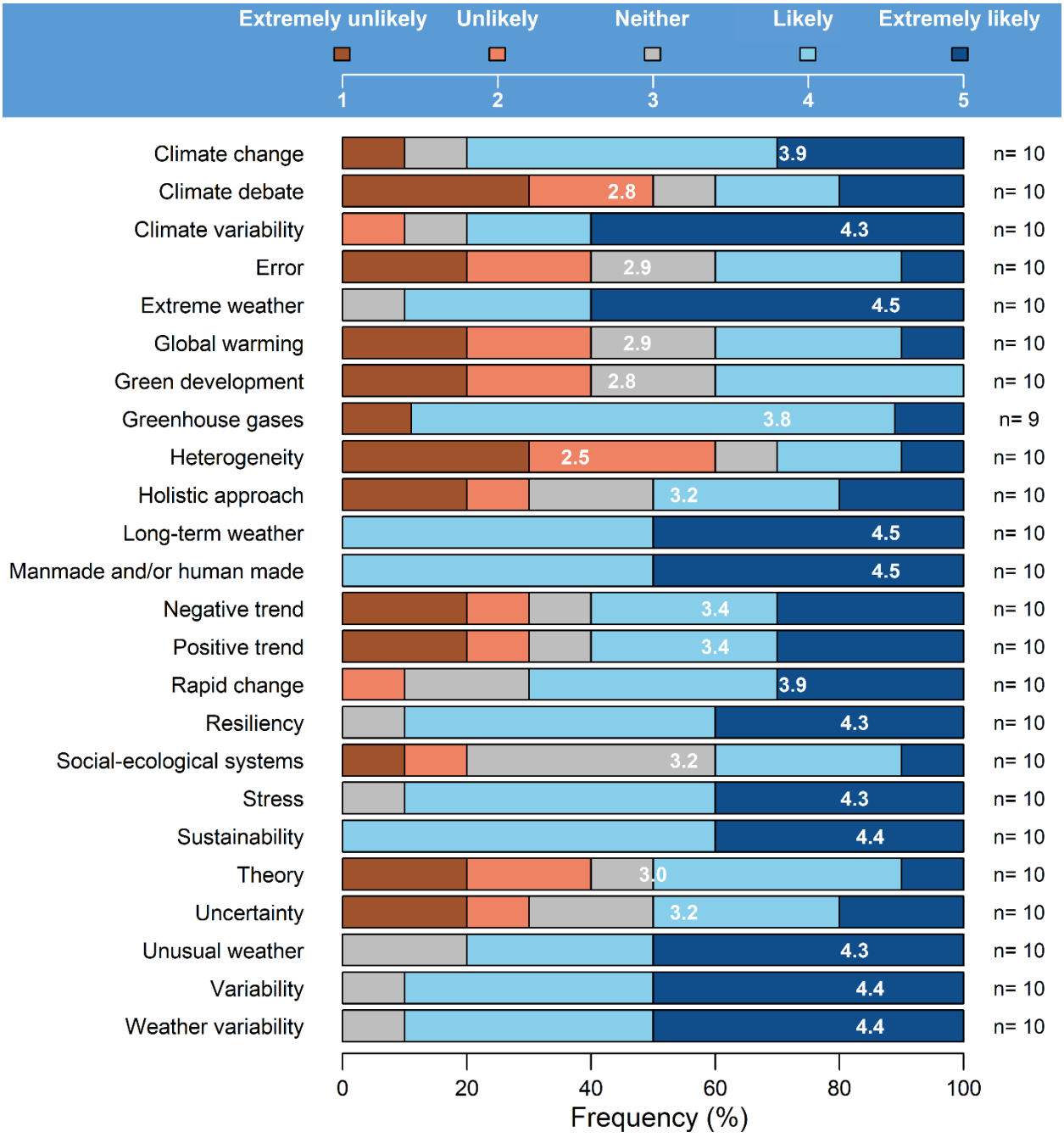

Figure 8. Terminology usage with crop advisors
Corresponds to Likert crop_advisors_Q3: "How likely are you to use the following terms/phrases when talking to crop advisors about climate change?"

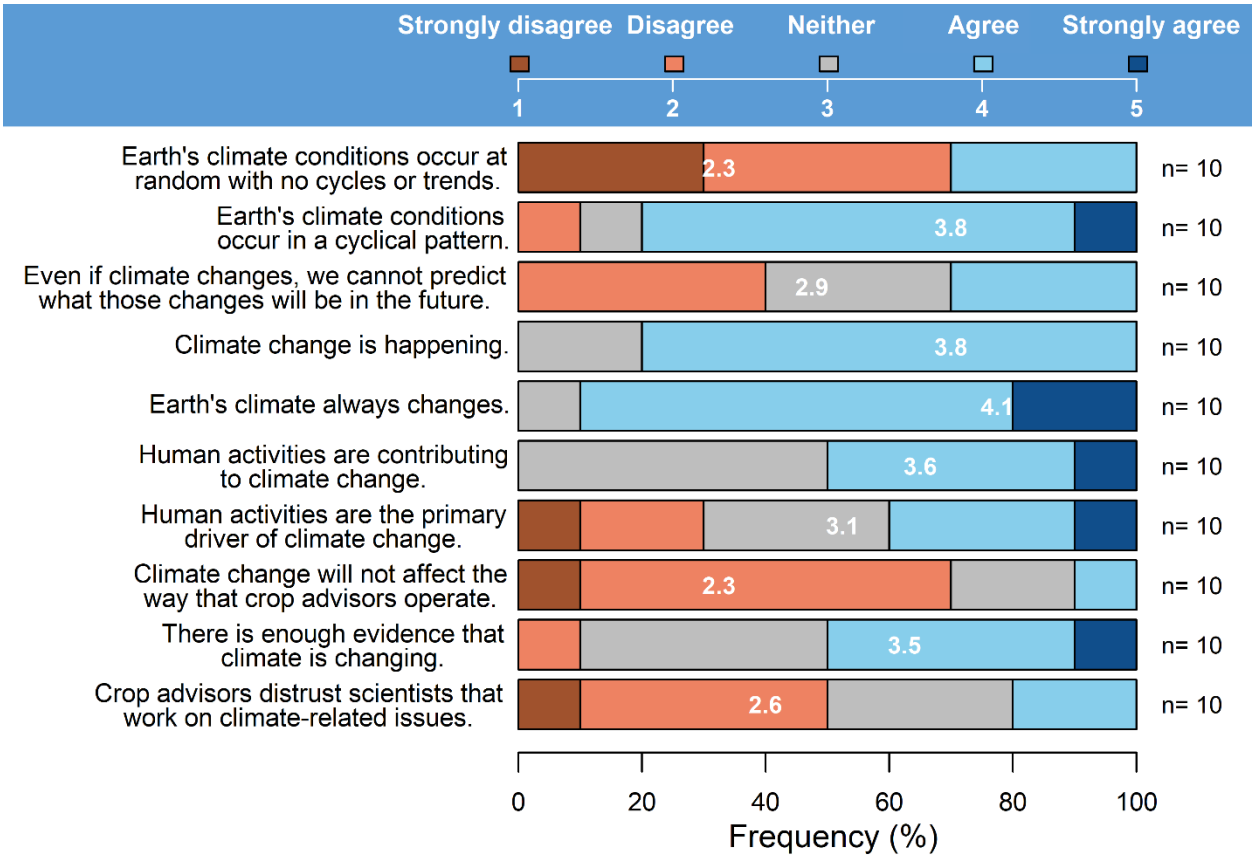

Figure 9. Perception of crop advisors' views on climate change
Corresponds to Likert crop_advisors_Q5: "In your opinion, what would the majority of crop advisors' level of agreement be with the following statements?"

3.4.3 Crop and/or livestock producers

Under a quarter (22.6%, total n=75; producers_Q1) of respondents indicated that 10 years would be sufficient for modeling climate projections to maximize usefulness to crop and/or livestock producers. The mean value of years for model projections was 16.9 (Table 18).

The challenges most frequently identified for communicating with crop and/or livestock producers were "timescale" (n=20), "economics" (n=13), and "making it personal" (n=13; Table 19).

Respondents were asked to indicate the likelihood (Likert scale from 1-5; 1="extremely unlikely," 5="extremely likely;" producers_Q3) of using a series of terms/phrases when talking to crop and/or livestock producers about climate change. The term/phrase most likely to be used by respondents (Likert mean 4.5) was "extreme weather." The least likely term/phrase (Likert mean 2.2) was "climate debate" (Figure 10).

The 50 respondents that reflected on terms/phrases they would avoid while talking to crop and/or livestock producers (producers_Q4) supplied:

- global warming (n=13),
- climate change (n=9),
- none (n=5),
- technical terms/jargon (n=4),
- regulation (n=3),
- audience dependent (n=2)
- cause (n=2
- man-made (n=2),
- Al Gore (n=1),
- alarmist (n=1),
- anthropogenic (n=1),
- belief (n=1),
- cap and trade (n=1),
- carbon tax (n=1),
- cities (n=1),
- climate action plan (n=1),
- climate denier (n=1),
- conservative (n=1),
- conspiracy (n=1),
- denial (n=1),
- EPA (n=1),
- ethanol (n=1),
- government (n=1),
- green peace
- greenhouse gas mitigation (n=1),
- heterogeneity (n=1),
- hoax (n=1),
- liberal (n=1),
- location dependent (n=1)
- mitigation (n=1),
- penalty (n=1),
- policy (n=1),
- politics (n=1),
- tax (n=1),
- theory (n=1),
- uncertainty (n=1), and
- vegan (n=1)
- not coded (n=10).

Respondents were asked to rate what they believed crop and/or livestock producers' level of agreement (Likert scale 1-5; 1="strongly disagree," 5="strongly agree;" producers_Q5) with statements regarding climate change. The greatest agreement (Likert mean 3.9) was to "earth's climate always changes." The greatest disagreement (Likert mean 2.3) regarded the statement "climate change will not affect the way that crop and/or livestock producers operate" (Figure 11).

Table 18. Climate projections for crop and/or livestock producers
Corresponds to numeric producers_Q1 (n=75): "How far (in years) would you model climate projections to maximize usefulness to crop and/or livestock producers (please enter numeric value)?"

Years	0	0.5	1	2	3	5	10	15	20	25	30	40	50	100	Mean
Respondents (n)	2	1	1	5	3	10	17	3	15	5	6	2	4	1	16.9

Table 19. Challenges to communication with producers

Corresponds to open producers_Q2: "In your opinion, what is the fundamental challenge in communicating climate change issues to crop and/or livestock producers?" Codes ordered by frequency (n=72).

Code	Frequency (n)	Examples
Timescale	20	*"Growers are focused on the immediate. They may recognize the need for longer term planning, but if they don't make a crop this year, there will be no long term."* *"Short term business decisions (1-5 years) vs. climate projections (30-100 years)."* *"Communicating the need for practices that promotes long term sustainability of their soil resource and providing adequate justification for practices that support sustainability."*
Economics	13	*"Helping folks see the economic impact of climate change. I work primarily with perennial crop producers and their crops are a long term investment that requires accurate predictions to ensure that their crops are economically viable investment over the long term."* *"Economic implications for the producer."* *"Crop producers do not want to change unless they are 100% sure the change will make money. That is almost impossible to do, so convincing farms to adapt new irrigation management technologist is almost impossible. They will buy new equipment but not change the way they operate the equipment. They are very slow to adapt micro irrigation because of the cost and even when they buy it they do not use it properly."*
Making it personal	13	*"A challenge is the ability to tell them what is the impact on them and their future family members by climate change that is and will happen in the future. Make it personal and not global. Also, talk about the changes that they have already made in relation to changing climate."* *"Access to data that demonstrates potential impacts on their livelihoods."* *"How exactly expected climate changes will affect their operations directly from changes in environmental conditions on their farm, as well as indirectly from changes in environment from regional and global production and how this affects socio-economic conditions for them on their farm in decision making."*
Culture	10	*"Sorting out climate change from random weather patterns. I think most growers believe that the climate is changing but they don't want to believe it because being a farmer requires a positive outlook and believing that next year will be better than last year. This is especially true with perennial crops. With perennial crops they make multi-year commitments/investments in a specific crop when they plant it and they never want to face the fact that the commitment they made was a mistake. The realities of climate change go against a fundamental psychological requirement of being a farmer; always hoping and believing that next year will be better. Positively addressing climate change requires a positive attitude toward making changes in practices and expecting positive outcomes. Too much of the climate change message is negative because negative outcomes of climate change are what we talk about and it is difficult to be positive toward change if we like and are adjusted to what we are doing."* *"'Belief' that future changes in weather will reflect past changes. i.e., lack of 'belief' in climate change."* *"Producers tend to be conservative and to be very skeptical about the climate models."*
Politics	6	*"The need to disengage the audience's political filters before communication can be successful."* *"Climate change has become politicized to a great degree. Democrats and liberals tend to support the concept of huge government investments to prevent climate change. Republicans and conservatives tend to be skeptical about the climate models. Climategate occurred during the review of my proposal to measure GHG from pork operations, and therefore no proposal was not fund at all. The BBC just published an article that supports this skepticism."* *"It's also become very political, and people on both sides of the communication are, I think, initially pretty defensive about the topic being mentioned at all."*

