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Wild-Harvested Venison Yields and Sharing by Michigan Deer Hunters

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ABSTRACT
An increased societal focus on wildlife as food and recent policy deliberations regarding legal markets for wild-harvested meat are encouraging wildlife managers and researchers to examine the amount, use, and distribution of meat yielded through recreational hunting. We used responses to questions on the Michigan Deer Harvest Study to estimate the maximum yield of edible venison and assess hunters’ sharing behaviors. We estimated 11,402–14,473 metric tons of edible venison were procured during the 2013 hunting season. Of hunters who harvested a deer, 85% shared their venison. Hunters who shared did so with an average of 5.6 people (SD = 4.5). Sharing occurred most frequently within tight social networks: members of hunters’ households (69%), relatives (52%), and friends, neighbors, or coworkers (50%). In the absence of legal markets, venison is distributed widely by hunters and greatly amplifies the number of people benefiting from hunting. Nonetheless, we also identified the potential breadth of exposure to disease or contaminants from wild-harvested meat.

KEYWORDS
Ecosystem services; game meat; hunting; meat consumption; wild-harvested meat

Introduction
Wild-harvested meat produces ecosystem services that contribute to the physiological and social development of humans (Larsen, 2003). Meat procured through hunting is consumed, shared, bartered, and traded for its nutritional, economic, ecological, and sociocultural importance throughout the world (Fischer et al., 2013; Freese, 1997). Although ample research has focused on bushmeat in the tropics or subsistence communities (Alvard, Robinson, Redford, & Kaplan, 1997; Davies & Brown, 2007; Gurven, 2004b), recreational hunters annually procure abundant yet mostly unquantified amounts of meat. During the past century an emphasis on recreational, management, and economic values of hunting in the US broadly supplanted views of hunting as a means to obtain food, creating gaps in our knowledge (Marchello, Berg, Slanger, & Harrold, 1985).

Early estimates suggest large yields of venison come from white-tailed deer (Odocoileus virginanus) in the US, which represents an overlooked or undervalued ecosystem service (Marchello et al., 1985; Novakowski & Solman, 1975; Wilcox, 1976). Harvests of white-tailed deer have nearly tripled since those early estimates, but little more is known about how much meat is yielded or how wild-harvested venison is used in the US. Insights into...
yields of meat and the breadth of sharing by hunters will inform deliberations about legal markets for wildlife, contribute to understanding the nutritional and cultural roles of hunting, and elucidate public health issues created by consumption of wild-harvested meats.

Meat produced from hunting is now gaining attention by stakeholders with diverse concerns. An inability to control white-tailed deer populations (Thogmartin, 2006), issues of food security (Burger, 2002), food safety (Iqbal et al., 2009), the role of wild-harvested meat in maintaining the relevancy of hunting (Ljung, Riley, Heberlein, & Ericsson, 2012), and the growing local food movements (Cerulli, 2012) are interests that motivated our inquiry.

**Wild-Harvested Meat**

We chose the term wild-harvested meat instead of game meat because the former more clearly defines the source (i.e., wildlife) and the means of procurement (i.e., hunters). We define wild-harvested meat as meat obtained through legal hunting of free-ranging wildlife (Food Law 2000; Peterson, Peterson, & Peterson, 2016). For our purposes, meat refers broadly to the meat of mammals, birds, reptiles and amphibians, but not fish or shellfish. Data presented in this article, however, focuses on meat of legal, hunter-harvested whitetailed deer from the wild (wild-harvested venison or venison).

**Sources of Wild-Harvested Meat in the United States**

The sale and trade of wild-harvested meat is illegal throughout most of the US, although regulations vary from state to state and exceptions exist for some species (Abhat & Unger, 2010; Geist, 1988). Because meat from most species is not available in U.S. stores or restaurants, it is normally obtained directly from a hunter without monetary exchange (i.e., sharing). Non-hunters who have consumed wild-harvested meat are evidence of hunters sharing their harvest (Burger, 2000, 2002; Responsive Management [RM] & National Shooting Sports Foundation [NSSF], 2011; Stedman & Decker, 1996). Although social networks of hunters play a key role in distribution (Ljung et al., 2012; Stedman & Decker, 1996), little is known about with whom and how much sharing takes place.

