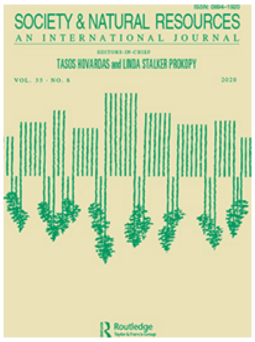

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Evaluating Nonresponse Bias in Survey Research Conducted in the Rural Midwest

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ABSTRACT
An understanding of private landowner's perceptions can guide decisions about conservation in rural landscapes. However, mailed surveys that evaluate landowner views are increasingly plagued by falling response rates and nonresponse bias. Using survey data from research conducted in the Midwestern United States in 2007 and 2017, we adapted a framework for testing nonresponse bias across demographics, attitudes, and land-use practices inferred from aerial imagery. We compared respondents and nonrespondents, early and late-respondents, low- and high-interest respondents, and our sample and published data. Across all comparisons, we found little consistent evidence of nonresponse bias, except a possible under-sampling of Amish landowners and conflicting results on gender. Many discrepancies were likely related to the sampling methodology. Because comparisons yielded conflicting results, we recommend that researchers engaged in survey research with rural communities use multiple methods to triangulate nonresponse bias to determine whether subgroups of rural populations are under-sampled.

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Mailback surveys; natural resource surveys; nonresponse bias; private land; response rates; rural communities; survey methods

Introduction

Total rural land area in the United States exceeds 70% of terrestrial systems (Lichter and Ziliak 2017). Because these places are managed primarily by private landowners, understanding management-related attitudes and beliefs is crucial for advancing conservation initiatives (Morton 2011; Miller et al. 2012). In rural contexts, the prevailing method used to assess landowner perceptions has been self-administered surveys. In a recent meta-analysis on the adoption of conservation practices in agricultural regions, over 50% of studies were self-administered mail surveys (Prokopy et al. 2019). However, survey response rates in rural areas and elsewhere have rapidly declined, raising substantive concerns about sample representativeness and nonresponse bias (Connelly, Brown and Decker 2003; Brick and Williams 2013; Stedman et al. 2019). These concerns

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are particularly salient for stakeholders from rural areas, where diminished trust between researchers and communities, heavy survey loads, aging patterns, and busy farming schedules interact to weaken data quality (Pennings, Irwin, and Good 2002). This is occurring even as social science information is urgently needed to support cross-boundary collaboration with private landowners on a multitude of environmental problems (Ives, Freeth, and Fischer 2019).

The uncertain future of survey research in light of falling response rates and nonresponse bias has gained traction in diverse literature, including work situated at the nexus of society and natural resources (e.g. Dillman 2016; Glas et al. 2018). Although some researchers have questioned whether self-administered surveys should continue to feature prominently in social science (Stedman et al. 2019), surveys remain a predominant method for addressing social-ecological problems. Therefore, in addition to developing new methods, there is a need for guidance on reducing and testing for nonresponse bias. In this paper, we review potential causes of nonresponse in rural areas, apply an adapted framework for assessing nonresponse bias using survey research conducted over a decade, and provide actionable suggestions for improving confidence in conclusions drawn from research with rural communities.

Causes of Nonresponse in Rural Survey Research

Survey research can be considered a social exchange. Decisions to respond to surveys are rooted in beliefs that benefits of responding (e.g. social, environmental, or economic gains) will eventually outweigh any costs (e.g. time, effort, privacy intrusions; Dillman, Smyth, and Christian 2014), although altruism may also explain some participation decisions (Spitzmüller et al. 2007). Benefits are not explicitly negotiated, but are developed through mutual reciprocity (Goyder, Boyer, and Martinelli 2006) and based on trustworthiness (van Riper et al. 2016). Among the many drivers of decreasing response rates, the increasing incidence of robocalls and mail and email spam may weaken sentiments of reciprocity between potential participants and researchers and influence response decisions (Hillygus 2015).

Although response rates are declining universally, environmentally focused surveys conducted in rural areas are of particular concern. Because people are more likely to participate when research feels relevant to them, survey salience may contribute to this trend (Heberlein and Baumgartner 1978). In rural contexts, environmental issues are often assumed to be less salient due to low environmental concern (Safford et al. 2012). However, rural residents do not necessarily have lower environmental concerns compared to urban counterparts, but rural individuals do tend to worry more about environmental regulation (Shoreman-Ouimet 2010). This is illustrated by a study that found the fear of Endangered Species Act regulation resulted in reticence to complete a survey about wildlife (Brook, Zint, and De Young 2003). Skepticism of outside intervention may be particularly strong within certain cultural groups, such as Indigenous or Amish people (Yost et al. 2005; Tourangeau, Edwards, and Johnson 2014), which may decrease sample representativeness. Intervention anxieties also carry implications for government institutions that sponsor rural surveys and may influence response decisions by people skeptical of a particular sponsor (Mase et al. 2015).

