Cooperative extension agents as key informants in assessing wildlife damage trends in Georgia

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Abstract: To manage emerging human–wildlife conflicts, wildlife managers will require more information regarding trends in wildlife damage and public perceptions of control measures. In 2017, we administered an online survey to Georgia Agriculture and Natural Resources (ANR) county cooperative extension agents to assess the types of inquiries or complaints about nuisance wildlife they had received during the previous year. We asked questions about the common species creating problems, the nature of the damage reported, and perceptions of client preferences regarding different types of nuisance wildlife control. We compared the results of our 2017 survey to a similar survey conducted in Georgia in 2002 to determine how human–wildlife conflict issues may have changed over time and how ANR agents could serve as information sources regarding these changing trends. In 2017, ANR agents received more inquiries about deer (*Odocoileus virginianus*) than any other species. Other species frequently identified included armadillos (*Dasypus novemcinctus*), wild pigs (*Sus scrofa*), moles (*Scalopus* spp.), squirrels (*Sciurus* spp.), and voles (*Microtus* spp.). Complaints about voles had increased since the previous survey ($P = 0.019$), as well as complaints about unknown sources of damage ($P = 0.041$) and requests for more general information on wildlife damage ($P = 0.041$). Fewer complaints about bats (Order: Chiroptera; $P = 0.0007$), woodpeckers (Family: Picidae; $P = 0.021$), squirrels ($P = 0.047$), and moles ($P = 0.026$) were reported during this survey than were reported in the 2002 survey. More ANR agents in Georgia received complaints about wild pigs ($P = 0.00004$). Most complaints about nuisance wildlife referred to damage to yards or landscapes, followed by gardens, and then row crops. Complaints about damage to row crops had increased since the 2002 survey ($P = 0.046$), while complaints about damage to houses or barns had decreased ($P = 0.01$). Lastly, ANR agents believed their clients were not opposed to lethal control of nuisance wildlife. We believe these findings highlight the many benefits of targeting ANR agents as key informants and recommend that other managers implement similar techniques to acquire information on nuisance wildlife trends within their own states.

Key words: cooperative extension, Georgia, human–wildlife conflict, key informants, nuisance wildlife management, survey, urban wildlife, wildlife damage

Conflicts between humans and wildlife have existed for thousands of years. However, the rate at which human populations are expanding and the novel environments created lead to increasingly frequent and complex conflict situations (Messmer 2000, Fall and Jackson 2002). Traditionally, human–wildlife conflicts were characterized as largely agricultural or rural issues with predatory wildlife depredating livestock or herbivorous species causing substantial crop loss (Conover 2001). Today, conflicts between humans and wildlife are manifesting in urban areas as well (Conover 1997, Fall and Jackson 2002).

While many wildlife species are displaced by growing urban centers and suburban/exurban sprawl and persist only in the diminished habitat remaining at the peripheries of these developments, other species have adapted to life in these human-dominated landscapes (Hadidian et al. 1987, Conover 1997, DeStefano and DeGraaf 2003, Santana and Armstrong 2017). Some urbanized wildlife do so well within human environments that populations burgeon to numbers beyond what is found in settings that are more natural and become unwelcome pests (Marion 1988, Conover 1997, Baker and Timm 2017). Nuisance wildlife can cause enormous economic impacts, estimated to be as high as $3 billion annually in the United States alone (Conover et al. 1995).

Traditional direct population control via lethal methods may often be effective at limiting the extent of wildlife damage, but such methods may be impossible to implement in

residential areas due to unacceptable risks to humans, pets, or other nontarget species (Breck et al. 2017). Furthermore, many urban residents may not support such practices because they are perceived as inhumane (Hadidian et al. 1987, Reiter et al. 1999, Slagle et al. 2017). Consequently, wildlife managers must balance controlling the extent of wildlife damage incurred by some residents while also ensuring the methods employed to do so are acceptable to the community (Miller 1991). Many scholars have proposed a disconnect between rural and urban/suburban communities with respect to wildlife conflicts (Kellert 1984, Fall and Jackson 2002, Adams 2005). Therefore, support for lethal control of nuisance wildlife will likely vary considerably across rural and more urbanized counties and may be directly correlated with the amount of damage experienced by respective residents (West and Parkhurst 2002).

Attempts to proactively manage human–wildlife conflict are hindered by a paucity of information regarding the extent of wildlife damage incurred (Messmer 2009). Knowledge about public perceptions of wildlife damage and management control options are also just as limited. Thus, wildlife managers would benefit greatly from information regarding longitudinal trends in human–wildlife conflict and public perceptions toward management, but this information is usually difficult and expensive to acquire. Surveys and questionnaires are popular instruments to assess perceptions toward wildlife management (Conover 1994, Messmer et al. 1999, Reiter et al. 1999). Online surveys are becoming increasingly common as accessibility improves; online surveys are cheaper to distribute than mail questionnaires, new programs are making them user friendly and easy to design, the need to manually enter survey responses is eliminated, and most programs even include preliminary data analyses (Wright 2005). With appropriate effort, response rates to online surveys are comparable to those of paper surveys (Kaplowitz et al. 2004, Archer 2007). However, online surveys pose other challenges, such as achieving adequate representation of the sample population (Evans and Mathur 2005). Other common problems with targeting a broad sampling population include respondents perceiving online surveys as junk email or that respondents are not

knowledgeable about using technology (Evans and Mathur 2005). Targeting appropriate key informants instead of the general public may be an effective approach to acquiring this information and overcoming some of these associated issues with online surveys, and it may prove to be a more sustainable method of tracking longitudinal trends if appropriate precautions are taken. In general terms, key informants are selected for their position within the community or relation to the phenomenon under investigation (McCaslin and Tibezinda 1998). Precedence for targeting key informants for information regarding nuisance wildlife has already been established (Conover and Decker 1991, Conover 1994).

County cooperative extension agents work across all 50 states in cooperation with land-grant universities, federal agencies, and municipal governments (Comer et al. 2006). Cooperative extension was created to make research conducted at public universities with the aid of public funding (i.e., at land-grant universities that are supported by the Morrill Acts of 1862 and 1890) more beneficial to the wider community (National Research Council 1995). This was to be accomplished through a concerted effort by extension agents to distribute relevant information to those who might benefit from it. Efforts to accomplish this goal began as early as the 1890s, but it wasn't until the Smith–Lever Act of 1914 that cooperative extension units were established at all land grant universities nationwide (Comer et al. 2006). Thus, extension agents are charged with serving as a critical link between university researchers and the public, achieved by providing practical information through any number of methods such as workshops, newsletters, seminars, and field days.

The extension agents working within Agriculture and Natural Resources (ANR; hereafter, agents) are one of the primary sources from which residents can acquire information about wildlife damage management. Agents can then inform researchers of which information they are in the most need. Thus, agents are well-positioned to serve as key informants because they serve at the interface of research and the public. The agents have been acting in this capacity for >100 years. By targeting agents, we also may be able to track

Table 1. Survey questions distributed in an online survey to extension agents in Georgia with programming duties in Agriculture and Natural Resources (ANR). Survey asked agents to reflect on calls or complaints received about nuisance wildlife or wildlife damage during the year prior (2016).

