Surveys

Hunting and Game Consumption Patterns of Hunters in South Carolina

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Abstract

Scarcity of site-specific consumption rates for use in contaminant exposure modeling has resulted in a lack of formal guidance for assessing risk of exposure to contaminants via consumption of wild game in the United States. Consequently, numerical estimation of what species hunters harvest, consume, and share is important for human health risk assessment, especially in areas with elevated risk of contaminant exposure. To address these information gaps, we designed and administered questionnaires to 260 hunters at two hunting expos in South Carolina and inquired about their harvesting, sharing, and consumption habits with respect to wild game and wild fish. Of the 11 game and fish we included in our survey, respondents reported hunting and consuming an average of 5.3 and sharing 3.5. We found a significant difference in number of wild game and fish meals eaten per year across a rural–urban gradient, with respondents from low population density counties consuming more than those from medium or high population density counties. Additionally, hunters in our survey reported sharing a considerable portion of the game they procure, and often consume more fish and game than they hunt. Thus, future surveys would benefit from asking more directed questions related to who is receiving harvested game and portion size shared. Additionally, 90% of surveyed hunters also reported consuming fish. Thus, our results also highlight the importance of considering cumulative wild game and fish consumption in future risk assessment analysis for the southeastern United States and other comparable populations, especially for high-risk groups such as children and pregnant women.

Keywords: contaminants, game consumption patterns, game sharing, hunters, hunting patterns, risk assessment analysis, urban–rural

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Introduction

Information needed to evaluate human health risks associated with consumption of contaminated wildlife includes 1) the species of game animals people consume, 2) the frequency and amount of each species of game consumed, and 3) concentrations of contaminants in consumable tissues of those wildlife species. Information on overall game consumption patterns is especially important for places like the southeastern United States where harvest seasons can extend for several months, and bag and possession limits can be liberal. For example, in approximately 60% of South Carolina (hunt units 3 and 4) the white-tailed deer

(*Odocoileus virginianus*) hunting season extends from August to January with hunters able to harvest $\sim$ 10 deer. Wildlife that comes into contact with environmentally contaminated sites, such as coal combustion waste disposal wetlands, could represent a pathway for exposure to many trace elements. In fact, Oldenkamp et al. (2017) documented significantly higher levels of several trace elements (e.g., selenium and mercury) in muscle tissue of wildlife collected from these areas in South Carolina in comparison to relatively uncontaminated sites. Likewise, Tipton et al. (in press) measured concentrations of perfluorinated alkyl acids in alligator meat harvested by recreational hunters and found that exposure risk to hunters varied geographically across South Carolina. Furthermore, South Carolina currently has 68 water bodies under fish-consumption advisories, primarily for mercury and polychlorinated biphenyls (South Carolina Department of Health and Environmental Control 2016). Because some hunters may consume a number of game and fish species with different exposure histories to environmental contaminants throughout the season, cumulative exposure in hunters may be underestimated, particularly in areas with elevated levels of contaminants.

Unlike the numerous state, local, and national site-specific studies evaluating fish consumption rates for use in human health risk assessments, there are limited data on contaminant burdens in many game species. Thus, there is little formal guidance for establishing whether wild game consumption advisories might be appropriate, especially in areas with known contaminant inputs (Conder and Arblaster 2016). In a recent review, Conder and Arblaster (2016) noted that, in addition to quantifying contaminant burdens in harvested game animals, a key challenge was identifying wild game consumption rates for use in exposure modeling. To address these shortcomings, Conder and Arblaster (2016) concluded that wild game consumption rates could be developed for site-specific areas using several approaches, but values based on empirical survey data from the area would be preferred, followed by values derived from survey data collected from comparable sites. In addition to exposure modeling, information on wild game and fish consumption also would be useful from an extension standpoint to better ascertain how these patterns interact with larger socio-ecological systems such as attitudes toward hunting and fishing (Ljung et al. 2012), and the ecological and nutritional benefits associated with these activities (e.g., Tidball et al. 2013).

