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Climate change typologies and audience segmentation among Corn Belt farmers

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Abstract: Development of natural resource user typologies has been viewed as a potentially effective means of improving the effectiveness of natural resource management engagement strategies. Prior research on Corn Belt farmers' perspectives on climate change employed a latent class analysis (LCA) that created a six-class typology—the Concerned, Uneasy, Uncertain, Unconcerned, Confident, and Detached—to develop a better understanding of farmer perspectives on climate change and inform more effective climate adaptation and mitigation outreach strategies. The LCA employed 34 variables that are generally unobservable—beliefs about climate change, experience with extreme weather, perceived risks of climate change, and attitudes toward climate action—to identify types. The research reported in this paper builds on this typology of Corn Belt farmers by exploring 33 measures of observable farm enterprise characteristics, land management practices, and farmer demographics to assess whether variations in these observable characteristics between the six farmer classes display systematic patterns that might be sufficiently distinctive to guide audience segmentation strategies. While analyses detected some statistically significant differences, there were few systematic, meaningful observable patterns of difference between groups of farmers with differing perspectives on climate change. In other words, farmers who believe that anthropogenic climate change is occurring, that it poses risks to agriculture, and that adaptive action should be taken, may look very much like farmers who deny the existence of climate change and do not support action. The overall implication of this finding is that climate change engagement efforts by Extension and other agricultural advisors should use caution when looking to observable characteristics to facilitate audience segmentation. Additional analyses indicated that the farmer types that tended to be more concerned about climate change and supportive of adaptive action (e.g., Concerned and Uneasy) reported that they were more influenced by key private and public sector actors in agricultural social networks. On the other hand, farmers who were not concerned about climate change or supportive of adaptation (e.g., the Unconcerned, Confident, and Detached groups, comprising between one-third and one-half of respondents) were less integrated into agricultural networks. This suggests that Extension and other agricultural advisors should expand outreach efforts to farmers who are not already within their spheres of influence.

Key words: adaptation—audience segmentation—climate change—farmer typology—social networks

The sustainability of corn (*Zea mays* L.)-based cropping systems under changing climatic conditions will depend in large part on how individual farmers react to climate and social signals (NRC 2010). That is, how farmers understand their agricultural systems, how they combine their own knowledge and experiences with available scientific research, and the degree to which they engage with public and private agricultural information and service providers will influence the sustainability of their own farms as well as agroecological outcomes at the watershed and larger regional scales. Under an increasingly variable climate and concomitant extreme weather events, the vulnerability of individual systems, agriculture, and the larger agroecosystem to climate change is dependent upon collective adaptive actions (Walthall et al. 2012). Adaptive actions are changes in practices and patterns of agricultural activities that capitalize on emerging opportunities while minimizing individual and societal costs associated with negative effects (Walthall et al. 2012). Every farm has particular climatic, biophysical, economic, and social characteristics that may influence selection of crop types and varieties, and different practices and management strategies. Although scientific evidence reveals chronic stress to agricultural production associated with extreme precipitation events, high temperatures, drought, and shifts in climate conditions, farmers' responses to climate information and adaptation have been heterogeneous and relatively limited (Arbuckle et al. 2014; Haigh et al. 2015; Loy et al. 2013; Prokopy et al. 2015). This suggests that Extension and crop advisors as well as policymakers would be better equipped to help farmers adapt if they had a better understanding of their perspectives on climate change.

Prior research by Arbuckle et al. (2014) revealed a heterogeneity among Corn Belt farmers' perspectives on climate change by employing a latent class analysis (LCA) that identified and labeled six classes of farmers—the Concerned, Uneasy, Uncertain, Unconcerned, Confident, and Detached—based on their beliefs about climate change, experience with extreme weather, perceived risks of climate change, and attitudes toward climate action. The primary research objective of Arbuckle et al. (2014) was to develop a better understanding of farmer perspectives on climate change to inform more effective climate adaptation and mitigation outreach strategies. Although the identification of the six-class typology has been employed to inform other research on effectiveness of outreach (Wandersee 2016), the variables employed in the LCA approach were primarily unobservable, intangible traits that cannot readily be used to segment farmers for targeted outreach and Extension programming. While valuable in understanding farmers' decisions and actions, beliefs and risk perceptions regarding climate change are invisible until expressed, may be a highly

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sensitive subject, and may not be a good starting point from which to initiate information exchanges about best management practices (BMPs) for climate change adaptation and mitigation.

The research reported here uses observable farm and farmer characteristics to evaluate differences and similarities between the six Corn Belt farmer types identified in Arbuckle et al. (2014). The overall research question is the following: do observable traits of the six climate perspectives groups vary in systematic, meaningful ways that Extension, crop advisors, and other agricultural actors could use to inform the development of audience-segmented engagement strategies, as recommended by Maibach et al. (2011)? If the six "climate perspective groups" vary systematically on observable variables such as farm characteristics or land management practices, those characteristics might be employed to guide targeted outreach campaigns.

Typology Research for Agricultural Extension. Recent research conducted to inform farmer outreach and engagement strategies has employed techniques that account for farmer heterogeneity. Improved understanding of this heterogeneity has been used to develop recommendations for educational strategies and technical support linking farmers and their advisers (Morton et al. 2016). Farmer typology research seeks ways to classify farmers as "types" in order to quantify the impact of various structural and perception-oriented variables on their behaviors (or intentions) toward a particular management situation (Barnes and Toma 2012). Typologies also can provide an analytical structure for assessing potential linkages between different measures of influence (Andersen et al. 2007). As such, typology research may assist in the development of targeted, directed outreach programming that accounts for specific information needs, interests, and infrastructural capacity, thereby improving program effectiveness and impact (Emtage et al. 2007; Arbuckle et al. 2014).