**Research on and Significance of Wild-Harvested Meat in the United States**

New Jersey (A3039, 2014) and Maryland (S. SB0748, 2015) recently put forth legislation to allow the commercial harvest of wild deer and sale of venison to aid in controlling abundant deer populations (Thogmartin, 2006; VerCauteren et al., 2011). Such proposed changes deviate from current policy and practices that explicitly prohibit sale of meat from wildlife.

Wild-harvested meat affects human health through food security and safety (Burger, 2000, 2002; Iqbal et al., 2009; Paulsen, Bauer, & Smulders, 2014). “Food Security is the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (Food and Agriculture Organization of the United Nations,
Food safety refers to the management of biological, chemical and physical hazards in food to prevent illness (Paulsen et al., 2014). Wild-harvested meat can be a healthy source of local, free-range, lean protein that is high in energy and essential macronutrients (Marchello et al., 1985). Access to such meat may address consumers concerns for meat free of antibiotics, hormone supplements, and other additives. Despite its benefits, wild-harvested meat also is associated with potential adverse health risks such as zoonotic diseases and ingestion of bio-accumulated chemical contaminants and heavy metals (Iqbal et al., 2009; Paulsen et al., 2014).

Societal transformations are changing the way humans interact with nature, potentially threatening the relevancy of traditional uses of wildlife (Manfredo, Teel, & Henry, 2009; Whittaker, Vaske, & Manfredo, 2006; Zinn, Manfredo, & Barro, 2002). When hunting is characterized as a method of obtaining food, however, public support is strongest (Campbell & Mackay, 2003; Duda, Jones, & Criscione, 2010; RM & NSSF, 2008). The effects of sharing wild-harvested meat on the relevancy of hunting to society may go beyond simply discussing hunting in terms of food. Sharing of meat may socialize non-hunters to hunting (Heberlein, 1991; Stedman & Decker, 1996). In Sweden, wild-harvested meat consumption is correlated with positive attitudes toward hunting (Ljung, Riley, & Ericsson, 2014; Ljung et al., 2012). Local food movements concerned with where and how meat is produced have embraced wild-harvested meat in recent years. Hunting recruitment strategies based on this new stakeholder group are being considered (Larson, Stedman, Decker, Siemer, & Baumer, 2014; Tidball et al., 2013).

The Current Study

Our objectives were to identify the amount of wild-harvested venison produced annually in Michigan and to investigate characteristics and extent of sharing of venison by recreational hunters in Michigan. To achieve these objectives, we assessed the amount of venison produced in a single hunting season and explored sharing of this venison by quantifying the number of hunters who shared, with whom they shared, and identifying characteristics of hunters who shared. We studied venison because: (a) the keen interest in deer hunting (Fuller, 2016); (b) deer harvests typically yield large quantities of venison, which creates opportunities for sharing (Gurven, 2004a); (c) venison is readily used and valued by humans (Roth & Merz, 1996); and, (d) desire for venison is being explored as a motivation for additional harvest to control deer populations (Robinson et al., 2016; VerCauteren et al., 2011).

Methods

Study Area and Population

The state of Michigan has a population of 9,883,640 people (U.S. Census, 2010). Michigan’s hunting population ranks second in the US in the proportion that pursue deer and ranks fifth in the total number of resident deer hunters 16 years and older (Fuller, 2016). About 90% of Michigan hunters obtain a license to hunt white-tailed deer, the most abundant deer species present in the state (Frawley, 2006). In Michigan in 2013, 712,404 people purchased at least one deer hunting license, and an estimated 661,788
people hunted deer (Frawley, 2014). The 2013 harvest of 385,302 deer was a reduction in total harvest of 8.3% and 8.7% from 2012 and 2011, respectively (Frawley, 2014). The mean age of Michigan deer hunters in 2013 was estimated to be 42 years, 89% of whom were male (Frawley, 2014). Our estimates of venison yield and sharing are limited to the actions of individuals who purchased a 2013 Michigan deer hunting license. Tribal members and others, who hunted under circumstances that did not require a license from the State of Michigan, were not included in our analyses. Additionally, responses to our questionnaire do not pertain to deer harvested with Damage Management Assistance (DMA) permits though DMA harvests were included in estimates of venison yield.