Hunting and consumption patterns of wild-caught game and fish are likely to vary along a rural–urban gradient. For instance, Thompson and Floyd (2015) found the percentage of the population participating in fishing or hunting doubled from 15% in metropolitan areas (cities or towns with $\geq$ 50,000 people) to 30% in more rural areas. In the United States, wild game meat generally cannot be commercially sold, which may limit its availability to nonhunters, especially those in more urbanized areas. However, sharing of wild-caught game, both within and between households, represents a potential avenue for inclusion of game meat in the food chain to nonhunters in the Unites States, although the extent to which hunters share game is poorly understood.

Data on local consumption patterns of wild game are often lacking. To address this knowledge gap, we report on patterns of harvesting, consumption, and sharing of game and fish meat by recreational hunters and anglers in South Carolina for 11 species and taxa across a rural–urban gradient. Our primary objectives were to determine 1) how hunting and consumption patterns by residents vary among fish and game animals, 2) how long respondents have been hunting and consuming wild-caught game and fish, 3) rates at which game meat is shared with other households, and 4) how these patterns vary across a rural–urban continuum.

Methods

Administering questionnaires

We administered questionnaires to attendees at the Southeastern Wildlife Exposition (13–15 February 2015, Charleston, South Carolina) and the Palmetto Sportsman's Classic (27–29 March 2015, Columbia, South Carolina). Approximately 40,000 people attend the Southeastern Wildlife Exposition each year and an estimated 30,000 people attended the 2015 Palmetto Sportsman's Classic. The population from which we sampled consisted primarily of recreational hunters and anglers from the South Carolina. Exhibit regulations prohibited us from approaching attendees away from our booth, thus we recruited volunteers to take our survey as they passed by our educational booth and after we provided an overview of the purpose of our surveys. Consequently, respondents were not selected randomly from the general population, but should be representative of those attending the exhibition as nearly everyone ($>$ 90%) we asked agreed to take the survey. One or more researchers from the University of Georgia's Savannah River Ecology Lab were available to answer questions as respondents completed the questionnaire. Only individuals at least 18 y old who resided and hunted in South Carolina were included in our survey, and only one individual per household was allowed to complete a questionnaire. All responses were anonymous in that respondents were not asked to provide their name or contact information. The questionnaires and interview protocol were approved by University of Georgia's Human Subjects Institutional Review Board (study 00001755).

We divided the questionnaire into four main sections: 1) socio-demographic information about the respondents, 2) their hunting patterns, 3) their consumption patterns, and 4) the extent to which they share game with other households. Socio-demographic information included their South Carolina county of residence, the counties in which they hunt or fish, names of freshwater waterbodies in which they hunt or fish, age, number of people in their household, and number of adults and children in household that consume game. For the

remaining sections of the questionnaire, we asked respondents a suite of questions regarding hunting and consumption patterns of the following species and taxa: white-tailed deer, wild pigs (*Sus scrofa*), eastern wild turkey (*Meleagris gallopavo*), northern bobwhite quail (*Colinus virginianus*), waterfowl, rabbits (*Sylvilagus* spp.), squirrels (*Sciurus* spp.), raccoons (*Procyon lotor*), fish, turtles, and alligators (*Alligator mississippiensis*). Unless otherwise noted, hereafter we use the term game meat or game animal to refer to all the above species or taxa (i.e., fish and wild pigs are included). Although wild pigs are not considered a game animal in most states, they are recreationally hunted throughout much of their range (including South Carolina), and many states require a license in order to do so. For each species and taxa, we asked respondents the following questions:

- Do you hunt these game? (yes or no)
- Do you consume these game? (yes or no)
- How many years have you been consuming these game?
- How many meals do you consume of these game? (Respondents could provide number based on per week, per month, or per year depending on the frequency. We then converted all responses to number of meals per year.)
- How many other household members consume these animals?
- Do you share these with others outside your household? (yes or no)
- How many other households do you share these game with?