Question		Type of answer
1.	Name of your county.	Write in
2.	How many years have you been an ANR agent in this county?	Write in
3.	Is your county primarily rural, suburban, or urban?	Select one
4.	From which groups do you receive complaints about wildlife damage/nuisance wildlife?	Check all that apply
5.	Please indicate the species or species-groups that account for damage complaints received last year.	Check all that apply
6.	Please estimate the total number of complaints you received last year about damage to each of the following [physical structures].	Write in
7.	Please estimate the number of questions or requests for information you received last year for each of the following [species/species-groups].	Write in
8.	My clients tend to solve wildlife damage/nuisance problems themselves without calling for advice from me (or my office) first.	5-point Likert
9.	After receiving advice from me (or my office), my clients tend to solve wildlife damage/nuisance problems themselves (rather than contacting a private company).	5-point Likert
10.	My clients prefer to hire private companies to resolve issues of wildlife damage/nuisance problems rather than solving the issues themselves.	5-point Likert
11.	My clients are largely opposed to lethal actions taken against nuisance wildlife.	5-point Likert
12.	Have you conducted or sponsored workshops, field days, lunch-n-learn, or other programs in your county on the topic of nuisance wildlife management?	Yes/No
12a.	If yes, what programs (e.g., workshop on feral hog control)?	Write in
12b.	How many attended? Please specify which program, if there were multiple.	Write in
12c.	Would you conduct this program again (yes or no)? Please explain your answer.	Write in
13.	Are you familiar with the following sources of information to help solve wildlife damage problems?	Check all that apply
14.	Is there anything else you think we should know about nuisance wildlife/wildlife damage issues in your county?	Write in

longitudinal information from a series of key informants that will occupy similar positions as their predecessors.

In 2017, we administered an online survey to agents in Georgia to better understand current nuisance wildlife issues across the state. We subsequently compared these results to those reported in similar surveys distributed to agents in 1980 (Jackson 1980) and in 2002 (Mengak 2003). The 1980 survey was a paper questionnaire mailed to agents working only in the Atlanta Metropolitan Area and the Eastern Coastal Plain. The 2002 survey was also a paper questionnaire that was distributed to agents during an in-service training workshop. Although the survey formats differed between each iteration, responses to paper and online surveys are comparable (Ansolabehere and Schaffner 2014), and we were unconcerned that the switch to an online format would bias results. However, the variability between respondents targeted between the 1980 survey and the 2 later surveys makes statistical analysis involving the former inadvisable. Thus, we used information from the 1980 survey only very generally.

Methods

We sent an online survey (SurveyMonkey Inc., San Mateo, California, USA) to all 138 agents in Georgia. This survey was a third adaptation of a similar instrument originally delivered to agents in 1980 (Jackson 1980) and again in 2002 (Mengak 2003).

In Georgia, cooperative extension is organized into four approximately equal districts (about 40 counties each). Each district is supervised by a district extension director (DED), who is responsible for all cooperative extension activities, and a district program development coordinator (PDC), who handles training and daily operations. We emailed the survey link to district PDCs and asked them to forward it to agents within their district. We believed that including the PDCs in this process would demonstrate administrative support and approval of our research and encourage more participation. This step also helped to ensure neither agents nor their email filters perceived the survey as junk email. We kept the survey open for 1 month (March 15, 2017 to April 15, 2017). After 1 and 2 weeks, we asked the PDCs to send follow-up email reminders to boost response rates (as suggested by Archer 2007). The Institutional Review Board at the University of Georgia determined that this survey did not qualify as "human research," and thus did not require approval for the use of human subjects (reference # STUDY00004570).

The survey asked the agents to reflect upon requests received from clients during 2016 regarding issues of wildlife damage. The survey consisted of a combination of open-ended, Likert-scale, and fixed-choice questions (Table 1). The survey contained 14 questions, separated onto 15 online pages to minimize scrolling requirements that may negatively affect respondents' attitudes toward surveys (Toepoel et al. 2009). All respondents received survey questions in the same order, similar to the order of questions presented in the most recent survey (Mengak 2003). We did not elect to have the survey force respondents to answer questions, as we believed that doing so would potentially cause more respondents to view the survey as too burdensome and withdraw.

We downloaded results from SurveyMonkey and imported all responses into Microsoft Excel (2016). We checked responses to ensure we were not including potential typographical errors or exaggerations. We removed 1 outlier that did not appear plausible. We pooled data from agents that had described their counties as suburban or urban to create a category of relatively high human density against which we could compare data from agents serving rural counties (low human density). We used R (R Core Team, Vienna, Austria) for all statistical analyses. We used equality of proportions tests to compare data involving percentages (e.g., percent of agents receiving complaints about wild pigs (*Sus scrofa*) in rural versus urban/suburban counties). We used nondirectional Welch's *t*-tests to compare all numerical responses between county types and between survey years, unless an *F* test confirmed equal variances, in which case we used Student's *t*-tests. We collapsed Likert-scale responses into 3 categories, and then we used Pearson's chi-square tests to assess responses (i.e., determine if the distributions of answers between agreement, disagreement, and neutrality deviated from what could be expected by chance). All statistical analyses were tested at $P < 0.05$. Before comparing our findings against the Mengak (2003) survey, we used an equality of proportions test to ensure county representation was equivalent between the 2 surveys. Only general trends were inferred from the 1980 survey (Jackson 1980) due to the variation in targeted agents in this survey compared to that of the latter 2 surveys. We did not assess nonresponse bias due to limitations of time and resources.

Results

Sixty-four agents responded to the survey (64/138, or 46.4%, response rate). Six survey respondents did not answer all 14 questions; skipped questions varied. We utilized what data were available from these partially incomplete surveys. Most respondents took 3–15 minutes to complete the survey ($\bar{x}$ = 00:09:17, excluding survey completion times >00:30:00). Respondents represented 65 of Georgia's 159 counties (41%).

Seventy percent of agents reported their counties as primarily rural, followed by 22% suburban, and 8% urban. This suggests a relatively representative sample of respondents across county types within Georgia, where 68% of
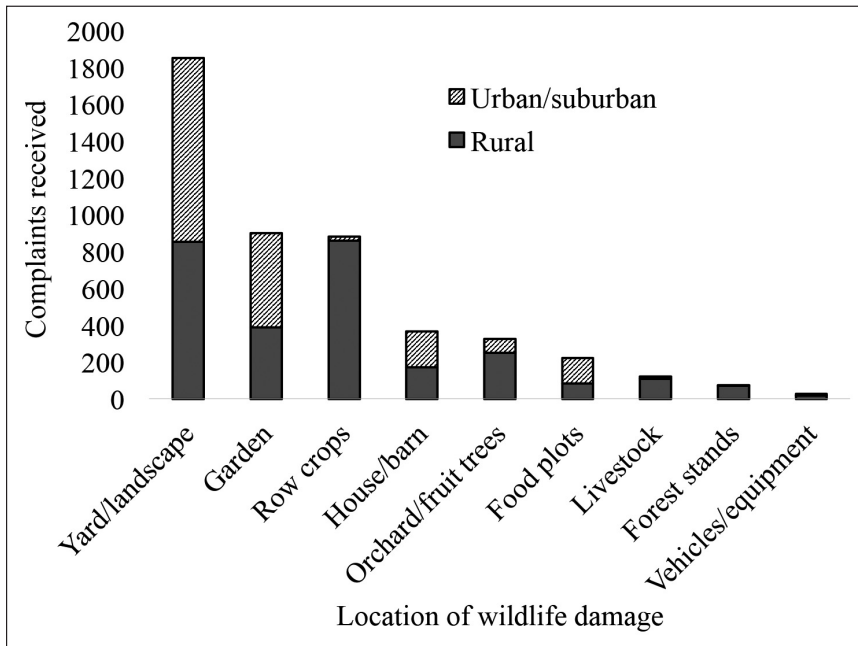
Figure 1. In an online survey, Agricultural and Natural Resources Extension agents in rural (*n* = 41) and urban/suburban (*n* = 17) counties in Georgia reported that most complaints received during 2016 about wildlife damage dealt with yards/landscape, but agents also received complaints from clients about many other forms of wildlife damage.

counties are designated as rural within the state of Georgia (i.e., they have <35,000 people; U.S. Census Bureau 2012). Agents reported an average of 7.2 years of experience in the county (s = 8.02 years, range = 1 month to 38 years, *n* = 64).