Typology research in agricultural decision-making is wide-ranging, and in the Corn Belt region has focused on how different types of farmers might support or otherwise react to policy reform (Briggeman et al. 2007), behave in certain ways regarding specific conservation actions (Daloğlu et al. 2014), or undertake certain production activities such as biomass management (Skevas et al. 2014). Despite the broad appeal of typology research, depending upon the type of data used (e.g., observed versus unobserved data), there can be concerns regarding the saliency of typologies (as noted in Hyland et al. [2016]), as well as limits to their use due to a lack of robust validation (Guillum et al. 2012). Farmer perception-based typologies in particular have been criticized for not accurately anticipating farmer behavior, thus limiting a typology's utility in policy formulation or in directing specific programming (Guillum et al. 2012). Guillum et al. (2012) note that observed data regarding past farming strategies across time are reasonable proxies for gaining confidence in how different profiles of a typology might actually behave. Other observable factors that are correlated with farmer behavior, such as management actions in relation to experienced weather events, trends, or conditions (Morton et al. 2015) can also be utilized in various ways to validate a typology.

Six Distinct Classes of Corn Belt Farmers. A typological technique used by Arbuckle et al. (2014) assigned 4,778 farmers from 11 US Corn Belt states to discrete classes based on several dimensions of their perspectives on climate change and potential adaptation and mitigation actions. LCA was employed to develop six discrete classes (Concerned, Uneasy, Uncertain, Unconcerned, Confident, and Detached) based on responses on 34 survey items. The items measured farmers' beliefs about the existence and causes of climate change, their self-reported experience with extreme weather events, their perceptions regarding predicted impacts of climate change on agriculture, perceived efficacy (e.g., capacity to adapt to changes), and support for adaptive and mitigative action. Table 1 summarizes the results of the LCA for each conceptual domain. Results indicated that midwest farmers varied greatly in terms of beliefs, experiences, and risk perceptions, but had similarities on variables associated with self-confidence and support for adaptation.

The identification of these classes provided valuable information to inform engagement strategies and other typology research (Wandersee 2016; Wilke and Morton 2015; Morton et al. 2016). However, as noted above, the variables employed in the analyses were, for the most part, intangible and unobservable. The primary objective of this follow-up study is to characterize and compare farmer class groups by observable characteristics including observed local incidence of extreme weather, the composition of farm enterprises, and land management practices (especially conservation practices) used. The second objective is to assess whether the level of influence that a range of agricultural actors have on decisions farmers make regarding their agricultural practices and strategies varies by class.

Materials and Methods

Survey Data. Data were collected through a survey of farmers from 11 US Corn Belt states: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin. The survey was a collaboration between the USDA National Institute for Food and Agriculture (NIFA) grant-funded Cropping Systems Coordinated Agricultural Project (CSCAP) and Useful to Usable (U2U) project. The geographic region that the survey covered comprises more than one-third of the global corn production (USDA NASS 2011; USDA FAS 2012) and is categorized as a "major crop area" for corn and soybean (*Glycine max* L.) (USDA 1994).

The sample was drawn from the USDA National Agricultural Statistics Service (NASS) Census of Agriculture master list, which is the most comprehensive and up-to-date list of US farmers. The sample was drawn from the population of corn farmers who reported at least 33 ha (80 ac) of corn and US$100,000 gross farm income in the 2007 Census of Agriculture. These minimum production criteria were set for two reasons: (1) the projects that funded the survey were focused on enhancing the resilience of grain-based agricultural systems (see www.sustainablecorn.org; www.agclimate4u.org), and (2) larger-scale operations farm a disproportionately large amount of acreage relative to their numbers. Across the 11 states, farm operations with 2007 gross sales of at least US$100,000 represented 27% of farms with cropland, but cultivated 78% of all cropland hectares (USDA NASS 2009).

The mail survey was sent in February of 2012 to 18,707 eligible farmers. Completed surveys were received from 4,778 farmers for an effective response rate of 26%. Tests for nonresponse bias were conducted using Census of Agriculture data that NASS provided for both respondents and nonrespondents. No meaningful differences between respondents and nonrespondents were detected on 28 variables measuring

Table 1

Typology of Corn Belt farmers based on climate change beliefs, experienced extreme weather, risk perceptions, perceived efficacy, and support for action, adapted from Arbuckle et al. (2014) (*n* = 4,778).

Class and percentage in group	Climate change beliefs	Reported experience weather extremes*	Risk perceptions†	General views on efficacy and support for action‡
The Concerned: 14%	82% believed that climate change is occurring and due mostly to human activities (18.4%), equally human and natural (40.2%), or mostly natural (23.4%).	Second-highest levels of experienced weather extremes	Highest levels of concern about potential impacts of climate change	Scored lowest on efficacy measures. Most supportive of individual, private sector, and government action toward climate adaptation and greenhouse gas reduction.
The Uneasy: 25%	75% believed that climate change is occurring and due mostly to human activities (9.1%), more or less equally human and natural (45.9%), or mostly natural (20.1%).	Highest levels of experienced extremes	Second highest concern	Second lowest efficacy scores. Second highest support for action.
The Uncertain: 25%	73% believed that climate change is occurring and due mostly to human activities (8.8%), more or less equally human and natural (40.8%), or mostly natural (23.3%).	Third lowest levels of experienced extremes	Middle ground	Third lowest efficacy scores. Closely parallels the "uneasy" group's support action.
The Unconcerned: 13%	58% believed that climate change is occurring and due mostly to human activities (5.4%), more or less equally human and natural (25.7%), or mostly natural (27.0%).	Lowest levels of experienced extremes	Lowest levels of concern	Ranked third in efficacy. Middling support for action.
The Confident: 18%	54% believed there is either insufficient evidence to know if climate change is occurring (47.7%) or believed that climate change is not occurring (6.5%).	Third highest levels of experienced extremes	Third highest levels of concern	Second highest efficacy scores. Tended to not support adaption and mitigation action.
The Detached: 5%	72% believed there is either insufficient evidence to know if climate change is occurring (51.1%) or believed that climate change is not occurring (20.9%).	Second lowest levels of experienced extremes	Second lowest on concern	Highest on all measures of efficacy. Lowest on support for action.