We also provided respondents the opportunity to list any other wildlife species consumed that we did not specifically include in our survey.

Data handling and analysis

We included responses from all respondents meeting the above criteria (e.g., $>$ 18 y old and resident of South Carolina). We were primarily interested in hunters; therefore we excluded respondents that indicated they were only anglers (n = 37, 12%). We did include information on fishing habits if respondents indicated they also hunted $\geq$ 1 of the other game animals included in the questionnaire. We excluded portions of respondent's answers if they were illegible or if they provided contradictory information. For example, if a respondent reported hunting or consuming game for more years than their reported age, we excluded the number of years consuming game from analysis for that individual. We also had three instances where respondents reported two counties of residence. When this occurred we considered the first county recorded on the data sheet as their primary county of residence. Additionally, when respondents recorded a range of values (e.g., 3–4 meals consumed per month) we used the average of the values provided (i.e., 3.5 meals/mo). We collapsed respondents into six age categories (i.e., 18–24, 25–34, 35–44, 45–54, 55–64, and $>$ 64 y old) based on criteria used by the U.S. Fish and Wildlife Service's National Survey of Fishing, Hunting and Wildlife-Associated Recreation Report (U.S. Department of the Interior et al. 2014). We used county of residence to evaluate differences in hunting or consumption patterns by population density using information derived from the U.S. Census Bureau 2010 TIGER data. We classified counties as having low (11.0–36.0 people/km^2), medium (47.3–108.7 people/km^2), or high (128.3–240.0 people/km^2) human population density. We used natural breaks in the data to determine cutoffs for each category. We used an analysis of variance to test for differences in meals per year and number of game animals hunted by population density. We conducted analyses in program R (R Core Team 2014).

Results

A total of 322 people participated in our survey: 93 at the Southeastern Wildlife Exposition (80 South Carolina residents, 13 Georgia residents) and 229 at the Palmetto Sportsman's Classic (227 South Carolina residents, 2 Georgia residents). South Carolina residents comprised the majority of respondents (95.3%). Questionnaires from 62 respondents were excluded because they either did not fit our previously described criteria (e.g., they resided in Georgia, only fished and did not hunt) or they opted not to include any information regarding their hunting or fishing habits. Overall, 99.2% (n = 258) of the remaining 260 respondents reported their county of residence; 42.2% (n = 109) came from high population density areas, 26.0% (n = 67) from medium population density areas, and 31.8% (n = 82) from low population density areas. Age of respondents ranged from 18 to 76 y old (mean = 39.4, SE = 0.9 y).

Respondents were fairly evenly distributed across the four youngest age groups (range 19.2–23.8%), but fewer fell into the 55–64 (9.6%) and $>$ 64-y-old (8.1%) age groups. Overall, 232 respondents (89.2%) self-reported the number of years they had been consuming game (sample sizes across all game animals provided in Table S1, *Supplemental Material*), which ranged from 1–70 y (mean = 30.6, SE = 1.0 y). Most respondents had been consuming game the majority of their lifetime (mean = 79.2% of lifespan), although a few had only recently started consuming game (minimum, 3.6% of lifespan). Overall fish were consumed the longest period of time and alligator the least (Figure 1).

Average reported household size (n = 260) was 3.2 individuals (SE = 1.3,range: 1–9), with an average of 2.2 adults (SE = 0.06) and 1.0 child (SE = 0.07) per household consuming game. Overall, respondents self-reported that 75% (SE = 0.02%) of their household members consumed game. Respondents self-reported hunting an average of 5.3 (SE = 0.13) and consuming 5.3 (SE = 0.15) of the 11 game animals we included in our survey. Most respondents reported consuming the game they hunted, although this pattern varied across surveyed game (Figure 2). Furthermore, while many respondents report-

