EVALUATING MIXED-MODE SURVEY DESIGNS FOR COLLECTING DEER AND FALL TURKEY HUNTER HARVEST DATA IN NORTH DAKOTA

by

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Bachelor of Science in Natural Resources, University of Minnesota, 2014

Master of Science, University of North Dakota, 2020

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota

August

2020

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Degree: Master of Science

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July 31, 2020

TABLE OF CONTENTS

LIST OF TABLES

Table Page

ACKNOWLEDGEMENTS

I want to sincerely thank my graduate committee for their continuous support during my time as a master's student and throughout this project. This research was funded by Federal Aid in Wildlife Restoration Project No. F17AF01063 (Study No. W-68-R-2) and administered by the North Dakota Game and Fish Department and the University of North Dakota, College of Arts and Sciences.

ABSTRACT

Achieving state wildlife agency biological goals for deer (*Odocoileus* spp.*)* and turkey (*Meleagris gallopavo*) rely on high quality data collection via hunter harvest surveys. Concomitantly, better information is needed to optimize best survey methods. From 2017 to 2019, we surveyed North Dakota, USA, deer and fall turkey hunters using a self-administered mail control survey and 3 mixed-mode internet/mail surveys to gain a better understanding of alternative survey designs that may be used to estimate harvest of game populations and inform future management efforts. Our first objective was to measure response rates across various segments of deer and fall turkey hunters in North Dakota, and across mixed-mode treatments that could easily be implemented with existing wildlife agency resources. Our second objective was to investigate and understand factors that may be associated with hunters returning certain treatment modes to further North Dakota Game and Fish Department's ability to tailor surveys to certain demographic groups and account for those over or underrepresented. We found that internet-mail and mail-internet mixed mode survey treatments resulted in significantly increased response rates than a traditional mail-only survey mode, supporting our hypothesis. We also found that hunters who successfully harvested an animal were more likely to return questionnaires shortly after the initial wave of surveying. Finally, we found that older, nonresident, and urban hunters were more likely to return questionnaires. Our research demonstrates potential use of tailored mixed-mode surveys to increase response rates, reduce bias, and potentially reduce administrative costs.

CHAPTER I

LITERATURE REVIEW

Introduction

Wildlife agencies rely on hunters to manage game species (Goddard and Miller 2009). Important to these efforts, wildlife managers must acquire information from hunters regarding hunting activities via harvest surveys (Skalski et al. 2006, Aubry and Guillemain 2019). Most management agencies use one or multiple forms of survey techniques to gather harvest information. It has been suggested that intermittent review of current methodologies used to gather harvest information should be practiced to inform sound management (Rupp et al. 2000 and Lukacs et al. 2011). Additionally, wildlife managers are tasked with adapting to new wildlife management data requirements and hunter communication preferences to maximize accuracy of hunter harvest data used in decision-making (Goddard and Miller 2009). These tasks are often compounded and constrained with robust data needs, time, and monetary costs, leading managers to search for more efficient methodologies to accomplish hunter harvest data collection goals (de Leeuw and Hox 2011, Greenlaw and Brown-Welty 2009). When considering adjustment to harvest survey strategies, wildlife mangers must review modern survey techniques, including validation of these practices (Lesser et al. 2011, Henderson and Gigliotti 2018). Here we review current hunter harvest survey practices, data needs, management goals, biases, and areas of the field lacking full reviews.

There are several survey strategies (modes) used to reach hunters after a hunting season, which are usually sent or performed on an annual basis at the close of hunting season. Survey modes depend on the goals of the researcher, tools or resources at their disposal, and the population of interest. In the U.S., deer (*Odocoileus spp*.) and turkey (*Meleagris gallopavo*) are

some of the most pursued species in North America, and have management unit levels that vary by state (Skalski et al. 2006). The availability of licenses or hunting access in each management unit and the level of precision of estimates desired by managers influence the number of survey responses needed to represent different hunter activities within these units. Specifically, the population of interest is comprised of the hunters that have purchased a license within a management unit. The licensing databases used by agencies serve as pools of license purchasers from which to randomly select a sample if a complete census is unnecessary or cost prohibitive. The specificity of the population to pull from is kept consistent from year to year if management goals and units remain unchanged. Ideally, the effect that harvest questionnaires have on a potential respondent, and the answers that they illicit, are kept consistent for comparability across years. Harvest reporting has a long history (Lukacs et al. 2011) and changes in methodology mirror that of surveys found in other fields of research. Because of the ability to use other fields of research to inform sound practices, long histories of harvest reporting, and specialization and investment into surveyed populations, it is not uncommon for harvest surveys to have good response rates. Survey research in general, however, has been plagued in the last few decades with declining response rates (Connelly et al. 2003). Wildlife managers have specific goals, traditions, needs, and limitations. Tailoring harvest and other natural resource surveys to user groups creates a unique challenge in that researchers may not have the resources to accomplish best practices. Understanding the way these challenges have influenced survey performance in other fields may elucidate solutions attractive to researchers, or help discern gaps in knowledge.

Survey Traditions

In the last several decades, survey methodology has changed. The development of new technologies has resulted in less direct contact with respondents as modes have evolved from in-person interviews to telephone calls, to mailed questionnaires (Dillman et al. 2014, Henderson and Gigliotti 2018). In recent years, single-mode, mail-based wildlife surveys have been widely used to glean responses from stakeholders (Gigliotti 2011, Decker et al. 2012).

Mail surveys have been widely used and have consistently shown satisfactory response rates compared to other survey types (Dillman et al. 2014). North Dakota hunter survey research conducted by Black (2017) suggested that 64% of the general gun hunting population preferred hunting-related contact via mail surveys. Similarly, others found that mail surveys were preferred by an older, less-educated demographic (Cornicelli and Grund 2011, Carrozzino-Lyon et al. 2013). Hunter harvest mail surveys also benefit from a convenient and accurate sampling frame given that management agencies collect postal addresses for those who purchase hunting licenses. This reliability, paired with high response rates for those above age 35 (constitutes 78% of licensed hunters in 2016; U.S. Department of the Interior and U.S. Department of Commerce 2018), results in mail surveys being widely considered the current "gold standard" for harvest surveys (Decker et al. 2012). However, mail surveys do have drawbacks. For example, mail surveys have slower turnaround times compared to other survey techniques (Lukacs et al. 2011, Decker et al. 2012, Dillman et al. 2014). Labor is also intensive with this method, including packaging, mailing, and proofing tens of thousands of surveys (Greenlaw and Brown-Welty 2009, Carrozzino-Lyon et al. 2013). Moreover, mailing expenses for postage can be costly. Personalization of survey materials to respondents, a tactic commonly used to increase response

rates, can further increase monetary and temporal costs. Mail survey recipients may also mistake their survey mailing as junk mail (Connelly et al. 2003).

Other traditional survey techniques used in research include personal interviews face-to-face or over the telephone. For face-to-face harvest surveys (such as check stations) these would usually be performed at a time when hunters are travelling through an area where they were likely to be encountered or at an access point such as a boat landing. Properly trained interviewers can obtain information directly and can ensure that questions are understood (Fricker and Schonlau 2002), but they also contain their own sorts of biases and concerns. The presence of an interviewer may affect the respondent in a way that influences their responses. This technique can also be costly requiring trained individuals to be present. A benefit for interviewing is transcription errors are minimal due to consistency with properly trained recorders and their ability to act as a guide for complicated surveys. This survey type also eliminates uncertainty from the lag period between sending and return of a survey. Another advantage of a hunter check station would be timeliness of data collection. These are often conducted during peak hunting times such as opening day of a season or a long holiday weekend concurrent with a hunting season. Respondents have better recall when being interviewed shortly after their experiences; moreover, researchers have an added opportunity for collecting biological samples or other information from harvested animals (e.g., collection of tissue for disease testing or measurements). Another advantage with face-to-face interviews, and to some extent telephone surveys, is the ability to confirm the identity of the respondent (Decker et al. 2012). Hunter harvest survey modes such as telephone interviews and hunter check stations are still commonly used in some wildlife management agencies, and implemented in 41% and 46% of 58 states and provinces, respectively in 2014 (LaBonte and Kilpatrick 2017). Face-to-face interview surveys in

other fields of research were most widely used prior to the advent of telephones and eventually internet surveys (Vaske 2011).

Trends in wildlife surveys over the last 20 years suggest that electronic web-based surveys have been gaining popularity due to their possible benefits (Rupp et al. 2000, Goddard and Miller 2009, LaBonte and Kilpatrick 2017). It has been shown that web-based surveys have the potential to reach a large demographic with reduced response time, while eliminating costs of paper and postage (Fricker and Schonlau 2002, Greenlaw and Brown-Welty 2009). Moreover, without the need for hand-written responses, labor costs can decrease because of less need for data proofing. Additionally, the design and layout of online surveys can be adjusted based on previous responses to prior questions, as they are not confined to a paper instrument. Unique, self-updating question and answer trees provide clear survey procession and can keep respondents from experiencing redundant questions that can result in confounding selections (Fricker and Schonlau 2002). Furthermore, an advantage built into web-based surveys is the ability to have incomplete surveys submitted automatically. Additionally, the ability to monitor the status of a survey after it is sent to a responder can help dispel questions about deliverability and survey abandonment among the sample. However, it has been previously demonstrated that undeliverable surveys occur more frequently in web-based than in mail-based surveys (Dillman et al. 2014). With an increasing demography of internet users and ubiquitous web survey applications, web-based surveys appear to be increasing in popularity (Dillman et al. 2014). For those reasons, along with the increased time- and cost-efficiencies, web-based surveys have been gaining popularity with researchers. However, efficacy, often measured by either overall response rates, differences in specific responses, or other recorded variables like demographics

have shown mixed results in the literature (Table 1.). A potential solution to some of these issues has been mixing modes of contact.

Mixed-mode surveys combine two or more survey modes to gain their separate advantages. Used in combination, two or more modes may be able to maximize coverage of the population of interest while saving time and money. For example, an internet survey may be used initially to gather a portion of the responses cheap and quickly, followed by another survey which has better coverage (Gigliotti 2011) and may give previously unrepresented groups a chance to respond (Lesser et al. 2011). Combining survey modes has been shown to raise response rates (Couper 2008, Greenlaw and Brown-Welty 2009, Wallen et al. 2016). Mixed-mode surveys can come in many different forms and should be selected carefully according to the population being targeted. A combination of certain modes, depending on the population, may even be able to counter one another's weaknesses (Greenlaw and Brown-Welty 2009, Carrozzino-Lyon et al. 2013, Dillman et al. 2014). Different survey modes have shown to represent demographic groups differently, such as mail surveys over-representing older age groups and internet surveys over-representing younger age groups (Table 1.). All survey types contain risks of introducing biases and error, resulting in conclusions that may not be true. Representing some surveys or questionnaires in different formats could influence responses in ways a researcher may not realize. Consideration of how new modes may influence collected data is pertinent if the data is to be considered the same or have "measurement equivalence" (de Leeuw and Hox 2011). Combining two or more modes does not ensure that biases are not present.