**Sampling Design**

Questions were included on the Michigan Department of Natural Resources (MDNR) 2013 Michigan Deer Harvest Study (Frawley, 2014). A full description of survey methodologies is reported elsewhere (Frawley, 2014). Deer hunters who voluntarily reported their harvest online (n = 3,772) were removed from the sample frame prior to drawing a sample for the mail-back questionnaire, which created an effective population size of N = 708,632. To ensure inclusion of all hunting license purchasers the population was divided into four mutually exclusive strata based on the type of deer hunting license purchased (e.g., firearm or archery, antlerless, mentored youth, or combination) and the season in which it was valid. The first stratum included hunters eligible only for the archery, firearm and muzzleloader seasons (N = 439,173). The second stratum included hunters eligible only for the early and late antlerless seasons in addition to the seasons in the first stratum (N = 208,866). The third stratum included hunters eligible for the Liberty (veterans and youth) season (N = 56,931) and the fourth stratum included only disabled hunters (N = 3,662). Strata were sampled separately to ensure all types of hunters had sample sizes large enough for statistical tests. Strata also were sampled randomly, resulting in a final sample of 55,537 hunters who were mailed questionnaires: 27,438 from the first stratum, 13,106 from the second, 11,517 from the third, and 3,476 from the fourth stratum.

**Data Collection**

The 2013 Michigan Deer Harvest Study used a modified Dillman Tailored Design Method (Dillman, Smyth, & Christian, 2009) with three mailings on January 22nd, March 14th and April 26th, 2014. In addition to the questionnaire, mailings included a letter of consent describing the study from the chief of the MDNR Wildlife Division and an offer from Safari Club International Michigan Chapter to be entered in a drawing to win a firearm or bow if the questionnaire was returned by February 20, 2014. Permission to access demographic data from license sales and survey responses was given by MDNR.

Level of urbanization of a hunters’ residential area was identified by mapping zip codes used in survey mailing in relation to census defined urbanized areas using ArcGIS 10.1 (Environmental Systems Research Institute [ESRI], 2012; Urban area criteria for the 2010 census, 2011. Zip code polygons completely within the urbanized area layer were identified as urban. Zip code polygons that intersected the urbanized area boundary line were
identified as the urban buffer. Zip code polygons completely outside the urbanized areas layer were identified as not urban.

Survey Instrument

The 2013 Michigan Deer Harvest Study was a four-page questionnaire about hunter harvest activities, satisfaction, and statewide deer management issues. Standard survey questions provided information on hunter harvest for the 2013 season including total number of deer harvested and specifics on antlered and antlerless harvest, seasons in which the hunter participated, and the type of hunting equipment used. We included additional questions about individuals with whom hunters shared their wild-harvested venison in the past 12 months. Response options included I did not share; immediate household members; relative not within household; friends, neighbors, or coworkers; landowner whose property they hunted; community group game dinner; food bank or other donation program; or other open-ended response. We also asked for an estimated number of people with whom they directly shared venison within the past 12 months. The response option was a fill-in-the-blank with number. (See Goguen [2015] to view the complete questionnaire.)

Categories for possible relations with whom a hunter shared venison were derived from pilot interviews with hunters, discussions with MDNR researchers, and previous surveys asking non-hunters about their relationships with hunters (Ljung et al., 2012; Stedman & Decker, 1996). Sharing was defined in the questionnaire as “offering raw (meat) or prepared (cooked) venison to another person.” All questions about wild-harvested venison sharing behaviors were limited to a reference period of 12 months to assist respondent recall (Dillman et al., 2009; Vaske, 2008). A 12-month period was used due to the seasonal nature of venison availability combined with the possibility of long-term cold storage of venison. Venison a hunter reported sharing was not limited to the 2013 harvest and could have been harvested during any season. Only the behavior of sharing venison was limited to a 12-month recall. An open-ended estimate for the number of people with whom hunters directly shared their venison was used to elicit a range of possible answers and avoid influencing potential answers with response options (Tourangeau, Rips, & Rasinski, 2000; Vaske, 2008).