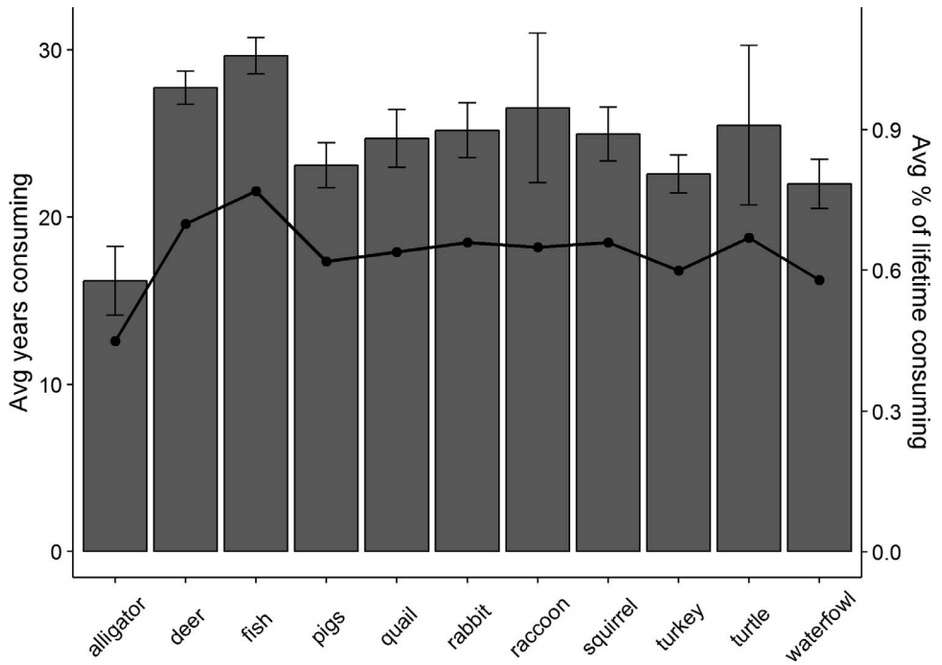

Figure 1. Average number of years respondents reported consuming 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.], wild turkey [*Meleagris gallopavo*], turtle, and waterfowl), as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina, from February to March 2015. Error bars indicate ± 1 SE.

ed sharing game with other households (Figure 3a), the proportion of active hunters sharing game also varied considerably (Figure 3b). It is worth noting that when we asked the question "Do you hunt these game?" we made the assumption that respondents actually harvested those animals. Consequently, if some respondents indicated they did hunt, but in fact had not harvested a particular animal, our estimates in Figure 3b may be biased somewhat high.

The percentage of respondents consuming game animals ranged from 97.3% for white-tailed deer to 5.0% for turtle (Figure 3a). Other species respondents reported as consuming but that were not included in our survey were mourning dove (*Zanaida macroura*), frog, black bear (*Ursus americana*), beaver (*Castor canadensis*), American woodcock (*Scolopax minor*), and snake. Respondents reported consuming on average 105.6 meals of wild game (including fish) per year (SE = 9.8 meals/y). Reported number of meals consumed per year was greatest for white-tailed deer (mean = 60.3 meals/y, SE = 4.7) while alligator (mean = 3.4 meals/yr, SE = 0.7) was consumed the least (Figure 4; sample size for all game animals provided in Table S1, *Supplemental Material*).

Proportion of respondents consuming and hunting game (Figure S1, *Supplemental Material*) exhibited slight variation across population density areas. When averaged across all 11 game and fish included in our survey, respondents from low population density areas reported the highest levels of consumption (51.2%) and hunting (50.1%). Respondents from medium population density areas reported they consumed slightly fewer game and fish (46.9%) than respondents from high population density areas (47.0%), although we found the opposite for hunting (medium = 48.4%, high = 45.7%). Average number of people per square kilometer across low, medium, and high population density groups was 22.7, 69.6, and 158.2, respectively. White-tailed deer were the most commonly consumed and hunted species across population density areas, followed by fish and wild turkey (Figure S1, *Supplemental Material*). Total meals of wild game consumed per year also varied significantly ($F_{1,210} = 4.332$, $P = 0.038$) across population density groups. This was primarily the result of respondents from low population density areas consuming more meals per year (mean = 179.0, SE = 27.3) than either high (mean = 118.1, SE = 12.9) or medium (mean = 121.8, SE = 24.3) density groups (meals per year by each game animal and human population density provided in Table S1, *Supplemental Material*). We found no difference in the number of game animals hunted ($F_{2,271} = 1.731$, $P = 0.189$) between the three human population density groups (low = 5.5, SE = 0.2; medium = 5.3, SE = 2.8; high = 5.1, SE = 0.2).