*Experienced significant drought, problems with saturated soils or ponding, a stream/river flooding, or significant soil erosion over the five years prior to the survey (2007 to 2011); also, whether or not any streams or rivers run through their farm.

†Level of concern regarding potential problems with longer dry periods and drought; more frequent extreme rains; and increases in incidence of crop disease, flooding, weed pressure, insect pressure, heat stress on crops, saturated soils and ponding, erosion, and loss of nutrients into waterways.

‡Capacity, confidence, knowledge, and capability of maintaining a viable operation; action is associated with support for private, government, and nonprofit entities such as seed companies and government technical assistance.

farm enterprise (e.g., farm size, crops and livestock produced) and farmer (e.g., age and sex) characteristics, indicating that our sample is representative of the target population, and statistics calculated for respondents will lead to unbiased estimates of the population parameters of interest (see Arbuckle et al. [2013] for a more detailed description of the sampling and nonresponse bias analysis methods). Data on farm characteristics employed in these analyses are from the NASS master listframe database, which is constantly updated as NASS conducts other surveys (e.g., crop reporting and Agricultural Resource Management Survey). Data on farmer age were provided by NASS from the 2007 Census of Agriculture.

Observable Traits and Social Influence Variables. Thirty-three variables were employed to characterize and compare farmer class groups by observable characteristics. Variables measure dimensions of five general categories:

1. Local measurements of trends in weather extremes;
2. Land management practices that can influence vulnerability to weather extremes, such as cropping of erodible land or use of conservation practices;
3. Farm enterprise characteristics such as farm size and crop mix;
4. Farmer characteristics (age and education); and,
5. Relative influence of key agricultural actors on agricultural practice and strategy decisions.

The first four categories of variables are employed because they are (for the most part) readily observable characteristics that, if they vary by class group in systematic ways, might point to ways to identify farmers who may be more or less likely to be open to outreach on climate change and adaptive action. The final category, influence of agricultural actors, is included to examine how farmers in the different class groups were integrated into agricultural stakeholder social networks.

Weather Extremes. Experienced hazard has been shown to be related to perceived risks, attitudes toward adaptive action, and other dimensions of potential responses to future hazards (Akerlof et al. 2013; Brody et al. 2008; Myers et al. 2013; Spence et al. 2011). The LCA that generated the six-class categorization of Corn Belt farmers included self-reported experience of weather extremes, including drought, flooding, and saturated soils. For this analysis, we employ observed measures of local weather extremes rather than self-reported measures.

Six variables that measure local incidence of weather extremes are employed. The variables were constructed from the National Weather Service (NWS) Cooperative Observer (COOP) data archive, which includes daily values of minimum temperature, maximum temperature, precipitation, and snowfall. Each respondent was linked to the closest COOP station. The data archive constructed for the CSCAP-U2U survey includes all available data from January 1, 1971, through December 31, 2011. From this historical record, the incidence of extreme seasonal and daily weather events for the five-year period from 2007 to 2011 was computed. Additional data on drought extent for the same five years were obtained from the US Drought Monitor (http://droughtmonitor.unl.edu). Detailed explanations of the weather variable construction are found in Loy et al. (2013) and Morton et al. (2015).

The percentile rank of growing season total precipitation (April to September) provides an indicator of the overall tendency for unusually wet or dry seasons over this period (table 2). The sample mean of 64% indicates that the region experienced unusually wet conditions overall. A second weather variable measures the frequency of extreme daily precipitation as the percentage of days with rainfall greater than the 99th percentile from the historical record. A cumulative drought index measures the number of weeks in drought, weighted by severity.

The final three weather variables incorporate the impacts of extreme temperatures. The seasonal aridity index measures the combined impact of anomalous seasonal temperatures and precipitation. A negative aridity index indicates unusually cool and/or wet conditions. A standardized stress degree days index captures the tendency for prolonged periods of high daytime temperatures, with a positive value representing a higher incidence of hot days relative to the historical record. The final weather variable is the percentage of unusually warm nights, defined as the overnight temperature exceeding the 90th percentile from the historical record.

Land Management Practices. The variables in this category comprise four measures of land management practices and one measure of land characteristics that can influence the degree farm operation vulnerability to weather extremes (table 2). All five variables reference the year 2011. Three of the land management variables are (1) percentage of farmland planted to crops that is considered to be "highly erodible land" (HEL), (2) percentage of farmland that is "artificially drained through tile or other methods," and (3) percentage of farmland that is irrigated. For each of these questions, farmers were asked to estimate the percentage for both owned and rented land. The higher of the two estimates for each variable are used for this analysis. Additionally, a single variable measuring whether or not a stream or river flowed through any of the respondents' farmland was included.