Calculating Edible Wild-Harvested Venison Yield

Five studies provided ratios, regression equations, or raw data to calculate edible venison yield from white-tailed deer (Table 1). Although equations to estimate yield vary, likely due to differences in location and methodologies, these equations currently provide the best available methods for estimating the maximum edible venison yield. Regression equations were used when possible to improve the accuracy of estimates. Regression equations are more accurate than ratios for estimating edible venison yield because larger deer provide more edible venison per kilogram than smaller deer (Severinghaus, 1949). When necessary, regression equations were converted from pounds to kilograms. Average live weight and composition of the harvest by age class and sex are needed to use these equations. Average live weights for Michigan white-tailed deer by age (0.5, 1.5, 2.5, 3.5, 4.5, and 5.5+), sex (doe or buck) and year-round nutrition (poor or good) were adapted
from Ozoga, Doepker, and Sargent (1993, p. 43). Average of field dressed weights from deer with poor and good nutrition were used for each individual age class within each sex. Field dressed weights were converted to kilograms and multiplied by the conversion factor 1.28 to estimate live weights (Case & McCullough, 1987; Harder, 1980).

The age structure and total antlered and antlerless harvest from the 2013 Michigan deer hunting season was determined from 2013 MDNR deer checking station data (Mayhew, 2014) and from the 2013 Michigan Deer Harvest Survey Report (Frawley, 2014), respectively. The yield of venison for a single deer, based on average live weight by sex and age class for each equation was calculated, and then multiplied by the total number of deer harvested during the 2013 Michigan deer seasons (385,302 deer) per sex and age class to get the estimated edible venison yield by deer sex and age. These estimates were then totaled by equation and the average and range of these sums were used to estimate the maximum yield of edible venison taken during the 2013 Michigan deer hunting season.

### Analysis

**Statistical Tests**

Pearson’s Chi-squared ($\chi^2$) was used to test if hunters’ sharing behaviors (0 = not share; 1 = share) differed across the binary and categorical covariates. The phi ($\Phi$) coefficient and Cramér’s $V$ were used to measure the strength of association (effect size) between hunters’ sharing behaviors and the binary and categorical covariates, respectively. Two-sample $t$-tests were used to test if hunters’ sharing behaviors differed across the continuous covariates. Point biserial correlations ($r_{pb}$) were used to measure the strength of association between hunters’ sharing behaviors and continuous covariates. Ninety-five percent confidence intervals for the proportion of the sample observed with trait of interest ($\hat{p}$) were calculated using the formula for a known population (Zar, 1996). A binary logistic regression and zero-
inflated negative binomial regression were used to predict a hunter’s sharing behaviors. These models had issues with interpretation due to misspecification and small effect sizes; their results are discussed briefly within the article, and full model outputs are provided as supplemental materials (https://msu.edu/~goguenam/SupplementalMaterials_Wild-harvestedvenisonyieldsandsharingbyMichigandeerhunters.pdf).

**Non-Response Bias**

External non-response bias was not estimated due to lack of telephone numbers for respondents. There are also concerns about internal non-response bias, meaning within recorded responses to the questionnaire. Hunters who did not harvest a deer in 2013 were more likely to skip questions about venison sharing than hunters who harvested a deer. To minimize potential biases associated with those non-respondents, hunters’ sharing behaviors are reported in a binary variable that is a combination of their responses to both questions about sharing. Sharing behaviors of non-respondents to both questions were inputted using reported sharing percentages for respondents based on their deer harvest for 2013. Imputed data were used for overall sharing estimates, not for statistical analysis. Without these adjustments, sharing estimates would be exaggerated.