Table 1. Natural resources survey response rates, response differences, and demographic differences for several groups across the United States and Canada. Mail, internet, and mixed-mode return rates (RR) are shown in decimal form and followed by the initial sample size in parentheses.

State System	Author and Year published	Year surveyed	Mail RR	Internet RR	Mixed-mode RR	Response differences	Demographic differences
Oregon deer and elk hunter opinion survey	Lesser et al. 2011	2004	0.56(2,000)	-	0.45(2,000)	25% of P-values were less than 0.1 Internet vs. Mail for response rates.	Response rates for males were significantly higher than females. And rates of response for each age group were significantly different.
South Dakota turkey hunters	Gigliotti 2011	2009	0.75(1,200)	0.44(1,200)	-	25% variables significantly differed but unrelated to those of interest.	2 of the 9 were significant differences in Age and Gender between Internet and Mail responders.
Pennsylvania resident survey about outdoor recreation participation	Graefe et al. 2011	2011	(2,287)	(361)	0.21(1,600)[a]	Minimal differences in wildlife activities besides bird watching.	Age differences with internet responders being younger, more educated, and having higher incomes than mail responders.
Users of 52 National Wildlife Refuges	Sexton et al. 2011	2011	-	-	0.72(8,000+)	-	Age, education, and income differed between modes, but with small to medium effect sizes.
Virginia Department of Game and Inland Fishes wildlife management area visitors over 18	Carrozzino-Lyon et al. 2013	2009-10	0.48(1,156)	0.46(305)	-	Almost zero differences in attitudes to management questions.	Age differences with web users being younger and more educated. Mail responders were more rural living.

Louisiana waterfowl hunters	Laborde Jr. et al. 2014	2009-10	0.34(2,500)[b]	(949)[c]	-	Web users had more participation, harvest, and ranked waterfowl hunting higher than mail users.	Minimal age differences, but web users had higher incomes.
Southwestern Minnesota deer hunters	D'Angelo and Grund 2015	2012	0.59(3,600)	-	-	Only few small differences between landowners that hunt and those that don't.	-
Southwestern Minnesota landowners	D'Angelo and Grund 2015	2012	0.48(4,604)	-	-		
Texas sport fishermen	Wallen et al. 2016	2011-12	0.20(3,486)[a]	0.29(2,685)	0.63(640)	The number of days fished differed significantly between web and mail responders.	The email users were significantly younger than the other mode responders, and there was a larger proportion of female responders in the web push mode than the others.
British Columbia, CA, white sturgeon anglers from the lower Fraser River	Barrett et al. 2017	2014-15	.44(1,098)	.22(4,248)	-	Total effort and total catch significantly differed between survey modes.	-
South Dakota anglers	Henderson and Gigliotti 2018	2011	.50(1,600)	.34(81,294)	-	Negligible percent fishing differences in two license types and minimal effect sizes.	Age and sex differed significantly. Internet users were younger and had a larger proportion of males.
		2012	.53(2,700)	.32(93,114)	-		

[a] Mail with an online push.
[b] Mail with an online option.
[c] Open access convenience survey

Potential Biases in Surveys

Survey responses are inherently subject to varying degrees of bias and error. Dillman et al. (2014) suggested four types of error that must be considered and controlled: sampling, coverage, measurement, and nonresponse errors. Sampling error is essentially contained within all surveys that do not completely census a population of interest. Coverage error is when not all of the members of a population have the same chance of being contained in the sample frame. Measurement error results when the survey process is unable to obtain true or accurate information from individuals because of question ambiguity, or transcription errors. Nonresponse bias or error is an inaccuracy created by differences between respondents and non-respondents. Careful consideration of the target population and the overall goals of survey should assist with decisions on survey design aimed to reduce the probability or effect of biases. Examples of how these error sources may manifest in harvest data is contained in Table 2. Resource agencies may have ways to combat different sources of error. A complete listing of all licensed hunters in the licensing database can show what contact information is available for an individual as well as hunting license specific information, such as, management unit a license is valid in. This sort of data can be used to inform upon certain groups that may not be included when sampling has been done. Other ways to mitigate errors, such as measurement error, included cross-referencing or scanning software that flag ambiguous text on hand written responses. Some of the more often problematic sources of bias include nonresponse and coverage errors associated with hunter harvest surveys.

Table 2. Bias and error source (Dillman et al. 2014) manifestation examples in hunter harvest data collection.

Type of Error or Bias	How might these errors or biases manifest in hunter harvest data
Sampling	There is always some hunters that are not sampled so information from those hunters is never perfectly represented.
Coverage	Hunters that do not list an email address do not have the chance to be sampled for a survey sent through the internet.
Measurement	The mark recognition software that an agency uses to digitize written responses mistakes the unit of harvest as a 1 instead of the true intention of a 7.
Nonresponse	Individuals who did not return a survey harvested game at a lower rate than those who did return one resulting in an overestimate of total game harvested by the survey results.

Nonresponse error or bias is one of the most commonly unaddressed problems associated with making inferences from survey data, often leading to unrepresentativeness of the true population (Lindner et al. 2001, Dillman et al. 2014). This error, if unaddressed, will simply be unknown. Moreover, a researcher may not have the funding for additional follow-ups to assess or reduce this error (Aiken 1981). Reviews by Dooley and Lindner (2003) and Werner et al. (2007) suggest that 82% and 70% of the manuscripts they reviewed, respectively, failed to mention control or methods of analysis for addressing nonresponse bias. In a review conducted by Rupp et al. (2000), 42% of individual states using mail questionnaires for collecting harvest data reported evidence of nonresponse bias. According to other studies, the easiest way to reduce the effect of nonresponse error on precision of estimates is to increase response rates (Miller and Smith 1983, Groves 2006, Archer 2008). However, any survey that does not achieve a 100% completion and return rate is subject to potential nonresponse bias (Chen 1996). Even when high response rates are achieved, a nonresponse check should be implemented whenever possible

(Archer 2008). An accepted nonresponse check compares early to late respondents with the assumption that late respondents are more similar to nonrespondents (Armstrong and Overton 1977). However, a check involving direct comparisons between respondents and nonrespondents who replied to follow-up surveys, often via an additional contact mode, has been regarded by researchers as the most acceptable and empirically sound method for analyzing nonresponse bias (Armstrong and Overton 1977, Miller and Smith 1983, Lindner et al. 2001, Dooley and Lindner 2003, Werner et al. 2007, Archer 2008). If adequate nonresponse checks have been completed, researchers can take steps to weight results or tailor future surveys more accurately to the population. However, questions concerning comparability across different survey modes, coupled with survey sample frames of email addresses, makes correcting for these errors difficult (Sax et al. 2003, Lukacs 2007).

Coverage bias is an issue in any survey where portions of the population don't have the same chance of receiving the survey. This could be an issue for managers that do not have accurate email addresses for all members of a hunting or fishing population (Henderson and Gigliotti 2018). However, resource agencies are continuously transitioning into greater amounts of online presence. Online websites run through the managing department have increasingly been used to convey information and all-online licensing in some agencies have necessitated the use of an email address (NDGF personal communication). Moreover, in the last 10 years multiple studies have shown that mail-based surveys are still garnering more responses than web-based surveys (Barrett et al. 2017). Despite concerns, it has been shown that with proper survey design and bias checks that internet surveys can play an important role in surveying and still be representative of a population even when the percentage of members of the population providing an email address is as low as 45% (Henderson and Gigliotti 2018).

Game Management Information Needs

Specific information that is to be collected by a survey is dependent on agency goals. Collection of post-season hunter harvest data is viewed as the minimum for wildlife management agencies to make inferences (Aubry and Guillemain 2019). Game manager decisions are driven by value-based goals, science, and agency direction. Hunter harvest data is ideally collected in a scientifically robust way, and survey items relating directly to ways that managers can evaluate management goals. Specificity of questions depends on the scale at which managers are interested. Overall, questionnaires and the questions themselves are kept short, direct, specific, and consistent year to year, usually pertaining to hunter effort, location and time of the effort put forth, and harvest information. Different agencies employ different methods and shift when needed. The diversity and evolution of methods used is illustrated in a series of recent reviews of deer harvest surveying practices on the national and regional (Rupp et al. 2000, Goddard and Miller 2009, and LaBonte and Kilpatrick 2017; Table 3).

Best Practices in Harvest Surveys

Although often simple in layout, emphasis needs to be placed on the design of hunter harvest surveys to ensure they perform and are interpreted correctly while refraining from being taxing to the respondent (Skalski et al. 2006). Best survey practices are often researched in fields other than the natural resources. While not always feasible for wildlife surveys, tactics used by survey researchers in other fields may help guide survey design practices in the natural resources fields. The most accepted suggestions in surveying research are already used in wildlife surveys. Probably the most common advantageous aspects that aids harvest surveys is the familiarity with a targeted population and the simplicity of design (LaBonte and Kilpatrick 2017). Another

example is the idea that too many questions can result in respondent survey fatigue (Dillman et al. 2014, preventing a survey respondent from finishing their survey to completion. Survey

Table 3. Percentage of U.S. states and Canadian provinces using a specific deer harvest data collection technique in 1998, 2009, and 2014.

State or provinces reporting	Study	Year of survey	Mail	Internet	Telephone	In-person check stations	Self-report
48 states	Rupp et al. 2000	1998	54%	-	13%[a]	56%	19%[b]
23 eastern and central states	Goddard and Miller 2009[c]	2009	13%	44%	39%	70%	-
48 states and 8 provinces	LaBonte and Kilpatrick 2017	2014	25%[c]	64%	41%	46%	-

[a] Self-reported.
[b] Report cards.
[c] Study did not differentiate between sample questionnaires and self-reporting.

researchers attempt to overcome this by using design features, such as numbering questions in relation to the total number of questions or inserting encouragement during an interview (Dillman et al. 2014). Incomplete survey instruments can still be useful to researchers, especially if the survey was designed to begin with the most important questions (Dillman et al. 2014). Wording of questions is also very important in survey research and those that can be specified to a level in which misinterpretation is minimal is necessary (Schmidt et al. 2015). The results gained from clear questions could differ in areas with multiple hunting opportunities. Using specific wording in questions as well as italicized directions beneath questions can aid respondents in navigating a mail or internet survey. However, some agencies with long harvest

datasets may resist question wording changes in an effort to preserve comparability. Subtle tactics that were developed in other fields of research may assist managers looking to improve overall response rate with minimal effort, but other popular techniques such as providing incentives, additional waves, or increased personalization may be beyond what an agency can afford monetarily or temporally. Analyzing survey goals and available resources annually to reach those goals are only parts of harvest data collection. Additionally, understanding the group surveyed and how they will perceive those surveys, along with how cultural or technological changes will influence these interactions is necessary.

