Effects of the COVID-19 pandemic on 2020 spring turkey hunting across the United States

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Abstract

Spring wild turkey (Meleagris gallopavo) hunting is a foundational activity for many hunters across North America. Managing turkey hunters and turkey hunting is, therefore, a priority for state and provincial fish and wildlife management agencies. Early stages of the current SARS-CoV-2 (COVID-19) pandemic in the United States coincided with 2020 spring turkey hunting seasons across the U.S. Potential effects of increases in peoples’ time available for hunting on effort and turkey populations could have been substantial. We surveyed the primary wildlife biologist tasked with wild turkey management for each state and provincial jurisdiction with a huntable wild turkey population to determine turkey hunter and hunting dynamics before and during the spring 2020 turkey season. Biologists in 47 states responded to the survey. Results varied among states but hunting license sales, the number of hunters afield, harvest, total hunter-days afield, and the number of days individual hunters were afield were greater in 2020 than the mean from the previous 3 years (2017–2019) in many states. Although hunting effort and total reported harvest increased in most states in 2020 from the previous 3-year average, take-per-unit-effort (i.e., harvest per hunter day) decreased in 93% of jurisdictions from which data were available, supporting the finding that increases in turkey harvest in spring 2020 were a result of a COVID-related increase in participation and effort and not increases in turkey abundance. We recommend using these reference data for turkey population and turkey hunter monitoring pre- and post-pandemic. Monitoring
efforts should include wildlife population and habitat evaluations and study of hunter dynamics in a social science framework.

KEYWORDS
COVID-19, hunter effort, hunting seasons, Meleagris gallopavo, outdoor recreation, pandemic, reported harvest, SARS-CoV-2, wild turkey, wild turkey hunting

In January 2020, China confirmed a cluster of SARS-CoV-2 (COVID-19) infections discovered the previous month in Wuhan province was caused by a novel coronavirus. The World Health Organization (WHO) and U.S. Centers for Disease Control (CDC) subsequently issued health advisories. By late January, the virus had been discovered in the United States, prompting the CDC to immediately declare a public health emergency. In March 2020, the WHO formally declared COVID-19 a global pandemic and the U.S. government issued a series of advisories concerning travel, gatherings, and person-to-person contact. Through March and April 2020, many individual states began issuing various legal restrictions and recommendations for public gatherings, workplaces, travel, and/or other activities with the potential to congregate people. Although governmental regulations broadly limited the public’s ability to congregate, engagement and participation in outdoor activities, including wild turkey (Meleagris gallopavo) hunting, were relatively unrestricted.

Wild turkeys are popularly pursued during their spring hunting seasons (Erikson et al. 2015). This timing parallels the species’ breeding biology, thereby challenging wildlife managers to balance biological constraints among social demands (Isabelle et al. 2018). In some states, wild turkeys have exhibited recent declines in reproduction and/or abundance, causing unease amongst some turkey hunters and state wildlife agencies about future trajectory of the species (Byrne et al. 2014, Casalena et al. 2015, Erikson et al. 2015).

In 2020, the opening of spring wild turkey hunting seasons throughout their North American range loosely coincided with the governmental regulatory responses to the COVID-19 pandemic’s global spread. Participation in the spring 2020 wild turkey season was one of the first hunting seasons in the U.S. that could have been impacted by state agency and public response to the COVID-19 pandemic. With the onset of spring turkey hunting seasons, changes in hunter effort or success may have impacted turkey harvest in 2020. Increased time availability by resident hunters and low levels of pandemic-related restrictions for resident and nonresident hunters may have increased hunter effort in some states.

The elevated sense of concern surrounding potentially declining turkey populations, in combination with the unique constraints already inherent in regulating spring turkey seasons, caused many hunters, biologists, and state wildlife agencies to express concern about an increased user demand due to closures in work places, events, and other forms of recreation as a result of COVID-19 restrictions, potentially placing unsustainable pressure on wild turkey populations during the 2020 spring hunting seasons (Goldman 2020). Also, some state and local governments worried that traveling hunters—especially nonresidents traveling from other states—could increase COVID-19 occurrence and distribution at local levels. This concern led several states to restrict turkey hunting to residents in 2020.