Demographic trends explain some changes occurring around response rates in rural regions. Rural populations are aging rapidly as younger individuals emigrate to cities (Gilbert, Coussens, and Merchant 2006). While retirees have more time to respond to surveys, they are generally less interested in participating and may experience difficulties from poor eyesight or mental fatigue (Couper 1997). This can manifest as either refusals or item nonresponse (Colsher and Wallace 1989). In the case of agricultural surveys, retired landowners who no longer farm may feel it is inappropriate to respond. Additionally, concerns that older residents may be targeted by fraudulent mail or email schemes (Grimes, Hough, and Signorella 2007) may also complicate survey response decisions. Because age may either increase or decrease response rates, evaluations of bias should include assessments of age-related patterns.

Survey loads also contribute to nonresponse rates. Rural landowners–especially farmers–experience high survey loads. Every year, the U.S. National Agricultural Statistics Services (NASS) sends surveys to thousands of farmers, including over a dozen on environmental topics (www.nass.usda.gov). Depending on how diversified their landholdings are, farmers may receive multiple NASS surveys every year (G. Thessen, *pers. com.*). Pennings, Irwin, and Good (2002) reported that farmers asked "for relief from the flood of surveys that inundate them on a daily basis" (p. 276). In addition to the survey deluge, farmers also have seasonally busy schedules that response decisions (Johansson, Effland, and Coble 2017). Survey fatigue and demanding schedules are thus likely causes of lower response rates in rural areas (Pennings, Irwin, and Good 2002).

Techniques for Assessing Nonresponse Bias

As survey response rates precipitously decline, researchers have become attuned to conducting tests of nonresponse bias (e.g. Brick and Williams 2013). Although high response rates increase the representativeness of a sample, even surveys with high response rates can experience nonresponse bias (Groves and Peytcheva 2008). One framework developed by Halbesleben and Whitman (2013) provides a useful guide that outlines options for evaluating nonresponse bias in surveys (Table 1). While this guide has only been widely used in the health sciences (e.g. Phillips, Reddy, and Durning 2016), it describes tactics that are applicable to all disciplines that involve survey research. The guide identifies options for nonresponse bias analyses depending on the availability of primary or secondary data. For example, if researchers have access to nonrespondents, there are strategies for comparing respondents and nonrespondents. Without access to nonrespondents, researchers can employ methods such as comparing samples to U.S. Census data, or in farming areas, to data from NASS.

In addition to comparisons to other data sources, researchers can assess nonresponse bias using wave and interest-level analyses (Halbesleben and Whitman 2013; Phillips, Reddy, and Durning 2016). Survey waves refer to multiple points of contact, including questionnaires or reminders. Wave analysis assumes that late-respondents are similar to nonrespondents because they are less eager to answer surveys (Choi, Ditton, and Matlock 1992). Similarly, interest-level analyses are meant to test the salience of survey topics among respondents and nonrespondents (Groves and Peytcheva 2008). If nonrespondents are not accessible, Halbesleben and Whitman (2013) recommend measuring

Table 1. Decision chart for analyzing nonresponse bias analysis in mailed surveys.

Decision framework	Analysis	Possible data sources	Critique
1. Is the original population accessible?	Follow-up analysis	• Abbreviated mail or phone surveys administered to nonrespondents • Qualitatively evaluate reasons given for partial nonresponse	Sample is likely not random
2. Do you have access to secondary data about the original population?	Archival analysis	• Land-use/land-cover inferred from aerial imagery • Plat maps showing parcel size/configuration	Unlikely to have access to attitudinal variables
3. Are there any questions that suggest reasons for nonresponse?	Interest-level analysis	• Compare low- and high-interest • Compare busier/less busy respondents • Qualitatively evaluate reasons given for partial nonresponse	Very indirect; lower-interest or busier individuals may not be more similar to nonrespondents
	Passive nonresponse analysis	• Evaluate active versus passive nonresponse using workshops and interviews	Costly
4. Were there multiple waves of data collection?	Wave analysis	• Compare early-respondents with late-respondents	Very indirect; late-respondents may not be similar to respondents
5. Is population information available?	Sample/ population comparison	• Compare to U.S. Census • Compare to USDA Census of Agriculture	Unlikely to have access to attitudinal variables and differences in sampling protocol
6. Have others published similar data?	Benchmarking	• Published literature • Longitudinal studies	Differences in sampling protocol
7. If no other options	Replication	• Replication using the same methods • Replication using new methods (e.g., intercept or phone surveys)	Costly

Adapted from Halbesleben and Whitman (2013).

interest-level by asking whether respondents would participate in future surveys. Those that say "no" are hypothesized to be "future nonrespondents" those are similar to current nonrespondents.

Existing methods for assessing nonresponse bias have shortcomings. First, some analyses (e.g. wave and interest-level) assume that certain respondents are similar to nonrespondents, which is not always true (e.g. Lankford et al. 1995). Second, comparing surveys depends on the relevance and quality of available datasets (Groves 2006) and is complicated by different sampling criteria. In such comparisons, it is impossible to distinguish nonresponse bias from inherent differences between populations. Following-up with nonrespondents is also problematic, as it is difficult to obtain random samples. For example, following-up by phone may be biased because women answer at higher rates (Jacobson, Brown, and Scheufele 2007). In general, determining whether nonrespondents are different than respondents through direct comparisons is challenging because nonrespondents are less interested in participating (Smith 2012).