Wildlife damage complaints

Eighty-one percent of the agents surveyed had received wildlife damage complaints from homeowners or tenants, 80% from farmers or producers, 19% from garden clubs, 14% from the green industry (e.g., landscapers, urban foresters), and 13% from forest landowners. The agents were also provided an option to write in responses to this question. One agent reported complaints about wildlife damage from golf course managers while another received complaints from the local school system.

We asked agents to estimate the total numbers of complaints received during the year prior regarding 9 specific categories of wildlife damage. Fifty-eight agents reported 4,785 complaints (83 complaints per agent). On average, agents from urban/suburban counties estimated 1.7 times more complaints in response to this question ($\bar{x}$ = 115.4, s = 99.1, *n* = 17) than agents from rural counties ($\bar{x}$ = 68.9,

s = 62.6, *n* = 41), though this difference was not significant (*P* = 0.087). Agents reported more complaints about yard and landscape damage than any other category (Figure 1).

Agents from rural counties reported more complaints regarding row crops, livestock, and forest stands (1,040 total complaints) than their urban/suburban counterparts (39 total complaints). All agents from urban/suburban counties received complaints about yard and landscape damage. Other types of damage were much less ubiquitous; the next complaint most common in urban/suburban counties was wildlife damage to gardens, received by 58.9% of agents. Nearly equivalent numbers of agents from rural counties received complaints about yard and landscape damage and row crop damage (85.7% and 88.1% of agents, respectively).

Two questions addressed which species or species groups were responsible for wildlife damage complaints. The first question provided a species list and asked respondents to check off all species about which the agent had received complaints during 2016. More agents selected deer (*Odocoileus virginianus*; 92%) than any other species or species group.
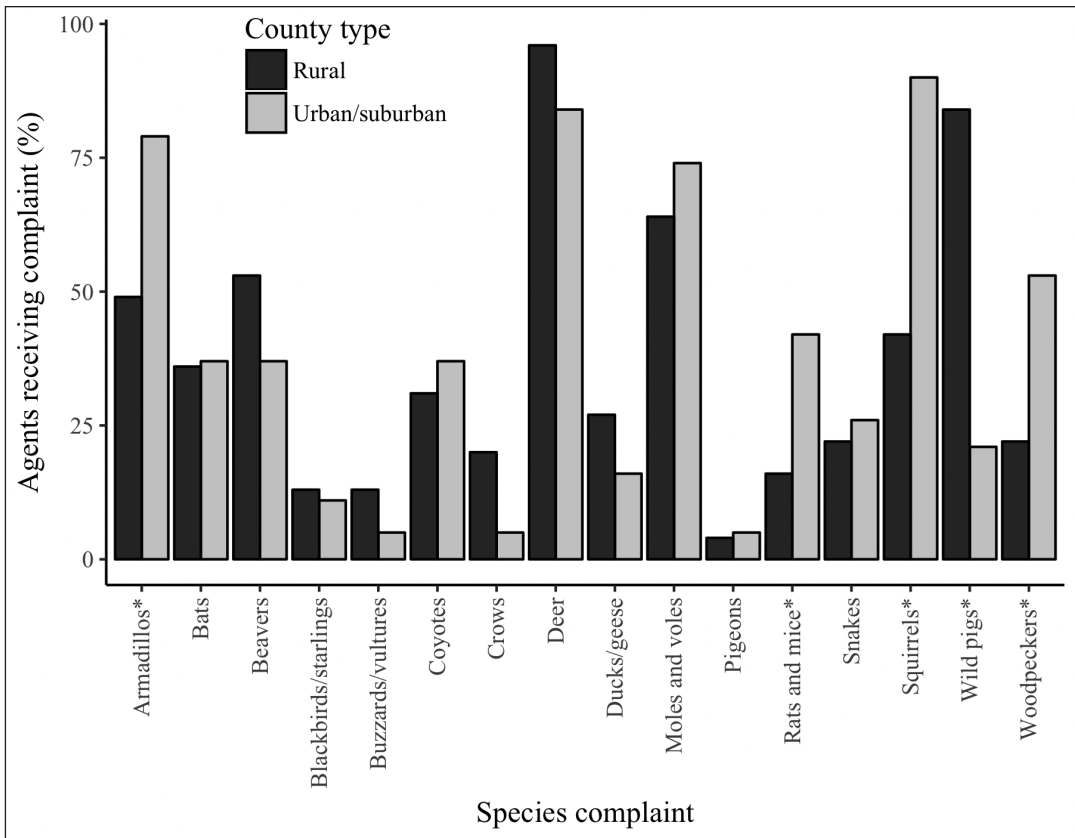
Figure 2. In an online survey, Agricultural and Natural Resources Extension agents in Georgia were provided with a list of species/species-groups and were asked to select all those about which they had received damage complaints during the year prior (2016). The percentages of agents who selected each species group are shown, categorized by whether their representative counties were rural (*n* = 45) or urban/suburban (*n* = 19). Statistically significant differences (*P* < 0.05) between county types are indicated with asterisks.

Moles (*Scalopus aquaticus*) and voles (*Microtus* spp.; 67% of agents), wild pigs (66%), and squirrels (*Sciurus* spp.; 56%) were the next most frequently reported species/species groups. While deer were a common problem in both rural and urban/suburban counties (with 96% and 84% of agents reporting, respectively), other species were not so ubiquitous (Figure 2). For example, agents in urban/suburban counties were more likely to receive complaints about squirrels (χ_1^2 = 10.28, *P* = 0.001), woodpeckers (Family: Picidae; χ_1^2 = 4.42, *P* = 0.035), and rats (*Rattus* spp.) or mice (*Mus* spp.; χ_1^2 = 3.87, *P* = 0.049), while wild pigs were a more prominent issue for agents in rural counties (χ_1^2 = 21.07, *P* = 0.000004).

The second question prompted agents to estimate the number of questions or requests for information received during 2016 regarding 38 species or situations of damage. Sixty-one agents reported 9,393 requests for information