A current shift among wildlife agencies is an increase in online presence, which may make the use of online surveys more feasible for wildlife agencies. Some agencies already use the internet exclusively for purchase of licenses, and self-registration of harvested animals. This can increase the availability of email addresses for contact, which are often required when using these online services. In 2015–2018, North Dakota Game and Fish Department began phasing out paper based applications for hunting licenses and switching to an all online license system. Today, percent email address coverage of some North Dakota hunter groups increased to over 98% (NDGF personal communication), providing additional opportunities to contact hunters. Surveying deer hunters through $\geq$ 2 modes, for example, has increased in the last two decades, rising from 33% to 61% in 48 states in 1998 and 48 states and 8 Canadian provinces in 2015, respectively (Rupp et al. 2000, LaBonte and Kilpatrick 2017). Additionally, other studies depict the effects of socioeconomic status on survey results, response rates, and mode preferences (Table 1), thereby allowing managers to further tailor surveys to specific groups of hunters.

State of the Field; Gaps in the research

Routinely assessing hunter harvest data collection practices is necessary for all game management agencies to inform sound and modern management. Additionally, when investigating a change of harvest survey technique, it is not only the overall response rate that should be tested. Kilpatrick et al. (2005), for example, emphasized the differences produced when comparing one reporting system versus another on the same population of white-tailed deer hunters. In that study, estimates of harvest were up to 2.5 times greater for one reporting technique versus the other. The availability of hunter email addresses to managers is forecasted to increase in the coming years, but, if utilized, how a change of survey methods will affect varying aspects of data collection is unknown. Research conducted by Gigliotti (2011) outlined ways that mail, internet, and mixed-mode versions of two surveys may differ, and explored how the population of interest receives and perceives internet surveys would greatly benefit researchers considering their use. Additionally, it is known that hunter specialization groups differ in their preferences and response rates (Bryan 1977, Miller and Graefe 2000, Black et al. 2018). Many states implement a blanket approach to harvest surveys, despite having distinct hunter subgroups. Moreover, specific demographics of a hunter subgroup are usually unknown or unexplored. Combining knowledge of how survey methodologies have changed with research exporing tailoring to specific groups may inform better opportunities to reach hunters. Commonalities in the relevant literature regarding the consideration of implementing new or additional survey modes is the need to consider suvey logistics (Gigliotti 2011, Carrozzino-Lyon et al. 2013), results (Lesser et al. 2011, Dillman et al. 2014, Henderson and Gigliotti 2018), and reliability (Graefe et al. 2011, LaBonte and Kilpatrick 2017) on a case-by-case basis. Taking this one step further to the hunter subgroup level may provide more insight as to what factors play

into survey response, potentially making harvest surveys a more accurate and dependable tool (Goddard and Miller 2009).

We aimed to implement deer and fall turkey harvest surveys using combinations of mixed-mode mail and internet modes to understand their efficiency. Specifically, our aim was to evaluatee 3 mixed-mode survey treatments compared to a control consisting of NDGF's traditional mail survey which had been used for decades. Our objective was to measure response rates across various segments of deer and fall turkey hunters in North Dakota, and across several mixed-mode treatments that could easily be implemented with existing NDGF resources. An additional objective was to investigate and understand factors that may be associated with hunters returning certain treatment modes to further the NDGF's ability to tailor surveys to certain demographic groups and account for those over or underrepresented. We hypothesized that a mixed-mode harvest survey would provide greater returns via increased response rates when compared to control efforts. We also hypothesized that certain hunter demographic groups such as urban-living, older aged, those who successfully harvested, and nonresident North Dakota hunters would be associated with a higher likelihood of responding. Ultimately, we hoped to gain a better understanding of mixed-mode harvest surveys and to contribute to the growing literature of harvest survey design.

CHAPTER II

A COMPARISON OF MIXED-MODE SURVEY DESIGNS FOR COLLECTING DEER AND FALL TURKEY HARVEST DATA IN NORTH DAKOTA

Abstract: Achieving state wildlife agency biological goals for deer (*Odocoileus* spp.*)* and turkey (*Meleagris gallopavo*) rely on high quality data collection via hunter harvest surveys. Concomitantly, better information is needed to optimize best survey methods. From 2017 to 2019, we surveyed North Dakota, USA, deer and fall turkey hunters using a self-administered mail control survey and 3 mixed-mode internet/mail surveys to gain a better understanding of alternative survey designs that may be used to estimate harvest of game populations and inform future management efforts. Our first objective was to measure response rates across various segments of deer and fall turkey hunters in North Dakota, and across mixed-mode treatments that could easily be implemented with existing wildlife agency resources. Our second objective was to investigate and understand factors that may be associated with hunters returning certain treatment modes to further North Dakota Game and Fish Department's ability to tailor surveys to certain demographic groups and account for those over or underrepresented. We found that internet-mail and mail-internet mixed mode survey treatments resulted in significantly increased response rates than a traditional mail-only survey mode, supporting our hypothesis. We also found that hunters who successfully harvested an animal were more likely to return questionnaires shortly after the initial wave of surveying. Finally, we found that older, nonresident, and urban hunters were more likely to return questionnaires. Our research demonstrates potential use of tailored mixed-mode surveys to increase response rates, reduce bias, and potentially reduce administrative costs.

Key words: deer, harvest, hunter, *Meleagris gallopavo*, mixed-mode, North Dakota, *Odocoileus virginianus*, survey, turkey.

Introduction

Effective monitoring of a managed wildlife system requires consistent data quality that accurately reflects current states or future projection. Some of the most commonly collected and widely used data for managing game species such as white-tailed deer (*Odocoileus virginianus*) are estimates of harvest (Roseberry and Woolf 1991, Hansen 2011). Integral to these efforts is obtaining reliable data via hunter harvest surveys, which are used to estimate harvest of game populations and inform future management efforts (Skalski et al. 2006). The importance placed on harvest data and the spatial-scale at which management agencies survey hunters creates the need for robust survey data collection. However, there remain challenges associated with data collection, including inherent bias in sampling methods used to survey hunters (Schmidt et al. 2015), high temporal and monetary costs, and dated techniques retained due to management agency tradition or public influence (Hawn and Ryel 1969, Lukacs et al. 2011). Sampling of hunters rarely represents characteristics beyond that which may be found on a driver's license, precluding detail that could otherwise be useful for discerning influence on hunting season statistics. The need for faster data turnaround times or budget restrictions may limit the number of surveys implemented, further limiting detail. Additionally, agencies adapting to new methodologies may confound direct comparisons from previous years. Ultimately, these factors may negatively affect the intended purpose of harvest surveys, and subsequently the estimates derived from these surveys.

Recent research pertaining to survey methodology aimed at hunters and anglers has focused on concerns including response rates and demographic differences between internet and

mail survey recipients (Lesser et al. 2011, Gigliotti 2011, Laborde Jr. et al. 2014, Barrett et al. 2017). Researchers often assess differences between subsets of respondents typically delineated by sociodemographic groups, experiences, opinions, or whether or not a survey was returned. In other research fields, the effects of survey mode (e.g., mail vs. internet survey type) on gathering responses and influences on the responses themselves are more common (de Leeuw and Hox 2011). Sociodemographic factors that have been largely attributed to differences in survey return rates and or content of responses include: level of urbanization (Carrozzino-Lyon et. al. 2013), age of respondent (Wallen et. al. 2016, Henderson and Gigliotti 2018), familiarity or saliency of topic (Connelly et. al 2003), and education or income level (Sexton et. al. 2011, Laborde Jr. et. al. 2014).

Overall, response rates to natural resource surveys have been declining (Connelly et al. 2003), resulting in the need for managers to reassess potential impacts related to data collection techniques and analyses. Lower response rates do not necessarily mean that a survey is inaccurate, but if unexplored, there exists greater potential for results being unrepresentative of the population, resulting in error (Miller and Smith 1983). Representativeness requires robust surveying practices to discern detail at fine scales. Wildlife managers may consider identifying harvest survey contact modes that can maximize returns and subsequently discern more detail in harvest data trends. In sum, regularly assessing effectiveness of survey modes and data collection may inform managers of possible areas for improvement.

Typically, managers employ a single survey mode of contact due to logistics, cost, or tradition (Dillman 2014). Survey methods such as mail, phone, internet, or in-person interviews are all prone to some degree of bias, but mail surveys are currently considered the standard by which other methods are judged (Decker et al. 2012). However, mail surveys can be expensive,

time consuming, and biased against some age demographics (Sheldon et al. 2007). Surveying hunters of popular game species such as deer (*Odocoileus spp.*) via mail can be intensive with short turnaround times to interpret data used to inform management. Internet surveys provide an attractive alternative to wildlife managers because they may be faster and less expensive to implement (Henderson and Gigliotti 2018). However, internet surveys require a device that can access the internet, proficiency in using the device, and an email address; therefore, internet surveys may also result in differential age-related response rates (Gigliotti and Dietsch 2014) or coverage issues (Henderson and Gigliotti 2018). Despite these concerns, use and applicability of internet surveys in general continues to grow along with the U.S. population's internet access (Pai et al. 2018). The concept of mixing multiple modes of surveys, such as combining mail with internet to evaluate the benefits of each, has recently gained support (Dillman et al. 2014). Attempts to specifically assess mixed-mode survey methods for use in statewide game management are uncommon (Lesser et al. 2011).

Previous research evaluating mixed-mode surveys to natural resource user groups has yielded mixed results, with some citing acceptable response rates from over 60% (Wallen et al. 2016) and 70% (Sexton et al. 2011) to others reporting less desirable rates ranging from 34% (Laborde Jr. et. al. 2014) to 21% (Graefe et. al 2011). Some studies have demonstrated the feasibility of using mixed mail-electronic survey modes to gather data from specific resource user groups, but caution that results may not be applicable outside of these situational contexts (Lesser et al. 2011, Gigliotti 2011, Henderson and Gigliotti 2018).

The North Dakota Game and Fish Department (NDGF) is responsible for implementing hunting seasons for popular game species such as white-tailed deer, mule deer (*O. hemonius*), and wild turkey (*Meleagris gallopavo*). License allotments for these seasons vary annually,

depending on a variety of factors, including population trends, harvest in previous year, overwinter survival, fawn production, age ratios, and social carrying capacity. In recent years, turkey populations have been somewhat stable in North Dakota (Parent et al. 2015). However, North Dakota, unlike many areas of the U.S. with chronic deer over abundance (Côté et al. 2004, Bissonette et al. 2008, Kilpatrick et al. 2014, Blossey et al. 2019), deer populations have varied recently with populations slowly rebounding from consecutive severe winters (Stillings et al. 2013). Other factors contributing to deer population trends in the area include a reduction in habitat-associated land management practices due to broad-scale shelterbelt removal (Burke 2014) and Conservation Reserve Program losses (Otto et al. 2018, Nagy-Reis et al. 2019); energy development-induced land fragmentation (Kolar et al. 2017); and sporadic disease outbreaks in some parts of the state (Kreil 2013, Pybus et al. 2014).