Although not in the Halbesleben and Whitman (2013) decision framework, secondary data from archival analysis can provide an insight into nonrespondents who are reluctant to provide information (Shultz, Hoffman, and Reiter-Palmon 2005). For example, medical researchers can examine medical records of nonrespondents to compare to respondents (Rogelberg, Stanton, and Stanton 2007). An analog for household surveys about natural resources could be land-use differences found in publicly available spatial data. Using parcel boundaries purchased from County Assessors' offices or third-party companies, researchers could evaluate land use (e.g. extent of cropland) using the aerial imagery. To illustrate, if a survey on grassland management is less salient to landowners that only own cropland, then landowners without cropland may be over-represented in the sample. Given that survey salience is a strong predictor of participation in natural resource surveys (Stedman et al. 2019), this measure of nonresponse bias may provide another avenue for exploring nonresponse bias.

The interactions among complex drivers of participation in survey research necessitate careful consideration of nonresponse bias in rural areas. Therefore, in this study, we applied an adapted Halbesleben and Whitman (2013) decision framework to identify potential sources of nonresponse bias using survey data from a rural Midwestern community conducted in 2017 with a 32.7% response rate and in 2007 with a 51% response rate. We also compared the relative utility of each method for assessing nonresponse bias for research conducted in rural communities.

Methods

Focal Case Study

We assessed nonresponse bias using surveys conducted in the Grand River Grasslands, a 62,000-ha conservation priority area on the Iowa-Missouri border (Miller et al. 2012). About 80% of the area is private grasslands that are mostly used for cattle production (Morton et al. 2010). In recent years, landowners have increasingly engaged in programs that incentivize removing land from production and converting it into grassland (e.g. Conservation Reserve Program; Coon, Morton, and Miller 2018). Researchers, agency personnel, and landowners have been working collaboratively in the region since 2006 to foster the voluntary adoption of conservation practices, including prescribed fire and invasive species control (Miller et al. 2012).

To understand landowners' beliefs and attitudes regarding grassland management, we implemented a mixed-mode survey in 2017. This was a partial replication of a survey conducted 10 years earlier (Morton et al. 2010). The sampling universe was expanded from 6 townships in 2007 to 12 townships in 2017 to ensure the survey universe matched updated boundaries of the region used by management groups (Figure 1). We were not able to follow-up with individual landowners between survey periods. Survey methods and archival analysis were approved by the Institutional Review Boards at the University of Illinois and Iowa State University.

We censused all landowners who owned >8 ha of land (~20 ac) identified with county plat maps from Farm and Home Publishers (Belmond, IA). This size threshold was identified in collaboration with local agencies. Respondents were asked about land use, livelihoods, attitudes toward wildlife and restoration, and demographics (survey available online at ideals.illinois.edu/handle/2142/99941). Willingness to complete a

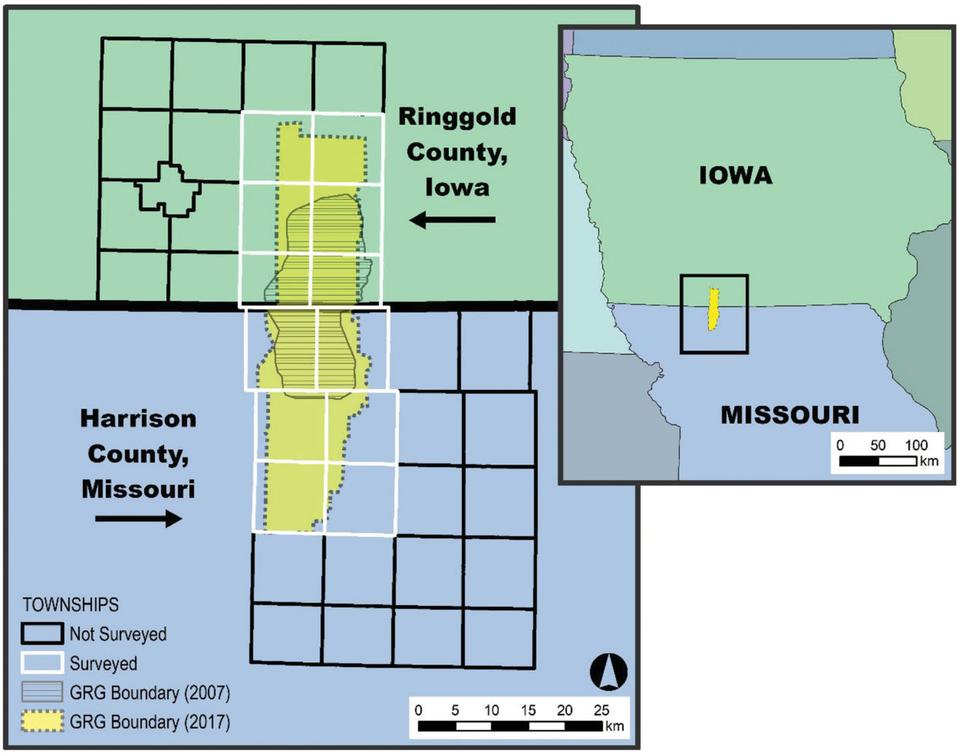

Figure 1. A map of the townships surveyed in the Grand River Grasslands conservation priority area in southern Iowa and northern Missouri.

follow-up survey was evaluated using a five-point Likert scale that ranged from "Not willing" to "Extremely willing." This served as an opportunity for respondents to opt-in to future research. Attitude items were assessed using five-point Likert scales that ranged from "Not important" to "Extremely important" and measured beliefs about the importance of management techniques and wildlife species. Data were also collected on age, size of property, income, and gender (male, female, or other). At the end of the survey, we invited respondents to provide additional information in an open-ended question.