A fourth variable measures degree of diversity in use of soil and water conservation BMPs. There is growing recognition that adaptation to increasingly variable weather will require implementation of diverse practices that address both on and off-farm impacts of weather extremes by reducing soil erosion, ameliorating nutrient loss, improving water infiltration and holding capacity, and so forth (Castellano and Helmers 2015; Drinkwater and Snapp 2007; ISU 2012; McLellan et al. 2015; Walthall et al. 2013). The survey provided a list of 18 BMPs that are recommended for adapting to the predicted impacts of climate change in the region (ISU 2012; Hatfield et al. 2013; Janowiak et al. 2016). These ranged from fairly common practices such as grassed waterways, no-till farming, and cover crops, to less common practices such as drainage water management and nitrogen (N) deficiency sensors. Survey respondents were asked to indicate whether or not they had any of 18 practices in place on the land they farmed (owned and/or rented). A summative scale that ranged from 0 to 18 was created as a simple indicator of BMP use diversity.

Each of these five variables can be considered to be related to potential vulnerability, or resilience, depending on perspective. For example, higher percentages of HEL or presence of a stream or river might be associated with greater levels of potential vulnerability, while for drainage and irrigation higher values might be associated with lower levels of potential vulnerability. Similarly, farms with a greater diversity of BMPs in place—even farms with HEL planted to crops—might be less vulnerable to weather extremes.

Farm Enterprise Characteristics. Nine variables measure farm size and crop and livestock composition (table 2). These include hectares of land owned, percentage of cropland that is rented, and hectares of land in field crops. Crop mix variables include hectares in corn, soybean, wheat (*Triticum aestivum* L.), hay, and pasture. A single measure of livestock production—number of cattle and calves—was also employed.

Farmer Characteristics. Two demographic variables are employed: age and education (table 2). Age is a continuous variable in years. Education is measured through a dichotomous variable with 1 representing a two-year college degree or greater.

Influence of Agricultural Stakeholders. The survey asked farmers to rate the degree of influence that several groups and individuals had regarding their "decisions about agricultural practices and strategies" (table 2). Influence was measured on a five-point scale from "no contact" (1) to "strong influence" (5). Stakeholder groups included private sector retailers such as fertilizer and agricultural chemical dealers and seed dealers, public sector agencies and organizations including University Extension and the USDA Natural Resources Conservation service (NRCS), NGOs such as farmer organizations, and individuals such as neighbors and other farmers.

Analytical Approach. Multivariate Analysis of Variance (MANOVA) with Games-Howell post-hoc pairwise comparisons were employed to evaluate between-group differences among the six classes (see table 1, left column for the list of classes and their labels). Five MANOVA models were run, one for each conceptually related category of variables. Table 2 presents the full sample variable means and proportions used in this analysis for reference.

Results and Discussion

The six farmer typologies in table 1 (Concerned, Uneasy, Uncertain, Unconcerned, Confident, and Detached) assigned farmers into groups based on their climate beliefs, perceptions of risk associated with climate change, and other intangible traits that are difficult or impossible to observe directly (Arbuckle et al. 2014). These farmer types are examined to find associations with five categories of readily observable traits—experienced weather extremes, land management practices, farm enterprise characteristics, and farmer demographics—as well as relative influence of key agricultural stakeholders. Tables 3, 4, and 5 present the MANOVA results. The tables provide the observed trait variable means for the Concerned, Uneasy, Uncertain, Unconcerned, Confident, and Detached groups and indicate any statistically significant differences between them.

Weather Extremes. For the weather variables MANOVA, the Wilks' Lambda statistic (Λ = 0.967, F[30, 19,070] = 5.36, p < 0.001, η^2 = 0.007) indicates that there were significant between-group differences in experience of extreme weather events. The groups had similar experiences with unusually wet growing seasons, based on the seasonal precipitation extremes variable, with the only significant difference detected between the Concerned and the Detached classes (table 3). On the daily precipitation extremes variable, the Concerned, Uneasy, Unconcerned, and Confident classes had higher group means than the Detached class, indicating that those farmers experienced heavy rainfall events more frequently, on average, than farmers in the Detached class. There were no significant differences detected for drought.

In addition to precipitation extremes, differences were detected for the variables that incorporated heat. While the region broadly saw slightly less extreme high temperatures than average during the time period in question, group means differed. The Concerned and the Confident classes had higher aridity extreme scores than the Uncertain and Unconcerned classes, and the Uneasy class had a higher mean score than the Uncertain, Unconcerned, and Confident classes (table 3). Likewise, the Concerned class experienced more stress degree day extremes than the Uncertain class, and the Uneasy class had more stress degree day extremes than the Uncertain, Unconcerned, and Confident classes. Finally, the Concerned class experienced more extreme night temperatures than all of the other groups except the Uneasy class. The Uneasy class experienced more high night temperatures than the Uncertain, Unconcerned, and Confident classes.

Land Management Practices. For the land management variables MANOVA, the Wilks' Lambda statistic (Λ = 0.932, F[25, 14,330] = 11.021, p < 0.001, η^2 = 0.014) indicates that there were some significant between-group differences in land management practices used. Several important differences between classes were noted in this category. The Concerned and Uncertain groups reported the highest levels of HEL planted to crops, at 27.1% and 26.8%, respectively (table 4). Differences were significant between the Concerned and Confident groups (19.2%), and between the Uncertain and Uneasy groups (22.2%) and the Confident group. The Uneasy and the Confident groups reported the highest percentage of land with artificial drainage (55% and 52.6%), with the former reporting higher levels than the Concerned (46.8%), Uncertain (41.9%), and Unconcerned (42.1%) groups, and the latter having significantly more drainage than the Uncertain and Unconcerned groups. The Unconcerned (16.6%) and the Detached (16.8%) groups had the highest percentages of irrigated cropland. The Unconcerned group reported significantly higher percentages than the Concerned (10%) and Uneasy (8.2%) groups. The Uncertain, Confident, and Detached groups had significantly higher percentage of irrigated land than the Uneasy group.