Code	Frequency (n)	Examples
Stakeholder knowledge	6	*"Climate knowledge"* *"Lack of producers' knowledge on the topic."*
Disinformation	5	*"Getting past mis/dis information."* *"I think that disinformation is the biggest challenge. Many producers strongly identify with 'conservative' political ideas. Conservative Republicans clearly oppose climate change research and many deny that climate change is real or caused by human actions. Consequently, many producers are not convinced that threats from climate change are real. Therefore, many producers are not receptive to hearing about climate change issues, even those these issues will have a direct impact on their livelihood. The problem is that by the time these changes become more extreme and therefore obvious, we will have lost valuable time needed to prepare and adapt for the coming changes."*
Credibility	4	*"The livestock producers I work with are reliant upon public land allotments for their grazing. Many of them are aware that changes are occurring during their lifetimes that can only be attributed to climate change. In my region, the fire cycle that has been driven by invasive annual grasses is seen as the largest threat for productive landscapes for producers (and conservation of native plant communities and wildlife habitats -- my focus). The challenge in communicating climate change is more about developing trust with those producers than it is about discussing actual climate change impacts. If the trust relationship does not exist, none of the conversations are meaningful."* *"Trusting models."*
Uncertainty	4	*"Bridging the gap between uncertainty and helping to create an action plan for the producer."* *"Our weather is naturally highly variable so it is difficult to suggest to producers that we can predict future weather patterns with climate models."*
Overworked	3	*"Time. They don't have the time/energy to learn new things that don't have immediate benefit."* *"Many farmers/ranchers face such a large set of issues and complex decisions every single day that they barely have enough time to pause for lunch! Having grown up on a dairy farm myself, I have seen first-hand that day-to-day tasks and tactical (short-term) decisions demand so much of a farm manager's time and energy that they rarely have the luxury of enough spare time to develop a well-thought-out strategic (long-term) plan, let alone revisiting that plan regularly or incorporating new information or technology."*
Variability	3	*"Every year is different."* *"That climate variability is increasing and at the same time the climate is changing (trend change)."*
Knowledge gap	2	*"Need rigorous economic analysis of management options."* *"More specific climate information about what could be happening in coming years to encourage changes in management strategies."*
None	2	*"This is not an issue we discuss, as it is not directly relevant to the usage of vaccines in poultry."* *"Observational data is noisy. However, the crop producers that I work with know that the climate is changing and they are concerned. Communication is not a problem."*
Using layperson language	1	*"Contrasting direction changes (increasing atmospheric CO2, temperatures, longer growing seasons) with increasing variability and extreme events (fewer rain days but more received per event, flash drought, etc.)."*
Access	1	*"In the previous question, none of the answers was descriptive of who I primarily work with - crop producers is closest to the land management professionals who are my clients. I see the fundamental challenge is the limited number of opportunities for scientists and stakeholders to interact and share information. Many users of information I collect do not read journal articles."*
Fear of regulation	1	*"Fear of added regulation."*
Pathway	1	*"Also developing information delivery capabilities that will capitalize on users' backgrounds to encourage active decision-making in production efforts."*

Code	Frequency (n)	Examples
Pipeline	1	*"We also need to know the history of the place and find the key people who can help us communicate climate change related stresses and how the farmers can be prepared and cope with those stresses. Most of all, how they can minimize some of the stresses their operations cause and how they can sustain their farming practices without ignoring the neighbors and our natural treasures!"*
Risk management	1	*"Risk management."*
Scientist knowledge	1	*"My lack of knowledge about the economic constraints of producers."*
Miscellaneous	2	*"The need to be adaptable."*
Not coded	4	*"Current production systems must be changed, and in some instances change will be considerable."* *"Impacts have not been felt fully yet as existing management practices can address small changes in the climate."*

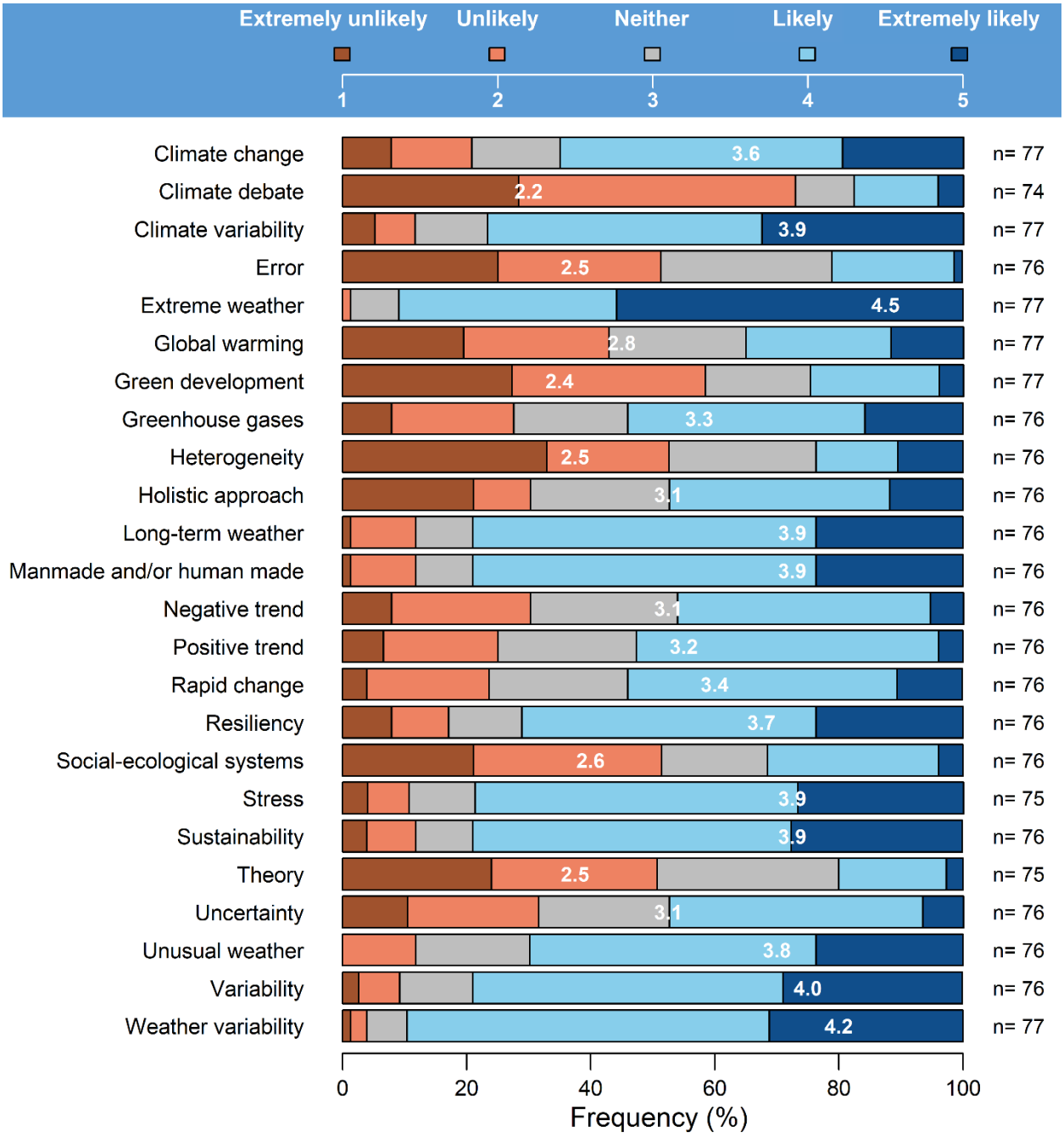

Figure 10. Terminology usage with crop and/or livestock producers
Corresponds to Likert producers_Q3: "How likely are you to use the following terms/phrases when talking to crop and/or livestock producers about climate change?"

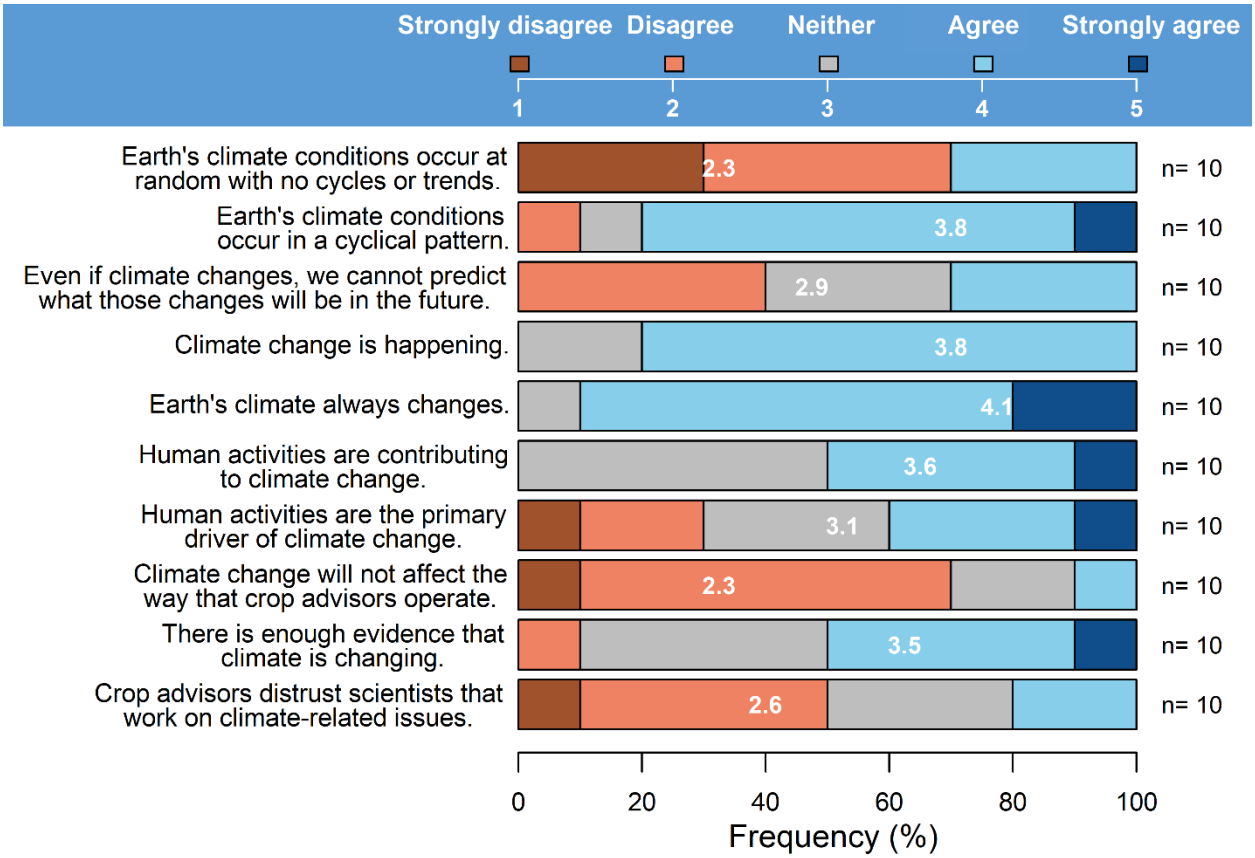

Figure 11. Perception of crop and/or livestock producers' views on climate change
Corresponds to Likert producers_Q5: "In your opinion, what would the majority of crop and/or livestock producers' level of agreement be with the following statements?"

3.4.4 General Public

Approximately a quarter (25.7%, total n=70; general_public_Q1) of respondents indicated that 10 years would be appropriate for modeling climate projections to maximize usefulness for the general public. The mean value of years for model projections was 25.7 (Table 20).

The challenges most frequently identified for communicating with general public were "stakeholder knowledge" (n=18), "making it personal" (n=16), "culture" (n=14), and "disinformation" (n=12; Table 21).

Respondents were asked to indicate likelihood (Likert scale from 1-5; 1="extremely unlikely," 5="extremely likely;" general_public_Q3) of using a series of terms/phrases when talking to the general public about climate change. The phrase most likely to be used by respondents (Likert mean 4.3) was "extreme weather." The least likely to be used phrase (Likert mean 2.5) was "error" (Figure 12).