Research on hunter values and satisfaction has shown that competing demands on a hunter’s time and a lack of free time are important factors in hunting participation (Siemer et al. 1995, Boulanger et al. 2013). With a potential windfall of free time due to COVID-19-related travel restrictions and alterations to work schedules, substantial increases in hunting participation, effort, and harvest and subsequent impacts of turkey populations were valid concerns; however, more information is needed to accurately evaluate the effects of activities during the COVID-19 pandemic on turkey populations and hunting.

To address the above concerns, our goal was to establish a series of reference points of information about spring turkey hunters, turkey hunting effort, and turkey harvest across the U.S. range before and during the 2020 COVID-19 pandemic. Our objective was to survey the primary turkey management biologist in each state and provincial
jurisdiction with a turkey population and hunting season to determine the activities of wild turkey hunters and characteristics of turkey hunting during the spring 2020 turkey season, corresponding with the beginning of the COVID-19 pandemic. Our second objective was to document potential changes in these metrics which may have resulted from this historic event as a way of informing future evaluations and decisions about wild turkey management. Understanding how a societal shift in the availability of free time may have influenced hunting participation has applicability beyond wild turkey management, given previous work which has reported a lack of available time as a primary factor cited by former hunters for their disengagement from hunting (Miller and Vaske 2003).

METHODS

We surveyed the primary wildlife biologist tasked with wild turkey management for each state and provincial jurisdiction with a hunt-able wild turkey population. We determined the activities of wild turkey hunters and characteristics of turkey hunting before (i.e., 3 to 5 years prior, depending on the variable of interest) and during the spring 2020 turkey season, corresponding with the beginning of the COVID-19 pandemic. The sampling frame included state (n = 49) and provincial (n = 3) representatives that participate in the National Wild Turkey Federation (NWTF) Technical Committee (TC). We reported hunter totals, hunter-days, turkey harvest, and harvest per unit effort for both prior to and during the 2020 spring turkey hunting seasons from across the established range of the wild turkey. Our analysis represents the information current at the time of the survey and the interpretation of the questions by the respondent.

The on-line survey (Appendix A) was developed in the Qualtrics platform (Qualtrics, Provo, UT, USA; www.qualtrics.com). Survey questions were in 4 categories: respondent information, state-specific pandemic conditions, turkey population status, and turkey hunting dynamics (including effort and license sales). The survey was opened on 19 March 2021 and after several extensions to reduce non-response was closed on 7 May 2021.

All data were analyzed using program R (v.4.0.5; R Core Team 2020). Data were reported by state, but as expected, responses varied appreciably among respondents. To evaluate potential regional patterns across the U.S.,

FIGURE 1  State designations among Association of Fish and Wildlife Agencies regional associations: NE = Northeast, SE = Southeast, MW = Midwest, and W = Western; and reported turkey population trajectory by state from 2015–2020.
we analyzed some individual questions using Association of Fish and Wildlife Agencies regional associations (Figure 1, i.e., region): Northeast (n = 14 states and 6 provinces), Southeast (n = 15 states, Puerto Rico, and the U.S. Virgin Islands), Midwest (n = 13 states and 3 provinces), and Western (n = 19 states and 5 provinces) but reported results in many cases by region and state. Data were not available from all respondents for every aspect of the questions. Because we were interested in qualitative assessment, statistical comparisons among states were not conducted.

Although our goal was to use the survey to identify the conditions present and turkey hunting characteristics during the 2020 spring turkey hunting season, we did not hope to identify any specific effects of turkey hunting on turkey populations after only one hunting season. Statements of the impacts of hunter and hunting dynamics in one hunting season on turkey populations at any scale would be speculative at best. Elucidating any effects, if they occurred, will only be possible with continued turkey population monitoring and hunter and reported harvest data collection.