NDGF had been using mail-based surveys to estimate deer and turkey harvest for nearly 50 and 40 years, respectively. As two of the most spatially-explicit managed game species in the state (i.e., multiple game management units), deer and turkey hunter mail surveys take up nearly half of NDGF's annual survey efforts. North Dakota deer and turkey hunter surveying is further broken into hunter subgroups, each with their own specific requirements and season timing. NDGF collects additional information within each management unit, such as any deer or antler restrictive tag specifications. This survey process has remained largely unchanged, using mailed questionnaires to sampled hunters. Within the last several decades, NDGF has been able to avoid substantially reduced response rates by providing a second follow-up wave of harvest surveys. In an effort to ensure acceptable response rates and data reliability for the long-term, NDGF has made it a goal to maintain survey participation at high levels while maximizing survey efforts in ways the agency can implement in future years. Our efforts presented here may serve to explore

concerns about potential increases in sampling bias associated with NDGF methodology, such as older individuals returning paper surveys at relatively higher rates than other age groups. Supplementation of traditional mail-based surveys with electronic questionnaires in North Dakota may be feasible to potentially increase response rates, save time and costs, and to satisfy those hunters who still desire a mail option (Black 2017) despite recent implementation of online licensing systems.

To best assess implementation of a mixed-mode harvest survey in North Dakota, it is first necessary to understand what contributes to whether or not a hunter responds to a survey. For example, North Dakota resident and nonresident hunters comprise a diverse continuum of sociodemographic traits such as type of participation (e.g., firearm vs. archery deer hunter), age, and urban or rural residency, to name a few, which may affect survey response rates (Lesser et al. 2011, and Carrozzino-Lyon et al. 2013). Deer hunting in North Dakota occurs in three different hunting seasons: rifle, archery, and muzzleloader. This produces a natural delineation in the type of hunters who participate in deer hunting because each hunter type requires varying degrees of specialization to be successful or participate (Bryan 1977). Also, some research suggests that some survey recipients do not fill out questionnaires or fill them out at different rates based on demographics. Rural areas, for example, such as those predominately found in North Dakota, have been associated with demographics that tend to have lower internet survey participation (Carrozzino-Lyon et. al. 2013). Age ranges of individuals returning surveys have also been shown to be associated with different survey modes (Gigliotti and Dietsch 2014). Younger age groups usually respond to internet surveys more readily than older age groups and some hunter groups naturally contain younger average-aged hunters and others older aged

(Ndembe et al. 2019). Identifying differences in demographics may help explain how and why some groups respond better to surveys.

After survey implementation, there is often a bulk of returns early followed by others that take longer via additional waves of contact. Some researchers suggest that late responders are more similar to nonrespondents, and these data may be used as a proxy for nonresponse checks when time or funding prohibit their use (Armstrong and Overton 1977). In harvest surveys, it is commonly assumed that those failing to respond to a harvest survey did not harvest any game (Aubry and Guillemain 2019). While not always true, this issue presents a source of unknown variation. These issues exemplify how biases may be introduced into survey research, suggesting the importance of conducting nonresponse checks (and weighting data, if necessary; Vaske 2008). Even if a nonresponse check is conducted and results are found to be representative, there is still potential for variation in responses among early and late returns (Armstrong and Overton 1977, Werner et al. 2007, Archer 2008). It remains unknown whether North Dakota hunter survey responses differ between early and late respondents throughout a survey period.

We aimed to implement deer and fall turkey harvest surveys using combinations of mixed-mode mail and internet modes to understand their efficiency. Specifically, we evaluated 3 mixed-mode survey treatments compared to a control consisting of NDGF's traditional mail survey which had been used for decades. Our objective was to measure response rates across various segments of deer and fall turkey hunters in North Dakota, and across several mixed-mode treatments that could easily be implemented with existing NDGF resources. An additional objective was to investigate and understand factors that may be associated with hunters returning certain treatment modes to further the NDGF's ability to tailor surveys to certain demographic groups and account for those over or underrepresented. We hypothesized that a mixed-mode

harvest survey would provide greater returns via increased response rates when compared to control efforts. We also hypothesized that certain hunter demographic groups such as urban-living, older aged, those who successfully harvested, and nonresident North Dakota hunters would be associated with a higher likelihood of responding. Here, we report results from these efforts to gain a better understanding of mixed-mode harvest survey use and to contribute to the growing literature of harvest survey design.

Methods

Data collection

NDGF maintains a database of licensed hunters from which we identified sampling frames for resident and nonresident deer (archery, rifle, landowner, and muzzleloader) and fall wild turkey hunters. These hunter groups were selected because they each have their own unique set of human dimensions (Black et al. 2018) and are thus thought to be representative of the population of big game hunters in North Dakota (Chad Parent, North Dakota Game and Fish Department, personal communication). The deer-archery season in North Dakota spans 129 days between September and January and is not restricted to specific hunting units (i.e., a statewide season). The deer-rifle season is a 16.5 day season in early November. Deer-rifle hunting licenses are distributed via a lottery and harvest pressure is distributed across multiple strata, including: hunting units, deer species (mule deer and white-tailed deer), and sex (antlered and antlerless). Landowners who own at least 60.7 ha (150 acres) of land in North Dakota also are eligible to hunt during the regular deer-gun season. However, they are restricted to hunting on their own property. The deer-muzzleloader season is a 17-day season starting in December. Deer-muzzleloader hunting is a statewide, white-tailed deer only season restricted to resident hunters. The fall wild turkey harvest is a 79-day season beginning in mid-October and ending in

January and harvest pressure is distributed across turkey hunting units. Hunters may take any sex of turkey using any legal firearm or bow.

NDGF exerts significant sampling effort in order to produce harvest estimates with meaningful levels of precision—generally a Type I error rate of 5% and Type II error rate of 10%—across multiple strata (hunting unit, deer species, and deer sex). For larger harvests such as the deer-archery, deer-rifle, and landowner seasons there were enough participants leftover in the sampling frame (after NDGF drew the samples needed for their harvest surveys occurring outside of this research), to draw large sample sizes (Appendix Table 4). We chose large sample sizes for hunter groups because it was unclear how participants would respond to mixed-mode treatments, and because we wanted to maintain NDGFs criteria for precision. For hunting seasons with smaller hunter numbers we aimed to census the hunter population (deer-muzzleloader, Appendix Table 4). We included all hunters of legal hunting age (any individual turning 12 years old by 31 December.

Survey instruments

Our mailed survey instrument consisted of one 21.6 x 27.9 cm (8.5 x 11 in) page with up to 8 questions related to harvest and hunting effort (Fig. 1). Survey questions pertained to season type, hunting participation, hunting location (e.g., deer management unit or county turkey hunted most), hunting effort, harvest success, date of harvest, sex and age of animal harvested, and species of animal harvested. We included an additional question on the turkey questionnaire asking hunters if they had hunted turkeys before in North Dakota. Otherwise, we used a standardized questionnaire for all deer hunter groups. We also used demographic data from NDGFs licensing database, which included: hunter address, age, sex (if available), residency, and specific unit or deer type assigned to the hunter if applicable.

We designed the self-administered questionnaire based on Dillman et al. (2014) and to maintain cohesion with questionnaires NDGF has used over the past 40 years, not all best practices recommended by Dillman et al. (2014) could be adopted. Incentives, penalties, or additional reminder card mailings are either inappropriate for use in NDGF surveys, which are voluntary, or temporally or cost-prohibitive. However, this tradeoff permitted NDGF to continue comparing data collected with new mixed-mode questionnaires with previous harvest surveys. Questionnaires were labeled by specific season, and included a greeting with assurance of confidentiality, reasoning for survey, and instructions. Our control mode of delivery was based on previous NDGF efforts, employing a stratified random sample for deer rifle lottery, landowner, and fall turkey hunters, a simple random sampling for archery deer hunters, and a census for muzzleloader deer hunters. NDGF implements annual hunter harvest surveys immediately following each respective season to reduce recall bias (Beaman et al. 2005), allow time for follow-up contacts, and perform necessary analyses in time for subsequent regulations to be set. We timed questionnaires arriving to recipients on the Monday following the closing weekend of each season.

Our control was comprised of a 2-wave self-administered mail survey sent via United States Postal Service (Washington, D.C., USA), and followed up with an identical survey instrument mailed 3–4 weeks later. For comparison, we implemented 3 additional mixed-mode survey treatments that included internet-mail, mail-internet and a mail-URL mode, and formatted online questions to replicate the control. The internet-mail treatment, consisted of 3 waves of internet surveys spaced 1-week apart, followed by a final mailed survey instrument arriving at week 4. The mail-internet treatment was comprised of an initial mail survey that, starting week 4, was followed by 3 waves of internet contact via email. The mail-URL treatment, was similar to

our control with the addition of a printed URL and Quick Response (QR) code with directions on how to complete an online option of the survey. We used SurveyGizmo (Boulder, Colorado, USA) to host internet portions of survey instruments, where hunters could answer questions via computers, tablets, or smart phones. Internet-mail and mail-internet hunter treatment samples were subsampled from hunters with known email addresses on file. A switch to all-electronic licensing in North Dakota in 2016 necessitated the collection of reliable email addresses from hunters, and coverage has increased annually thereafter. As of 2020, email coverage for lottery license applicants across different hunter types had reached 96%. If a hunter returned questionnaires from more than one survey wave (e.g., mail survey and later an email survey), possibly because of lag time in mail delivery, we used the first response and eliminated subsequent returns from analyses.

Data analysis

All analyses unless otherwise noted were done using the program R (Version 3.3.2, www.r-project.org). We considered all differences at $P \leq 0.05$ to be statistically significant.

Hunter attributes. We evaluated descriptive statistics pertaining to respondent demographics. We reported hunter age, sex, and area of residence (rural vs. urban) to give a snapshot of North Dakota hunters. To determine area of residence, we used participant's mailing addresses and ArcGIS Geolocator services (ESRI ArcMap, Environmental Systems Research Institute, Inc., Redlands, CA) to plot addresses as points on a map in ArcGIS using a street data layer. The program estimates a degree of certainty if ambiguous language was used in a listed address. No points with less than 70% certainty were found in the data. We then classified hunters as urban or rural using the United States Census Bureau's urban area layer (United States Census Bureau 2010); addresses containing only Post Office boxes in urban areas could not be

assigned to one group through simple geocoding (McElroy et al. 2003), so addresses meeting these criteria were eliminated from analyses.