**Results**

**Respondent Characteristics and Analysis Sample**

Of an initial 55,537 questionnaires mailed to licensed hunters, 54,277 (98%) were delivered, and 27,834 (51%) were returned. Minors (less than the age of 18, \( n = 5,856 \)), hunters who reported they did not participate in the 2013 season (\( n = 1,775 \)), and nonresident hunters (\( n = 1,041 \)) were removed from the sample, which resulted in a final sample size of 19,981. Males comprised 89% of respondents. The mean age of the total sample was 44 years, which closely resembles population parameters for all deer hunting license buyers in Michigan (89% male, mean age = 42 years).

**Maximum Edible Wild-Harvested Venison Yield**

A maximum estimated 11,402–14,473 metric tons (\( M = 13,256 \) metric tons) of edible wild-harvested venison were yielded during the 2013 Michigan deer hunting seasons; 4,496–5,447 metric tons were derived from antlerless deer (\( M = 5,118 \) metric tons) and 6,905–9,025 metric tons from antlered deer (\( M = 8,138 \) metric tons) (Table S1 online). The estimates vary considerably depending on which equation was used. This converts to approximately 101–128 thousand meals of venison or 10–13 meals of venison per person per year in Michigan (1 meal equals 113 grams or 4 ounces). The 2015–2020 Dietary Guidelines for Americans suggest consumption of 737 grams (26 ounces) of meat, poultry, or eggs per week based on a 2,000-calorie diet (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). If venison comprised an individuals’ entire recommended animal protein for one year (38 kilograms), the wild-harvested venison produced in Michigan would provide the annual recommended animal protein intake for 297–378 thousand people or 3–4% of the total Michigan population.
Wild-Harvested Venison Sharing by Hunters

Nearly 52% of respondents who participated in the 2013 deer-hunting season reported sharing wild-harvested venison in the 12 months prior to survey administration. The percentage who shared increased to 85% when a hunter reported harvesting a deer in 2013. Nearly 25% of hunters who did not harvest a deer in 2013 still reported sharing venison in the 12 months prior to receiving the questionnaire. Extrapolating to all Michigan hunters who participated in the 2013 deer hunting season, an estimated 341,483 ± 4,500 Michigan deer hunters shared their venison. Only variables related to 2013 deer harvest (harvested at least one deer, harvested an antlered deer, harvested antlerless deer and total harvest) were statistically significant predictors of sharing behaviors with functional effect sizes (Table 2, Table S2 online, & Table S3 online). Age and level of urbanization of residence were statistically significant predictors of sharing behaviors, but effect sizes were small. Increase in age exhibited a negative statistical

Table 2. Hunting-related characteristics and demographic profile of hunters who did and did not share wild-harvested venison