RESULTS

Of the 52 NWTF TC members representing 49 US states and 3 Canadian provinces in the current range of the wild turkey in North America who were invited to take the survey, 47 US state turkey biologists (90%) responded by the closing date.
As is the case each year, opening day of the 2020 turkey hunting season varied across the country ranging from 15 March in Mississippi to 5 May in Washington (Figure 2). Six possibilities (plus check all that apply) were available for respondents to report the status of their state during the 2020 spring turkey hunting season relative to the COVID-19 pandemic (Question 7, Appendix A). Because of the variability among states and the ability of respondents to select multiple responses related to COVID restrictions, we re-coded and merged all responses into 2 categories: restrictions directly related to turkey hunting (Turkey Hunting and/or Access) and those that were not (None or COVID Only; Table 1). Most states (70.2%) had no restrictions that would have affected turkey hunters or hunting, or the restrictions were COVID-related only with no likely impact to hunting. Conversely, 29.8% of the states had restrictions that directly affected turkey hunting, including changes in allowed license sales and restrictions on access to turkey hunting areas. On average, turkey seasons across the country opened prior to state-specific implementation of COVID-19 restrictions (Questions 8 and 9) but there was significant variation, with season opening dates ranging from 38 days before to 46 days after state-specific implementation of COVID-19 restrictions (Table 2).

In evaluating the effects of COVID-19 restrictions on turkey hunters and hunting in spring 2020, respondents were asked to provide their professional opinion as to whether more or fewer people hunted, individual hunters hunted more or less, or none of those (Questions 10a and 10b, Appendix A). In this case, we categorized the question and reporting by resident versus non-resident hunters. Not surprisingly, biologists believed that more resident hunters hunted turkeys in 2020 and that individual turkey hunters hunted more in 2020 than previously (Table 3). In the case of non-residents, >50% of respondents reported that there were fewer non-resident turkey hunters in their states during the 2020 spring season (Table 4).

### TABLE 1  Status of public mobility and access during the 2020 turkey season relative to the COVID-19 pandemic.

| Status of your state during 2020 turkey season in relation to the pandemic? | n  | %  |
|---|---|---|
| None or COVID Only<sup>c</sup> | 33 | 70.2% |
| Turkey Hunting and/or Access<sup>d</sup> | 14 | 29.8% |

<sup>a</sup>n = number of respondents for the category.  
<sup>b</sup>% = percentage of respondents for the category.  
<sup>c</sup>Included the following categories: No restrictions, Restrictions on Public Gatherings of >10 people, Stay-at-Home Orders Statewide, Stay-at-Home Orders by County.  
<sup>d</sup>Included the categories Restrictions on Turkey Hunting (including license sales restrictions), Restrictions on Public Access to Turkey Hunting Areas, and possibly any of the above COVID restrictions.

### TABLE 2  Time (days) between opening of the 2020 spring wild turkey hunting season and state-specific implementation of COVID-19 restrictions, pooled by Association of Fish and Wildlife Agencies regional associations.

| Association of Fish and Wildlife Agencies Regional Association | Days between turkey season and COVID-19 restrictions<sup>a</sup> | Minimum | Median | Mean | Maximum |
|---|---|---|---|---|---|
| Western | −38 | 15 | 15.1 | 43 |
| Midwest | 5 | 26 | 23.3 | 38 |
| Southeast | −17 | 2 | 4.7 | 31 |
| Northeast | 27 | 34 | 36.0 | 46 |
| Overall | −38 | 25 | 19.1 | 46 |

<sup>a</sup>Negative value indicate that turkey season started before COVID-19 restrictions.
Because some assertions regarding impacts of the COVID-19 pandemic could be based on evaluations of reported turkey harvests, the reliability of those estimates is crucial (Question 4, Appendix A). From 2015–2020 and across all states and years (n = 276), only 7% of respondents rated the reliability of spring turkey harvest estimates as Poor; the remainder rated harvest estimates as Excellent or Good. In all AFWA regions, biologists had relatively high confidence in harvest estimate reliability. Western and Midwest biologists gave more Excellent than Good ratings (53% vs. 33% and 67% vs. 33%, respectively) than did Southeast and Northeast biologists (30% vs. 55% and 42% vs. 58%, respectively). Most importantly, across years (2015–2020), biologists’ ratings of harvest estimate reliability were consistent (Table 5), with ratings within a category varying ≤5% across years. Poor ratings accounted for <10% of harvest estimate reliability ratings.