(approximately 154 requests per agent). Trends were similar between the responses to this survey question and the former; agents received more requests for information about deer than any other species. This was followed by armadillos (*Dasypus novemcinctus*), wild pigs, moles, and squirrels (Figure 3). Agents also received many requests from clients seeking assistance from wildlife specialists to diagnose unknown sources of damage or for more information on dealing with wildlife damage in general. On average, agents from urban/suburban counties reported more than twice the number of requests for information ($\bar{x}$ = 261, s = 401.9, *n* = 16) than agents in rural counties ($\bar{x}$ = 116, s = 130.8, *n* = 45). However, this was driven by 2 urban/suburban county agents who together estimated having received more complaints than the other 14 agents combined, and the difference was not significant.
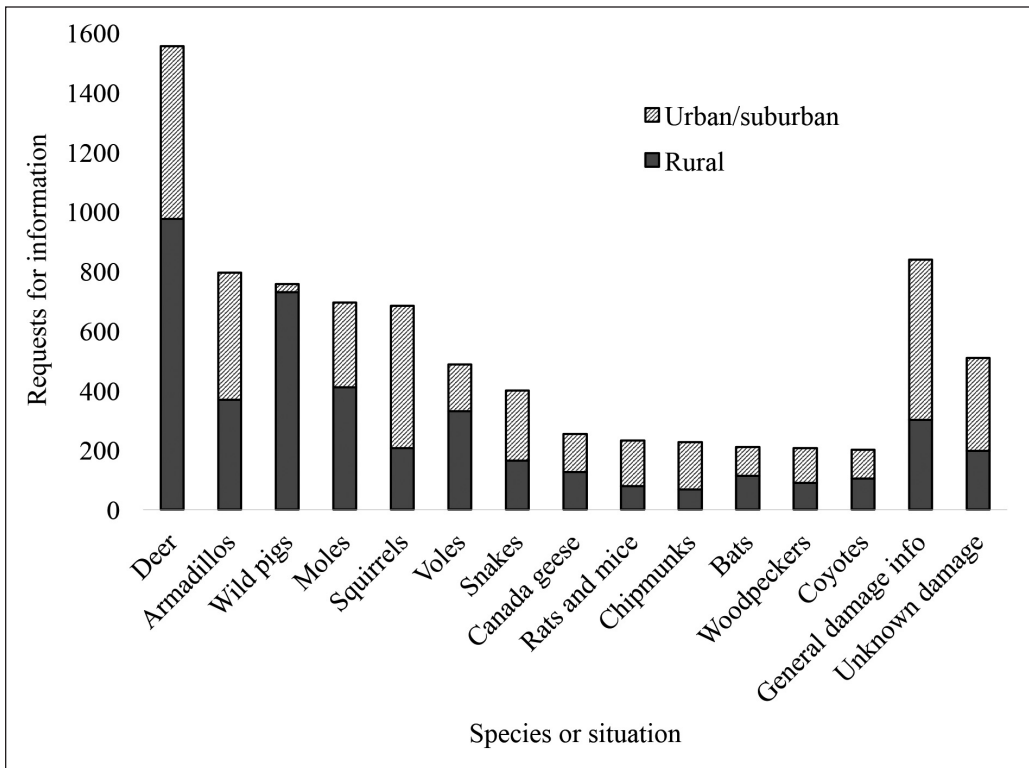
Figure 3. In an online survey, Agricultural and Natural Resources Extension agents in rural (*n* = 45) and urban/suburban (*n* = 16) counties in Georgia estimated the total numbers of requests for information received regarding 41 different species or situations involving wildlife for the year prior (2016). The 16 most frequent requests are shown (a complete list of responses is available from the authors).

Client behaviors and preferences for wildlife damage management

We included 3 Likert-scale questions to assess the perceptions of agents regarding client behaviors and attitudes toward nuisance wildlife management. When we asked agents if they had a sense that clients were generally resolving wildlife damage or nuisance problems themselves without calling for assistance from the agent first, responses were well-dispersed. Overall, agents were just as likely to express disagreement, agreement, or neutrality (Figure 4). However, agents serving urban/suburban counties, specifically, were more inclined to express disagreement (clients were calling agents for assistance) or neutrality ($\chi_2^2 = 6.11$, $P = 0.047$).

When asked if agents believed their clients preferred to hire private nuisance wildlife control operators (NWCOs) rather than resolve the issues themselves, responses were again well-dispersed, and we detected no difference in the number of agents reporting agreement,

disagreement, or neutrality (Figure 5). However, when we examined these data by county type, we found that agents serving rural counties were more likely to express disagreement rather than agreement or neutrality (i.e., clients in rural counties do not prefer to hire private companies; $\chi_2^2 = 6.40$, $P = 0.041$).

When asked if agents believed their clients were opposed to lethal control of nuisance wildlife, agents were more likely to express disagreement or neutrality rather than agreement ($\chi_2^2 = 18.03$, $P = 0.0001$; Figure 6). When examined by county type, this held true for agents in rural counties ($\chi_2^2 = 17.73$, $P = 0.0001$) but not for agents in urban/suburban counties, where we detected no significant deviation from that which could be expected by chance.

Open-ended call for additional information

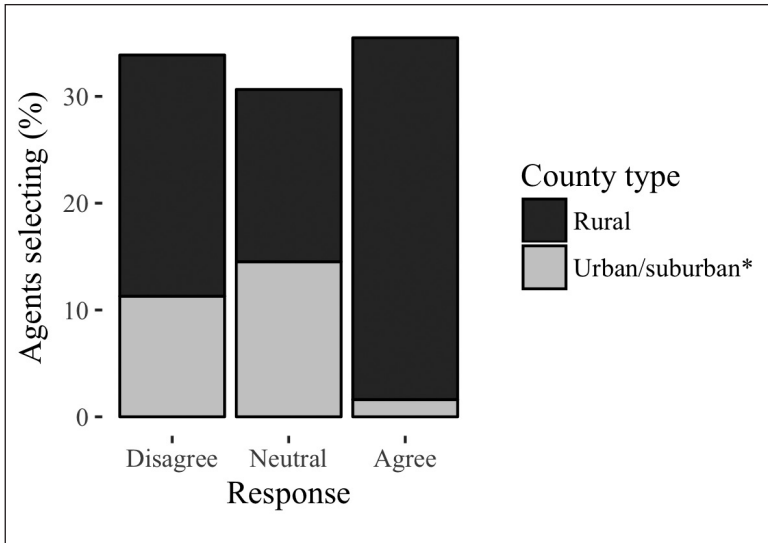The survey closed with an open-ended question asking respondents if they had anything further
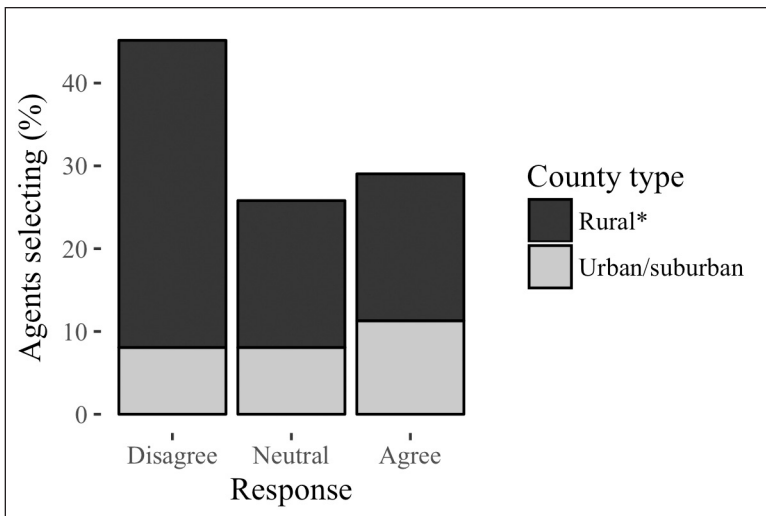
Figure 4. In 2017, Agricultural and Natural Resources Extension agents in Georgia were asked in an online survey to indicate the level to which they agreed with the following statement: My clients tend to solve wildlife damage/nuisance problems themselves without calling for advice from me (or my office) first. Responses are categorized by agents representing rural (*n* = 45) versus urban/suburban (*n* = 17) counties. Asterisks indicate a significant deviation from the null distribution for the county type.