<table>
<thead>
<tr>
<th>Variable</th>
<th>All respondents (n = 17,262)*</th>
<th>Shared venison (n = 9,475)</th>
<th>Did not share venison (n = 7,787)</th>
<th>Tests for statistical difference between share and not share</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested in 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8,537</td>
<td>7,263</td>
<td>1,274</td>
<td>χ² = 6200 p &lt; .001 Φ = .600</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>8,725</td>
<td>2,212</td>
<td>6,513</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvested Antlered Deer in 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5,675</td>
<td>4,861</td>
<td>814</td>
<td>χ² = 3200 p &lt; .001 Φ = .433</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>11,587</td>
<td>4,614</td>
<td>6,973</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvested Antlerless Deer in 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4,507</td>
<td>3,898</td>
<td>609</td>
<td>χ² = 2500 Φ = .378</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>12,755</td>
<td>5,577</td>
<td>7,178</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of Deer Harvested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>8,725</td>
<td>2,212</td>
<td>6,513</td>
<td>t = 81.567 rpb = .509</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5,817</td>
<td>4,834</td>
<td>983</td>
<td>p &lt; .001 t = 77.603</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1,994</td>
<td>1,747</td>
<td>247</td>
<td>p &lt; .001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>535</td>
<td>507</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>133</td>
<td>119</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>34</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>18</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>1,988</td>
<td>1,120</td>
<td>868</td>
<td>t = 9.041 rpb = -.069</td>
<td></td>
</tr>
<tr>
<td>30–39</td>
<td>2,173</td>
<td>1,273</td>
<td>900</td>
<td>p &lt; .001 Pr (T &gt; t) = t = −9.041</td>
<td></td>
</tr>
<tr>
<td>40–49</td>
<td>3,352</td>
<td>1,965</td>
<td>1,387</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>50–59</td>
<td>4,405</td>
<td>2,537</td>
<td>1,868</td>
<td>p &lt; .001</td>
<td></td>
</tr>
<tr>
<td>60–69</td>
<td>3,851</td>
<td>2,192</td>
<td>1,649</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70–79</td>
<td>1,255</td>
<td>576</td>
<td>679</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80–89</td>
<td>230</td>
<td>97</td>
<td>133</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90+</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>51</td>
<td>51</td>
<td>53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15,940</td>
<td>8,754</td>
<td>7,186</td>
<td>χ² = 0.071 p = .790 Φ = -.002</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1,322</td>
<td>8</td>
<td>601</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Type (n = 17,215)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Urban</td>
<td>9,838</td>
<td>57</td>
<td>4,395</td>
<td>χ² = 1.830 Cramer’s V = .010</td>
<td></td>
</tr>
<tr>
<td>Urban Buffer</td>
<td>5,944</td>
<td>34</td>
<td>2,720</td>
<td>p = .400</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>1,433</td>
<td>8</td>
<td>651</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All respondents who provided information on sharing behaviors.
relationship with sharing, while levels of urbanization had an inverse relationship with sharing behaviors.

Michigan deer hunters, who shared their venison, shared with a mean of 5.6 (SD = 4.5) people, excluding events that resulted in numerous recipients, such as game dinners or donations to food banks (Figure 1). Considering the number of hunters who share, an estimated 1,912,305 people ± 67,209 (95% CI) people, or 19% ± 0.7% of the total Michigan population, received venison from hunters during the 12 months prior to survey administration. Of hunters who reported sharing their venison, approximately 69% shared with members of their household, 52% with relatives, and 50% shared with friends, neighbors, or coworkers (Table 3). Slightly more than 2% of hunters who shared reported donating their deer to a food bank or other donation program: This equates to an estimated 15,882 ± 1,390 (95% CI) hunters.

Discussion

Our results establish the relative magnitude of wild-harvested venison yielded annually by Michigan deer hunters and the extent of sharing occurring under current regulations and

![Figure 1](image-url). Number of people with whom hunters reported sharing venison.

<table>
<thead>
<tr>
<th>Receivers</th>
<th>n</th>
<th>% Out of those who shared (n = 9,063)</th>
<th>% Out of all respondents to the question (n = 15,223)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not share any of my venison</td>
<td>6,160</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Members of my household</td>
<td>6,243</td>
<td>69</td>
<td>41</td>
</tr>
<tr>
<td>Relatives not in my household</td>
<td>4,713</td>
<td>52</td>
<td>31</td>
</tr>
<tr>
<td>Friends, neighbors, or coworkers</td>
<td>4,568</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Landowner whose property I hunted</td>
<td>1,165</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Community group game dinner</td>
<td>243</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Food bank or other donation program</td>
<td>219</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other - not specified</td>
<td>75</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
social norms. Despite an absence of legal markets for wild-harvested meat, recreational hunters distribute venison frequently and broadly through their social networks, highlighting the cultural importance of venison to hunters. This magnitude of sharing occurred despite only 6% of the state’s population in any given year being licensed deer hunters (Fuller, 2016). Sharing behaviors amplify ecosystem services provided by venison beyond the hunting population. Yet, our findings also highlight potential pathways for the transmission of disease and contaminants from venison handling and consumption.

Venison produced and shared by hunters in Michigan demonstrates one ecosystem service, nutrition, provided by wild-harvested meat. Based on our estimates, it is possible that a small portion of the Michigan population can rely on venison to meet their annual animal protein intake. Venison is a potential key factor in the food security of some Michigan households, although more information on hunter household consumption of venison is needed to refine estimates.