The Concerned group mean for the index measuring the number of BMPs in place was, at 8.0, significantly higher than that for all of the rest of the classes (table 4). The Uneasy (7.4) and the Confident (7.3) groups had higher than that of the Unconcerned (6.8) group. Finally, significantly higher proportions of the Concerned, Uneasy, Uncertain, and Confident groups reported the presence of a creek, stream, or river running through or along any of the land they farm.

Farm Enterprise Characteristics. For the farm enterprise variables MANOVA, the Wilks' Lambda statistic (Λ = 0.965, F[40, 20,773] = 4.259, p < 0.001, η^2 = 0.007) indicates that there were differences between classes in this category. Some differences between classes were detected on measures of farm size and composition. The Detached group's mean owned land area of 209 ha (517 ac) was substantially higher than that of the Concerned (147 ha [364 ac]) and the Uncertain (148 ha [365 ac]) groups (table 4). The Confident group had the highest mean area of rented land (257 ha [634 ac]), followed by the Uneasy (242 ha [598 ac]) and the Concerned (240 ha [593 ac]) groups. All three of those means were significantly higher than the means for the Uncertain (186 ha [460 ac]) and the Unconcerned (175 ha [432 ac]) groups. Considering owned and rented hectares combined, the Detached group had the highest mean, at 429 ha (1,061 ac), followed by the Confident (417 ha [1,032 ac]) and the Uneasy (394 ha [973 ac]) groups. The means for the Confident and the Uneasy groups were significantly higher than the means for the Uncertain (334 ha [825 ac]) and the Unconcerned (336 ha [830 ac]) groups.

Corn and soybean were the primary cropland uses. The Confident (204 ha [503 ac]) and Detached (198 ha [489 ac]) groups had the most land planted to corn, with the Confident group significantly higher than the Concerned, Uncertain, and Unconcerned groups, and the Detached group higher than the Uncertain group (table 4). All groups reported less land area planted to soybean than corn, with the Uneasy (140 ha [346 ac]), Confident (137 ha [338 ac]), and Concerned (136 ha [335 ac]) groups reporting the largest land area in soybean, which was significantly different than the Unconcerned (100 ha [246 ac]) and Uncertain (109 ha [269 ac]) groups. Although there was some variation in other crops (hay, wheat, and pasture) among the six classes, considerably less land area was reported to be planted to these crops. The Detached class had the largest land area in hay (19 ha [48 ac]), which was significantly different than the Concerned (11 ha [26 ac]), Uneasy (11 ha [26 ac]), Confident (12 ha [30 ac]), and Uncertain (12 ha [30 ac]) classes. The Concerned (12 ha [30 ac]) and the Uneasy (11 ha [28 ac]) classes had more land in wheat than the Uncertain (7 ha [17 ac]) and Unconcerned (6 ha [15 ac]) classes, and the Confident class reported more wheat hectares than the Unconcerned class. There were no significant differences between the six classes on pasture acres or cattle and calves.

Farmer Characteristics. For the farmer demographic variables MANOVA, the Wilks' Lambda statistic (Λ = 0.988, F[10, 8,432] =

Table 2
Means for variables used for class comparisons.

Variable	Mean	Std. dev.
Weather extremes (2007 to 2011 compared to historical record) (n = 4,778)		
Seasonal (April to September) precipitation percentile rank	64.1	11.2
Daily precipitation greater than 99th percentile (%)	1.3	0.389
Drought: Weeks in drought weighted by drought magnitude	56.27	40.799
Aridity: Combined April to September precipitation and heat index	−0.316	0.372
Stress degree days	−0.328	0.678
Historically warm nights (%)	13.2	3.1
Land management practices (n = 3,867)		
Highly erodible land planted to crops (%)	23.29	32.574
Drained (%)	48.11	40.159
Irrigated (%)	12.03	28.620
Best management practices in place (number used out of 18 possible)	7.27	2.680
Stream on land (No = 0, Yes = 1)	0.76	0.430
Farm enterprise characteristics* (n = 4,778)		
Land owned (ac)	385.37	497.043
Land rented (ac)	545.39	718.885
Land owned and rented (ac)	930.76	941.620
Corn (ac)	429.38	469.715
Soybean (ac)	309.10	331.311
All hay (ac)	29.44	77.841
Wheat (ac)	22.71	69.464
Pasture (ac)	76.23	400.148
All cattle and calves (head)	80.94	392.734
Farmer characteristics (n = 4,223)		
Age (yr)	55.34	11.204
Education (1 = two-year degree or greater; 0 = no college degree)	0.41	0.491
Influence of agricultural stakeholders† (n = 4,342)		
Farm chemical dealer (e.g., fertilizer, pesticides)	2.84	0.823
Seed dealer	2.70	0.831
Other farmers	2.51	0.818
USDA Natural Resources Conservation Service or county Soil and Water Conservation District staff	2.20	0.997
Landlord/farm management firm	2.13	1.160
Banker, insurance agent, or lawyer	1.94	1.064
Farm organizations (e.g., Farm Bureau, Corn Growers, etc.)	1.67	0.971
University Extension (e.g., local staff, campus staff and faculty, online information)	1.69	1.071
Nonfarming friends or neighbors	1.41	0.770
State climatologist	1.39	1.014
Conservation nongovernmental organization	1.08	0.931

*Farm enterprise statistics provided by the USDA National Agricultural Statistics Service from the Census master listframe database.
†Influence on "decisions about agricultural practices and strategies" was measured on a five-point scale from "no contact" (1) to "strong influence" (5).