In 2017, we used several techniques to increase response rate. First, we offered both online and mailed surveys. We also used brown envelopes, blue ink, and individually stamped and addressed correspondences (Dillman, Smyth, and Christian 2014). Both surveys occurred outside peak planting, harvest, and calving season beginning in November 2007 and February 2017. We used a modified Dillman approach in both years with five "waves" occurring at two-week intervals. In the first wave, participants were sent a postcard with a link to an online version (qualtrics.com). In 2017, local newspaper articles announcing the survey appeared concurrently with this wave. In wave two, participants were mailed a survey and cover letter explaining the importance of the study. Nonrespondents were sent reminder postcards (waves three and five), and surveys were re-sent (wave four). In 2017, we also called nonrespondents with available phone numbers ($n = 150$). During this final wave, if individuals expressed that they would not complete the survey, we asked if they would answer five questions over the phone.

Response Rate and Missing Data

From 456 eligible addresses, 149 individuals returned surveys (32.7%). We classified addresses as ineligible ($n = 58$) if mailings were returned as undeliverable or if individuals were deceased (The American Association for Public Opinion Research 2016). Only 7% responded online ($n = 11$; Figure 2). When calling nonrespondents to remind them to return the survey, 13 individuals declined to complete the survey but agreed to participate in a short phone survey (8.7% of 150 calls). Repeated calls were not made to avoid damaging relationships between residents and the research team. To clean the data, we omitted eight cases where respondents completed ≤ 2 survey sections. Average percent missing for variables used in analyses was 9%. While this dataset narrowly passed the Little (1988) missing-completely-at-random (MCAR) test ($X^2 = 809.67[752]$, $p = 0.071$), we found that older respondents completed fewer sections of the survey ($p = 0.01$). Given age-related missing values, we classified our data as missing-at-random (MAR).

Mapping Landowner Properties

To evaluate whether land-cover influenced nonresponse bias, we conducted archival analysis by obtaining digital parcel boundaries from County Assessors' Offices. We found the parcels of 141 respondents and selected a random sample of 30 nonrespondents, 15 from each county. We overlaid parcels with the most recent aerial imagery with adequate resolution to differentiate between land-cover types (Ringgold: 2013 NAIP 1-m resolution, USDA; Harrison: 2016 NAIP imagery, 0.61-m resolution, USDA) and digitized the area of trees, grassland, and cropland in ArcMap 10.6 (ESRI).

Analysis

To assess nonresponse bias, we adapted the Halbesleben and Whitman (2013) decision framework (Table 1). First, the reasons for nonresponse provided by nonrespondents were qualitatively evaluated. Next, respondents were compared to nonrespondents ($n = 13$) who answered questions by phone. Because of the small sample size, we also compared respondents to randomly selected nonrespondents ($n = 30$) using secondary archival data to assess land-use. Third, we assessed differences across survey waves by comparing early-respondents (i.e. waves 1–3) with late-respondents (i.e. waves 4–6). Fourth, interest in survey topics was assessed through respondent willingness to participate in future research, divided by those who had "no interest" and those who had at least some interest. Finally, we compared the 2017 sample to the 2007 survey administered in the same region, and to farmers in the broader region using the 2007 and 2012 USDA Census of Agriculture (NASS). We did not implement Halbesleben and Whitman's recommended passive nonresponse or survey replication methods (Table 1) due to time and cost constraints.

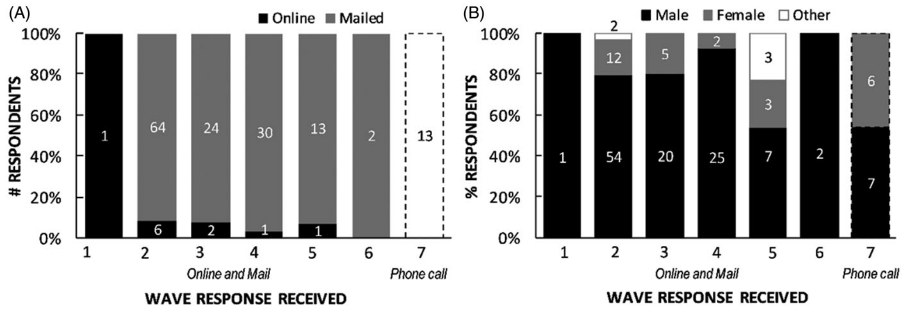

Figure 2. Survey responses from landowners living in the Grand River Grasslands from February 2017, including percentage of responses over 'waves' of the survey by online or mailed responses (A) and gender differences across waves (B). Sample size is indicated on the graph, and the bars outlined by dotted lines indicate a follow-up nonresponse questionnaire given over the phone.