### Table 3

**Respondent professional opinions regarding impacts of the COVID-19 pandemic on resident hunter participation in the 2020 spring wild turkey hunting season.**

| How did COVID-19 affect resident participation in turkey hunting? | n | % |
|---------------------------------------------------------------|---|---|
| Individual turkey hunters hunted more | 1 | 2.2% |
| Less people turkey hunted; Individual turkey hunters hunted more | 1 | 2.2% |
| More people turkey hunted | 18 | 39.1% |
| More people turkey hunted; Individual turkey hunters hunted more, Individual turkey hunters hunted less | 22 | 47.8% |
| None of the above | 2 | 4.3% |

*Respondents could choose all that apply, thus categories can be combinations of those in Question 10a.*

**Table 4**

**Respondent professional opinions regarding effects of the COVID-19 pandemic on non-resident hunter participation in the 2020 spring wild turkey hunting season.**

| How did COVID-19 affect nonresident participation in turkey hunting? | n | % |
|---------------------------------------------------------------|---|---|
| Individual turkey hunters hunted more | 2 | 5.1% |
| Less people turkey hunted | 22 | 56.4% |
| Less people turkey hunted; Individual turkey hunters hunted less | 1 | 2.6% |
| Less people turkey hunted; Individual turkey hunters hunted more | 3 | 7.7% |
| More people turkey hunted | 1 | 2.6% |
| More people turkey hunted; Individual turkey hunters hunted more | 4 | 10.3% |
| None of the above | 5 | 12.8% |

*Respondents could choose all that apply, thus categories can be combinations of those in Question 10b.*

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**Table 3**

**Respondent professional opinions regarding impacts of the COVID-19 pandemic on resident hunter participation in the 2020 spring wild turkey hunting season.**

| How did COVID-19 affect resident participation in turkey hunting? | n | % |
|---------------------------------------------------------------|---|---|
| Individual turkey hunters hunted more | 1 | 2.2% |
| Less people turkey hunted; Individual turkey hunters hunted more | 1 | 2.2% |
| More people turkey hunted | 18 | 39.1% |
| More people turkey hunted; Individual turkey hunters hunted more | 22 | 47.8% |
| More people turkey hunted, Individual turkey hunters hunted more, Individual turkey hunters hunted less | 1 | 2.2% |
| None of the above | 2 | 4.3% |

*Respondents could choose all that apply, thus categories can be combinations of those in Question 10a.*

**Table 4**

**Respondent professional opinions regarding effects of the COVID-19 pandemic on non-resident hunter participation in the 2020 spring wild turkey hunting season.**

| How did COVID-19 affect nonresident participation in turkey hunting? | n | % |
|---------------------------------------------------------------|---|---|
| Individual turkey hunters hunted more | 2 | 5.1% |
| Less people turkey hunted | 22 | 56.4% |
| Less people turkey hunted; Individual turkey hunters hunted less | 1 | 2.6% |
| Less people turkey hunted; Individual turkey hunters hunted more | 3 | 7.7% |
| More people turkey hunted | 1 | 2.6% |
| More people turkey hunted; Individual turkey hunters hunted more | 4 | 10.3% |
| None of the above | 5 | 12.8% |

*Respondents could choose all that apply, thus categories can be combinations of those in Question 10b.*

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Because some assertions regarding impacts of the COVID-19 pandemic could be based on evaluations of reported turkey harvests, the reliability of those estimates is crucial (Question 4, Appendix A). From 2015–2020 and across all states and years (n = 276), only 7% of respondents rated the reliability of spring turkey harvest estimates as Poor; the remainder rated harvest estimates as Excellent or Good. In all AFWA regions, biologists had relatively high confidence in harvest estimate reliability. Western and Midwest biologists gave more Excellent than Good ratings (53% vs. 33% and 67% vs. 33%, respectively) than did Southeast and Northeast biologists (30% vs. 55% and 42% vs. 58%, respectively). Most importantly, across years (2015–2020), biologists’ ratings of harvest estimate reliability were consistent (Table 5), with ratings within a category varying ≤5% across years. Poor ratings accounted for <10% of harvest estimate reliability ratings.
### TABLE 5  State-reported reliability of reported turkey harvest estimates pooled across states by year for 2015–2020.

| Spring turkey harvest estimate reliability | 2015        | 2016        | 2017        | 2018        | 2019        | 2020        |
|-------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Excellent                                 | 47% (22)    | 47% (22)    | 47% (22)    | 45% (21)    | 47% (22)    | 45% (21)    |
| Good                                      | 47% (22)    | 45% (21)    | 45% (21)    | 45% (21)    | 47% (22)    | 45% (21)    |
| Poor                                      | 6% (3)      | 6% (3)      | 6% (3)      | 9% (4)      | 4% (2)      | 6% (3)      |

*aPercentage of respondents per category by year.  
*bNumber of respondents per category by year.