Harvest survey response rates. We used binomial logistic regression (Hilbe 2009) to understand relationships between response rates and mixed-mode treatments. We modeled relationships between response rates and treatments at two levels: within hunter groups (lottery rifle, landowner, muzzleloader, archery, and fall turkey), and more broadly, between treatments (i.e., treatments were pooled across hunter groups). We coded surveys as returned or not returned, forming a response variable with a binomial distribution. We tallied undeliverable surveys for both internet and mail portions of a respective control or treatment. Undeliverable internet surveys were either non-working emails due to mistakes in listed email addresses or firewalls in the hunter's email service. Undeliverable mail surveys were those that were returned to us due to wrong or invalid mailing addresses. We did not include undeliverable surveys and follow-up telephone surveys in these comparisons. We adjusted sample size and response rates by eliminating undeliverable surveys and summarized the number and proportions of mail and internet returns for treatments.

Factors related to harvest survey response. To understand relationships between why a hunter does or does not return a survey, we examined 3 aspects of survey and response processes. First, we quantified nonresponse in an attempt to depict whether response differences themselves explain why some individuals chose not to return surveys. Second, we examined within return survey variation, or whether there are enough differences between early and late responses, to explain why some respondents take longer to return a survey. Third, we sought to

further understand the effects of demographic factors on whether or not a hunter returned a survey.

Investigations into the form of nonresponse bias and the degree to which it may affect harvest estimates was made a priority in our research because of the unknown nature or presence of a bias in current or tested treatments. We conducted systematic follow-up phone interviews with 2018 deer and turkey hunter nonrespondents beginning 25 April to 10 June 2018, until a minimum sample size (n = 25) for each treatment subgroup was reached. To achieve this minimum sample size, we contacted 1,931 nonrespondents. To assess whether there were differences between nonrespondents and hunters whom responded to the initial survey mode, we asked a reduced set of questions from the original survey instrument: hunt participation, harvest success, sex and age of any deer harvested, species of any deer harvested, and a final question seeking any reasons a survey was not returned. Questions concerning specific dates of hunt participation or harvest and specific management units hunted within and the first time turkey hunter question were eliminated due to the increased chance of recall bias. The respective pairs were also compared using available demographic data (age group, residency, and area of residence) derived from the licensing database. Chi-square and Fisher's exact tests were used to test for differences between hunters that responded and those that did not respond to initial surveying and were contacted via follow-up telephone surveys. For this study, we followed all guidelines outlined in the UND Institutional Review Board Human Subjects Policies and Procedures (IRB Approval No. IRB-201904-269).

To assess whether variation existed within a survey period on factors important to management, we chose harvest success as a representative survey item. This allowed us to assess whether early responders were an accurate representation alone to be used as an early snapshot

of harvest and whether late responders were an accurate proxy for a formal nonresponse check. We aimed to compare early and late wave survey respondents by harvest success, and predicted that later respondents would have lower rates of harvest. To determine whether associations existed between response times and harvest success, we segregated early (weeks 1–3) and late (weeks 4–6) responders by those who successfully harvested game and those who did not. Following formal nonresponse bias investigation, we combined treatment groups for each hunter group and compared the number of successful harvests. We conducted these analyses via chi-square tests for all 5 hunter groups. Due to the low numbers of URL and QR code option users, returns from these were not used in this analysis.

We used binomial logistic regression models to evaluate the effect of demographic factors associated with survey response. We created a binary response variable for returned questionnaires (returned vs. not returned) tested for effects of age group, residency (North Dakota resident vs. non-resident), and area of residence (urban or rural). We classified age groups based on previous North Dakota research: under 18, 18–24, 25–44, 45–64, and 65 or over (Black et al. 2017, Ndembe 2019). We derived these variables from the NDGF licensing database to represent possible avenues for stratification. We subsequently constructed a set of 3 candidate models that used single predictor variables of interest. We considered covariates as categorical factors, requiring the designation of a baseline against which to compare other levels. We used the youngest age group (≤17 years) as the baseline for age, nonresident hunter as the baseline for residency, and rural as the baseline for area of residence.

Results

Harvest survey response rates

We present sample sizes, descriptive statistics, and harvest rates for five individual hunter groups receiving a control mail survey or three mixed-mode treatments (Appendix Table 4). Compared to traditional mail only surveys (control), when looking across all hunter groups, the internet-mail and mail-internet treatments resulted in significantly increased response rates. When further breaking down highest response rates for treatments by hunter groups, there were no obvious patterns regarding the highest response rates. Highest return rates for lottery-rifle came from the internet-mail (0.66), archery deer from mail-internet (0.64), landowner deer from mail-URL (0.65), muzzleloader deer from mail-internet (0.84), and fall turkey hunters from internet-mail (0.71); (Appendix Table 5). Proportions of responses via internet use for mixed-mode treatments ranged from 0.02 (mail-URL treatments for archery, landowner, and muzzleloader hunters) to 0.86 (fall turkey internet-mail treatment). Overall, internet-mail and mail-internet treatments had similar patterns with the greater proportion of responses coming from whichever mode was offered first (mail for mail-internet and internet for internet-mail) rather than a clear preference for one mode (Appendix Table 6). Mail-URL treatments showed minimal internet participation in all groups with all respective proportions of the responses being less than 0.06. Numbers of undeliverable questionnaires were higher in treatments with larger internet components and ranged in percentage of the sample size from 0.001% (control treatment for muzzleloader hunters) to 2.10% (mail-internet treatment for archery hunters).

Factors related to harvest survey response

We tested for nonresponse bias by comparing responses from telephone nonrespondent data to those from initial survey respondents. Overall, we saw no differences ($P \leq 0.05$) between

respondents and nonrespondents among 43 out of 48 questionnaire management item comparisons. Of the differences in management item comparisons, we saw differences in hunt participation for four hunter treatment groups and a harvest success difference in one, but these differences were inconsistent with any one hunter group or treatment type (Appendix Table 7). We also discerned differences in 31 out of 60 demographic comparisons (Appendix Table 8); of these, 19 related to differences in age group proportions where respondents tended to be older. However, these age differences did not appear to carry-over into management item differences. In sum, we opted to not weight data, and believe our samples were representative of their populations concerning typical data collected in a harvest survey.

We segregated wave of response by harvest success across treatments for each hunter group. First wave respondents were more likely to have reported harvest success compared to second wave respondents for lottery rifle deer hunters ($\chi^2_1 = 7.19$, $P = 0.007$), archery deer hunters ($\chi^2_1 = 22.57$, $P < 0.001$), landowner deer hunters ($\chi^2_1 = 24.79$, $P < 0.001$), muzzleloader deer hunters ($\chi^2_1 = 5.62$, $P = 0.018$), and fall turkey hunters ($\chi^2_1 = 25.21$, $P < 0.001$). Small sample sizes for responses by URL or QR code from the mail-URL treatment precluded comparisons with responses of these types, but anecdotally, harvest rates were higher than their paper response counterparts.

We explored each demographic variable individually in order to gain understanding of their effect on survey response. We found that the odds of returning a survey by a hunter were 1.84 (=13.76, CI = 1.687–2.006) and 3.78 (= 25.89, CI = 3.418–4.181) times greater in age groups 45–64 and 65 and older, respectively, than hunters under the age of 18 (Appendix Table 9). North Dakota resident hunters were found to have only 0.75 (= -5.88, CI = 0.677–0.822) of the odds of responding as nonresident North Dakota hunters. It was also found that urban living

hunters were 1.22 (= 9.43, CI = 1.171–1.272) times as likely to respond as rural living hunters. We present remaining differences in Appendix Table 9.

Discussion

Using mixed-mode and internet surveys are an attractive alternative to mail-based surveys for wildlife managers needing data from natural resource users such as hunters (Lesser et al. 2011, Gigliotti 2011, Henderson and Gigliotti 2018). In this study, we attempted to evaluate efficiency and other aspects of using a mixed-mode mail and internet survey system for deer and fall turkey hunter data collection in North Dakota.

We demonstrated that surveyed hunter groups varied in response rates among treatments, similar to previous studies (Beaman et al. 2005, Gigliotti 2011, Lesser et al. 2011). In our study, providing two separate opportunities to complete surveys via internet or mail produced higher response rates than a traditional mail-only survey mode, supporting our hypothesis that mixed-mode treatments could improve return rates when compared to control efforts. Ultimately, for managers, this may translate to better coverage, less chance or degree of bias, and better estimates of harvest. When implementing a harvest survey that uses the internet we had higher than average response rates than those experienced by managers in a review conducted by Goddard et al. (2009). In their review they reported perceived compliance by harvest survey managers using the internet to gather deer harvest data from hunters in the range from 1–19%. We believe that the improvement seen in internet survey participation by hunters from their review compared to our study illustrates the acceleration of internet use and confidence by many demographic groups that make up hunters as well as managers implementing them (LaBonte and Kilpatrick 2017).

Through three steps including: nonresponse investigations, explorations into variation within survey period, and exploration of effects of demographic variable on response rates we attempted to inform upon what contributes to whether or not a hunter returns a survey. Although we found our surveys to be representative for items important for management, those that responded to our questionnaires were consistently older than nonrespondents. These age differences were not surprising, however, given older survey recipients often respond at higher rates than younger recipients (Sexton et al. 2011, Gigliotti and Dietsch 2014, Wallen et al. 2016). Moreover, effect sizes for nonresponse follow-up comparisons were generally small or minimal per Vaske (2008), suggesting that these comparisons may not differ in a significant way. Differences found when comparing harvest success rates for early versus late responders suggest that early responders alone are not an accurate representation of the final harvest rate estimate, and would overestimate harvest in all hunter groups in this study. Additionally, lower harvest success rates for later respondents suggested that they would not be a good proxy for a more formal nonresponse check, as they harvested game at a lesser rate than nonrespondents in general. This trend has been demonstrated elsewhere. In New Mexico, for example, harvest success from resident big game hunters decreased in successive survey waves (MacDonald and Dillman 1968). We note that the most commonly stated reason from nonresponse follow-up calls among mixed-mode survey recipients was "I do not recall receiving a survey", suggesting overall deliverability or visibility of electronic surveys in this study may have been lower than paper surveys, as suggested by (Gigliotti and Henderson 2015), and supported by our nonresponse follow-up survey results depicting similar participation and harvest rates. We also noted that nonresidents were more likely to return questionnaires than residents. Although unclear, we hypothesize the possibility that the greater difficulty involved with obtaining North Dakota

nonresident deer and turkey tags may, in part, explain these differences. We speculate that satisfaction associated with successfully drawing a rare nonresident license may increase enthusiasm to complete surveys. Although rural North Dakotans comprise a majority of those hunters living within the state, urban dwellers were more likely to return questionnaires, aligning with previous research (Carrozzino-Lyon et al. 2013, Schmidt et al. 2015). If urban and rural hunters were to differ significantly on items important to management in the future, especially as urban growth continues in North Dakota (Ndembe et al. 2019), there could be justification to stratify sampling towards rural living hunters.