Figure 5. In 2017, Agricultural and Natural Resources Extension agents in Georgia were asked in an online survey to indicate the level to which they agreed with the following statement: My clients prefer to hire private companies to resolve issues of wildlife damage/nuisance problems rather than solving the issues themselves. Responses are categorized by agents representing rural (*n* = 45) versus urban/suburban (*n* = 17) counties. Asterisks indicate a significant deviation from the null distribution for the county type.

they thought could be useful in understanding wildlife damage or nuisance wildlife issues in their counties. Sixteen agents responded. Most of these agents elaborated on species that were most destructive. Seven respondents stated that wild pigs were causing extensive damage to crops ("costing our producers hundreds of thousands of dollars each year"), and/or that populations were growing out of hand. The agents stated they were in need of "better answers" when "trapping, hunting, dog hunting, and fencing" were not sufficient for control. Five agents spoke
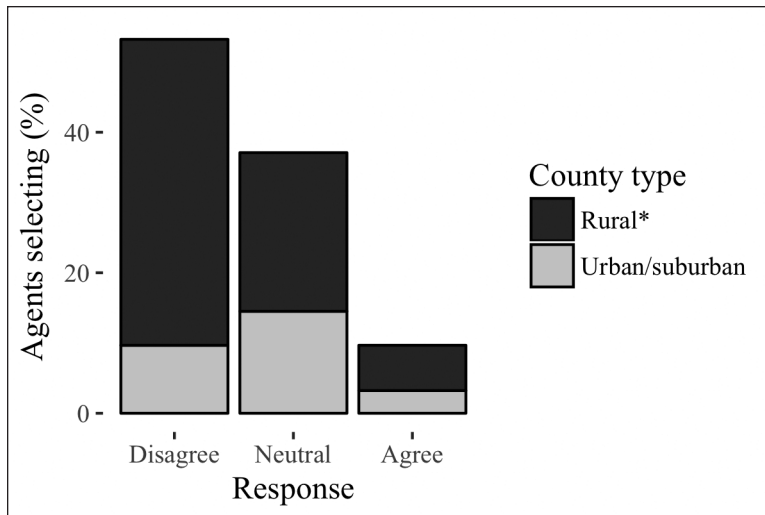
Figure 6. In 2017, Agricultural and Natural Resources Extension agents in Georgia were asked in an online survey to indicate the level to which they agreed with the following statement: My clients are opposed to lethal actions taken against nuisance wildlife. Responses are categorized by agents representing rural ($n = 45$) versus urban/suburban ($n = 17$) counties. Asterisks indicate a significant deviation from the null distribution for the county type.

of issues with deer populations; 2 comments were specifically in the context of crop or agricultural damage (for "blueberries" [*Vaccinium* sp.] and "corn, soybeans, and cotton" [*Zea mays, Glycine max*, and *Gossypium* sp.], respectively). Two agents were concerned about wild/domesticated dogs (1 agent cited a concern about rabies). Two agents mentioned coyotes (*Canis latrans*), 1 agent cited growing coyote populations, while another stated that they were "present but [there was] no apparent damage." One agent each reported increasing numbers of damage complaints about bears (*Ursus americanus*; getting into garbage cans) or armadillos. One agent suspected that bird damage during blueberry harvest season was having a "large economic impact." Moles and voles were mentioned once as the prominent wildlife species causing problems within the county.

Two agents offered other types of insight for addressing wildlife damage. The first suggested the need for "clear realistic options" and that we should be providing "landowner[s] all of their options regardless of method." The second agent expressed doubt that agents were "the first place people go for wildlife information," and was unsure how to change that. However, the agent also reported that complaints had been increasing over the last 4 years ("not a huge change, but some").

Longitudinal trends

An equality of proportions test concluded there was no difference in the proportions of agents from rural counties between the 2002 and 2017 surveys. This assured us the 2 surveys had comparable representations of county types, and thus comparable respondents.

Mengak (2003) reported that the 3 most cited locations of wildlife damage occurred in, or to, yards/landscapes, gardens, and houses/barns. Complaints about wildlife damage to houses or barns had declined significantly ($t_{62} = 2.54$, $P = 0.01$), while complaints about row crops had increased ($t_{78} = -2.03$, $P = 0.046$). Complaints about damage to yards/landscapes and about damage to gardens had declined, though not significantly. Overall, agents in 2017 reported having received fewer complaints in response to this survey question than their predecessors ($t_{84} = 2.42$, $P = 0.018$; Figure 7).

We identified many differences in the numbers of complaints reported about different species between the 2 most recent surveys (Figure 8). We found declines in the numbers of complaints received about bats ($t_{62} = 3.56$, $P = 0.0007$), moles ($t_{78} = 2.27$, $P = 0.026$), squirrels ($t_{117} = 2.01$, $P = 0.047$), and woodpeckers ($t83 = 2.35$, $P = 0.021$), while we found an increase in complaints about voles ($t_{75} = -2.39$, $P = 0.019$). Agents also reported more complaints about
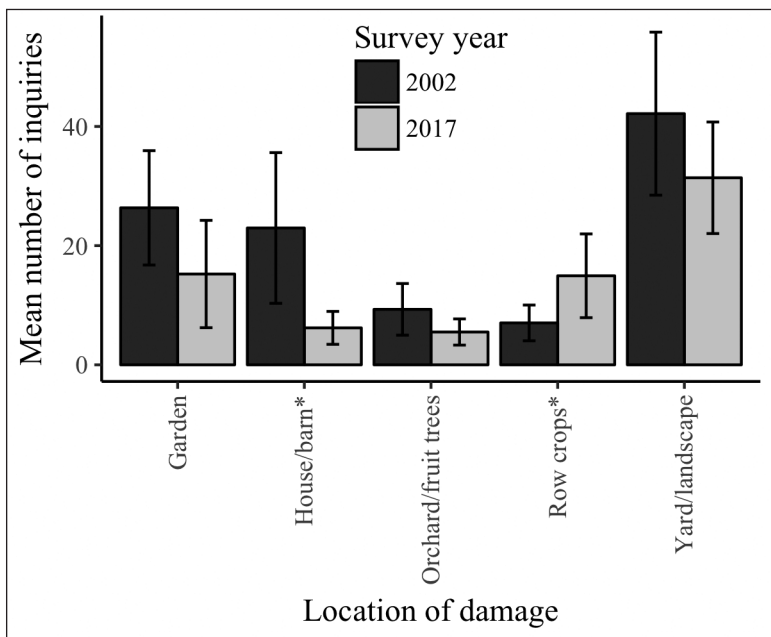
Figure 7. In 2002 (*n* = 58) and again in 2017 (*n* = 64), Agricultural and Natural Resources Extension agents were provided with lists of wildlife damage categories and were asked to estimate the cumulative number of complaints or inquiries they had received in regards to each during the years prior (i.e., 2001 and 2016, respectively). In 2017, agents reported more complaints about damage to row crops than agents had reported in 2002, while complaints about damage to houses/barns had decreased (*P* < 0.05).
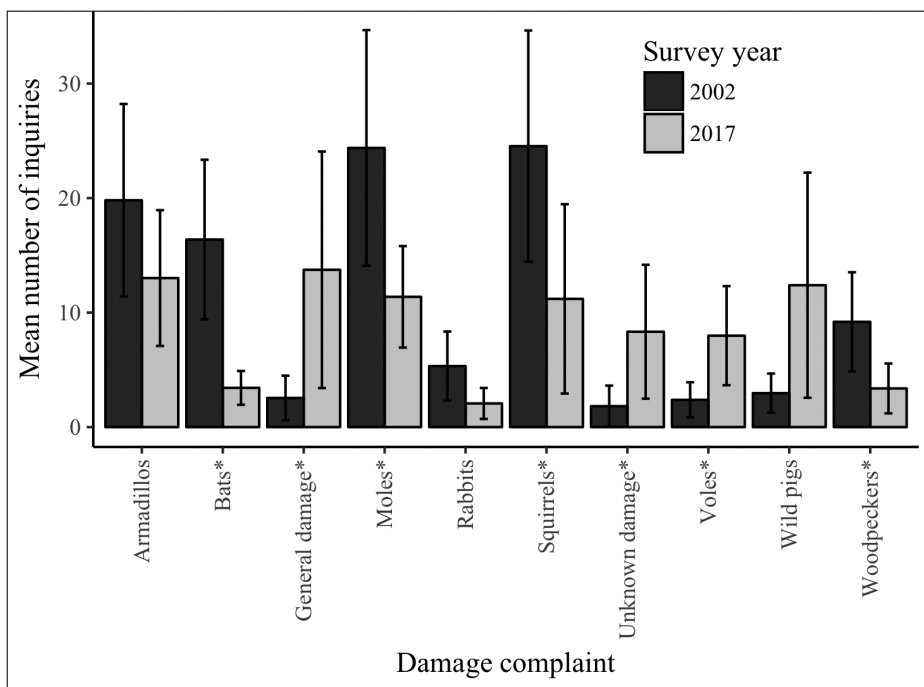