We used Welch's test to compare means for continuous predictors and chi-square goodness of fit tests for categorical predictors. Dependent variables included landowner and farm characteristics and land-use on properties. Respondents that chose "other" gender ($n = 5$) were dropped from gender analyses due to a low sample size. For wave and interest-level analyses, we examined attitudes toward wildlife and grassland restoration. Interest-level was used as a dependent variable in the wave analysis. Analyses were completed in SPSS Statistics v24.

Results

Qualitative Assessment of Nonresponse

There were anecdotal observations collected during the research process that provided valuable insight on nonresponse. Several nonrespondents contacted by phone explained that they did not complete surveys because they were retired or too old to answer questions ($n = 3$), although they did not provide their age. Many respondents ($n = 47$) left written comments in the space provided for additional information. Several noted that they only filled out part of the survey because they did not farm or own grassland ($n = 3$), with one commenting "All of my land is cropland and many of the questions asked do not apply due to having only corn or soybeans for grain." A small but vocal minority ($n = 6$) expressed strong anti-academic or anti-conservation opinions, with one landowner expressing: "This endeavor as I see it is a waste of time and money and confirms many of my worst concerns about modern academics."

Nonresponse Questionnaire, Land Cover, Wave Analysis, and Interest-Level

A total of 40 tests were completed to statistically assess nonresponse bias, and 7 tests indicated significant differences ($\alpha = 0.05$). Direct comparisons between respondents and nonrespondents showed no differences for most variables (Table 2), except more women answered the nonresponse phone survey (46.1% versus 15.7%; $X^2 = 7.58$, $p = 0.023$). Almost no variables differed between early and late-respondents (Table S1, Supplementary Materials), including gender (Figure 2; $X^2 = 0.28$, $p = 0.60$) and interest-level ($X^2 = 0.16$, $p = 0.69$). However, late-respondents gave soil conservation higher importance. Interest-level was not related to land-cover or landowner characteristics, including gender ($X^2 = 0.83$, $p = 0.36$). Several attitude variables (5 tests) did vary by interest-level (Table 3), with those interested in a follow-up survey giving higher importance to deer, songbirds, game birds, restoring prairies, and soil conservation.

Comparisons to Other Data Sources

The third phase of our analysis involved comparing the 2017 and 2007 surveys with data from the Census of Agriculture. While we found similar percentages for individuals producing cattle, a number of acres owned, and rates of women participating between our two surveys (Table 4), the average age increased (62 to −66 years; Figure 2). The 2017 sample was older than the principal farm operators in the 2012 Census of Agriculture, and women and cattle producers were over-represented compared to NASS data.

Discussion

Evaluating Nonresponse in the Case Example

To test an adapted Halbesleben and Whitman framework, we broadened the evaluation of nonresponse bias beyond demographic assessments by also exploring attitudes and land use. This was accomplished using direct (e.g. respondents versus nonrespondents) and indirect statistical comparisons (e.g. early versus late-respondents, interested versus uninterested respondents), benchmarking against results from other research, and qualitative analysis of comments. Across all comparisons, we found little consistent evidence for nonresponse bias in our survey of Grand River Grasslands landowners, and in several cases found contradictory results. The main exception to this was that landowners interested in a follow-up survey consistently had more positive attitudes toward wildlife and conservation. The emergence of conflicting and inconsistent results supports recommendations that multiple assessments should be used to triangulate and contextualize potential sources of nonresponse bias (Phillips, Reddy, and Durning 2016).

When conflicting results emerged, careful consideration was necessary to ascertain impacts on data quality. For example, while we found the same percentage of cattle producers in both 2007 and 2017, both surveys had a notably higher percentage than the Census of Agriculture. This was likely due to sampling criteria, as our research was conducted in a smaller area with more cattle operations than the broader region (Miller et al. 2012). Another inconsistent result was related to age. Respondents were older than those in earlier surveys conducted in the same study region, in the same county, and in Iowa more broadly (e.g. Duffy and Johanns 2014), yet no age differences were found between early and late-respondents. We believe that observed age differences between surveys were likely related to aging trends in the rural United States, including Iowa (The Iowa Department on Aging 2018). In addition, the 2012 Census of Agriculture is based on data from farm operators sampled from a larger geographic scope, whereas our sample included all landowners from a smaller region, including retirees. Nonetheless, there is some evidence that older residents had more difficulty with the survey, with several people indicating their age made the survey challenging.

Table 2. Comparisons between survey respondents and a sample of nonrespondents who answered a subset of the survey over the phone (landowner characteristics) or between survey respondents and a random sample of nonrespondents (land-use/land-cover).