Our research presented here demonstrates potential use of tailored mixed-mode surveys to increase response rates, maintaining low degree of biases, and potentially reducing costs. We suggest there are 3 major findings to come from this work. First, including an internet mode to paper-based surveys improved response rates. Second, respondents responded at about the same rate to whichever mode is delivered first. Finally, providing a URL or QR code on a paper survey did not meaningfully improve response rates over a standard mail survey.

Every hunter group in this study showed increased response rates at least nominally from the inclusion of an internet portion supplementing a paper survey. Substituting the best mixed-mode survey treatment (internet-mail) for the control methodology across all hunter groups increased overall response rates from 59% to 64%. This 5% increase demonstrates a large number of hunters in North Dakota are able and willing to respond to internet surveys. The trend of increasing internet survey use and applicability for harvest data collection has been demonstrated in reviews by Rupp et al. 2000, Goddard and Miller 2009, and Kilpatrick and LaBonte 2017. Internet survey use is widely forecasted to increase along with the U.S.

population's internet access in general, indicating that internet survey familiarity will only increase in the near future.

Internet survey effectiveness in mixed-mode treatments could have been masked if hunters were only responding to the mail survey portions at higher rates than usual. However, whichever mode was offered initially in a mixed-mode treatment always contained the majority of total responses even when internet versions were offered first. Our results indicate that there are large portions of North Dakota hunters that may actually see internet surveys better than mail surveys or prefer them. This allows managers to optimize their resources and potentially capture the bulk of responses with initial internet surveys. These findings were similar to Holmberg et al. (2010) who found that mixed-mode contact strategies containing internet waves prior to standard mail waves had higher proportions of internet responses overall. These findings may be important to managers that desire fast initial results common with internet surveys. As a secondary benefit, similar to Greenlaw and Brown-Welty (2009) and Holmberg et al. (2010), cost savings may have resulted following the use of some mixed-mode treatments in our study. For example, the highest response rates in our study for lottery deer-rifle and fall turkey hunters came via internet-mail. This treatment required less paper, postage, and associated scanning digitization and verification efforts compared to traditional mailed surveys. This is due to the maximum number of paper surveys produced or returned having been limited by the number of internet surveys that did not get returned and simple data cleaning for internet responses. Lastly, we found that the addition of a URL and QR code on a mail survey did not significantly affect the number of responses received and additional costs associated with printing and maintaining of online version for the included links are not justified given the lack of participation by North Dakota hunters. This suggests that while internet surveys are becoming

more effective for surveying hunters the widespread use of certain smartphone apps associated with reading QR codes or the time it takes to manually type in a URL link is beyond what the majority of North Dakota hunters find convenient.

Management implications

In effort to continue with current management practice guidelines, managers are increasingly reliant on the consistency and reliability of data gathered from hunters. We demonstrated that surveyed hunter subgroups varied in response rates among treatments, similar to previous studies. Thus, wildlife managers may consider mixed-mode surveys catered to specific hunter subgroups such as Internet-Mail and Mail-Internet treatments, which often performed better than traditional mail only surveys. Moreover, consideration of electronic and traditional mail surveys aimed towards younger and older hunters, respectively, may be warranted. However, we caution the reader that inferences from our results should be considered within their specific context. North Dakota has a long history sampling hunters to obtain data on hunter harvest, and hunters often receive multiple surveys each year. Hence, surveys may be a part of the hunting tradition and culture in North Dakota, and may be why NDGF sees little non-response error. Additionally, age related differences between respondents and nonrespondents didn't seem to translate into management item differences in our nonresponse investigation. However, it is unknown how well some of the other management items, such as number of days participated or specific days or units hunted in, are being represented in younger averaged aged groups such as archery hunters when older participants are much more likely to respond. Other agencies adopting our methodology may not receive similar results. North Dakota also has good email coverage, and in 2016, NDGF transitioned to all electronic licensing, which requires hunters to provide a valid email address in order to purchase licenses, apply for lotteries, and

learn about lottery results. As a result, this facilitates NDGF's ability to carry out internet modes. We also caution that email address coverage and unknown email filtering could play a larger role for some or all groups in the future. Continued experimentation with mixed-mode harvest surveys for other wildlife and potentially fish species will continue to be an integral part of the wildlife management process in North Dakota.

Acknowledgments

This research was funded by Federal Aid in Wildlife Restoration Project No. F17AF01063 (Study No. W-68-R-2) and administered by the North Dakota Game and Fish Department and the University of North Dakota, College of Arts and Sciences.

APPENDIX

2018 DEER GUN HUNTER QUESTIONNAIRE
NORTH DAKOTA GAME AND FISH DEPARTMENT
WILDLIFE DIVISION
SFN 6497 (11-2018)

NOTICE
PLEASE return this questionnaire within 5 days.

Dear, Hunter:

The Game & Fish Department relies on hunters like you to provide information about your hunting activity during the firearm deer season. This information is important to the management of deer in North Dakota. Please take a minute to complete this questionnaire about your hunting activity, and return it in the postage-paid envelope (your responses are completely confidential). **Please complete and return your questionnaire even if you did not attempt to hunt, or were unsuccessful shooting a deer.**

1. DID YOU HUNT DEER THIS YEAR?
If, NO - Stop after Question 1 and return the survey.
◯ Yes ◯ No

2. WHICH HUNTING UNIT DID YOU HUNT MOST?
☐☐☐ *See map on the back of this page*

3. WHICH DAYS DID YOU HUNT FOR YOUR DEER?
Use the calendar on the right to shade ovals for each hunt day.

4. DID YOU HARVEST A DEER?
If, NO - Stop after Question 4 and return the survey.
◯ Yes ◯ No

5. WHICH DAY IN NOVEMBER DID YOU HARVEST YOUR DEER?
☐☐ *e.g., if you shot your deer on the 15th, enter "15" in the box below.*

6. WHAT WAS THE SPECIES?
◯ Mule Deer ◯ White-tailed Deer

7. WHAT WAS THE SEX & AGE OF YOUR DEER?
◯ Antlered Buck ◯ Button Buck ◯ Large Doe ◯ Small Doe (Fawn)

8. IN WHICH HUNTING UNIT DID YOU HARVEST YOUR DEER?
☐☐☐ *See map on the back of this page*

NOVEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					9 ◯	10 ◯
11 ◯	12 ◯	13 ◯	14 ◯	15 ◯	16 ◯	17 ◯
18 ◯	19 ◯	20 ◯	21 ◯	22 ◯	23 ◯	24 ◯
25 ◯						

THANK YOU! Your participation helps preserve North Dakota wildlife resources.

53749

2018 DEER MUZZLELOADER HUNTER QUESTIONNAIRE
NORTH DAKOTA GAME AND FISH DEPARTMENT
WILDLIFE DIVISION
SFN 6486 (12-2018)

Dear, Hunter:

The Game & Fish Department relies on hunters like you to provide information about your hunting activity during the muzzleloader deer season. This information is important to the management of deer in North Dakota. Please take a minute to complete this questionnaire, and return it in the postage-paid envelope. **Please complete and return the questionnaire even if you did not attempt to hunt, or were unsuccessful shooting a deer.**

1. DID YOU HUNT DEER THIS YEAR?
If, NO - Stop after Question 1 and return the survey.
◯ Yes ◯ No

2. WHICH HUNTING UNIT DID YOU HUNT MOST?
[ ][ ][ ] *See map on the back of this page*

3. WHICH DAYS DID YOU HUNT FOR YOUR DEER?
Use the calendar on the right to shade ovals for each hunt day.

NOVEMBER / DECEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					30 ◯	1 ◯
2 ◯	3 ◯	4 ◯	5 ◯	6 ◯	7 ◯	8 ◯
9 ◯	10 ◯	11 ◯	12 ◯	13 ◯	14 ◯	15 ◯
16 ◯						

4. DID YOU HARVEST A DEER?
If, NO - Stop after Question 4 and return the survey.
◯ Yes ◯ No

5. WHICH DAY IN NOVEMBER -or- DECEMBER DID YOU HARVEST YOUR DEER?
[ ][ ] *e.g., if you shot your deer on the 15th, enter "15" in the box below.*

6. WHAT WAS THE SEX & AGE OF YOUR DEER?
◯ Antlered Buck ◯ Button Buck (Fawn) ◯ Large Doe ◯ Small Doe (Fawn)

7. IN WHICH HUNTING UNIT DID YOU HARVEST YOUR DEER?
[ ][ ][ ] *See map on the back of this page*

THANK YOU! Your participation helps preserve North Dakota wildlife resources.

28085

2018 DEER BOW HUNTER QUESTIONNAIRE

NORTH DAKOTA GAME AND FISH DEPARTMENT
WILDLIFE DIVISION
SFN 6479 (12-2018)

Dear, Hunter:

The Game & Fish Department relies on hunters like you to provide information about your hunting activity during the deer bow season. This information is important to the management of deer in North Dakota. Please take a minute to complete this questionnaire about your hunting activity, and return it in the postage-paid envelope (your responses are completely confidential). Please complete and return your questionnaire even if you did not attempt to hunt, or were unsuccessful shooting a deer.