Figure 8. In 2002 (*n* = 58) and again in 2017 (*n* = 59), Agricultural and Natural Resources Extension agents were provided with lists of wildlife damage categories and were asked to estimate the cumulative number of complaints or inquiries they had received in regards to each during the years prior (i.e., 2001 and 2016, respectively). The 10 categories for which we detected the greatest change are shown. Asterisks indicate that the difference in means between survey years was significant (*P* < 0.05).
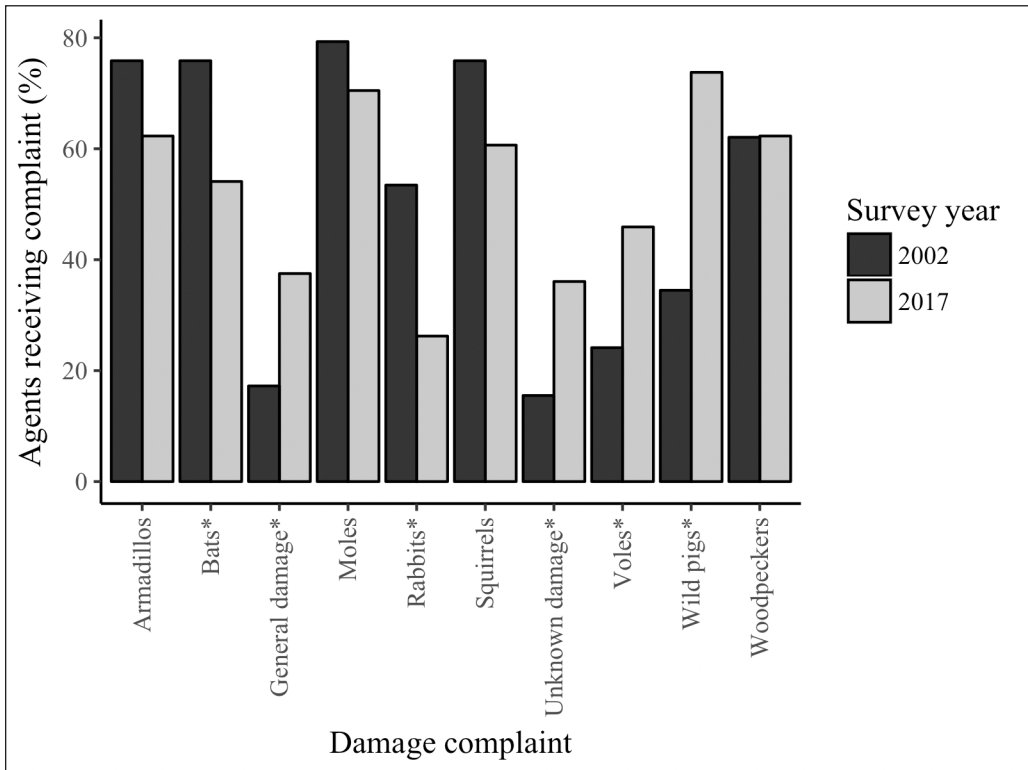
Figure 9. In 2002 (*n* = 58) and again in 2017 (*n* = 59), Agricultural and Natural Resources Extension agents were provided with lists of wildlife damage categories and were asked to estimate the cumulative number of complaints or inquiries they had received in regards to each during the years prior (i.e., 2001 and 2016, respectively). The percent of agents that had reported receiving any complaints for 10 species are shown. Asterisks indicate that the difference in the percentage of agents reporting complaints for that category had changed from the previous survey (*P* < 0.05).

general wildlife damage (t_{64} = -2.08, *P* = 0.041) and complaints about unknown damage (t_{71} = -2.08, *P* = 0.041) in 2017 than agents reported in 2002. We compared these data alongside the percentages of agents that had reported receiving any complaints about these species or situations to better understand complaint trends (Figure 9). For example, though the increase in the numbers of complaints received about wild pigs was not significant, there were more agents receiving complaints about wild pigs than in the Mengak (2003) survey (χ_1^2 = 16.96, *P* = 0.00004).

General comparisons to the Jackson 1980 survey suggest some possible overarching longitudinal trends. Moles and squirrels featured prominently in all 3 surveys, and thus have been a consistent wildlife damage issue in Georgia over the last 40 years. Deer, armadillos, and especially wild pigs have become more problematic in recent decades. Complaints about bats, snakes (Suborder: Serpentes), woodpeckers, and rabbits (*Sylvilagus* spp.) seem to be decreasing.

Discussion

In 2016, agents received more inquiries about deer than any other species. Other species frequently identified included armadillos, wild pigs, moles, squirrels, and voles. These results were not altogether surprising. Moles and squirrels were consistently ranked as 2 of the species about which agents had received the most complaints within all 3 surveys. Moles and squirrels are 2 leading causes of wildlife problems in the nation (Marion 1988). Although some control measures are readily available, these species are well-adapted to coexisting in human-dominated landscapes. Even if offending individuals were removed, population recovery is usually rapid unless more aggressive habitat modification measures are simultaneously employed (Jackson 1994).

Deer, which cause considerable economic damage across the nation (Marion 1988), are increasing across much of their range in North America, especially in the eastern United States (Warren 1997, DeNicola et al. 2002). White-tailed deer populations in Georgia have almost tripled since 1980 (Killmaster 2014). This explains the increasing frequency with which agents were receiving complaints about this species compared to the 1980 Survey (Jackson 1980). The Georgia 2014 urban deer management plan encouraged the use of regulated hunting to manage urban deer (Killmaster 2014). However, urban deer management is not a straightforward task. Hunting as a management technique may be an impractical solution for urban and suburban counties with large deer populations due to safety concerns associated with high human densities (Brown et al. 2000). However, few alternative management options exist, so these developed areas often become refugia for local deer populations (Williams et al. 2012). Furthermore, even though large deer populations cause considerable damage, hunting provides an enormous economic boom. Thus, deer are a valued resource, and many people have not yet become convinced that overabundant white-tailed deer populations are problematic (Warren 1997).

Deer hunting was estimated to generate >$800 million annually in the state of Georgia alone (Georgia Department of Natural Resources 2017*a*). Future management challenges must address the conflicting issues of providing hunters with healthy deer populations while also appeasing those who endure the most damage from such large populations (Mengak and Crosby 2017).

Wild pig populations and related damage issues also are increasing in many southern states, including Georgia (Mengak 2016). Wild pigs are also popular for sport hunting, but unlike deer, they are invasive and the damage they cause to natural and agricultural ecosystems is not offset by the revenue generated (Rollins et al. 2007, Mengak 2016). While we did not find that the number of complaints about wild pigs had increased significantly between the 2002 and 2017 surveys, we confirmed that more agents serving Georgia counties were receiving complaints about this species. This suggests that the distribution of wild pig populations

has increased within Georgia over the last 15 years. Some agents in our survey expressed the need for more answers to the considerable problems caused by wild pigs. Privately, agents conveyed the public's desire for toxicants or contraceptives. Both tools are years away from widespread availability, if they become available at all, and we will likely only see increasing reports of wild pig damages into the future (Mengak 2016). Diligent application of proper trapping techniques, focused on whole-sounder removal, is still the best tool for wild pig control (Smith et al. 2014).