Discussion

Consumption of wild-caught game with elevated levels of contaminants represents a potential exposure pathway to hunters, their families, and other households with which they share game (Coburn et al. 2005), although these risks are likely to vary based on species,

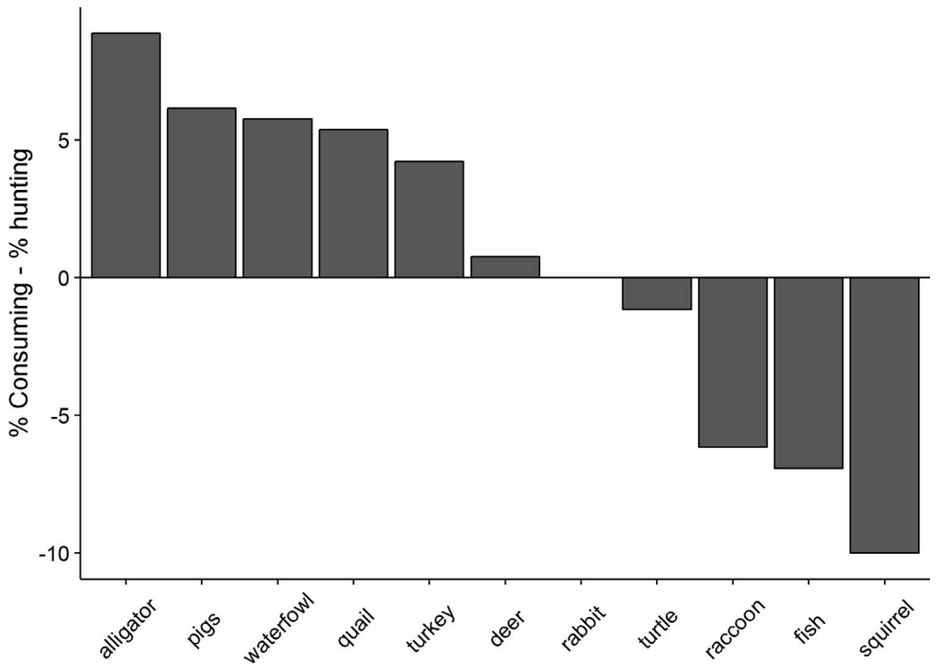

Figure 2. Percentage of respondents who reported consuming minus percentage of respondents who reported hunting 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.], wild turkey [*Meleagris gallopavo*], turtle, and waterfowl), as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina from February to March 2015. Positive values (bars above the horizontal line) indicate respondents were more likely to consume than hunt a specific species or taxa; negative values (bars below the horizontal line) indicate respondents were more likely to hunt than consume them.

location of animals harvested, and overall consumption patterns (Oldenkamp et al. 2017; Tipton et al. in press). Hunters who participated in our survey indicated they typically hunt and consume multiple species and 137 meals per year of the 11 game animals we surveyed. Furthermore, we found consumption rates varied considerably across all game, and nearly 90% of all hunters indicated they also consume fish. Fish consumption advisories are often considered independent of other exposure pathways. However, we believe our results indicate a need to assess consumption limit calculations more holistically. For example, some vulnerable members of the hunting population (e.g., children, pregnant women, or nursing mothers) that also consume fish could be at increased risk of exposure to some pollutants, such as mercury, for which 36% of river miles in the United States are under a consumption advisory (U.S. Environmental Protection Agency 2011). These risks could be further exacerbated through consumption of other aquatic species, especially higher trophic game such as turtles, alligators, and waterfowl, in which elevated levels of mercury also have been documented (Jagoe et al. 1998; Rumbold et al. 2002; Green et al. 2010; Cristol et al. 2012; Oldenkamp et al. 2017). Many game species are highly mobile and thus risks of exposure to pollutants are not restricted to areas near contaminated sites. For instance, mercury-exposed waterfowl have been harvested as far as 1,054 km from contaminated areas (Cristol et al. 2012), and ducks banded on the U.S. Department of Energy's Savannah River Site in South Carolina have been harvested as far as Cuba and Manitoba, Canada (Kennamer 2003).