1. DID YOU HUNT DEER THIS YEAR?
If, NO - Stop after Question 1 and return the survey.
◯ Yes ◯ No

2. WHICH HUNTING UNIT DID YOU HUNT MOST?
See map on the back of this page

3. DID YOU HARVEST A DEER?
If, NO - Stop after Question 3 and return the survey.
◯ Yes ◯ No

4. WHICH DAY DID YOU HARVEST YOUR DEER?
Month / Day / Year

5. WHICH HUNTING UNIT DID YOU HARVEST YOUR DEER? *See map on the back of this page*

6. WHAT WAS THE SPECIES OF YOUR DEER?
◯ Mule Deer ◯ White-tailed Deer

7. WHAT WAS THE SEX & AGE OF YOUR DEER?
◯ Antlered Buck ◯ Button Buck (Fawn) ◯ Large Doe ◯ Small Doe (Fawn)

WHICH DAYS DID YOU HUNT FOR YOUR DEER?
Use the calendars below to shade ovals for each hunt day

SEPTEMBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
					31 ◯	1 ◯
2 ◯	3 ◯	4 ◯	5 ◯	6 ◯	7 ◯	8 ◯
9 ◯	10 ◯	11 ◯	12 ◯	13 ◯	14 ◯	15 ◯
16 ◯	17 ◯	18 ◯	19 ◯	20 ◯	21 ◯	22 ◯
23 ◯	24 ◯	25 ◯	26 ◯	27 ◯	28 ◯	29 ◯

OCTOBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
30 ◯	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯	6 ◯
7 ◯	8 ◯	9 ◯	10 ◯	11 ◯	12 ◯	13 ◯
14 ◯	15 ◯	16 ◯	17 ◯	18 ◯	19 ◯	20 ◯
21 ◯	22 ◯	23 ◯	24 ◯	25 ◯	26 ◯	27 ◯
28 ◯	29 ◯	30 ◯	31 ◯			

NOVEMBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
				1 ◯	2 ◯	3 ◯
4 ◯	5 ◯	6 ◯	7 ◯	8 ◯	9 ◯	10 ◯
11 ◯	12 ◯	13 ◯	14 ◯	15 ◯	16 ◯	17 ◯
18 ◯	19 ◯	20 ◯	21 ◯	22 ◯	23 ◯	24 ◯
25 ◯	26 ◯	27 ◯	28 ◯	29 ◯	30 ◯	

DECEMBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
						1 ◯
2 ◯	3 ◯	4 ◯	5 ◯	6 ◯	7 ◯	8 ◯
9 ◯	10 ◯	11 ◯	12 ◯	13 ◯	14 ◯	15 ◯
16 ◯	17 ◯	18 ◯	19 ◯	20 ◯	21 ◯	22 ◯
23 ◯	24 ◯	25 ◯	26 ◯	27 ◯	28 ◯	29 ◯

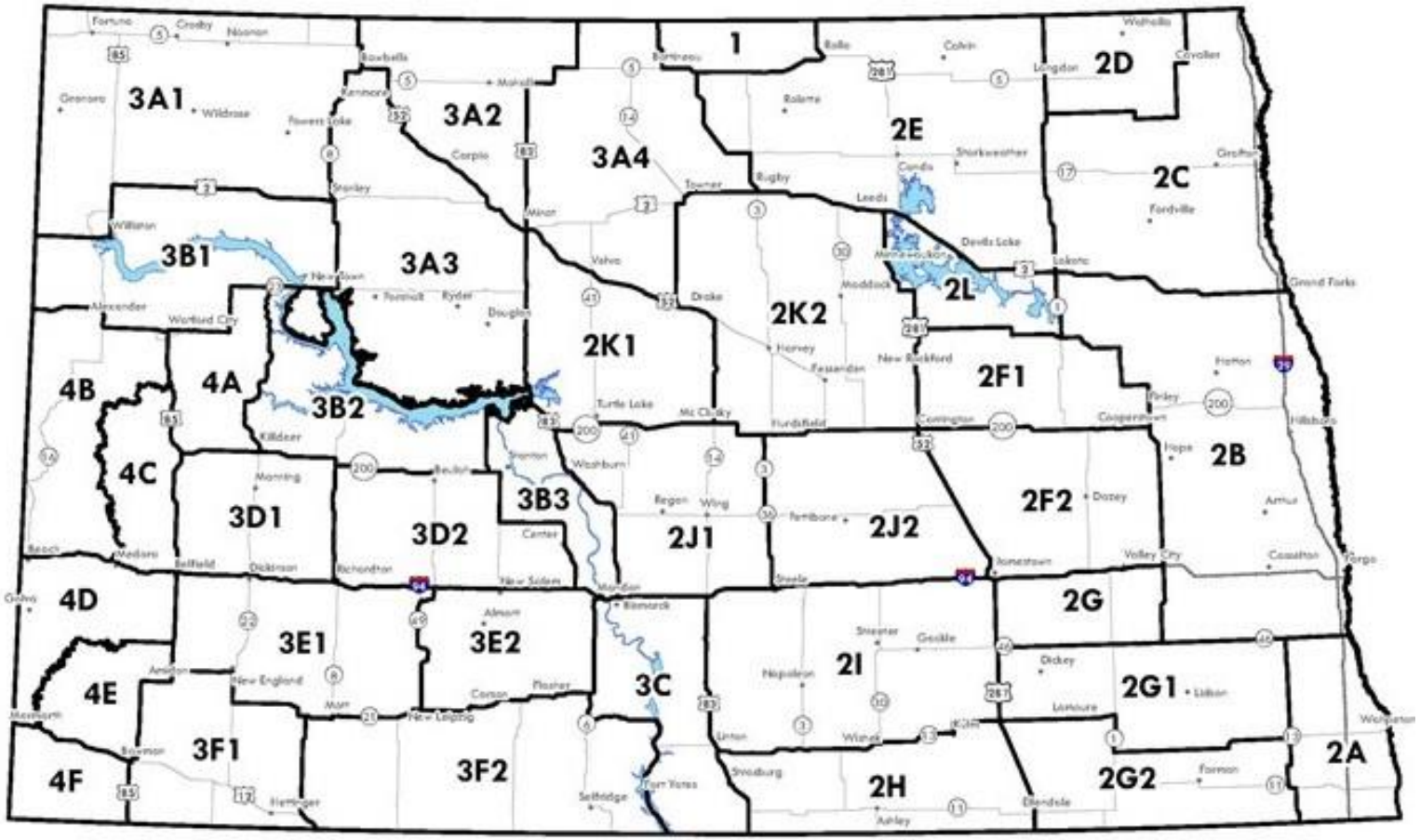
JANUARY 2019

SUN	MON	TUE	WED	THU	FRI	SAT
30 ◯	31 ◯	1 ◯	2 ◯	3 ◯	4 ◯	5 ◯
6 ◯						

53930

NORTH DAKOTA GAME AND FISH DEPARTMENT

DEER HUNTING UNITS



2018 FALL WILD TURKEY HUNTER QUESTIONNAIRE

NORTH DAKOTA GAME AND FISH DEPARTMENT
WILDLIFE DIVISION
SFN 6462 (12-2018)

NOTICE
PLEASE return this questionnaire within 15 days.

Dear, Hunter:

The Game & Fish Department relies on hunters like you to provide information about your hunting activity during the fall turkey season. This information is important to the management of turkeys in North Dakota. Please take a minute to complete this questionnaire about your hunting activity, and return it in the postage-paid envelope. Please complete and return your questionnaire even if you did not attempt to hunt, or were unsuccessful shooting a turkey.

1. DID YOU HUNT TURKEYS THIS YEAR?
◯ Yes ◯ No

2. IS THIS YOUR FIRST TIME HUNTING TURKEYS IN NORTH DAKOTA?
◯ Yes ◯ No

3. WHICH COUNTY DID YOU HUNT MOST?
☐☐ *See map on the back of this page -or- County Codes to the right*

4. DID YOU HARVEST A TURKEY?
If, NO - Stop and return the survey
◯ Yes ◯ No

5. WHICH DAY DID YOU HARVEST YOUR TURKEY?
☐☐ / ☐☐ / ☐☐
Month / Day / Year

6. IN WHICH COUNTY DID YOU HARVEST YOUR TURKEY?
☐☐

WHICH DAYS DID YOU HUNT TURKEYS?
Use the calendars below to shade ovals for each hunt day

OCTOBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
						13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

DECEMBER 2018

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

JANUARY 2019

SUN	MON	TUE	WED	THU	FRI	SAT
30	31	1	2	3	4	5
6						

County Codes

Adams	01
Barnes	02
Benson	03
Billings	04
Bottineau	05
Bowman	06
Burke	07
Burleigh	08
Cass	09
Cavalier	10
Dickey	11
Divide	12
Dunn	13
Eddy	14
Emmons	15
Foster	16
Golden Valley	17
Grand Forks	18
Grant	19
Griggs	20
Hettinger	21
Kidder	22
LaMoure	23
Logan	24
McHenry	25
McIntosh	26
McKenzie	27
McLean	28
Mercer	29
Morton	30
Mountrail	31
Nelson	32
Oliver	33
Pembina	34
Pierce	35
Ramsey	36
Ransom	37
Renville	38
Richland	39
Rolette	40
Sargent	41
Sheridan	42
Sioux	43
Slope	44
Stark	45
Steele	46
Stutsman	47
Towner	48
Traill	49
Walsh	50
Ward	51
Wells	52
Williams	53
Unknown	99

11635

NORTH DAKOTA GAME AND FISH DEPARTMENT

COUNTY MAP

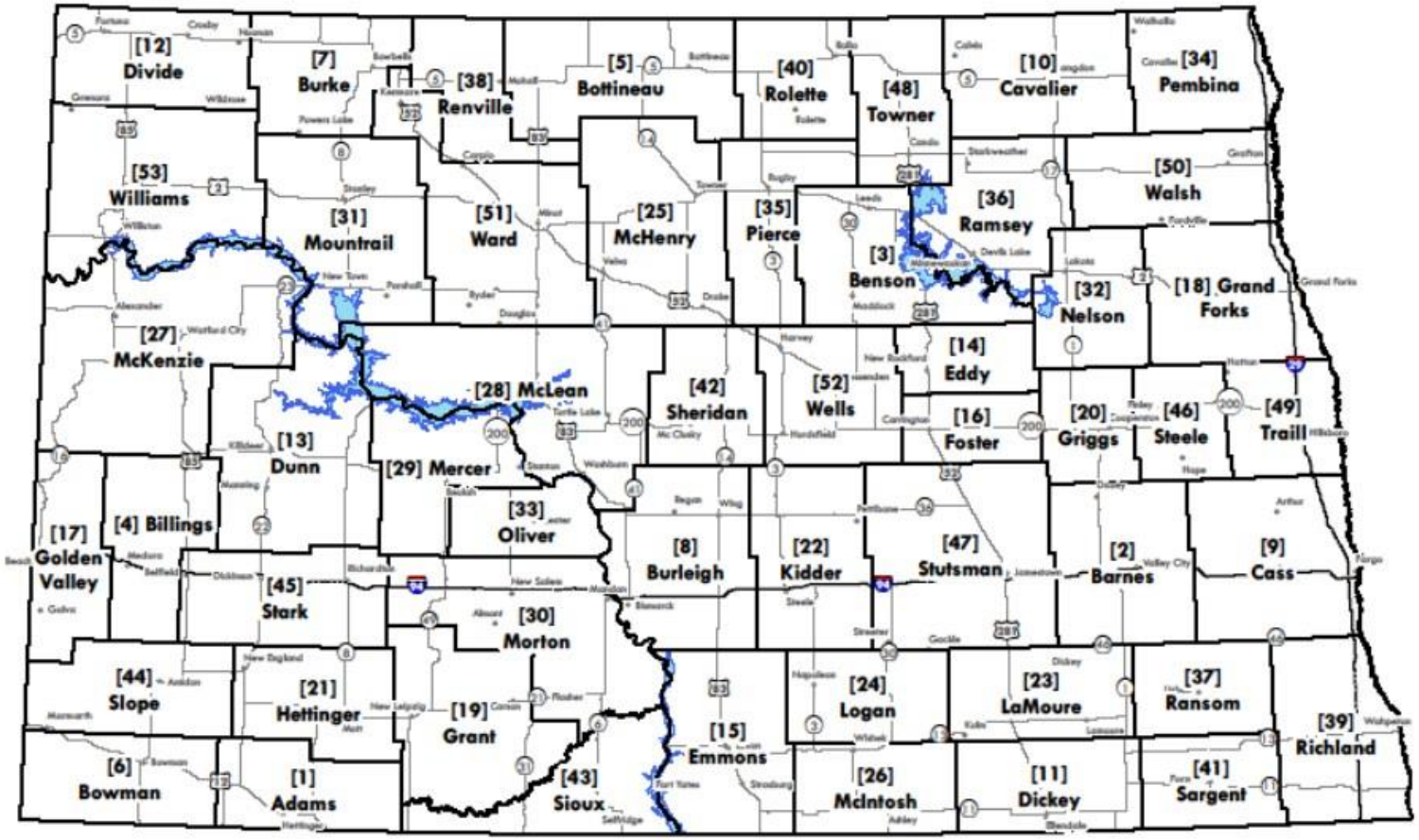


Table 4. Sample sizes, descriptive statistics, and harvest rates for five individual hunter groups receiving a control mail survey or three differing mixed-mode treatments in North Dakota, USA, for survey years 2017–19.