The 38 respondents that reflected on terms/phrases they would avoid while talking to crop and/or livestock producers (general_ public_Q4) supplied:

- global warming (n=12),
- none (n=6),
- technical terms/jargon (n=4),
- audience dependent (n=2),
- catastrophic (n=2),
- climate change (n=2),
- debate (n=2),
- politics (n=2),
- belief (n=1),
- blame assignment (n=1),
- chance (n=1),
- climate denier (n=1),
- climate models (n=1),
- doomsday (n=1),
- endangered (n=1),
- error (n=1),
- extinction (n=1),
- irreversible (n=1),
- location dependent (n=1),
- mitigation (n=1),
- negative feedback (n=1),
- policy (n=1),
- positive feedback (n=1),
- probability (n=1),
- randomness (n=1),
- religion (n=1),
- science can't know everything (n=1),
- science can't prove anything (n=1),
- science deniers (n=1),
- severe weather threats (n=1),
- unavoidable (n=1),
- uncertainty (n=1),
- unprecedented (n=1),
- waiting (n=1), and
- not coded (n=4).

Respondents were asked to rate what they believed the general public's level of agreement (Likert scale 1-5; 1="strongly disagree," 5="strongly agree;" general_public_Q5) with the same statements regarding climate change presented to them in climate_change_Q1. The greatest agreements (Likert mean 3.9) were statements "earth's climate always changes" and "climate change is happening." The greatest disagreements (Likert mean 2.8) were with statements "the general public distrusts scientist that work on climate-related issues" and "earth's climate conditions occur at random with no cycle or trends" (Figure 13).

Table 20. Climate projections for the general public
Corresponds to numeric general_public_Q1 (n=70): "How far (in years) would you model climate projections to maximize usefulness to the general public (please enter a numeric value)?"

Years	0	3	5	7	10	15	20	25	30	50	75	80	100	Mean
Respondents (n)	2	1	4	1	18	1	14	8	8	8	1	1	3	25.7

Table 21. Challenges to communication with the general public

Corresponds to open general_public_Q2: "In your opinion, what is the fundamental challenge in communicating climate change issues to the general public?" Codes ordered by frequency (n=67).

Code	Frequency (n)	Examples
Stakeholder knowledge	17	*"Most people have very little science training and remember little about what they have been taught. They do have a strong inherent interest about science; hence, the broad audiences of many public outlets about science."* *"The public has no understanding of how weather or climate works, so they believe whatever they are told in sound bytes."* *"Basic education (citizen literacy) at fundamental level, not just climate but on all subjects at the K12 stage."*
Making it personal	15	*"Not connecting to human or shared values."* *"Communicating the impacts such that the average person finds a need for investment in the concept."* *"Making climate matter to them, individually (though not as difficult as it may seem at first glance)."*
Culture	14	*"Trying to deal with people who have no knowledge on a topic but who seem to believe they know something. They are a small percentage but in an open forum they can really hijack the conversation."* *"The public in general only accepts science when it is convenient and fit their own beliefs."* *"People experience weather, have selective memories for climate variability but have a hard time sensing change."*
Disinformation	12	*"Fake news is becoming more common and can impact how the public views climate change issues."* *"Misinformation and (worse) disinformation being disseminated by various outlets."* *"The primary challenge is overcoming the disinformation that vested interests generate which creates 'science fatigue' and doubt in the minds of the general public."*
Timescale	7	*"Difficult to gain understanding for the timescale of fossil fuel consumption versus earth climate system impacts."* *"Getting people to think of climate change and variability (including the past) on time scales of decades rather than years."*
Using layperson language	7	*"Explaining complex science in terms they can understand."* *"Use of terminology and provide clear scenarios of potential impacts."*
Politics	6	*"The political pundits that try to confuse the general public on these issues."* *"I feel like policy makers' politicians agendas are self-driven focusing on themselves not general public. They provide few baits for people to bite on and the rest of the essential and important issues put under the carpet. Our major issue is that leaders are moving in the direction scientifically unsound and focus on short-term solution."*
Uncertainty	4	*"Telling them the difference between something that is fully understood and something that still requires research."* *"Fundamental challenge is communicating what WILL happen. There's too much uncertainty and such a wide range of model output projections to apply any sort of confidence to that discussion."*
Credibility	2	*"Getting past, in some audiences, the initial distrust (with no real reason) of 'science' and the confusion between science and religion."* *"... and to create trust in science."*
Pipeline	2	*"Get the right audience."* *"Find messengers that are from constituent groups (Republicans, Christians, libertarians, etc.)."*

Code	Frequency (n)	Examples
Collective strategy	1	*"The issue is complicated by past approaches that look at climate change issues in isolation from the multiple drivers of change with which it interacts to shape livelihood sustainability."*
Pathway	1	*"The frequency of gatherings and events that bring the public to experience, listen to (or see) information on climate change."*
Variability	1	*"There is a critical need to explain the differences between short-term climate variability and the long-term trends or rates of climate change."*
Miscellaneous	6	*"Trusted news outlets to communicate a balanced message."* *"Sadly, being conversant on key science skeptics' arguments."*
Not coded	1	*"I communicate drivers and consequences of land use change, urban farms and community gardens."*

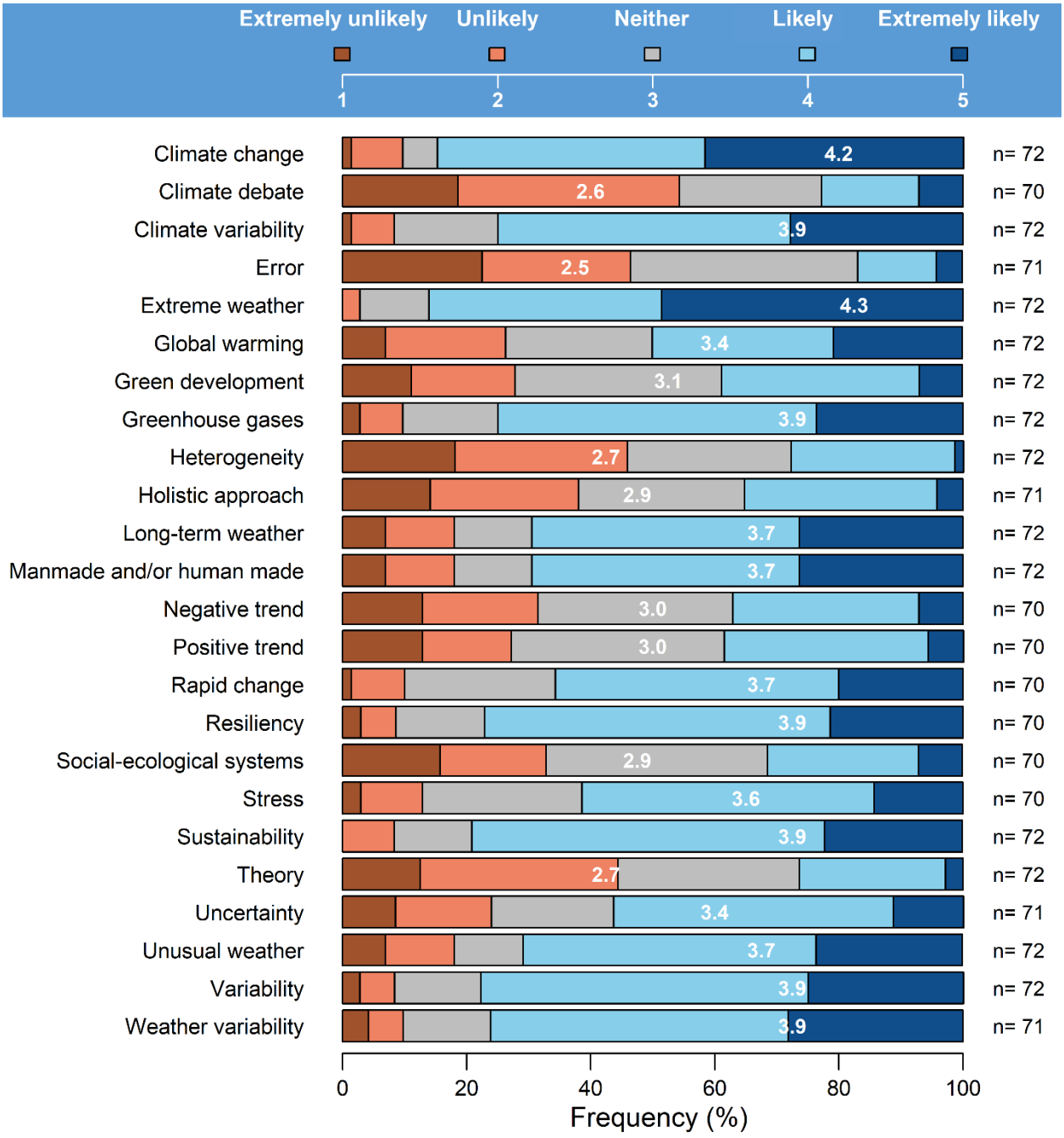

Figure 12. Terminology usage with general public
Corresponds to Likert general_public_Q3: "How likely are you to use the following terms/phrases when talking to the general public about climate change?"

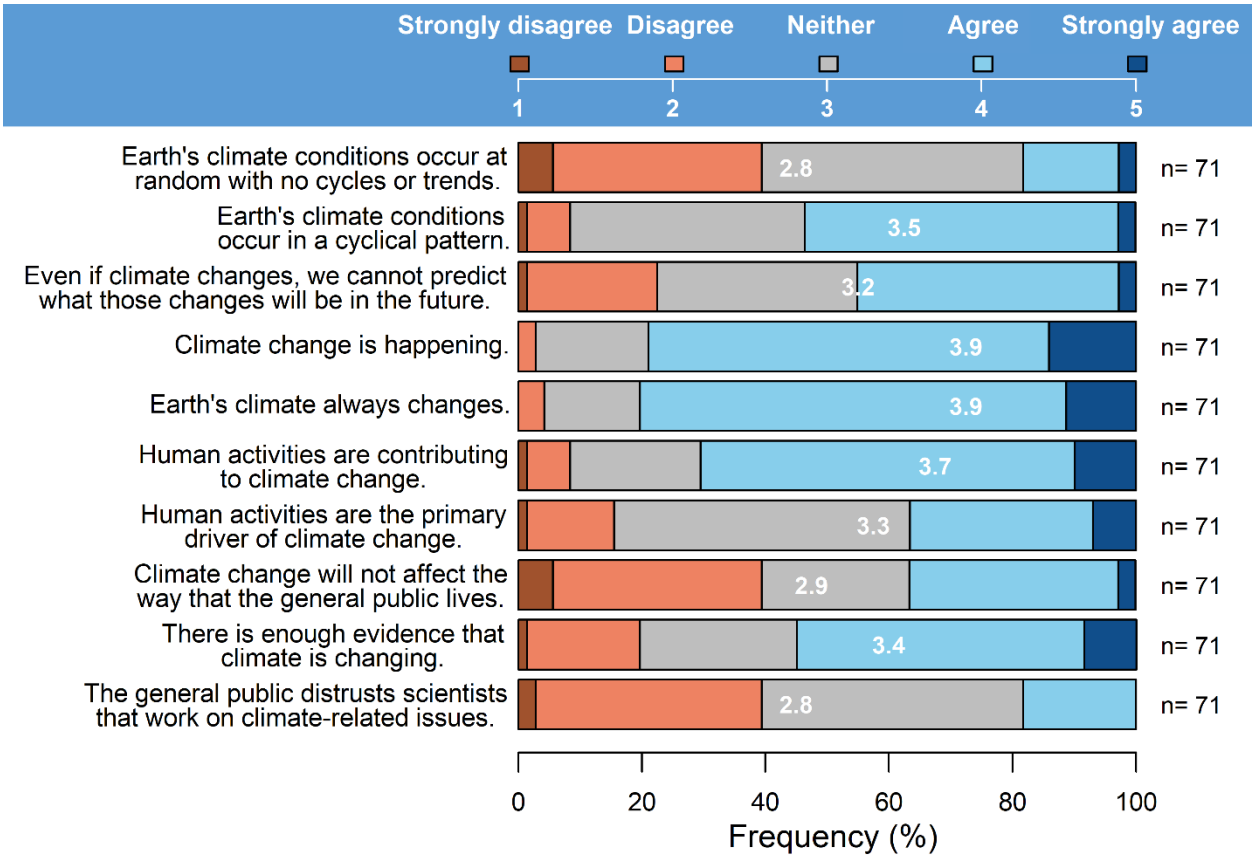

Figure 13. Perception of general public's views on climate change
Corresponds to Likert general_public_Q5: "In your opinion, what would the majority of the general public's level of agreement be with the following statements?"

3.4.5 Policymakers

Approximately a quarter (24.6%, total n=65; policymaker_Q1) of respondents indicated that 50 years would be sufficient for modeling climate projections to maximize usefulness to policymakers. The mean value of years for model projections was 33.6 (Table 22).

The challenges most frequently identified for communicating with policymakers were "timescale" (n=20), "culture" (n=14), and "disinformation" (n=14; Table 23).