If our estimates are broadly applicable, the 2011–2013 average estimated harvest of 6.1 million white-tailed deer in the US (Adams & Ross, 2015) yielded 182–231 thousand metric tons of venison. This estimate is derived from multiplying the average amount of edible venison produced per deer (29.6 – 37.6 kilograms of meat per deer) by the total mean annual harvest of white-tailed deer. The only other available estimate to compare is from Wilcox (1976), who estimated the amount of edible venison produced from hunter-harvested deer for all 50 states from 1969–1974 was over 2.3 million deer, providing over 51 thousand metric tons of venison annually. Estimated yields of meat from white-tailed deer, combined with yields from other hunted wildlife species, illustrate an immense ecosystem service provided by wild-harvested meat.

Estimated values of wildlife resources typically are reported in monetized economic terms, such as price per pound of a roughly equivalent product (Ready, 2012; Wilcox, 1976). Purposefully, no monetary value for wild-harvested venison is realized under the current management framework (Organ, Mahoney, & Geist, 2010). Farm-raised venison is available in stores, restaurants, and online, but prices vary considerably and market research is lacking. Venison is comparable to U.S. Department of Agriculture (USDA) standard grade beef in amino acid content, but has lower levels of fat and calories, and greater levels of protein, ash and cholesterol (Marchello et al., 1985). From January 2015 to January 2017, the average retail price per pound for the lowest cost beef (ground beef) was $3.74 and the highest cost beef (USDA choice boneless sirloin steak) was $8.34 (Hahn, 2017). Based on our estimates, the economic value of venison procured by Michigan deer hunters during the 2013 deer seasons ranged between $94-$266 million U.S. dollars. At a national scale, venison from hunter-harvested white-tailed deer represents an economic value annually exceeding 1.5 billion U.S. dollars.

Ecosystem services provided by venison extend beyond nutrition. An overwhelming majority of hunters who harvested a deer reported sharing their venison. Venison may play an important cultural role in the life of deer hunters. Cultural food practices serve economic, political, recreational, social, aesthetic, religious, and ceremonial values (Bryant, DeWalt, Courtney, & Schwarts, 2003). Sharing of food is a social activity that builds and maintains the social bonds within and external to the familial unit and is a way these bonds are expressed (Jiménez, Montón-Subías, & Romero, 2011). Food also may function as a symbol of social status and prestige (Bryant et al., 2003). Although conclusions drawn directly from our data about hunters’ motivations for or benefits from sharing venison are
speculative, the presence and popularity of sharing does suggest widespread cultural importance of wild-harvested meat sharing among recreational hunters.

Hunter-sharing behaviors were highly correlated with having a deer; hunters cannot share what they do not have. The effect sizes for age and level of urbanization were minimal, evoking questions about the role of sample size in producing statistically significant results (Johnson, 1999). The bivariate logistic regression failed the Hosmer-Lemeshow Goodness of fit test for \( p < .05 \) regardless of group size. Nonetheless, this test is more likely to reject model fit as sample size increases (Kramer & Zimmerman, 2007). Although we report age and level of urbanization as factors affecting hunters’ sharing behaviors related to venison, there is no theoretical basis on which to draw cause and effect conclusions about these relationships. The variables used to identify the characteristics of hunters who share originate from the 2013 Michigan Deer Harvest Study. Theory-based research is needed to provide insights into the relationships between demographic variables and sharing behaviors.

It is possible that hunters involved in our survey shared with some of the same people, which caused double reporting and increased our estimates of sharing. Our estimate of the number of people with whom hunters shared, however, is conservative in comparison to other research. Nearly 61% of non-hunters who responded to a survey in upstate New York reported eating some sort of wild-harvested meat (Stedman & Decker, 1996). An estimated 42% of Americans nation-wide consume wild-harvested meat annually (Responsive Management [RM] & the National Shooting Sports Foundation [NSSF], 2011). Importantly, these studies used the term game meat and did not specify the source of meat or whether hunters procured it. Likely, some respondents in previous studies who reported that they ate game meat had farm-raised in lieu of wild-harvested meat. The act of sharing venison may be habitual enough for deer hunters that they may be less likely to remember each specific occurrence (Nolin, 2010; Tourangeau et al., 2000), which results in an underestimate of sharing. In addition, the estimates hunters provided did not include people with whom they shared at large events. Consumption by non-hunters reported in other studies also is affected by sharing of meat other than venison.