Survey item	Sample	Mean	SD	Statistic	df1	df2	Sig.
Landowner characteristics							
For how long have you/your family owned land in the region? (years)	Nonresp. ($n = 13$)	57.85	24.06	0.40	1	18.22	0.54
	Resp. ($n = 136$)	53.18	37.76				
How many acres do you own in southern IA and northern MO?	Nonresp. ($n = 12$)	450.17	481.9	0	1	13.76	0.99
	Resp. ($n = 139$)	447.31	565.53				
Age (years)	Nonresp. ($n = 12$)	71.17	13.16	1.62	1	12.45	0.23
	Resp. ($n = 134$)	66.19	11.13				
What portion of your income comes from your land? (0–100%)	Nonresp. (n = 11)	55.09	46.95	0.95	1	11.06	0.35
	Resp. ($n = 127$)	40.96	36.24				
Land-use/land-cover (ha)							
Parcel area (ha)	Nonresp. ($n = 30$)	131.7	147.4	0.278	1	47.11	0.60
	Resp. ($n = 147$)	147.8	174.1				
Crop area (ha)	Nonresp. ($n = 30$)	15.2	34.2	2.647	1	69.39	0.11
	Resp. ($n = 147$)	28.0	58.7				
Grassland area (ha)	Nonresp. ($n = 30$)	91.6	110.5	0.022	1	45.41	0.88
	Resp. ($n = 147$)	95.0	124.6				
Tree area (ha)	Nonresp. ($n = 30$)	15.6	20.8	2.436	1	51.60	0.13
	Resp. ($n = 147$)	22.5	27.2				

Due to item-level nonresponse, sample sizes will differ between variables. Statistical results are from Welch's tests.

Table 3. Comparisons between those not interested in a follow-up survey and those who were interested in a follow-up survey on the same topics.

Survey item	Sample	Mean	SD	Statistic	df1	df2	Sig.
Landowner characteristics							
Length of land ownership	Not interested ($n = 70$)	52.13	35.17	0.12	1	114.81	0.74
	Interested ($n = 59$)	54.44	41.15				
Acres owned	Not interested ($n = 71$)	378.28	463.16	2.55	1	101.02	0.11
	Interested ($n = 60$)	544.17	682.02				
Age (years)	Not interested ($n = 70$)	65.54	11.91	0.28	1	124.81	0.60
	Interested ($n = 57$)	66.54	9.31				
Portion of income from land (0–100%)	Not interested ($n = 63$)	367.00	33.49	1.39	1	111.84	0.24
	Interested ($n = 57$)	44.79	38.35				
Landowner attitudes (importance)							
Deer	Not interested ($n = 63$)	2.92	1.40	4.753	1	118.66	**0.031**
	Interested ($n = 58$)	3.47	1.35				
Bees	Not interested ($n = 66$)	3.48	1.41	2.507	1	124.37	0.12
	Interested ($n = 61$)	3.85	1.21				
Songbirds	Not interested ($n = 58$)	2.91	1.23	5.293	1	108.09	**0.023**
	Interested ($n = 53$)	3.45	1.23				
Game birds	Not interested ($n = 58$)	3.48	1.27	4.792	1	104.91	**0.031**
	Interested ($n = 50$)	3.96	0.99				
Restoring prairies/grasslands	Not interested ($n = 69$)	2.64	1.28	4.731	1	123.20	**0.032**
	Interested ($n = 58$)	3.12	1.22				
Controlling invasive plants	Not interested ($n = 71$)	3.94	1.05	1.435	1	128.88	0.23
	Interested ($n = 60$)	4.15	0.92				
Importance of reducing soil erosion	Not interested ($n = 72$)	4.21	0.79	7.105	1	125.4	**0.009**
	Interested ($n = 60$)	4.52	0.54				
Land-use/land-cover (ha)							
Crop area	Not interested ($n = 68$)	25.66	51.40	0.142	1	109.07	0.71
	Interested ($n = 59$)	29.66	65.90				
Grassland area	Not interested ($n = 69$)	82.51	99.00	2.30	1	91.08	0.13
	Interested ($n = 59$)	120.10	167.00				
Tree area (ha)	Not interested ($n = 69$)	1.65	12.37	1.02	1	68.09	0.32
	Interested ($n = 59$)	0.15	0.29				

Bold values indicate $p < 0.05$. Due to item-level nonresponse, sample sizes will differ between variables. Statistical results are from Welch's tests.

Table 4. Comparisons between data from the USDA Census of Agriculture (NASS 2007 and 2012) and data from surveys completed in the Grand River Grasslands in 2007 and 2017.

Census of agriculture			Grand River Grassland surveys		
Variable measured	2007	2012	Variable measured	2007	2017
%Farms producing cattle (Ringgold County, IA)	40.2	49.0	%Landowners producing cattle	72	70
%Women principal operators (Ringgold County, IA)	14.6	10.1	%Women	17	15
%American Indian principal operators (Ringgold County)	0.27	0.46	%American Indian	–	1
Average age (years) of principal operators (IA)	56	57	Average age (years) of landowners	62	66
Average farm size (acres) (Ringgold County, IA)	361	414	Average size (acres) of property	451	446

USDA data are at the state- or county-level (noted), 2017 survey data are from six townships of Ringgold county, IA and six from Harrison county, MO, and 2007 survey data are from four townships in Ringgold county, IA and two townships in Harrison county, MO.

Older respondents also frequently returned unfinished surveys. These findings align with other studies that found problems with eyesight or mental fatigue can result in older individuals either not responding or overlooking questions (Colsher and Wallace 1989; Quinn 2010).