Respondents self-reported that 76% of their household members consumed at least some game, indicating that using household size to estimate game consumption may slightly overestimate the number of people consuming game. However, many respondents also reported they shared game with other households—a factor that may not typically be included in risk assessments because many of these individuals may not hunt game themselves. Thus, sharing of game with other households should be considered as a factor in future risk assessment.

For some game animals (i.e., white-tailed deer, wild pig, wild turkey, quail, waterfowl, and alligator), respondents were more likely to consume than hunt them, suggesting hunters from within their household or another household shared these species of game with them. For others (i.e., squirrel, raccoon, turtle, and fish), respondents were more likely to hunt than consume them, suggesting they were harvested for recreational purposes or because they were targeted as nuisance animals (Figure 2). However, in comparison to respondents at the Palmetto Sportsman's Classic in 1998 (Burger 2002), we found consumption rates reported by participants in our study were 29, 17, 24, and 9% higher for white-tailed deer, quail, squirrel, and fish, respectively. The increase in game consumption from

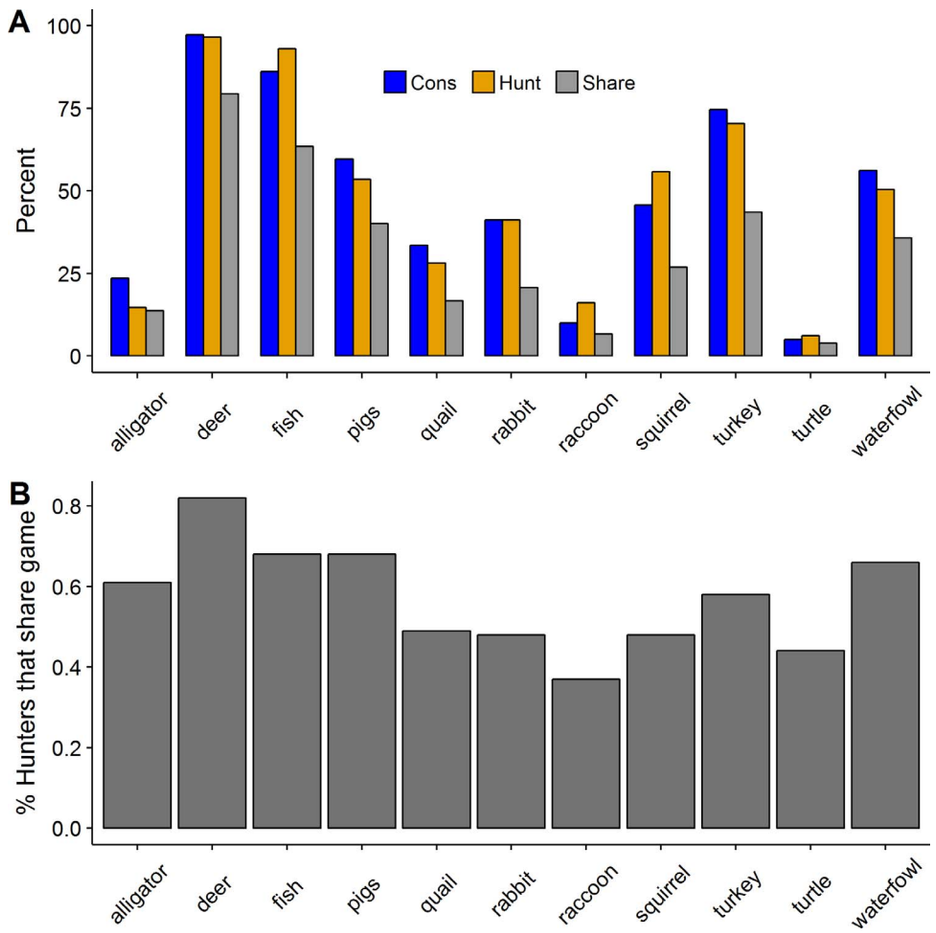

Figure 3. Percentage of (A) all respondents consuming (cons), hunting, and sharing 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.], turkey [*Meleagris gallopavo*], turtle, and waterfowl) and (B) hunters that reported sharing these 11 fish and game animals, as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina, from February to March 2015.

our study seems to reflect a more national trend (Responsive Management 2013), and, as some have speculated, could be related to increased interest in eating local and environmentally sustainable foods (Tidball et al. 2014).