The range expansion of the nine-banded armadillo from an introduced population in Florida is well-documented (Taulman and Robbins 2014). Few agents in 1980 had reported receiving complaints about armadillos, but this was one of the most problematic species of 2002 and 2017, which confirmed their range expansion in Georgia. Agents in Georgia counties near metro-Atlanta confirmed complaints about this pest in the 2017 survey. Armadillos have few natural predators, and their expanding range will likely only be halted by their limited capacity to tolerate cold temperatures along a latitudinal and altitudinal gradient. Climate change is predicted to increase temperatures throughout the southeastern United States (Environmental Protection Agency 2016). Thus, this barrier to the armadillo range expansion may deteriorate in the future.

Bat populations in Georgia, as elsewhere, have experienced rapid and severe population declines (~92%) since white-nose syndrome was first detected in the state in 2013 (Georgia Department of Natural Resources 2017*b*). This loss may have been reflected by a reduction in the number of bat complaints received by agents.

Although population dynamics may explain much of what we observed, this cannot be the case for all increasing or decreasing complaints about species. The increase in complaints about voles may be an artifact of inconsistent terminology between the Mengak (2003) survey and this one (in the Mengak survey, voles were referred to as pine mice). The Breeding Bird Survey indicated slight declines in hairy woodpecker (*Leuconotopicus villosus*; -1.87%) and downy woodpecker (*Picoides pubescens*; -0.15%) populations between 1966 and 2015 (Sauer et al. 2017); these declines do not seem to be

sufficient to explain the decrease in complaints received about woodpeckers. We also identified a decline in complaints about squirrels (numbers of complaints) and rabbits (percent of agents receiving complaints). Although we have no population data on these species, we believe these declines more likely result from successful dissemination of information to the public. Perhaps the last 14 years of directed education efforts (via Master Gardener and Master Naturalist type programs) have encouraged landowners to use effective repellents and implement exclusion techniques.

However, the general decrease in nearly all complaint types between surveys suggests other contributing factors may also be at work. Perhaps the most parsimonious explanation is the widespread increase of internet availability since the last survey of 2002. One of our respondents seemed to confirm this suspicion when he stated that he did not believe extension was the first place to which people went for this kind of information. Perhaps many clients reached out to agents only when their online queries did not provide satisfactory information (e.g., an online search could not help them identify unknown sources of damage, a category for which we saw increasing numbers of complaints). Online queries are also not likely to be helpful for managing damage from wild pigs, for which no easy solutions exist.

We detected many differences between the types of nuisance wildlife damage occurring in rural versus urban/suburban counties. Agents from urban/suburban counties reported, on average, more complaints or inquiries than agents from rural counties. Alhough these differences were never statistically significant, the trend held for all questions answered. As suspected, client attitudes toward nuisance wildlife management differed between rural and urban/suburban counties, though perhaps not as strongly as might have been anticipated based on other surveys (Kellert 1984). Agents serving urban/suburban counties believed their clients to be more likely to seek outside assistance (either by requesting information from an agent or by hiring NWCOs) for resolving wildlife problems than did agents of clients in rural counties. Urban and suburban cities are growing faster than their rural counterparts. This suggests that we will see an increasing demand for nuisance wildlife control services in the more populated counties and continued growth in the industry.

Agents benefit from knowing which methods of nuisance wildlife control their clientele prefer (Purdy and Decker 1989, Messmer et al. 1999). This information also benefits wildlife specialists and others who are working toward the development of new control methods. If methods are not likely to be acceptable to the public, their utility will be minimal.

Results from this survey indicated that, overall, agents in Georgia largely believed their clients to be receptive toward more active (i.e., lethal) population management strategies for nuisance wildlife. Some evidence exists that those who have experienced wildlife damage are more inclined to support lethal control (West and Parkhurst 2002). Our survey asked agents about perceptions regarding their clients' views of lethal control. Only 10% of agents reported that they believed their clients were opposed to lethal control of nuisance wildlife. Because these clients have likely experienced some degree of wildlife damage, they may view lethal control more favorably than the general public. Furthermore, we do not know how well clients that contacted agents represented the population in general (age, gender, socioeconomic status, etc.). However, other surveys that targeted the general public also concluded that a majority were in support of lethal control of nuisance wildlife when used responsibly (Messmer et al. 1999, Reiter et al. 1999, Koval and Mertig 2004). This survey was the first that contained questions regarding client preferences and attitudes; thus, we cannot assess whether any temporal changes have occurred.

Management implications

We observed many significant changes in the number and nature of nuisance wildlife complaints reported by Georgia agents between the 2 most recent statewide surveys. We believe these surveys successfully highlighted important trends in nuisance wildlife and wildlife damage in Georgia. Many of our results were not altogether surprising, but rather confirmed our suspicions about these trends within Georgia. Our results suggest that agents may serve as key informants for tracking

nuisance wildlife trends. Paper or online surveys that target the general population may be able to achieve more representativeness than our method, though response rates for these types of surveys can be extremely low. With only a few email reminders, we were able to achieve close to a 50% response rate, which is relatively high for an online survey (Sheehan 2006, Fincham 2008). Targeting agents as we did provided valuable and extremely cost-effective information that is difficult to acquire otherwise, and we recommend that managers consider adopting similar survey methods to track nuisance wildlife trends in their respective states.

Our survey also indicated an overall decline in the degree to which residents were seeking out advice from extension agents. This is either reflective of declining nuisance wildlife populations (which seems unlikely for many species), the successful dissemination of information to the public, or an increasing tendency for residents to seek and acquire information elsewhere, such as online or from NWCOs. One of our surveyed agents believed the truth lay somewhere with the latter explanation, though perhaps reality lies somewhere within an amalgamation of all three. Future endeavors to track nuisance wildlife trends might consider complementary studies to assess trends in NWCOs, though records of these businesses are currently poorly kept (personal observation). Whatever the explanation for the decline, a prudent course of action would be for cooperative extension to continue their endeavor in finding new methods to reach out to the public and let their services be known.

Acknowledgments

Literature cited

Adams, L. W. 2005. Urban wildlife ecology and conservation: a history of the discipline. Urban Ecosystems 8:139–156.

Ansolabehere, S., and B. F. Schaffner. 2014. Does survey mode still matter? Findings from a 2010 multi-mode comparison. Political Analysis 22:285–303.

Archer, T. 2007. Characteristics associated with increasing the response rates of web-based surveys. Practical Assessment 12(12).

Baker, R. O., and R. M. Timm. 2017. Coyote attacks on humans, 1970–2015: implications for reducing the risks. Human–Wildlife Interactions 11:120–132.

Breck, S. W., S. A. Poessel, and M. A. Bonnell. 2017. Evaluating lethal and nonlethal management options for urban coyotes. Human–Wildlife Interactions 11:133–145.

Brown, T. L, D. J. Decker, S. J. Riley, J. W. Enck, T. B. Lauber, P. D. Curtis, and G. F. Mattfield. 2000. The future of hunting as a mechanism to control white-tailed deer populations. Wildlife Society Bulletin 28:797–807.

Comer, M. M., T. Campbell, K. Edwards, and J. Hillison. 2006. Cooperative extension and the 1890 land-grant institution: the real story. Journal of Extension 44(3).