The contribution of gender to nonresponse bias in our sample was also complex. While gender did not differ between survey waves or by interest-level, at first glance, phone surveys with 13 nonrespondents indicated that women were underrepresented. Although our response rate (8.6% of 150 calls) was similar to higher-effort Pew phone surveys (Keeter et al. 2017), the over-representation of women in our survey is likely due to known phone survey biases toward women (Jacobson, Brown, and Scheufele 2007). In contrast, comparisons to the 2012 Census of Agriculture indicated we *over*-sampled women. This result may be explained by the Census's focus on farm operators. Although women participate in management decisions, they often do not consider themselves "primary operators" (Nass 2012), and thus may find such surveys less relevant (Jacobson, Brown, and Scheufele 2007).

Further complicating matters, our sampling frame may have been biased toward men. If the plat maps used to determine property ownership listed married couples or two owners, we addressed the survey to both landowners. However, sometimes a man's name was listed with "*et uxor*" (Latin for "and wife"), in line with power relationships that privilege men's roles in managing farmland (Carter 2017). In these cases, the survey was by necessity addressed to the man, which may have excluded some women from the study. Importantly, in the cover letter, we asked a primary decision-maker to respond regardless of the addressee, and women sometimes returned surveys addressed to men. These observations underscore the need to carefully consider gender, sampling frames, and survey response in farming communities. In our case, the "true" number of women in the population (i.e. women making management decisions) is unknown. Thus, finding that the percentage of women in our sample fell in the range of several published percentages suggests we are close to representative gender composition.

Tests for nonresponse bias often focus on demographics like age and gender because these are replicated in multiple data sources (Peytcheva and Groves 2009). Although useful, researchers should also examine whether other relevant variables differ between respondents and nonrespondents (Heberlein and Baumgartner 1978). In our study, we found few differences in wildlife and habitat restoration attitudes between early and late-respondents, but this does not guarantee nonresponse bias was absent (Rogelberg, Stanton, and Stanton 2007). In contrast, we found that respondents who were interested in a follow-up survey had more positive views of wildlife and grassland restoration. While measuring willingness to complete a follow-up survey is a recommended method to examine nonresponse bias (Groves and Peytcheva 2008; Halbesleben and Whitman 2013), we could not find other studies that used this measure. In our case, a high number of respondents were uninterested in future surveys (60%) but still responded to the current survey. This measure was possibly complicated by anonymity concerns, as respondents were informed of the data from the current study would be confidentially linked to follow-up studies. Overall, interest-level differences are likely problematic for follow-up surveys and could not be used to confirm substantive patterns of nonresponse in the current study.

The best way to assess nonresponse bias is to directly compare respondents and nonrespondents, but it can be difficult to gain access to a random sample of nonrespondents (Halbesleben and Whitman 2013). For example, we were only able to survey 13 nonrespondents by phone (2.8% of 456 eligible households). This small sample was nonrandom and led to low statistical power. Typical indirect comparisons, such as wave analysis, can achieve larger sample sizes, but carry problematic assumptions (e.g. late respondents being similar to nonrespondents; Rogelberg, Stanton, and Stanton 2007). These concerns may be addressed by archival research that directly compares respondents and nonrespondents. Because collecting these data is not dependent on individuals' willingness to participate, samples can be randomly selected. In our study, we analyzed differences between respondents and nonrespondents in terms of land use observed via aerial imagery, and found no differences, suggesting that land use categories in the sample accurately represented the study region.

Another source for nonresponse bias in our sample was under-sampling Amish landowners. Only two people identified themselves as belonging to an Amish community in 2017, and we did not ask Amish landowners to identify themselves in 2007. Amish individuals account for approximately 8% of the population of sampled counties (Yost et al. 2005; Donnermeyer, Anderson, and Cooksey 2013). Underrepresented populations are important to consider in assessments of public opinion because these groups are affected by policy change but are rarely included in the research. An inclusive approach to conservation and management should strive to represent diverse viewpoints and adjust methodologies to make participation accessible (IPBES 2018). Unfortunately, there is limited information on how membership to a subculture might influence nonresponse bias (Groves and Peytcheva 2008). The difficulties we faced in estimating the views of Amish people may have influenced the inferences made from our research and should receive increased attention in future research.

Recommendations for Surveying Rural Americans

Because low response rates are directly related to an increased chance for nonresponse bias, falling response rates in the rural United States are likely to degrade estimates derived from survey research (Dillman 2016; Stedman et al. 2019). We found that response rates fell from 50.1% in 2007 to 32.7% in 2017, and the only changes to the protocol were the addition of methods for increasing the response rate. This is not an isolated phenomenon; other natural resource surveys conducted in the rural United States (e.g. 30%, Lambert et al. 2014; 27%, Stuart, Schewe, and McDermott 2014; 26%, Roesch-McNally, Arbuckle, and Tyndall 2018; 31%, Foelske et al. 2019) reflect a trend of lower response rates for self-administered surveys. While others have supplied advice on increasing response rates (e.g. Mangione 2014), here we specifically focus on sources and reduction strategies to evaluate nonresponse in rural survey research.