Respondents were asked to indicate likelihood (Likert scale from 1-5; 1="extremely unlikely," 5= "extremely likely;" policymaker_Q3) of using a series of terms/phrases when talking to policymakers about climate change. The phrase most likely to be used by respondents (Likert mean 4.3) was "extreme weather." The least likely to be used phrase (Likert mean 2.5) was "climate debate" (Figure 14).

The 39 respondents that reflected on terms/phrases they would avoid while talking to policymakers (policymaker_Q4) supplied:

- global warming (n=6)
- audience dependent (n=5)
- climate change (n=4)
- none (n=4)
- regulation (n=2)
- technical terms/jargon (n=2)
- arctic (n=1)
- assemblages (n=1)
- blame (n=1)
- catastrophic (n=1)
- climate (n=1)
- climate change based on short-term weather patterns (n=1)
- climate change is a local issue (n=1)
- collapse (n=1)
- confidence intervals (n=1)
- connecting climate change with human health (n=1)
- debate (n=1)
- doomsday (n=1)
- fault (n=1)
- forcing factors (n=1)
- GOP (n=1)
- hoax (n=1)
- hopeless (n=1)
- inevitable (n=1)
- long-term (n=1)
- model predictions (n=1)
- Monte Carlo (n=1)
- must (n=1)
- pollutant (n=1)
- regardless of why the climate is changing (n=1)
- republicans (n=1)
- standard deviation (n=1)
- tax (n=1)
- Trump (n=1)
- unclear (n=1)
- you stupid ignoramus (n=1)
- not coded (n=6)

Respondents were asked to rate what they believed policymakers' level of agreement (Likert scale 1-5; 1= "strongly disagree," 5="strongly agree;" policymakers_Q5) with the same statements regarding climate change presented to them in climate_change_Q1. The greatest agreement (Likert mean 4.0) was for statement "earth's climate always changes." The greatest disagreement (Likert mean 2.5) was the statement "earth's climate conditions occur at random with no cycles or trends" (Figure 15).

Table 22. Climate projections for policymakers
Corresponds to numeric policymaker_Q1 (n=65): "How far (in years) would you model climate projections to maximize usefulness to policymakers (please enter a numeric value)?"

Years	0	2	3	5	8	9	10	15	20	25	30	50	75	80	100	Mean
Respondents (n)	2	1	1	1	1	1	8	4	10	5	8	16	1	1	5	33.6

Table 23. Challenges to communication with policymakers

Corresponds to open policymaker_Q2: "In your opinion, what is the fundamental challenge in communicating climate change issues to policymakers?" Codes ordered by frequency (n=63).

Code	Frequency (n)	Examples
Timescale	16	*"Climate change or any fore-looking issue is rarely the top priority for policymakers; they know they need to deal with these but are pressed by more immediate 'fires' to address."* *"Policymakers often have timeframes that are limited by the time they expect to be in their current job or the current election cycle."* *"Most policymakers are pressed by very immediate or short-term needs. The perception that climate change is something that will happen in the future dampens their interest and addressing climate adaptation right now."*
Culture	14	*"Overcoming silos of self- and special interests."* *"Getting them to think numerically."* *"Some Policymakers have closed minds, their goal is to get re-elected, therefore not always looking out for the interests of the entire country and world."*
Uncertainty	14	*"Communicating uncertainties honestly but in a context of all the other uncertainties within which policymakers already routinely make decisions, i.e., climate-change uncertainty is not fundamentally different than many other uncertainties that already are accommodated, like drought risks, market fluctuations, and technological change. All are certain to come and we even have a pretty good idea of time scales and directions of change; none can be predicted precisely in either timing or magnitude; and proactive planning and accommodation are the most economical responses to each of these sources of uncertainty and risk."* *"Explaining uncertainty."* *"Uncertainty at scales relevant to decisions."*
Politics	10	*Their need to get votes. The two party system."* *"In the past 10 years, the portion of policymakers truly interested in learning about science to allow them to make better informed decisions (why appropriately weighing non-science factors) has decreased markedly, as a larger fraction view the topic in a partisan manner. Identifying those policymakers and scientists that are interested, and willing to engage in meaningful dialogue has become more of a challenge."* *"Political party affiliation - Democrats and Republicans can view the same issue from a totally different perspective. Each party has its own 'filters' that may either over emphasize or deny evidence of climate change."*
Making it personal	9	*"Unit conversion. The challenge is to find the unit of interest to the policymaker and gear the conservation around that unit. For example, if a policymaker is primarily concerned with crop production then gear the information around how climate change may affect those crops."* *"Appealing to their emotions and still providing accurate info."*
Credibility	6	*"That the policy makers takes the results seriously."* *"Making sense without advocating - it offends many to hear an advocacy position as frequently policymakers feel that is their decision alone to make."*
Economics	5	*"The economic questions/issues associated with mitigation for climate change."* *"That they see mitigation and adaptation for climate change as having a negative impact on the economy."*
Collective strategy	4	*"Lack of sufficient understanding of each other's fields and nomenclature."* *"Avoiding doomsday predictions, and settling into a perspective of how to manage our human environment aware of climate change impacts. While there is much concern over climate change, tangible changes in how our environment is managed other than reducing emissions are not very clear or specific to different parts of the environment."*
Using layperson language	3	*"Keeping it simple, but accurate."* *"Presenting scientific findings with probabilistic clarity and using appropriate language."*

Code	Frequency (n)	Examples
Disinformation	2	*"The major challenge is getting them to focus on reliable sources for scientific data."* *"Countering the disinformation."*
Time management	2	*"Having enough time to work with them to go through a complete decision making process while also attending to professional requirements of being a federal scientists (i.e., publishing)."* *"Their time constraints."*
Access	1	*"Access to policy makers."*
Pathway	1	*"Getting their attention."*
Stakeholder knowledge	1	*"Education is the key to make the public more aware of the issues and understand the sources. Public needs to be educated enough to question and understand the motives of the policy makers and politicians."*
Not coded	1	*"I'm not an expert on climate change."*

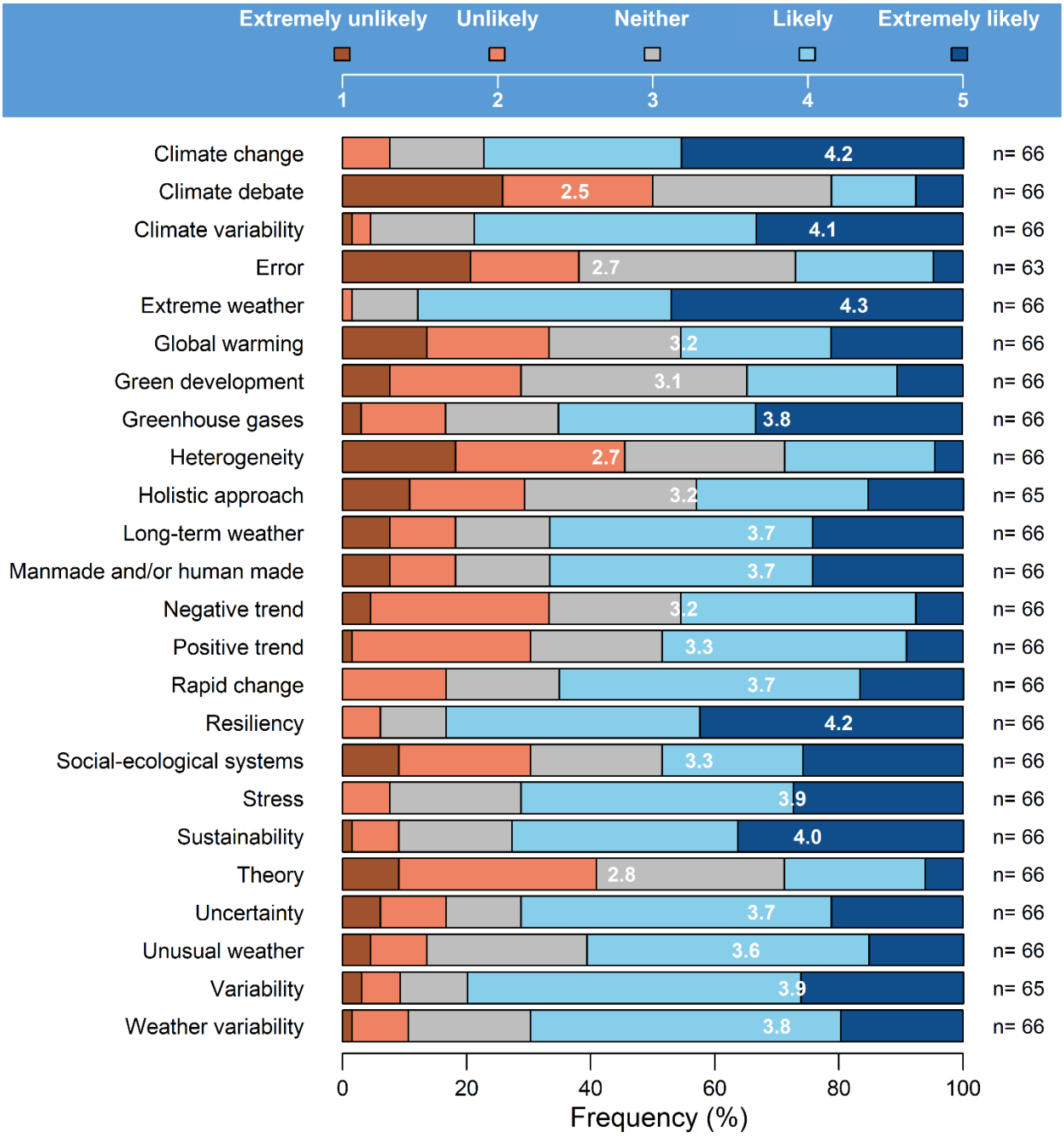

Figure 14. Terminology usage with policymakers
Corresponds to Likert policymaker_Q3: "How likely are you to use the following terms/phrases when talking to policymakers about climate change?"

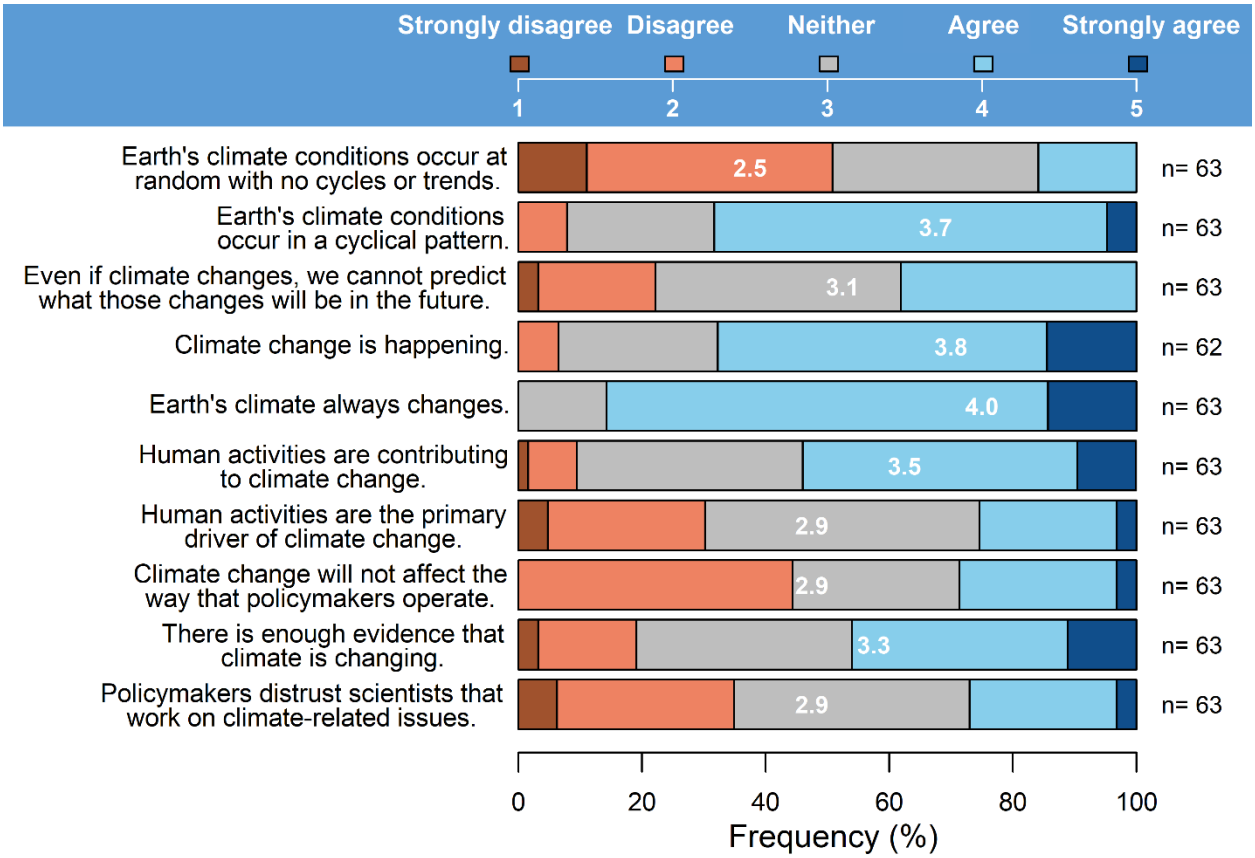

Figure 15. Perception of policymakers' views on climate change
Corresponds to Likert policymaker_Q5: "In your opinion, what would the majority of policymakers' level of agreement be with the following statements?"