Conover, M. R. 1994. Perceptions of grass-roots leaders of the agricultural community about wildlife damage on their farms and ranches. Wildlife Society Bulletin 22:94–100.

Conover, M. R. 1997. Wildlife management by metropolitan residents in the United States: practices, perceptions, costs, and values. Wildlife Society Bulletin 25:306–311.

Conover, M. R. 2001. Resolving human-wildlife conflicts: the science of wildlife damage management. CRC Press, Boca Raton, Florida, USA.

Conover, M. R., and D. J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildlife Society Bulletin 19:46–52.

Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. DuBow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. Wildlife Society Bulletin 23:407–414.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis, and S. E. Hyngstrom. 2002. Managing white-tailed deer in suburban environments—a technical guide. Cornell University Cooperative Extension, Ithaca, New York, USA.

DeStefano, S., and R. M. DeGraaf. 2003. Exploring the ecology of suburban wildlife. Frontiers in Ecology and the Environment 1:95–101.

Environmental Protection Agency. 2016. Climate change impacts: climate impacts in the southeast. U.S. Environmental Protection Agency, Washington, D.C., USA, <https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-southeast_.html>. Accessed March 28, 2018.

Evans, J. R., and A. Mathur. 2005. The value of online surveys. Internet Research 15:195–219.

Fall, M. W., and W. B. Jackson. 2002. The tools and techniques of wildlife damage management—changing needs: an introduction. International Biodeterioration & Biodegradation 49:87–91.

Fincham, J. E. 2008. Response rates and responsiveness for surveys, standards, and the journal. American Journal of Pharmaceutical Education 72:43.

Georgia Department of Natural Resources. 2017a. Deer fact sheet. Georgia Department of Natural Resources, Wildlife Resources Division, Social Circle, Georgia, USA, <http://www.georgiawildlife.com/DeerFacts>. Accessed April 22, 2017.

Georgia Department of Natural Resources. 2017b. White-nose syndrome in Georgia bats. Georgia Department of Natural Resources, Wildlife Resources Division, Social Circle, Georgia, USA, <http://www.georgiawildlife.com/WNS>. Accessed August 21, 2017.

Hadidian, J. D., D. Manski, V. Flyger, C. Cox, and G. Hodge. 1987. Urban gray squirrel damage and population management: a case history. Eastern Wildlife Damage Control Conference 3:219–227.

Jackson, J. J. 1980. Needs of county agents for vertebrate pest control information in Georgia. Proceedings of the Vertebrate Pest Conference 9:60–62.

Jackson, J. J. 1994. Tree squirrels. Pages B-171–175 in S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension, Lincoln, Nebraska, USA.

Kaplowitz, M. D., T. D. Hadlock, and R. Levine. 2004. A comparison of web and mail survey response rates. Public Opinion Quarterly 68:94–101.

Kellert, S. R. 1984. Urban American perceptions of animals and the natural environment. Urban Ecology 8:209–228.

Killmaster, C., editor. 2014. Georgia deer management plan, 2015–2024. Georgia Department of Natural Resources, Wildlife Resources Division, Social Circle, Georgia, USA.

Koval, M. H., and A. G. Mertig. 2004. Attitudes of the Michigan public and wildlife agency personnel toward lethal wildlife management. Wildlife Society Bulletin 32:232–243.

Marion, W. R. 1988. Urban wildlife: can we live with them? Proceedings of the Vertebrate Pest Conference 13:34–38.

McCaslin, N. L., and J. P Tibezinda. 1998. Assessing target group needs. Pages 56–66 in B. E. Swanson, R. P. Bentz, and A. J. Sofranko, editors. Improving agricultural extension: a reference manual. Food and Agriculture Organization of the United Nations, Rome, Italy.

Mengak, M. T. 2003. Wildlife damage management education needs: survey of Georgia county FASAT agents. Wildlife Damage Management Conference 10:7–15.

Mengak, M. T. 2016. Landowner opinions regarding wild pigs in Georgia, USA. Proceedings of the Vertebrate Pest Conference 27:162–169.

Mengak, M. T., and P. M. Crosby. 2017. Farmers' perceptions of white-tailed deer damage to row crops in 20 Georgia counties during 2016. Warnell School of Forestry and Natural Resources Publication WSFNR-17-38, University of Georgia, Athens, Georgia, USA.

Messmer, T. A. 2009. Human–wildlife conflicts: emerging challenges and opportunities. Human–Wildlife Interactions 3:10–17.

Messmer, T. A. 2000. The emergence of human–wildlife conflict management: turning challenges into opportunities. International Biodeterioration & Biodegradation 45:97–102.

Messmer, T. A., M. W. Brunson, D. Reiter, and D. G. Hewitt. 1999. United States public attitudes regarding predators and their management to enhance avian recruitment. Wildlife Society Bulletin 27:75–85.

Miller, J. E. 1991. The future of extension education programs in wildlife damage management. Proceedings of the Great Plains Wildlife Damage Conference 10:12–17.

National Research Council. 1995. Colleges of agriculture at the land grant universities: a profile. The National Academies Press, Washington, D.C., USA.

Purdy, K. G., and D. J. Decker. 1989. Applying wildlife values information in management: the wildlife attitudes and values scale. Wildlife Society Bulletin 17:494–500.

Reiter, D. K., M. W. Brunson, and R. H. Schmidt. 1999. Public attitudes toward wildlife damage management and policy. Wildlife Society

Bulletin 27:746–758.

Rollins, D., B. J. Higginbotham, K. A. Cearly, and R. N. Wilkins. 2007. Appreciating feral hogs: extension education for diverse stakeholders in Texas. Human–Wildlife Interactions 1:192–198.

Santana, E., and J. Armstrong. 2017. Food habits and anthropogenic supplementation in coyote diets along an urban-rural gradient. Human–Wildlife Interactions 11:156–166.

Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski, Jr., K. L. Pardieck, J. E. Fallon, and W. A. Link. 2017. The North American breeding bird survey, results and analysis, 1966–2015. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Sheehan, K. B. 2006. E-mail survey response rates: a review. Journal of Computer-Mediated Communication 6(2).

Slagle, K., J. T. Bruskotter, A. S. Singh, and R. H. Schmidt. 2017. Attitudes toward predator control in the United States: 1995 and 2014. Journal of Mammalogy 98:7–16.

Smith, T. N., M. D. Smith, D. K. Johnson, and S. S. Ditchkoff. 2014. Evaluation of continuous-catch doors for trapping wild pigs. Wildlife Society Bulletin 38:175–181.

Taulman, J. F., and L. W. Robbins. 2014. Range expansion and distributional limits of the nine-banded armadillo in the United States: an update of Taulman & Robbins (1996). Journal of Biogeography 41:1626–1630.

Toepoel, V., M. Das, and A. Van Soest. 2009. Design of web questionnaires: the effects of items per screen. Field Methods 21:200–213.

U.S. Census Bureau. 2012. Georgia: 2010 population and housing unit counts. U.S. Government Printing Office, Washington, D.C., USA.

Warren, R. J. 1997. The challenge of deer overabundance in the 21st century. Wildlife Society Bulletin 25:213–214.

West, B. C., and J. A. Parkhurst. 2002. Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. Wildlife Society Bulletin 30:139–147.

Williams, S. C., A. J. Denicola, T. Almendinger, and J. Maddock. 2012. Evaluation of organized hunting as a management technique for overabundant white-tailed deer in suburban landscapes. Wildlife Society Bulletin 37:137–145.

Wright, K. B. 2005. Researching internet-based populations: advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. Journal of Computer-Mediated Communication 10(3).

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