Lower response rates in rural areas may be influenced by increasing sociopolitical isolation in these regions (Harris-Kojetin and Tucker 1999). Because such isolation is highly salient in current discourse in the United States (Lichter and Ziliak 2017), it is increasingly important to consider implications for research. In our study, multiple individuals expressed anti-academic views in the margins of the questionnaire even though these topics were not referenced in any questions. The vocal response offered by some may, in part, be related to the timing of the survey in relation to the 2016 presidential election. These anecdotal data suggest that understanding the relationship between nonresponse and attitudes about the government, academia, and other survey sponsors is a valuable avenue for future research. In particular, researchers should be mindful of worries about government intervention and how that may impact nonresponse bias for environmental surveys (Brook, Zint, and De Young 2003).

Importantly, hints that sociopolitical marginalization may have impacted nonresponse did not originate from quantitative measures, but instead from exploring respondent and nonrespondent comments. Such qualitative assessments have appeared previously in methods-focused studies (e.g. Pennings, Irwin, and Good 2002; Johansson, Effland, and Coble 2017), which found that high survey loads negatively impact rural landowner response decisions. Although marginalization did not emerge as a nonresponse contributor from these studies, their findings also support the notion that providing respondents with less prescriptive, open-ended questions can allow researchers to identify and contextualize nonresponse bias.

Based on the exploration of nonresponse bias in our study region, we recommend that researchers tailor studies to rural contexts in several ways. First, because rural residents tend to be older on average, researchers should avoid using technology that could exclude this population and design short surveys with accessible formatting and large font size (Quinn 2010). Second, meaningful engagement of individuals often underrepresented in rural farm surveys, such as Amish communities, Indigenous people, and women and gender minorities, should be approached deliberately, with explicit consideration of bias from sampling frames and methodologies. Third, obtaining responses from busy individuals – like farmers – might be accomplished using gamification, which has been shown to increase response rate by making surveys fun (Pennings, Irwin, and Good 2002; Bailey, Pritchard, and Kernohan 2015). Finally, we recommend that researchers design studies with nonresponse bias in mind. This may involve adding questions that may be later used in the analysis, including open-ended questions, and specifically budgeting for follow-ups and archival data. Importantly, researchers planning nonresponse analyses must look beyond simple demographic analyses because such comparisons are not consistent indicators of attitude biases and because of the differences in sampling frames, methodology, and geographic scopes can render comparisons between some sources of demographic data uninformative.

Archival analysis should also be considered a part of the nonresponse toolkit because it shows promise for enhancing rural surveys on environmental topics. Depending on access to existing data, we have shown that archival analysis can be a cost-effective way to explore nonresponse bias. Given that past research has shown place-based values (e.g. perceived biodiversity, aesthetics) can be related to land-cover patterns (Brown 2004; van Riper et al. 2017), we used land classification as a metric to determine whether survey participation was influenced by grasslands or other land-cover types on properties. Assessing relationships between on-the-ground conditions and survey data has applications beyond nonresponse assessments by providing insight on landowner behavior. For example, we have used aerial imagery to evaluate whether land-cover on properties influenced pond management decisions (Swartz et al. 2019). While mapping land cover is not universally relevant, this method can be useful for linking survey data to land use on private land.

While our study shows the utility of using several methods to explore and contextualize nonresponse bias in surveys, we agree with other researchers that there is an urgent need to explore alternative methods in light of falling response rates (Stedman et al. 2019). For one, incentives may be used to boost the perceived benefits of responding to surveys and increase participation (Willcox, Giuliano, and Israel 2010; Glas et al. 2018). However, in some cases, incentives can increase nonresponse bias. For example, Merkle et al. (1998) found that offering a pen in exchange for participation in a poll led to more Democratic Party members to respond versus Republican Party members. The drop-off and pick-up method is a promising but resource-intensive way to achieve higher response rates and facilitate better researcher-respondent relationships (Allred and Ross-Davis 2011; Jackson-Smith et al. 2016). Intercept surveys are another alternative, where individuals are surveyed at a specific location, providing the advantages of in-person interaction and tending to have higher response rates (e.g. 95%, van Riper et al. 2017). However, while methods like intercept surveys and incentives may increase response rates, they can cost more and have their own set of sampling biases.

Conclusions

Solving complex environmental problems in rural, privately-owned landscapes must extend beyond the expertise of scientists and draw from the attitudes and experiences of private landowners (Morton 2011). Private landowners are key partners in many environmental problems, including invasive species control, soil conservation, and habitat protection (Estévez et al. 2015; Miller et al. 2012). Self-administered surveys are critical to public engagement, given that the social science information gathered in combination with ecological data can be used to facilitate outreach and cross-boundary collaboration between landowners, agencies, conservation groups, and private entities. Such surveys are cost and time efficient in rural areas with low population density (Mangione 2014). However, falling response rates and associated nonresponse bias threatens the validity of research findings drawn from rural populations. Whether falling response rates hit a "floor" or not remains to be seen – but the urgency of environmental issues means that collection of data must continue with methodological innovation. Surveys are likely to be an important component of conservation research for the foreseeable future, alongside qualitative and mixed-methods approaches (Ranjan et al. 2019). With careful consideration for nonresponse bias, surveys with lower response rates can still provide high-quality data that can be used to address these problems. We recommend that researchers working on natural resource topics in rural areas tackle nonresponse bias issues head-on by designing more accessible surveys and using multiple direct and indirect measures to test for nonresponse bias to ensure broad representation across diverse populations.

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