5.083, $p < 0.001$, $\eta^2 = 0.006$) indicates that there were some statistically significant differences between classes on age and education (table 4). Farmers in the Uncertain and Unconcerned groups were about two years older, on average, than farmers in the Concerned, Uneasy, and Confident groups. For education, the only difference was between the Uncertain and the Confident groups.

Influence of Agricultural Stakeholders. Among all the comparison variables, the measures of the influence that various agricultural stakeholders have on "decisions about agricultural practices and strategies" showed the most distinct pattern (table 5). For this MANOVA, the Wilks' Lambda statistic (Λ = 0.919, F(55, 20028) = 6.691, $p < 0.001$, η^2 = 0.017) also points to statistically significant differences between classes. In general, the Concerned and the Uneasy (and to a lesser extent, the Uncertain) classes reported significantly higher levels of influence by agricultural stakeholders than the other classes. The Detached group had the lowest influence means for all stakeholders, and the Unconcerned, Confident, and Detached groups reported significantly lower influence than the Concerned, Uneasy, and Uncertain groups for almost all agricultural stakeholder groups.

Overall Evaluation. A synthesis of the MANOVA results finds a limited number of systematic, meaningful patterns of differences in observable traits between the six classes of

Table 3
MANOVA with Games-Howell post-hoc tests: weather extremes 2007 to 2011 relative to the 1940 to 2011 historical record (n = 4,778).

	Concerned	Uneasy	Uncertain	Unconcerned	Confident	Detached
Weather type	**Column A**	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**
Seasonal precipitation	64.87 F	63.77	64.14	64.35	64.05	62.32
Daily precipitation events	1.32 F	1.31 F	1.27	1.31 F	1.30 F	1.22
Drought	54.79	55.70	57.63	56.70	55.48	58.17
Aridity	−0.28 CD	−0.26 CDE	−0.36	−0.38	−0.31 CD	−0.32
Stress degree days	−0.28 C	−0.25 CDE	−0.39	−0.37	−0.34	−0.37
Warm nights	13.68 CDEF	13.56 CDE	12.93	12.84	13.04	12.98

Notes: Results indicate differences between groups at a significance level of 0.05 or lower. For each significant pair, the column letter of the category with the smaller mean appears under the category with larger mean.

Table 4
MANOVA with Games-Howell post-hoc tests: land management practices, farm characteristics, and farmer characteristics.

	Concerned	Uneasy	Uncertain	Unconcerned	Confident	Detached
Variable	**Column A**	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**
Land management practices (n = 3,867)						
Highly erodible land planted to crops (%)	27.14 E	22.24	26.84 BE	21.99	19.20	20.39
Drained (%)	46.8	55.0 ACD	41.9	42.1	52.6 CD	45.9
Irrigated (%)	9.96	8.19	12.52 B	16.55 AB	13.57 B	16.79 B
Best management practices in place	8.01 BCDEF	7.35 D	7.15	6.76	7.30 D	6.84
Stream on land (No = 0, Yes = 1)	0.81 CDF	0.84 CDEF	0.70 D	0.64	0.78 CD	0.68
Farm enterprise characteristics (n = 4,778)						
Land owned (ac)	364.32	375.22	365.14	398.17	397.71	517.06 AC
Land rented (ac)	593.04 CD	597.86 CD	460.36	431.99	634.39 CD	543.84
Land owned and rented (ac)	957.35	973.08 CD	825.49	830.15	1,032.10 CD	1,060.91
Corn (ac)	422.03	436.13 C	378.15	396.1	502.51 ACD	489.29 C
Soybean (ac)	335.36 CD	345.52 CD	268.53	245.69	337.67 CD	315.79
All hay (ac)	25.95	25.60	30.16	32.38	29.29	47.86 ABCE
Wheat (ac)	30.20 CD	27.90 CD	16.73	14.92	24.50 D	19.8
Pasture (ac)	76.55	71.62	69.32	70.88	82.35	125.53
All cattle and calves (head)	57.06	63.86	89.84	115.43	77.89	109.09
Farmer characteristics (n = 4,223)						
Age (yr)	54.42	54.49	56.39 ABE	56.84 ABE	54.54	55.85
Education (1 = two-year degree +, 0 = no college degree)	0.40	0.42	0.38 E	0.37	0.44	0.46

Notes: Results indicate differences between groups at a significance level of 0.05 or lower. For each significant pair, the column letter of the category with the smaller mean appears under the category with larger mean.

farmers. In general, the Concerned class was the most distinctive of the six. Concerned farmers were more likely to farm in areas that had experienced extreme weather, with higher levels of seasonal precipitation and extreme rain events, greater stress degree days, and more unusually warm nights over the previous five years relative to the past 40 years. They also had higher levels on variables associated with vulnerability—percentage highly erodible cropland and presence of streams—than other groups. On the other hand, the Concerned class reported more BMPs in place than any other group. Considered together, these results suggest that the Concerned class tended to farm more vulnerable land and had been taking steps to reduce that vulnerability through BMPs.

A related finding was that the Concerned and Uneasy classes had similar scores on a number of measures that set them apart from the other four classes. These two groups reported similarly low percentages of irrigated land, and similarly high proportions reported streams running through their land, relative to the other groups (table 4)—perhaps indicators that their cropland would be more vulnerable to drought and/or flooding. They had also experienced similar levels of extreme aridity, stress degree days, and warm nights. Perhaps the most striking similarity was on the agricultural stakeholder influence variables (table 5). The two groups had virtually identical scores for many of the stakeholders, and their scores were significantly higher than all other groups except the Uncertain group.