3.5 Demographics

The respondent ages ranged from 28 – 80 years old and the mean age was 52.2 ± 10.9 years (n=224; demographic_Q1). Most (74.4%) of the respondents were male (total n=223; demographic_Q2). Almost 40% (37.8%; Figure 16) of the project respondents were "full professor" at the time they completed the survey. Over half (55.7%; Figure 17) of all respondents classified themselves as life scientists. Respondents worked in a climate-related field from 0 – 60 years and mean years within the field was 16.8 ± 11.5 years (n=226; demographic_Q5). The percentage of respondent's work that was climate-related ranges from 0 - 100% (Table 24); the majority (54.0%) of respondents work at least 50% of the time on climate-related issues. Respondents have spent on average, 11.4 ± 10.1 years in their current role. Of the agency respondents (i.e., non-portfolio or AASC), 47.1% have a role in making climate-related funding decisions (demographic_Q8). Of these respondents, the most frequent role was "distribute funding" (Table 25).

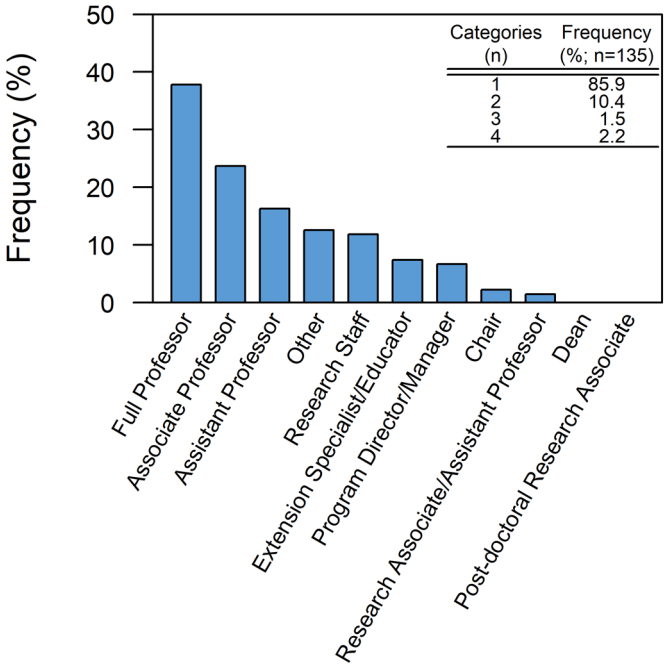

Figure 16. Job titles
Corresponds to closed demographic_Q3: "What is your job title (check all that apply)?" Inset table indicates the frequency of respondents to select ≥1 value.

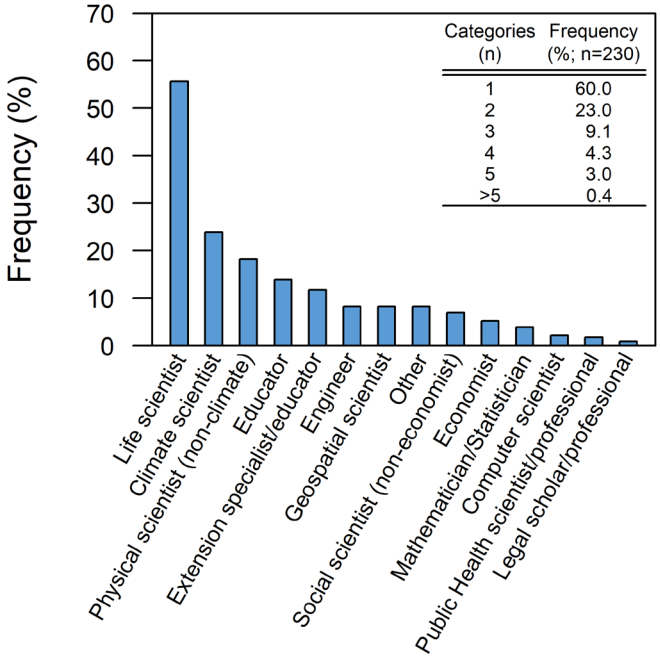

Figure 17. Scientist/professional types
Corresponds to closed demographic_Q4: "Please specify the type of scientist/professional you are (check all that apply):" Inset table indicates the frequency of respondents to select ≥1 value. Other responses include communications (n=4), soil science (n=2), conservation (n=1), energy (n=1), library science (n=1), social-ecological systems (n=1), and not coded (n=10) due to being irrelevant.

Table 24. Climate-related work as part of job
Corresponds to numeric demographic_Q6: "Please indicate the approximate percentage of time you spend on climate-related work as part of your job (please enter a numeric value):"

Percentage of Climate-related work	Frequency (%)
0	2.7
0-20	29.2
20-40	14.2
40-60	19.5
60-80	13.7
80-100	20.8

Table 25. Decision making role for climate-related funding
Corresponds to open demographic_Q9: "What is your current decision making role for climate-related funding?" Codes ordered by frequency (n=40).

Code	Frequency (n)	Description	Examples
Distribute funding	15	Distributes funding through grants, staffing, equipment, topics funded, etc.	*"Research Leader - distribution of discretionary funds to scientists and projects."* *"Have some workshop, travel, student, and seed funding decisions that I can make."* *"I administer and am ultimately responsible for an approximately $1M annual budget for funding climate research."*
Manage budget	10	Manages a budget; includes, center, department, program, project, etc.	*"I manage a collaborative science and science-delivery program with a modest budget to fund climate-related science."* *"Applying funds raised by my non-profit organization toward implementing on-the-ground actions for climate resilience."* *"Decision of how to allocate extension/research time on specific topics."*
Proposal review	7	Reviews proposals to recommend for funding	*"I review proposals submitted to study the effects of climate change on resources and identify ways to preserve those resources for future generations."* *"Evaluate RFPs for climate research. Our focus includes but is not limited to projects related to agriculture."*
Advisor	4	Advises or provides input on budgeting and research topics to be funded.	*"To ensure adequate consideration of climate factors when making water recommendations and when preparing species recovery plans."* *"Provide input to office budget and grant applications."*
Develop funding calls	4	Develops RFPs and research topic areas for RFPs	*"Identify key themes for funding announcements."* *"Research funding priorities."*
Pursue funding	2	Pursues grants or other funding	*"To pursue/not pursue the climate-related funding, and how vocal to be about research findings based on the political stance of the university on the topic of climate change."* *"Grant writer."*
Not coded	8	Vague, unclear, or irrelevant	*"Deputy decision maker."* *"Supporting relevant science for natural resource decision makers."*

3.6 Additional comments

Additional comments were primarily focused on the survey or general thoughts about the climate change and agroecosystem field.

Table 26. Additional comments
Corresponds to open demographic_Q10: "Do you have additional comments about this survey, climate change and agroecosystem science, and/or stakeholders?" Codes ordered by frequency (n=88).

Code	Frequency (n)	Examples
Survey comment	39	*"I did not like the question asking me how crop producers would answer climate questions. I have no interest in guessing what they would say. Perhaps I don't work directly enough with them, but I felt very uncomfortable with that question. The rest of the survey was excellent and had it not been for that question I would have sang the praises of how well written and thoughtful the survey is."* *"Yes, your occupation identification was not holistic. There should have been some mention of the employment disciplines in Agriculture. Why wasn't soil scientist/agronomist/plant physiologist listed since the NIFA grants also fund agriculture research topics."* *"This is the first time I've ever seen a box instead of a radio button for 'gender', and it made my heart really happy. Thank you."* *"I thought it unusual that there were no options to check 'no opinion.' In those cases I selected the middle option when the responses were provided as a gradient."* *"Maybe there is another survey, but would recommend inclusion of questions geared more toward stakeholders, e.g., how do THEY think about climate change? What terms would have the most meaning to THEM? What terms have scientists found to be most helpful in communicating to different audiences?"* *"You really didn't ask about opinions on what action should be taken, including carbon taxes, subsidies for renewable energy, and protecting climate science from the current administration."* *"Too long."* *"A lot of the questions would be answered differently depending on where in the country you reside. Perhaps there is a way you can sort out the answers per state, or region?"* *"Yes, interesting survey but some questions I answered in the middle and some I did not answer when I thought there were problems with the question. One whole section about policy makers would strongly depend on what scale. Global, national, state, local? Answers would differ depending on the audience for all of the questions. Other questions were going for one concept but could be construed in several others. There was no option to pass on the question or to say you disagree with the merit of the question."* *"I answered the questions as they pertain to the policy makers and stakeholders in my region (California). I did not try to look at what national opinions would be."* *"I'm retired so the last few questions are without value!"* *"Whether climate change is due to human behavior should be broken out to delineate what type of human behavior. Is it (private and public) policy, technology, corporate behavior, consumer behavior, or some other human behavior?"* *"Wording of some questions made there hard to answer. For example, there is a lot of variation across producers. They don't think as a single unit. No such thing as General Public or Stakeholder."* *"I think the research you are doing is critical, and addresses our needs to communicate climate science to a variety of audiences. I would like to stay informed on the progress of this research.* *"No, but I thought the questions were good at differentiating subtle differences in one's opinion."* *"It will be good to see the results."* *"Please don't repeat the questions asked in previous sections since it gives the impression that you are trying to trick the survey-taker and expect that their answers might change as the survey*

Code	Frequency (n)	Examples
		continues. The way the questions are worded indicates a bias toward climate change and policy." *"Survey is too long!!!"* *"I did not like the set of questions where you asked me to estimate what policymakers thought. First of all there is variation among policymakers. Second, I don't know what they are thinking."* *"I am very interested in seeing the results as I expect that they could help me improve my effectiveness."* *"I hope the survey will provide further guidance and direction on future research and funding on effect of climate changes in agroecosystems and adaptation of practices to mitigate greenhouse gases."* *"Very interested in the results. Hope it drives research into the future."* *"This is a VERY long survey. People are busy. I suggest developing shorter survey tools."* *"The latter questions assume groups fall into discreet categories regarding beliefs. In my experience, this is not the case. Answering the average between the two extremes is not very informative."* *"Only that when I tried to enter a number concerning the desired funding cycle length for climate-related research, the system did not accept my entries so I gave up."* *"The main stakeholders I work with are agency personnel, academia, and consultants. This group is not covered well by this survey."* *"Too long."* *"I invite the investigators to contact me directly at [email] if they would like to discuss any of my responses."* *"I am not able to scroll back far enough to add to my answer about research priorities, but I would like to add research on microorganisms and GMO approaches that can increase heat tolerance in crops."* *"Throughout the survey, I noted that climate versus climate-change are not always clearly distinguished. For example, one of the final questions asked what percentage of time is spent on climate. I replied 100%, but if the question was about climate-change, then the answer would have been considerably lower, perhaps 50%."* *"There were questions where it would have been helpful to distinguish between physical and social scientists."* *"The survey is very academic-centric."* *"Good idea to do this."* *"Good survey and good luck."* *"Excellent Survey!!!"* *"Some of the terms in the survey have a very wide applicability and yet many people define them with a very narrow meaning."* *"Thus, my work is not directly related to climate change, although I see it can be somehow related. I just wanted to clarify this, as sometimes the questions did not apply directly to my job duties."* *"But excellent survey."* *"I am hopeful that the information we shared in this survey will be useful and reach the correct authority to help them make better decisions. It is with both heart and mind, we make decisions on climate change."*
Musing	31	*"The key is two-way communication between stakeholders/customers and the research community - this needs to be fully collaborative with stakeholders/customers having a vested stake in the research in a trusted relationship. Economics is sorely lacking in terms of reduction*