Hunter type	Surveys per treatment per year	Total sample Drawn	Mean age (SE)	% Rural	% Male (number of hunters reporting)	% Harvest success				
						All surveys	Control	Internet-mail	Mail-Internet	Mail-URL
Lottery rifle deer	1000[a]	12394	41.1 (0.12)	60%	79% (7232)	59%	57%	60%	59%	60%
Archery deer	1000	12000	38.6 (0.08)	64%	91% (5979)	32%	34%	30%	32%	32%
Landowner deer	1000[a]	12327	54.2 (0.10)	87%	86% (5749)	44%	41%	45%	45%	44%
Muzzleloader deer	255	3060	49.3 (0.12)	61%	93% (1709)	35%	33%	35%	35%	35%
Fall turkey	750[b]	6000	41.1 (0.12)	58%	87% (2408)	27%	29%	27%	24%	30%

[a]2017 samples for the Mail-internet treatment contained 1394 hunters for lottery rifle deer and 1327 hunters for landowner deer groups.

[b]Fall turkey hunters were not surveyed in 2017.

Table 5. Results for tested survey treatments for pooled and five individual hunter groups in North Dakota, USA, for survey years 2017–19. Response rates for treatments for each hunter group were compared using binary logistic regression models. Response rates were calculated using the number of returned surveys divided by the adjusted sample size.

Hunter groups and tested survey treatments	Undeliverable surveys	Adjusted[a] sample size	Response rate	Odds ratios	P-value
All Groups					
Control	86	11099	0.59		
Internet-Mail	155	11028	0.64	1.207	<0.001
Mail-Internet	131	11780	0.62	1.142	<0.001
Mail-URL	87	11097	0.60	1.017	0.537
Lottery Rifle					
Control	22	2953	0.62		
Internet-Mail	33	2942	0.66	1.195	0.001
Mail-Internet	27	3342	0.59	0.891	0.026
Mail-URL	23	2952	0.63	1.041	0.458
Archery					
Control	40	2935	0.49		
Internet-Mail	56	2918	0.57	1.389	<0.001
Mail-Internet	61	2914	0.64	1.842	<0.001
Mail-URL	49	2926	0.47	0.919	0.106
Landowner Deer					
Control	10	2965	0.64		
Internet-Mail	32	2943	0.60	0.871	0.010
Mail-Internet	25	3277	0.58	0.802	<0.001
Mail-URL	10	2964	0.65	1.076	0.178
Muzzleloader					
Control	1	784	0.74		
Internet-Mail	12	767	0.78	1.199	0.123
Mail-Internet	3	788	0.84	1.816	<0.001
Mail-URL	3	782	0.75	1.095	0.434
Fall Turkey					
Control	13	1462	0.58		
Internet-Mail	22	1452	0.71	1.207	<0.001
Mail-Internet	15	1459	0.64	1.142	<0.001
Mail-URL	2	1473	0.59	1.017	0.537

[a]Adjusted sample size equals total number of individuals sent surveys minus the number of undeliverable.

Table 6. Numbers of returned surveys and proportions of mail and internet participation for tested survey treatment modes by hunter groups in North Dakota, USA, for the years 2017–2019.

Hunter groups and tested survey treatments	Number of surveys returned	Number returned through mail	Number returned through internet	Proportion mail	Proportion internet
All Groups					
Control	6563	6563	0	1.00	0.00
Internet-Mail	7012	1614	5398	0.23	0.77
Mail-Internet	7339	5644	1695	0.77	0.23
Mail-URL	6607	6415	192	0.97	0.03
Lottery Gun					
Control	1828	1828	0	1.00	0.00
Internet-Mail	1942	424	1518	0.22	0.78
Mail-Internet	1977	1581	396	0.80	0.20
Mail-URL	1855	1754	101	0.95	0.05
Archery					
Control	1427	1427	0	1.00	0.00
Internet-Mail	1658	328	1330	0.20	0.80
Mail-Internet	1852	1141	711	0.62	0.38
Mail-URL	1361	1340	21	0.98	0.02
Landowner Deer					
Control	1889	1889	0	1.00	0.00
Internet-Mail	1779	603	1176	0.34	0.66
Mail-Internet	1916	1581	335	0.83	0.17
Mail-URL	1938	1899	39	0.98	0.02
Muzzleloader					
Control	577	577	0	1.00	0.00
Internet-Mail	595	117	478	0.20	0.80
Mail-Internet	658	556	102	0.84	0.16
Mail-URL	589	575	14	0.98	0.02
Fall Turkey					
Control	842	842	0	1.00	0.00
Internet-Mail	1038	142	896	0.14	0.86
Mail-Internet	936	785	151	0.84	0.16
Mail-URL	864	847	17	0.98	0.02

Table 7. Significant differences found when using Fisher's exact tests to compare initial responders to sampled nonrespondent groups on key management variables such as whether a hunter participated in the hunt or whether they harvested during the hunt for tested mixed-mode mail/electronic survey treatments by hunter subgroup in North Dakota, USA, for the year 2018.

Variable	Subgroup	P-value	Odds Ratios (95%)
Hunt	Landowner deer mail-internet	0.004	3.525 (1.374, 8.672)
	Muzzleloader mail-internet	0.029	3.332 (0.957, 10.362)
	Turkey internet-mail	0.002	3.451 (1.422, 8.966)
	Turkey mail-internet	<0.001	5.191 (2.040, 14.912)
Harvest	Archery mail-URL	0.044	3.433 (1.00, 18.175)

Table 8. Significant differences found when using chi square and fisher's exact tests to compare primary responders to nonrespondent groups on demographic variables for tested mixed-mode mail/electronic survey treatments by hunters in North Dakota, USA, for the year 2018.

Variable	Subgroup	Test Statistic	P-value	Effect Size
Age group distribution	Lottery rifle control	55.23	<0.001[a]	*V* =0.238
	Lottery rifle internet-mail	25.08	<0.001[a]	*V* =0.160
	Lottery rifle mail-internet	43.585	<0.001[a]	*V* =0.213
	Lottery rifle mail-URL	53.104	<0.001[a]	*V* =0.234
	Archery control	78.297	<0.001[a]	*V* =0.285
	Archery internet-mail	21.96	<0.001[a]	*V* =0.151
	Archery mail-internet	42.881	<0.001[a]	*V* =0.212
	Archery mail-URL	68.254	<0.001[a]	*V* =0.265
	Landowner deer control	98.239	<0.001[a]	*V* =0.317
	Landowner deer internet-mail	37.775	<0.001[a]	*V* =0.197
	Landowner deer mail-internet	24.603	<0.001[a]	*V* =0.160
	Landowner deer mail-URL	69.544	<0.001[a]	*V* =0.160
	Muzzleloader control		<0.001[b]	
	Muzzleloader mail-internet		0.027[b]	
	Muzzleloader mail-URL		<0.001[b]	
	Turkey control	68.251	<0.001[a]	*V* =0.307
	Turkey internet-mail	30.965	<0.001[a]	*V* =0.209
	Turkey mail-internet	21.776	<0.001[a]	*V* =0.174
	Turkey mail-URL	52.905	<0.001[a]	*V* =0.270
Urbanity	Archery control	8.049	0.004[a]	*V* =0.091
	Landowner deer control	21.548	<0.001[a]	*V* =0.148
	Landowner deer internet-mail	11.675	<0.001[a]	*V* =0.110
	Landowner deer mail-internet	6.310	0.012 [a]	*V* =0.081
	Landowner deer mail-URL	15.075	<0.001[a]	*V* =0.124
	Turkey mail-URL	4.027	0.044[a]	*V* =0.074
Residency	Lottery rifle mail-URL		0.038[b]	
	Archery control	11.151	<0.001[a]	*V* =0.107
	Archery internet-mail	5.798	0.016[a]	*V* =0.077
	Archery mail-internet	7.876	0.005[a]	*V* =0.090
	Archery mail-URL	10.04	0.001[a]	*V* =0.101
	Landowner deer mail-internet		0.043[b]	

[a] Pearson chi square test

[b] Fisher's exact test

Table 9. Binomial logistic regression models resulting from individual variable investigations. Each model reflects how the levels affect response rates for all tested survey treatment mode by hunter groups in North Dakota, USA, for the years 2017–2019.

Model and levels	Estimate	95% CI	Standard error	Z value	P-value	Odds ratio	95% CI
Age group							
Intercept[a]	0.114	0.034–0.194	0.040	2.804	0.005	1.121	1.035–1.214
18–24	-0.344	-0.446– -0.242	0.052	-6.614	<0.001	0.709	0.640–0.785
25–44	-0.007	-0.093–0.078	0.044	-0.169	0.866	0.993	0.911–1.081
45–64	0.610	0.523–0.696	0.044	13.763	<0.001	1.840	1.687–2.006
65+	1.330	1.229–1.430	0.051	25.890	<0.001	3.780	3.418–4.181
Residency							
Intercept[b]	0.731	0.636–0.827	0.049	14.979	<0.001	2.077	1.889–2.287
ND resident	-0.293	-0.391– -0.196	0.050	-5.876	<0.001	0.746	0.677–0.822
Urban or rural							
Intercept[c]	0.389	0.366–0.412	0.012	33.359	<0.001	1.475	1.442–1.509
Urban	0.199	0.158–0.241	0.021	9.433	<0.001	1.221	1.171–1.272

[a]Under age 18.
[b]Nonresident North Dakota hunters.
[c]Rural North Dakota hunters.

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