The Detached group were distinctive primarily in terms of their distance from the

Table 5
MANOVA with Games-Howell post-hoc tests: influence of agricultural stakeholders on decisions about agricultural practices and strategies (n = 4,342).

	Concerned	Uneasy	Uncertain	Unconcerned	Confident	Detached
Agricultural stakeholder group	Column A	Column B	Column C	Column D	Column E	Column F
Fertilizer/ag chemical dealer	3.04 BCDEF	2.89 DEF	2.85 F	2.76	2.75	2.60
Seed dealer	2.92 BCDEF	2.73 F	2.69	2.62	2.64	2.50
Other farmers	2.60 DF	2.59 CDF	2.50 DF	2.35	2.53 DF	2.26
USDA Natural Resources Conservation Service	2.45 CDEF	2.36 CDEF	2.23 DEF	2.00 F	2.05 F	1.54
Landlord/farm management firm	2.23 CDF	2.31 CDEF	2.05	1.90	2.14 D	1.88
Banker, insurance agent, or lawyer	2.09 DEF	2.09 DEF	1.97 DF	1.71	1.86 F	1.58
Farm organizations (e.g., Farm Bureau, Corn Growers, etc.)	1.79 DEF	1.83 CDEF	1.71 DEF	1.45 F	1.57 F	1.17
Extension	1.84 DEF	1.83 DEF	1.76 DEF	1.49 F	1.56 F	1.20
Nonfarming friends/neighbors	1.46 DF	1.50 DEF	1.43 DF	1.30	1.36 F	1.12
State climatologist	1.55 DEF	1.55 DEF	1.45 DEF	1.20 F	1.24 F	0.92
Conservation nongovernmental organization	1.18 DEF	1.17 DEF	1.14 DEF	0.95 F	0.99 F	0.71

Notes: Results indicate differences between groups at a significance level of 0.05 or lower. For each significant pair, the column letter of the category with the smaller mean appears under the category with larger mean.

Concerned and Uneasy groups on some key variables. They reported nearly double the amount of irrigated land and were significantly less likely to report a stream flowing through their farmed land (table 4). They also reported fewer BMPs. They owned substantially more acres than any of the other groups, and also reported more hay ground. Considered together, these results suggest that farmers in the Detached group may have operations that are less agroecologically and economically vulnerable than farmers in the other groups, hence their "detachment" from concerns about climate change and lack of support for adaptive action. Lower levels of vulnerability might also help to explain why the Detached group tended to report lower levels of influence from different agricultural stakeholders.

While the MANOVA analyses detected numerous statistically significant differences and pointed toward some potentially interesting patterns, when all of the variables measuring readily observable characteristics are considered together, no highly distinctive systematic patterns with major practical implications for audience segmentation appeared to emerge. Figure 1 charts group means for all of the variables, scaled to range from the minimum to the maximum observed values for each variable. The chart shows that although there are statistically significant differences between many of the group means as reported above, the means are actually quite close for most variables. In short, a primary finding of this research is that there simply may not be enough of a difference between groups on the observed variables to allow identification of farmer type and subsequent tailoring of messages or similar audience segmentation efforts.

A second, potentially useful finding is that the only variables on which consistently large spreads between means were detected were the influence variables. It is striking that the Concerned and Uneasy (and the Uncertain, to a lesser extent) groups reported substantially higher levels of agricultural stakeholder influence on their decisions regarding agricultural practices and strategies. These two groups, which represent about 40% of farmers in the region, appear to be far more engaged with and influenced by agricultural stakeholders from across the spectrum (private and public). This finding suggests that the Concerned and Uneasy (and to a lesser extent, the Confident and the Uncertain) groups are more integrated into agricultural social networks than the Confident and Detached groups. This is an important finding, as this integration may help to explain why the Concerned and Uneasy groups were more likely to be supportive of adaptive action.

The flip side of this finding is that many of the surveyed farmers (approximately one-third to one-half of the sample) appeared to be little-engaged in key agricultural social networks and did not appear to be taking significant steps to adapt. This finding indicates that Extension and other outreach stakeholders who are working to help increase adaptive (and mitigative) action need to recognize that their agrienvironmental and agronomic networks may not be engaging a substantial proportion of Corn Belt farmers. These results suggest that Extension and other stakeholders should attempt to extend their programming efforts to farmers who are not already within their spheres of influence.