Of the respondents we surveyed, most had been consuming game the majority of their lives, reflecting the social and cultural importance of hunting and fishing in the southeastern United States (Burger 2002). Of the 11 game animals we included, only alligators (15.7 y) were consumed for $<$ 20 y, on average. Additionally, in comparison to other large game considered in our survey (i.e., white-tailed deer and wild pigs), alligators were 40–85% less likely to be consumed or hunted. These findings are likely the result of two events. First, American alligators were removed from the federal endangered species list in 1987, and the first harvest season in over 40 y occurred in South Carolina in 2008 (Butfiloski 2008). Consequently, legal harvest of alligators has only recently been allowed in the state. Second, in contrast to the other game species included in our survey, obtaining a tag to harvest alligators requires selection through a draw system, likely restricting the overall number of hunters who can participate. Given the relatively recent reopening of an alligator harvest season within the southeastern United States, our results represent some of the first baseline data on overall consumption patterns for this species.

Across an urban–rural gradient we found differences in consumption patterns with respondents from the most rural areas consuming approximately 50% more wild game meals per year than those residing in medium or high population density counties. Access to game is likely greater in rural environments, making acquisition easier and more cost effective. Nevertheless, some differences also may be driven by social interactions. For instance, having a friend or family member that hunts can influence both attitudes towards hunting (Stedman and Heberlein 2001; Ljung et al. 2012) and frequency of consuming game meat (Ljung et al. 2015). Given the number of game animals consumed and levels of consumption reported, rural residents may experience