Code	Frequency (n)	Examples
		of risk for producers. Transdisciplinary research involving social, biophysical and model researchers is needed at appropriate ranch/farm scales for relevance to producers." *"It is a tough question to communicate what we know and what we don't know. And as a trained climatologist, I think we assume that the general public knows more than they do. And the general public certainly does not understand the uncertainty that we deal with on this question."* *"How people feel about climate change and how we should adapt to it depends on how it will affect them financially."* *"Questions tend to get off on variants of all or nothing (cyclic or random), rather than focusing on observed changes in averages and extremes in weather variables and their impacts and possible future impacts on agroecosystems. I understand with the current federal administration this can appear to be a central topic, but a lot can be done to evaluate and plan for coming changes without having everyone on board with the concept. It was good to see that section of questions show up. I have found through my talks that relating to personal experience is a powerful communication tool. If you can get the target audience to relate to a personal experience (recent drought with record warmth) and talk about the challenges experienced and work from there on what might transpire in the future and what needs to be done to avoid an important negative outcome (inability to farm, etc.). Communication of the future needs to be over a range of future timelines from the next year to the next decade to planning out 50 to 100 years later when rapid change is expected. There is no one important horizon."* *"Just that we need more diversity in those who can speak to others. The communicators must look like the diversity of America."* *"During a radio interview today, I was asked 'what are some potential opportunities that farmers might take advantage of under future climate scenarios.' I was taken aback by the question at first, but it's a good one. While the bulk of our literature on climate change and adaptation focuses on what is being lost/broken in the process, farmers have to keep producing crops, and need a positive way forward."* *"To me it should be the duty of policymakers to seek out the scientists to understand the world. Somehow a fundamental distrust of scientists has taken hold."* *"This is a hugely important issue that has the potential to undo a century of good work conducted by governments, non-profits, and faith-based organizations working toward food security globally."* *"The next 4 years will certainly be a roller-coaster ride!"* *"Scientist and scientific communities need to push back and combat scientific misinformation."* *"Here in Alaska we do not have any agriculture per se...only extractive activities (e.g., fishing), although aquaculture is highly significant. However, everyone here is extremely concerned with climate change, it's all around us. The local people dependent upon subsistence hunting are very worried how climate change will affect the distribution of these species (caribou, whales, fish). Urban people are very concerned about the effects that CC may have on lower latitude agriculture, since most agricultural-based food is shipped.... There is no self-sufficiency in that. Finally, the changing patterns of insects and other disease-vectors are changing considerably, and we already are seeing increased incidence of black-fly associated disease in ungulates, mosquito-born pathogens in birds."* *"I have done some work with ag advisors, usually giving presentations on climate change at meetings. They seem fairly engaged on the topic. Agribusinesses are much harder to reach and I've had only limited success. The general public can be easier to reach, but many times they are not making major decisions based on climate information - they are more likely to be interested in climate change from a learning experience. Nothing wrong with that. State agencies that work with ag groups (e.g., DOT and DNR) are engaged on climate change issues in my state. Stakeholder interest in climate change has increased in recent years. I think the 2012 drought and several years of flooding problems have raised their level of awareness. One final thought and that is 'locals trust locals' when it comes to discussing climate change. Flying someone in from DC will not work. Bringing in known local experts and university scientists works much better."*

Code	Frequency (n)	Examples
		"People that know how to communicate with farmers and ranchers are needed. How climate affects economics is essential. Positive messages about land stewardship will resonate." *"I think that the only way forward is for *each sector* to find a reason and ways to mitigate GHG emissions. Part of this should be driven by "top-down" mandates, but this also makes people mad. The other part of this should come from thought leaders in those industries, who most likely see the writing on the wall. We scientists would do well by establishing relationships of mutual respect with key people in all sectors. I think we scientists need to adopt the model of extension, where trust is built through long-term relationships where one learns from the other. It will not be easy."* *"I would like to again stress that heating needs in agriculture are likely to be the largest on-site energy use. This is distinguished from how the farmer/grower/agribusiness buys energy (electricity, fuel oil, propane, etc. It is what the farmer/grower/agribusiness want the energy for (space heating, water heating, drying, cleaning, disinfecting, processing, etc.). For non-agricultural uses (residential, commercial and industrial), surveys by US DOE Energy Information Administration and Commerce have confirmed that heating use is the largest need in those building and processes. No 'agricultural' surveys of equal quality exist. So, it is not known how much more energy use or cost is required in agriculture compared to US residential/ commercial/ industrial use, or where the most agricultural expenses or uses are. However, as an example, farmers do not generally have access to low cost natural gas because running gas lines is too expensive for widely separated farms. So, they use propane, fuel oil or electric heat which are all more expensive then natural gas which is used by most US homes and businesses. Solar electricity is still expensive and roughly equivalent to utility offered electric power, while solar heat is typically 1/4 the cost of other heating sources. Final thought, survey agricultural heating needs and costs."* *"Policy makers and politician's private opinions (off record) and public positions differ significantly. So it becomes difficult to deal with this dichotomy."* *"Scientists have to be more communicative about facts of climate change as well as the solutions we have or working towards. This gives the public a positive feeling that there are solutions and they can be more supportive. If disaster scenarios are presented they are more likely to resort to 'alternative' solutions."* *"When climate research is conducted and change is recommended based on the research make sure the change has a plus economic benefit otherwise no one will use it. Too much research does not relate to the real work or producers and they do not trust it. Also any research results that will cause them to lose profits, they will ignore or fight to prevent. They are driven by profits first and everything else second. If science come up with anything that causes them to have to increase risk as they see it including collecting information that could be used against them in the future, they will resist even if it is good for society because they will believe it will hurt them. People hate change and usually fight it."* *"Treat agriculture as part of society, not as a separate component - agriculture and natural ecosystems can respond differently to climate change."* *"I cannot overemphasize my strong feeling that the code behind predictive climate models need to have a mechanism for public review."* *"It is difficult to separate environment science or agroecosystem science from work on earth systems and climate science. Also do you think students in agriculture related areas should be considered general public or producers? I suspect that their opinions are distinct from the general student population, they seem to be more aware of variability in weather and climate and interested in practicing management that will increase resiliency."* *"I do not believe it is 'settled science'. Global temperatures have risen but not for the last 17 years, thus global warming was changed to climate change and models have had to be adjusted. It is unfortunate that the subject is so politicized to the point that honest skeptics must remain quiet. All scientists should be skeptical, especially with regard to what we can do to alter climate trends. Once they close their mind, they are no longer scientists."* *"The scientific community needs to push back on extreme media narratives and insist, to the extent possible, that climate science be presented in the most transparent, honest way possible.*

Code	Frequency (n)	Examples
		Extreme headlines and scare tactics only worsen partisan divides on climate change as supporters of climate action become hysterical and opponents write them off as un-credible. Need to change narrative around climate change to highlight positive aspect of mitigation and adaptation." *"I think my answers regarding the general public as stakeholders are all applicable to policy makers. The agribusiness stakeholders have a much greater understanding of weather and climate and how it affects them specifically."* *"For example, I can imagine situations where social scientists could have a bigger role in policy development than a physical scientist might have, the latter informing the policy based on quantitative information, the former more involved in process."* *"Would like the climate hubs to be able to be more involved in guiding potential research areas - climate hubs should be strongly suggested to be involved at least collaboratively in future project areas to help utilize results and make connections among research and outreach. While this is a good effort, we have to have the conversation about we interact with private industry. They are a huge player in delivering information to producers daily as [project name] survey data shows. How do we interact?"* *"I have seen a few Tribal First Foods Initiatives presentations and programs. These emphasize and depend on the connection between food and ecology. This is a better way to present these concepts to the public and to people in general so they understand (i.e., food does not come from the grocery store)."* *"We need to point satellites toward earth not mars... water consumption from agriculture will be a huge issue in the future and we need ways to estimate it... you can't manage what you don't measure..."* *"My experience is that it's much more productive to discuss soil and cropping system vulnerability to extreme weather, rather than climate change, with farming populations."* *"My opinion is that dealing with 'climate change', man-made or otherwise would be addressed by identifying then developing mutually beneficial (economically, environmentally and socially) solutions. Key to this will also be developing a robust and adequately scaled monitoring system with local climate perspective and commitment."* *"Looming over this whole survey is the larger question of whether climate change and agroecological research will continue to be important for NIFA. I have watched with dismay as the new presidential administration has repeatedly undermined the standing of science in this country, especially climate science - for example, by censoring climate information on the EPA website, and by nominating a non-scientist climate denier (Sam Clovis) as the USDA Undersecretary for Research. I felt that this survey was somewhat ambiguous (perhaps intentionally so) about climate adaptation vs. mitigation. Adaptation is probably an easier sell for land users, whereas mitigation may be easier to study empirically and rigorously. I think it is OK for NIFA funding priorities to focus on mitigation at this point: I optimistically believe that most US producers will actually do OK in coming decades with regard to climate adaptation. I am far more concerned about climate adaptation in the developing world."*
None	17	*"No" (n=12)* *"None"* *"None that I can think of at this time, but I will reach out to Linda or Jerry if anything comes to my mind."* *"Good luck"* *"NA" (n=2)*
Thanks	6	*"Thanks for doing this assessment. If you're able to share the results, I'm sure more people than just me would be interested."* *"Thanks for doing this important work!"* *"Thanks"* *"Thanks to Drs. Prokopy and Hatfield for this great effort."*

Code	Frequency (n)	Examples
		"Thank you for the opportunity to participate in this survey." *"Thanks to Linda and Jerry."* *"Thank you for considering my input, and I hope you get some interesting results from this survey. I'd love to see the results if or when you're able to share them."*
Factoid	6	*"I work on plant biotechnology, including plant propagation (macro and micropropagation) and cryopreservation."* *"In the [name] program, we work peripherally with agro science, mainly as it relates to ecological systems. That is a bias due to the organization that is standing up LCCs (US FWS) which is expected. However it's become clear that we need to work across these disciplines more effectively and integrate our science and decision making as agriculture is clearly connected to ecological systems."* *"I would note that at my organization, the word 'stakeholders' is often avoided - we work with groups that dislike the term. It's difficult to come up with a term that everyone likes, so we stick with specifying which group we're referring to (ag, tribal, etc.) or 'users'/'clients.'"* *"The project that flagged me for inclusion in this survey, like most of my work, is not directly related to climate change. Climate and climate change obviously do affect the focus of my research program, however, which is on the strategic integration of perennials within Corn Belt landscapes."* *"...(until recently, the Coordinator of the USDA Climate Hub for[state]... we ran out of funding for the Coordinator position)."* *"I am at a private for-profit technology development company and have worked for multi-national agricultural and forestry companies. This survey may not be structured to capture the views of these types of respondents."*
Suggestion	1	*"Please look at my website: [link]."*
Question climate	1	*"My project has nothing to do with climate change but was put into this category."*

4 References

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Appendix A: NIFA Climate Portfolio Climate Professional Survey

NIFA Climate Change and Agroecosystems

Display: Introductory text and project Q1-Q7 only displayed to personnel identified through Project Direct Survey.

You have been identified as a scientist who works on climate-related issues by a Project Director within the NIFA Climate Change and Agroecosystems Portfolio (Climate Portfolio). The purpose of this survey is to gather your perspective on 1) Climate Portfolio projects, 2) the broad discipline of climate change and agroecosystems, and 3) climate change and agroecosystem stakeholders. This synthesis will identify critical findings, lessons learned, and evaluate the effectiveness of the Climate Portfolio in promoting climate change and agroecosystem solutions. Additionally, by participating in this survey you are assisting in identifying future funding priorities for the Climate Portfolio.

Your participation in this survey is voluntary. We recognize that some of the questions may be sensitive; however, your answers will be kept confidential and will be released only as summaries where individual answers cannot be identified. The survey should take approximately 30-40 minutes to complete. The system saves your progress as you go if you need to return at a later date to finish the survey. Please read each question carefully.

For information regarding the survey, please contact Linda Prokopy (lprokopy@purdue.edu; 765-494-0825) or Jerry Hatfield (Jerry.Hatfield@ARS.USDA.GOV). Thank you in advance for your help!

Introduction
In this section, please respond to the following questions and confirm your status within the Climate Portfolio.

project_question 1. (project_Q1). Are/were you involved with project account/accession number [ACCESSION NUMBER] entitled [PROPOSAL TITLE], a project within NIFA's Climate Change and Agroecosystems Portfolio?

- ❍ No
- ❍ Yes

If respondent selected "No" responses not included in survey results..

project_Q2. Is this an on-going project?

- ❍ No
- ❍ Yes

project_Q3 *Have/Will* the following outcomes *been/be* achieved or not?