Sharing of venison may serve several functions beneficial to hunters. Ecosystem services provided by sharing could be a key component of maintaining the relevancy of hunting to Michigan society. A positive relationship between frequency of consumption of wild-harvested meat and attitudes of non-hunters toward hunters and hunting was identified in Sweden (Ljung et al., 2012). Public support for hunting is consistently strong when the motivation for hunting is obtaining food (Campbell & Mackay, 2003; Duda et al., 2010; Responsive Management & The National Shooting Sports Foundation (RM & NSSF), 2008). Identifying how hunters use and distribute wild-harvested meat, and disseminating this information may be a simple way to encourage positive attitudes about hunting and maintain relevancy of hunting to society.

That hunters reported sharing venison most often just within their household is expected based on evolutionary theories of food sharing based on kin selection, which predicts increased sharing of food with kin because it increases chances of offspring survival (Kaplan & Gurven, 2005). Hunters reported sharing less often as social distance increased; social proximity appears to be a key factor influencing sharing behaviors among hunters. Hunters’ social networks most likely limit the distribution of venison and its potential benefits. Considering that hunters are a relatively homogeneous group
comprised of rural white middle-aged males (Fuller, 2016; Stedman & Heberlein, 2001), wild-harvested meat may not be as accessible to urban, young or elderly, female and non-white populations. People who are close to hunters, particularly household members, are likely more at risk from any potential negative effects of consuming wild-harvested meats.

We consider our estimated yields of wild-harvested venison as a maximum. Accuracy of hunters’ shots, care and speed in dressing and bleeding, butchering proficiency, and differences in deer size or weight all influence the amount of edible venison a deer yields (Cowan et al., 1968; Hamerstrom & Camburn, 1950; Hamilton, 1947; Marchello et al., 1985; Severinghaus, 1949). Weights of white-tailed deer vary based on subspecies, region, season, age, and habitat quality (Sauer, 1984). Michigan hunters typically harvest deer younger than five years, which likely further increases variability in live weights (Ozoga et al., 1993). Type of hunting equipment used and the physical condition of deer at time of kill also influence yields of edible venison (Jenkins & Bartlett, 1959). Additional studies that calculate realistic estimates of edible venison yielded by recreational hunters under the array of normal field conditions could enable more accurate estimation from total harvests.

There is a lack of data in the U.S. for conducting human health risk assessments for wild game (Conder & Arblaster, 2016). Our results provide information useful for conducting human health risk assessments and communication about current or future health risks from the handling and consumption of venison in Michigan. When providing public health information to consumers of wild-harvested meat, it is essential to recognize venison, and presumably wild-harvested meat generally, is consumed by more people than hunters. The vast quantity of venison produced and distributed throughout society may be a motivator for increased testing for food safety and for developing programs in food safety for hunters and receivers of wild-harvested meats.

**Conclusions**

Our research demonstrates that despite a lack of legal US markets in wild-harvested meat, venison is widely shared and distributed beyond the population of hunters. A system of sharing and consumption operated by informal institutions appears to have evolved. Imposing a legal market on wild-harvested meat in this system could change who benefits and how those benefits are interpreted by society. From a public health management perspective, the network of sharing we describe identifies pathways for exposure to zoonotic disease and contaminants.

Methods used to estimate yields of edible venison provide a starting point for others to make such estimates and stimulates collection of data on: (a) harvest statistics including age distribution and carcass weight; (b) average deer size based on age class and sex; and (c) the amount of edible venison produced by recreational hunters. Similar data from other states or countries and for other species could provide more accurate insights about yields of wild-harvested meat and its use.

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**References**