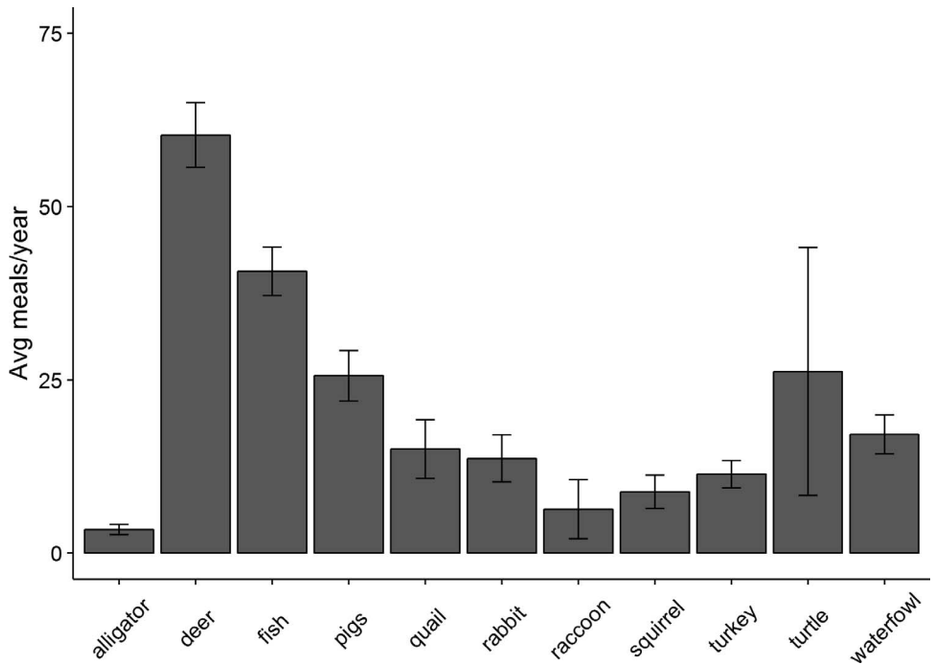

Figure 4. Average number of meals per year respondents reported consuming 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.], turkey [*Meleagris gallopavo*], turtle, and waterfowl), as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina, from February to March 2015. For each species and taxa, the bar corresponds to average meals consumed per year by the respondents who reported consuming. Error bars indicate ± 1 SE.

elevated risk to contaminant exposure depending on the species consumed as well as the distribution and bioavailability of contaminants within the environment where game was harvested. However, many consumers of wild game are likely to do so because it is wild and, in most instances, consumption would represent a relatively safe and environmentally friendly source of protein. Nonetheless, documenting site-specific or regional estimates of overall game consumption is important in order for regulators and consumers to make informed decisions regarding the risks and benefits, especially for those harvesting game from areas near known sources of contaminants.

Management implications

Because we specifically targeted people who hunt, the rates we report should not be viewed as representative of the general population, but should be useful for assessing behavior of people participating in consumptive wildlife recreation. Understanding how harvested game moves through human populations, and patterns related to the cumulative consumption of multiple species, is important for determining the relative health risks of contaminants, assessing benefits of consuming wild game, and developing more effective site-specific and regional estimates for consumption advisories. Our results for consumption rates of 11 different game and fish provide a robust assessment that will be useful for developing guidance for future risk assessment analysis for the region and other comparable populations. Given the high percentage of hunters who also reported consuming fish, we suggest public health officials consider informing the public of potential health hazards associated with other contaminated wildlife more holistically, especially in areas of existing fish consumption advisories. Additionally, hunters in our survey reported sharing a considerable portion of the game they procure, and often consume more game than they hunt. Consequently, future surveys would benefit from asking more directed questions related to who is receiving harvested game and portion size shared. Specifically, ascertaining how harvested game is transferred across the urban–rural landscape would be important for illustrating how potential risks and benefits contrast across these segments of the population.

Supplemental Material

Table S1. Number of respondents providing information on years consuming; number of meals consumed per year; whether they hunt, consume or share; and mean number of meals per year consumed by population density for 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.],

turkey [*Meleagris gallopavo*], turtle, and waterfowl), as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina, from February to March 2015.

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Figure S1. Percentage of respondents by population density (people/km^2; low = 11.0–36.0, medium = 47.3–108.7, and high = 128.3–240.5) reporting (A) consuming and (B) hunting 11 fish and game animals (American alligator [*Alligator mississippiensis*], white-tailed deer [*Odocoileus virginianus*], fish, wild pig [*Sus scrofa*], bobwhite quail [*Colinus virginianus*], rabbits [*Sylvilagus* spp.], raccoon [*Procyon lotor*], squirrel [*Sciurus* spp.], turkey [*Meleagris gallopavo*], turtle, and waterfowl), as surveyed from two public wildlife expositions (Southeastern Wildlife Southeastern Wildlife Exposition and Palmetto Sportsman Classic) in South Carolina, from February to March 2015.

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Reference S1: U.S. Department of Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2014. 2011 National survey of fishing, hunting, and wildlife-associated recreation. Washington, D.C.

Found at DOI: http://dx.doi.org/10.3996/032017-JFWM-028.S3; also available at https://www.census.gov/prod/2012pubs/fhw11-nat.pdf (23,430 KB PDF).

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