	Yes	No
Adaptation method(s)/strategy(-ies) to mitigate climate change impact on watersheds	❍	❍
Agricultural production method(s)/strategy(-ies) that can adapt to climate change	❍	❍
Agricultural science to optimize sustainable management of natural resources under a changing climate	❍	❍
Animal breed(s) that can adapt to climate change	❍	❍
Climate change impacts assessment data and/or method(s)/strategy(-ies)	❍	❍
Climate change impacts on water quality/quantity assessment data and/or method(s)/strategy(-ies)	❍	❍
Earth system model or component of an earth system model	❍	❍
Economic method(s)/strategy(-ies) to respond to climate change	❍	❍
Energy efficiency improvement method(s)/strategy(-ies)	❍	❍
Energy use reduction method(s)/strategy(-ies)	❍	❍
Extension and/or education method(s)/strategy(-ies) to communicate climate change issues to stakeholders	❍	❍
Forest management method(s)/strategy(-ies) for forestry to adapt to climate change	❍	❍
Forest production method(s)/strategy(-ies) that can adapt to climate change	❍	❍
Grazing land management method(s)/strategy(-ies) to adapt to climate change	❍	❍
Livestock production method(s)/strategy(-ies) that can adapt to climate change	❍	❍
Method(s)/strategy(-ies) to increase carbon sequestration	❍	❍
Method(s)/strategy(-ies) to increase the removal of CO_2 and/or other greenhouse gasses from the atmosphere by natural processes	❍	❍
Natural resource conservation improvement method(s)/strategy(-ies)	❍	❍
New technology(-ies)	❍	❍
Nitrogen fertilizer loss reduction method(s)/strategy(-ies)	❍	❍
Nitrogen fertilizer use reduction method(s)/strategy(-ies)	❍	❍
Plant variety(-ies) that can adapt to climate change	❍	❍
Supply chain method(s)/strategy(-ies) for agriculture to adapt to climate change	❍	❍
Sustainable method(s)/strategy(-ies) that use natural resources	❍	❍

project_Q4 If not listed above, what outcomes *have been/will be* developed through this project?

project_Q5 In your opinion, what is the largest contribution of your project relative to climate change and agroecosystems?

project_Q6 Based on your project findings, what do you believe to be the remaining knowledge gaps?

project_Q7 Please use the space below for any additional comments regarding this project.

The remainder of this survey does not pertain to your project within the Climate Portfolio. Once you click the next arrow (>>), you will proceed and not be able to return to this project-specific section. The remainder of this survey pertains to climate and agroecosystem work in general.

Display: Introductory text if personnel not identified through Project Direct Survey.

NIFA Climate Change and Agroecosystems Synthesis

You have been identified as a scientist who works on climate-related issues due to your role as ${e://Field/title_role} within the ${e://Field/organization}. The purpose of this survey is to gather your perspective on 1) the broad discipline of climate change and agroecosystems and 2) climate change and agroecosystem stakeholders. This synthesis will assist in the evaluation of the effectiveness of the NIFA Climate Change and Agroecosystems Portfolio (Climate Portfolio) in promoting climate change and agroecosystem solutions. Additionally, by participating in this survey you are assisting in identifying future funding priorities for the Climate Portfolio.

Your participation in this survey is voluntary. We recognize that some of the questions may be sensitive; however, your answers will be kept confidential and will be released only as summaries where individual answers cannot be identified. The survey should take approximately 30-40 minutes to complete. The system saves your progress as you go if you need to return at a later date to finish the survey. Please read each question carefully.

For information regarding the survey, please contact Linda Prokopy (lprokopy@purdue.edu; 765-494-0825) or Jerry Hatfield (Jerry.Hatfield@ARS.USDA.GOV). Thank you in advance for your help!

Section 1: Climate Change and Agroecosystems
We seek to understand the broader discipline of climate change and agroecosystems. Please answer the following questions regarding the field of climate change and agroecosystems science.

climate_change_Q1 Please indicate your level of agreement with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	❍	❍	❍	❍	❍
Earth's climate conditions occur in a cyclical pattern.	❍	❍	❍	❍	❍
Even if climate changes, we cannot predict what those changes will be in the future.	❍	❍	❍	❍	❍
Climate change is happening.	❍	❍	❍	❍	❍
Earth's climate always changes.	❍	❍	❍	❍	❍
Human activities are contributing to climate change.	❍	❍	❍	❍	❍
Human activities are the primary driver of climate change.	❍	❍	❍	❍	❍
Climate change will not affect the way that I live.	❍	❍	❍	❍	❍
There is enough evidence that climate is changing.	❍	❍	❍	❍	❍
The majority of the public distrusts scientists that work on climate-related issues.	❍	❍	❍	❍	❍

climate_change_Q2 In your opinion, what are up to 5 key areas to focus climate and agroecosystem research in the next decade?

climate_change_Q3 In your opinion, what is the ideal spatial scale to research the key areas you described above?

climate_change_Q4 In your opinion, how long (in years) should a funding cycle be to research climate change (please enter a numeric value)?

climate_change_Q5 Please indicate your level of agreement with the following statements in terms of climate change and agroecosystem science.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Climate change mitigation and/or adaptation strategies are on track and desired outcomes will be forthcoming.	❍	❍	❍	❍	❍
Climate change mitigation and/or adaptation strategies should focus on maximizing resilience rather than relying on climate model projections.	❍	❍	❍	❍	❍
Climate change policy should focus on promoting collective action.	❍	❍	❍	❍	❍
Climate model projections reflect too large of a scale to be useful to stakeholders.	❍	❍	❍	❍	❍
Climate model projections should focus on refining model accuracy to reduce the range of model outputs.	❍	❍	❍	❍	❍
Climate model projections should not be used to inform mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Disinformation campaigns contribute to the lack of climate change mitigation and/or adaptation strategy implementation.	❍	❍	❍	❍	❍
Media support is necessary for development of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Media support is necessary for implementation of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Policymakers need comprehensible scientific input to inform their decision making.	❍	❍	❍	❍	❍
Policymakers should frame climate change policy on the long-term consequences of inaction.	❍	❍	❍	❍	❍
Policymakers should frame climate change policy on the short-term benefits of immediate action.	❍	❍	❍	❍	❍
Political support is necessary for development of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Political support is necessary for implementation of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Public scientific illiteracy contributes to the lack of climate change mitigation and/or adaptation strategy implementation.	❍	❍	❍	❍	❍
Public support is necessary for development of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍
Public support is necessary for implementation of climate change mitigation and/or adaptation strategies.	❍	❍	❍	❍	❍

climate_change_Q6 Please indicate your level of agreement with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Scientists have a responsibility to society to provide scientific input to policymakers.	❍	❍	❍	❍	❍
Scientists have a responsibility to society to provide scientific input to the public.	❍	❍	❍	❍	❍
Scientists should advocate for climate change mitigation and/or adaptation policy.	❍	❍	❍	❍	❍
Scientists should conduct agricultural stakeholder needs assessments.	❍	❍	❍	❍	❍
Scientists should contribute to climate change mitigation and/or adaptation policy.	❍	❍	❍	❍	❍
Scientists should develop/create climate change mitigation and/or adaptation policy.	❍	❍	❍	❍	❍
Scientists should distinguish between uncertainty and variability when communicating with nonscientists.	❍	❍	❍	❍	❍
Scientists should drive climate change mitigation and/or adaptation solutions.	❍	❍	❍	❍	❍
Scientists should never refer to known variation as uncertainty.	❍	❍	❍	❍	❍
Scientists should receive training on how to communicate scientific findings to nonscientists.	❍	❍	❍	❍	❍

Section 2: Stakeholders

We seek to understand how information is disseminated to the following stakeholders. Stakeholders are persons or groups that have an interest or concern in your work topic(s), finding(s), and/or outcome(s). Please answer the following questions regarding stakeholders.

stakeholder_Q1 Have you received formal training on how to communicate with stakeholders?

- ❍ No
- ❍ Yes

Display: If respondent selected "Yes" to stakeholders_Q1, stakeholders_Q2 would display.

stakeholder_Q2 Please describe the *formal* training you received on communicating with stakeholders.

stakeholder_Q3 Please describe any *informal* training and/or research you have done to improve your ability to communicate with stakeholders.

stakeholder_Q4 Please select the following stakeholders that you currently or previously worked with (check all that apply). If none, click the next arrow (>>) to skip.

- ❑ Agribusinesses
- ❑ Crop advisors
- ❑ Crop and/or livestock producers
- ❑ General public
- ❑ Policymakers

In the following section you will receive a series of questions that correspond to the stakeholder(s) you selected in the previous section.

Display: If respondent selected more than one stakeholder in stakeholder_Q1, stakeholder_Q4 would display.

stakeholder_Q5 In the previous section you indicated that you worked with multiple stakeholders, in an attempt to shorten this survey we will ask you a series of questions regarding the stakeholder that is your main priority, which stakeholder is your main priority?

- ❍ Agribusinesses
- ❍ Crop advisors
- ❍ Crop and/or livestock producers
- ❍ General public
- ❍ Policymakers

Display: If respondent selected agribusiness in stakeholder_Q4 as single response, stakeholder_Q5 as the primary stakeholder, or in multi-stakeholder_2, display agribusiness questions 1-5.

Agribusinesses

agribusiness_Q1 How far (in years) would you model climate projections to maximize usefulness to *agribusinesses* (please enter a numeric value)?

agribusiness_Q2 In your opinion, what is the fundamental challenge in communicating climate change issues to *agribusinesses*?

agribusiness_Q3 How likely are you to use the following terms/phrases when talking to *agribusinesses* about climate change?

	Extremely unlikely	Unlikely	Neither likely nor unlikely	Likely	Extremely likely
Climate change	❍	❍	❍	❍	❍
Climate debate	❍	❍	❍	❍	❍
Climate variability	❍	❍	❍	❍	❍
Error	❍	❍	❍	❍	❍
Extreme weather	❍	❍	❍	❍	❍
Global warming	❍	❍	❍	❍	❍
Green development	❍	❍	❍	❍	❍
Greenhouse gases	❍	❍	❍	❍	❍
Heterogeneity	❍	❍	❍	❍	❍
Holistic approach	❍	❍	❍	❍	❍
Long-term weather	❍	❍	❍	❍	❍
Manmade and/or human made	❍	❍	❍	❍	❍
Negative trend	❍	❍	❍	❍	❍
Positive trend	❍	❍	❍	❍	❍
Rapid change	❍	❍	❍	❍	❍
Resiliency	❍	❍	❍	❍	❍
Social-ecological systems	❍	❍	❍	❍	❍
Stress	❍	❍	❍	❍	❍
Sustainability	❍	❍	❍	❍	❍
Theory	❍	❍	❍	❍	❍
Uncertainty	❍	❍	❍	❍	❍
Unusual weather	❍	❍	❍	❍	❍
Variability	❍	❍	❍	❍	❍
Weather variability	❍	❍	❍	❍	❍

agribusiness_Q4 Are there terms/phrases that you *avoid* using when talking to *agribusinesses* about climate change?

agribusiness_Q5 In your opinion, what would the majority of *agribusinesses'* level of agreement be with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	o	o	o	o	o
Earth's climate conditions occur in a cyclical pattern.	o	o	o	o	o
Even if climate changes, we cannot predict what those changes will be in the future.	o	o	o	o	o
Climate change is happening.	o	o	o	o	o
Earth's climate always changes.	o	o	o	o	o
Human activities are contributing to climate change.	o	o	o	o	o
Human activities are the primary driver of climate change.	o	o	o	o	o
Climate change will not affect the way that agribusinesses operate.	o	o	o	o	o
There is enough evidence that climate is changing.	o	o	o	o	o
Agribusinesses distrust scientists that work on climate-related issues.	o	o	o	o	o

Display: If respondent selected crop advisors in stakeholder_Q4 as single response, stakeholder_Q5 as the primary stakeholder, or in multi-stakeholder_2 , display crop advisor questions 1-5.

Crop Advisors

crop_advisor_Q1 How far (in years) would you model climate projections to maximize usefulness to *crop advisors* (please enter a numeric value)?

crop_advisor_Q2 In your opinion, what is the fundamental challenge in communicating climate change issues to *crop advisors*?

crop_advisor_Q3 How likely are you to use the following terms/phrases when talking to *crop advisors* about climate change?

	Extremely unlikely	Unlikely	Neither likely nor unlikely	Likely	Extremely likely
Climate change	❍	❍	❍	❍	❍
Climate debate	❍	❍	❍	❍	❍
Climate variability	❍	❍	❍	❍	❍
Error	❍	❍	❍	❍	❍
Extreme weather	❍	❍	❍	❍	❍
Global warming	❍	❍	❍	❍	❍
Green development	❍	❍	❍	❍	❍
Greenhouse gases	❍	❍	❍	❍	❍
Heterogeneity	❍	❍	❍	❍	❍
Holistic approach	❍	❍	❍	❍	❍
Long-term weather	❍	❍	❍	❍	❍
Manmade and/or human made	❍	❍	❍	❍	❍
Negative trend	❍	❍	❍	❍	❍
Positive trend	❍	❍	❍	❍	❍
Rapid change	❍	❍	❍	❍	❍
Resiliency	❍	❍	❍	❍	❍
Social-ecological systems	❍	❍	❍	❍	❍
Stress	❍	❍	❍	❍	❍
Sustainability	❍	❍	❍	❍	❍
Theory	❍	❍	❍	❍	❍
Uncertainty	❍	❍	❍	❍	❍
Unusual weather	❍	❍	❍	❍	❍
Variability	❍	❍	❍	❍	❍
Weather variability	❍	❍	❍	❍	❍

crop_advisor_Q4 Are there terms/phrases that you *avoid* using when talking to *crop advisors* about climate change?

crop_advisors_Q5 In your opinion, what would the majority of *crop advisors'* level of agreement be with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	❍	❍	❍	❍	❍
Earth's climate conditions occur in a cyclical pattern.	❍	❍	❍	❍	❍
Even if climate changes, we cannot predict what those changes will be in the future.	❍	❍	❍	❍	❍
Climate change is happening.	❍	❍	❍	❍	❍
Earth's climate always changes.	❍	❍	❍	❍	❍
Human activities are contributing to climate change.	❍	❍	❍	❍	❍
Human activities are the primary driver of climate change.	❍	❍	❍	❍	❍
Climate change will not affect the way that crop advisors operate.	❍	❍	❍	❍	❍
There is enough evidence that climate is changing.	❍	❍	❍	❍	❍
Crop advisors distrust scientists that work on climate-related issues.	❍	❍	❍	❍	❍

Display: If respondent selected producers in stakeholder_Q4 as single response, stakeholder_Q5 as the primary stakeholder, or in multi-stakeholder_2, display producer questions 1-5.