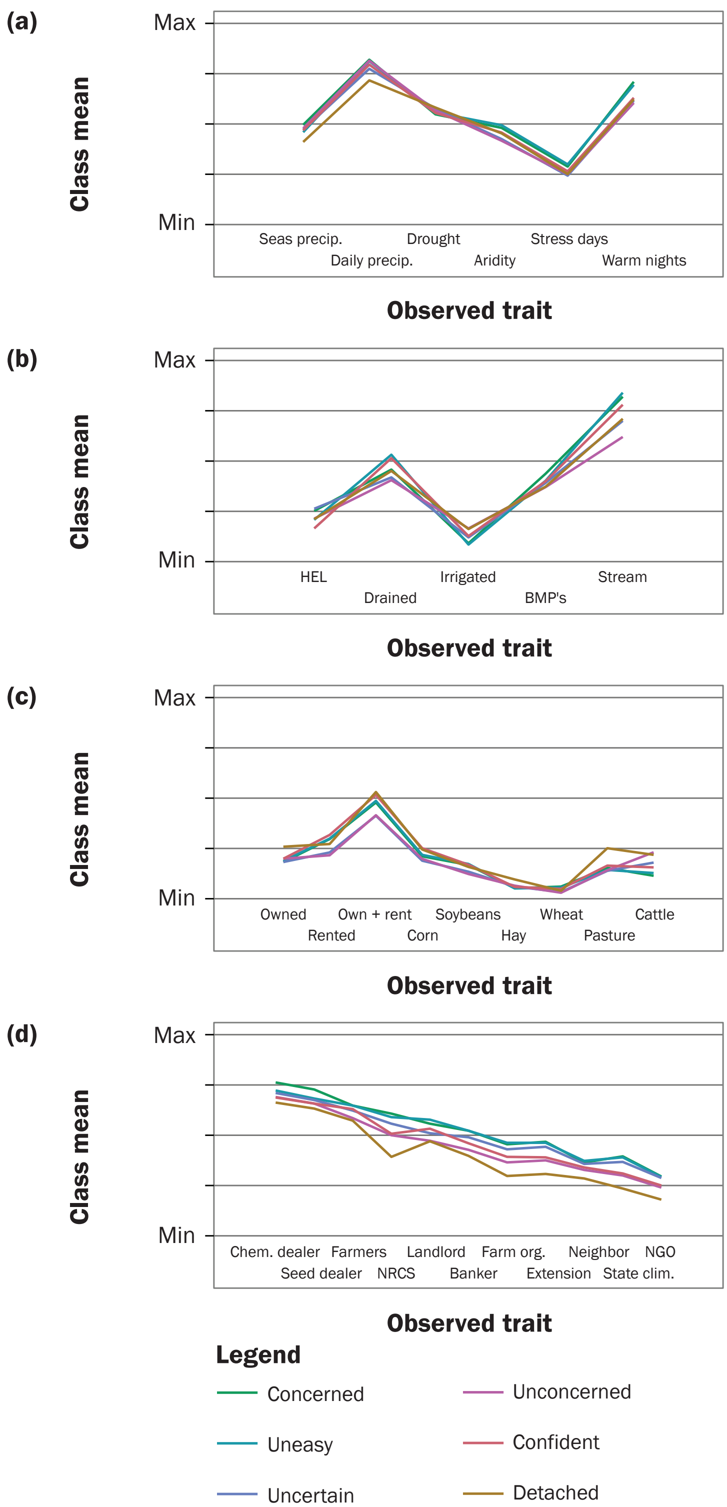
Summary and Conclusions

This research linked a farmer typology constructed from unobservable characteristics—beliefs about climate change, self-reported experience with extreme weather, perceived risks of climate change, and attitudes toward climate action (Arbuckle et al. 2014)—to a set of observed characteristics in four general categories: (1) objectively measured local trends in weather extremes, (2) land management practices, (3) farm enterprise characteristics, and (4) farmer characteristics. A fifth category—relative influence of key agricultural stakeholders on agricultural practice and strategy decisions—was also employed. The primary objective of the research was to evaluate whether Corn Belt farmers' intangible perspectives on climate change correlated with observable characteristics in systematic, meaningful ways that might be useful for guiding Extension and outreach efforts to help farmers better adapt to climate variability.

The development of typologies based on observable characteristics that represent underlying attitudes, values, and other intangible variables has been seen as a potentially fruitful strategy for improving the effectiveness of natural resource management engagement strategies for some time (Emtage et al. 2007). The idea that typology construction might help to improve outreach through audience segmentation has only recently been extended to the arena of climate change communication with the general public (Maibach et al. 2011) and

Figure 1

Summary of class means for observed traits by variable category ([a] weather; [b] land management; [c] farm characteristics; and [d] influence). The vertical axis is scaled to range from the minimum to maximum observed values for each variable. Precip. = precipitation; HEL = highly erodible land; BMP = best management practice; NGO = nongovernmental organization; NRCS = Natural Resources Conservation Service.



farmers (Arbuckle et al. 2014; Hyland et al. 2016). The results of this research, however, suggest that such typologies may have limited utility for audience segmentation among Corn Belt farmers.

The results of the research presented in this paper indicate that, at least for the variables employed in this study, there were few systematic, meaningful observable patterns of difference between groups of Corn Belt farmers with heterogeneous perspectives on climate change. In other words, farmers who believe that anthropogenic climate change is occurring, that it poses risks to agriculture, and that adaptive action should be taken may look very much like farmers who deny the existence of climate change and do not support action. The overall implication of this finding is that climate change engagement efforts by Extension and other agricultural stakeholders should use caution when looking to observable characteristics to facilitate audience segmentation.

Arbuckle et al. (2014) asserted that their typology findings could "be used to inform both targeted outreach to subgroups of farmers in this population and more broad-based engagement strategies." The findings reported here do not support the former assertion regarding targeted outreach, but do support the latter claim. The lack of systematic, meaningful patterns in observable characteristics that could facilitate audience segmentation suggests that Extension and other agricultural advisors should continue to develop communication and engagement strategies that resonate with broad swaths of farmers. However, the development of outreach strategies that engage farmers more broadly are likely to be more effective if based on the recognition that farmers have heterogeneous perspectives on climate change and potential adaptive and mitigative actions (Morton et al. 2016). Further, the finding that farmers who tended not to be supportive of climate change adaptation were also less influenced by key agricultural information providers such as university Extension, conservation agencies, and agricultural retailers suggests that these advisors may need to broaden their outreach efforts to reach those farmers who are not already engaged in their networks.

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