Producers

producers_Q1 How far (in years) would you model climate projections to maximize usefulness to *crop and/or livestock producers* (please enter a numeric value)?

producers_Q2 In your opinion, what is the fundamental challenge in communicating climate change issues to *crop and/or livestock producers*?

producers_Q3 How likely are you to use the following terms/phrases when talking to *crop and/or livestock producers* about climate change?

	Extremely unlikely	Unlikely	Neither likely nor unlikely	Likely	Extremely likely
Climate change	❍	❍	❍	❍	❍
Climate debate	❍	❍	❍	❍	❍
Climate variability	❍	❍	❍	❍	❍
Error	❍	❍	❍	❍	❍
Extreme weather	❍	❍	❍	❍	❍
Global warming	❍	❍	❍	❍	❍
Green development	❍	❍	❍	❍	❍
Greenhouse gases	❍	❍	❍	❍	❍
Heterogeneity	❍	❍	❍	❍	❍
Holistic approach	❍	❍	❍	❍	❍
Long-term weather	❍	❍	❍	❍	❍
Manmade and/or human made	❍	❍	❍	❍	❍
Negative trend	❍	❍	❍	❍	❍
Positive trend	❍	❍	❍	❍	❍
Rapid change	❍	❍	❍	❍	❍
Resiliency	❍	❍	❍	❍	❍
Social-ecological systems	❍	❍	❍	❍	❍
Stress	❍	❍	❍	❍	❍
Sustainability	❍	❍	❍	❍	❍
Theory	❍	❍	❍	❍	❍
Uncertainty	❍	❍	❍	❍	❍
Unusual weather	❍	❍	❍	❍	❍
Variability	❍	❍	❍	❍	❍
Weather variability	❍	❍	❍	❍	❍

producers_Q4 Are there terms/phrases that you *avoid* using when talking to *crop and/or livestock producers* about climate change?

producers_Q5 In your opinion, what would the majority of *crop and/or livestock producers'* level of agreement be with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	❍	❍	❍	❍	❍
Earth's climate conditions occur in a cyclical pattern.	❍	❍	❍	❍	❍
Even if climate changes, we cannot predict what those changes will be in the future.	❍	❍	❍	❍	❍
Climate change is happening.	❍	❍	❍	❍	❍
Earth's climate always changes.	❍	❍	❍	❍	❍
Human activities are contributing to climate change.	❍	❍	❍	❍	❍
Human activities are the primary driver of climate change.	❍	❍	❍	❍	❍
Climate change will not affect the way that crop and/or livestock producers operate.	❍	❍	❍	❍	❍
There is enough evidence that climate is changing	❍	❍	❍	❍	❍
Crop and/or livestock producers distrust scientists that work on climate-related issues.	❍	❍	❍	❍	❍

Display: If respondent selected general public in stakeholder_Q4 as single response, stakeholder_Q5 as the primary stakeholder, or in multi-stakeholder_2, display general public questions 1-5.

General Public

public_Q1 How far (in years) would you model climate projections to maximize usefulness to the *general public* (please enter a numeric value)?

public_Q2 In your opinion, what is the fundamental challenge in communicating climate change issues to the general public?

public_Q3 How likely are you to use the following terms/phrases when talking to the general public about climate change?

	Extremely unlikely	Unlikely	Neither likely nor unlikely	Likely	Extremely likely
Climate change	❍	❍	❍	❍	❍
Climate debate	❍	❍	❍	❍	❍
Climate variability	❍	❍	❍	❍	❍
Error	❍	❍	❍	❍	❍
Extreme weather	❍	❍	❍	❍	❍
Global warming	❍	❍	❍	❍	❍
Green development	❍	❍	❍	❍	❍
Greenhouse gases	❍	❍	❍	❍	❍
Heterogeneity	❍	❍	❍	❍	❍
Holistic approach	❍	❍	❍	❍	❍
Long-term weather	❍	❍	❍	❍	❍
Manmade and/or human made	❍	❍	❍	❍	❍
Negative trend	❍	❍	❍	❍	❍
Positive trend	❍	❍	❍	❍	❍
Rapid change	❍	❍	❍	❍	❍
Resiliency	❍	❍	❍	❍	❍
Social-ecological systems	❍	❍	❍	❍	❍
Stress	❍	❍	❍	❍	❍
Sustainability	❍	❍	❍	❍	❍
Theory	❍	❍	❍	❍	❍
Uncertainty	❍	❍	❍	❍	❍
Unusual weather	❍	❍	❍	❍	❍
Variability	❍	❍	❍	❍	❍
Weather variability	❍	❍	❍	❍	❍

public_Q4 Are there terms/phrases that you *avoid* using when talking to the *general public* about climate change?

public_Q5 In your opinion, what would the majority of the *general public's* level of agreement be with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	❍	❍	❍	❍	❍
Earth's climate conditions occur in a cyclical pattern.	❍	❍	❍	❍	❍
Even if climate changes, we cannot predict what those changes will be in the future.	❍	❍	❍	❍	❍
Climate change is happening.	❍	❍	❍	❍	❍
Earth's climate always changes.	❍	❍	❍	❍	❍
Human activities are contributing to climate change.	❍	❍	❍	❍	❍
Human activities are the primary driver of climate change.	❍	❍	❍	❍	❍
Climate change will not affect the way that the general public lives.	❍	❍	❍	❍	❍
There is enough evidence that climate is changing.	❍	❍	❍	❍	❍
The general public distrusts scientists that work on climate-related issues.	❍	❍	❍	❍	❍

Display: If respondent selected policymakers in stakeholder_Q4 as single response, stakeholder_Q5 as the primary stakeholder, or in multi-stakeholder_2, display policymaker questions 1-5.

Policymakers

policymaker_Q1 How far (in years) would you model climate projections to maximize usefulness to *policymakers* (please enter a numeric value)?

policymaker_Q2 In your opinion, what is the fundamental challenge in communicating climate change issues to *policymakers*?

policymaker_Q3 How likely are you to use the following terms/phrases when talking to *policymakers* about climate change?

	Extremely unlikely	Unlikely	Neither likely nor unlikely	Likely	Extremely likely
Climate change	❍	❍	❍	❍	❍
Climate debate	❍	❍	❍	❍	❍
Climate variability	❍	❍	❍	❍	❍
Error	❍	❍	❍	❍	❍
Extreme weather	❍	❍	❍	❍	❍
Global warming	❍	❍	❍	❍	❍
Green development	❍	❍	❍	❍	❍
Greenhouse gases	❍	❍	❍	❍	❍
Heterogeneity	❍	❍	❍	❍	❍
Holistic approach	❍	❍	❍	❍	❍
Long-term weather	❍	❍	❍	❍	❍
Manmade and/or human made	❍	❍	❍	❍	❍
Negative trend	❍	❍	❍	❍	❍
Positive trend	❍	❍	❍	❍	❍
Rapid change	❍	❍	❍	❍	❍
Resiliency	❍	❍	❍	❍	❍
Social-ecological systems	❍	❍	❍	❍	❍
Stress	❍	❍	❍	❍	❍
Sustainability	❍	❍	❍	❍	❍
Theory	❍	❍	❍	❍	❍
Uncertainty	❍	❍	❍	❍	❍
Unusual weather	❍	❍	❍	❍	❍
Variability	❍	❍	❍	❍	❍
Weather variability	❍	❍	❍	❍	❍

policymaker_Q4 Are there terms/phrases that you *avoid* using when talking to *policymakers* about climate change?

policymaker_Q5 In your opinion, what would the majority of *policymakers'* level of agreement be with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Earth's climate conditions occur at random with no cycles or trends.	❍	❍	❍	❍	❍
Earth's climate conditions occur in a cyclical pattern.	❍	❍	❍	❍	❍
Even if climate changes, we cannot predict what those changes will be in the future.	❍	❍	❍	❍	❍
Climate change is happening.	❍	❍	❍	❍	❍
Earth's climate always changes.	❍	❍	❍	❍	❍
Human activities are contributing to climate change.	❍	❍	❍	❍	❍
Human activities are the primary driver of climate change.	❍	❍	❍	❍	❍
Climate change will not affect the way that policymakers operate.	❍	❍	❍	❍	❍
There is enough evidence that climate is changing.	❍	❍	❍	❍	❍
Policymakers distrust scientists that work on climate-related issues.	❍	❍	❍	❍	❍

Multi-stakeholder
Display: If respondent selected multiple stakeholders in stakeholder_Q4, display multi-stakeholder_Q1.

multi-stakeholder_1 You indicated that you worked with multiple stakeholder types. You are welcome to answer the same block of questions about communicating to other stakeholder groups. Please be aware that the remainder of this survey is a brief demographic section.

- ❍ No, I am not interested in answering additional stakeholder questions.
- ❍ Yes, I am interested in answering the five stakeholder questions for additional group(s).

Display: If respondent selected "Yes, I am interested in answering the five stakeholder questions for additional group(s)." *in stakeholder_Q1, display multi-stakeholder_Q2.*

multi-stakeholder_Q2 Please select the stakeholder group(s) (check all that apply). If more than one group is displayed below, please select all the stakeholder groups that you are interested in answering the stakeholder questions for.

- ❑ Agribusinesses
- ❑ Crop advisors
- ❑ Crop and/or livestock producers
- ❑ General public
- ❑ Policymakers

Section 3: Demographics
demographic_Q1 What year were you born?

demographic _Q2 What is your gender?

Display: If respondent was identified through Project Direct Survey, display demographic_Q3.

demographic_Q3 What is your job title (check all that apply)?

- ❑ Assistant Professor
- ❑ Associate Professor
- ❑ Chair
- ❑ Dean
- ❑ Extension Specialist/Educator
- ❑ Full Professor
- ❑ Postdoctoral Associate
- ❑ Program Director/Manager
- ❑ Research Associate/Assistant Professor
- ❑ Research Staff (i.e. Scientist, Specialist, Technician, etc.)
- ❑ Other (please specify): _____

demographic_Q4 Please specify the type of scientist/professional you are (check all that apply):

- ❑ Climate scientist
- ❑ Computer scientist
- ❑ Economist
- ❑ Educator
- ❑ Engineer
- ❑ Extension specialist/educator
- ❑ Geospatial scientist
- ❑ Legal scholar/professional
- ❑ Life scientist (e.g. biologist, ecologist, botanist, zoologist, physiologist, biochemist or related subject) (please specify): _____
- ❑ Mathematician/Statistician
- ❑ Physical scientist (excluding climate scientist) (e.g. chemist, astronomer, geologist, physicist or related subject) (please specify): _____
- ❑ Public Health scientist/professional
- ❑ Social scientist (non-economist)
- ❑ Other (please specify): _____

demographic_Q5 Please indicate how many years you have been working in a climate-related field as your occupation (please enter a numeric value):

demographic_Q6 Please indicate the approximate percentage of time you spend on climate-related work as part of your job (please enter a numeric value):

demographic_Q7 Please indicate the number of years you have been working in your current role (please enter a numeric value):

Display: If respondent was not identified through Project Direct Survey and not a State Climatologist, display demographic_Q8.

demographic_Q8 Do you have a role in making climate-related funding decisions in your current agency position?

- No
- Yes

Display: If respondent selected "Yes" in demographic_Q8, display demographic_Q9.

demographic_Q9 What is your current decision making role for climate-related funding?

demographic_Q10 Do you have additional comments about this survey, climate change and agroecosystem science, and/or stakeholders?

Thank you for completing this survey and providing your perspectives on climate change and agroecosystems. Once you click the next arrow (>>) your responses will be submitted. We may contact you in the future for additional input and information. For information regarding the survey, please contact Linda Prokopy (lprokopy@purdue.edu; 765-494-0825) or Jerry Hatfield (Jerry.Hatfield@ARS.USDA.GOV).