### TABLE 6  Consistency of methods used to estimate turkey hunting variables (i.e., reported spring harvest, participation, and effort) pooled across states by year for 2015–2020.

| Consistency of Spring Turkey Hunting Estimates | 2015        | 2016        | 2017        | 2018        | 2019        | 2020        |
|------------------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Changed and significantly changed estimate quality | 0% (0)      | 2% (1)      | 2% (1)      | 2% (1)      | 4% (2)      | 6% (3)      |
| Changed but did not significantly affect estimate quality | 6% (3)      | 6% (3)      | 4% (2)      | 4% (2)      | 6% (3)      | 17% (8)     |
| Methods did not change from previous year | 94% (44)    | 91% (43)    | 91% (43)    | 91% (43)    | 87% (41)    | 74% (35)    |

*aPercentage of respondents per category by year.  
*bNumber of respondents per category by year.

### TABLE 7  Constancy of spring turkey hunting regulations pooled across all states, years, and state by year combinations from 2015 through 2020.

| Constancy of spring turkey hunting regulations | n   | %  |
|-----------------------------------------------|-----|----|
| Bag limit decreased compared to previous year | 1   | 0  |
| Bag limit increased compared to previous year | 3   | 1  |
| Hunting season length contracted compared to previous year | 6   | 2  |
| Hunting season length contracted compared to previous year, bag limit decreased compared to previous year | 1   | 0  |
| Hunting season length expanded compared to previous year | 9   | 4  |
| Hunting season length expanded compared to previous year, bag limit decreased compared to previous year | 1   | 0  |
| No change from previous year                   | 232 | 90 |
| No change from previous year, hunting season length expanded compared to previous year | 1   | 0  |
| Shooting hours expanded compared to previous year | 2   | 1  |
| Shooting hours expanded compared to previous year, Bag limit increased compared to previous year | 1   | 0  |

*aRespondents could choose all that apply, thus categories can be combinations of those in Question 6.  
*bWhole percent of respondents for whom at least one response included the category.
### Table 8
Coarse groupings (increased, stayed the same, decreased) of change in wild turkey population from 2015–2020 in states grouped by Association of Fish and Wildlife Agencies regional associations. State abbreviations follow U.S. Postal Service standards.

| Wild Turkey Population Trend, 2015–2020 | Western | Midwest | Southeast | Northeast |
|----------------------------------------|---------|---------|-----------|-----------|
| % States                               | % States | % States | % States | % States |
| Increased                              | 54% CA, ID, ND, OR, UT, WA, WY | 0% NC | 18% MD, NH |
| Stayed the same                        | 46% AZ, CO, MT, NV, NM, SD | 44% IL, MI, OH, WI | 50% KY, LA, MS, TN, TX, VA, WV | 64% DE, MA, ME, NJ, NY, RI, VT |
| Decreased                              | 0% - | 56% IN, IA, KS, MO, NE | 43% AL, AR, FL, GA, OK, SC | 18% CT, PA |

### Figure 3
Change in number of licenses sold that allow for spring wild turkey hunting between the 3-year average for 2017–2019 and 2020 during the COVID-19 pandemic. Open circles indicate states either with no COVID-19 restrictions or those which did not relate to turkey hunting. Solid circles indicate states with COVID-19 restrictions related directly to turkey hunting and/or access. The x-axis abbreviations represent Association of Fish and Wildlife Agencies regional associations: NE = Northeast, SE = Southeast, MW = Midwest, and W = Western. State abbreviations follow U.S. Postal Service standards.
In addition to estimate reliability, we believed consistency in estimation technique could influence results of the survey or future interpretation of the data. Respondents were asked to report the consistency in techniques for estimating variables related to turkey hunting during the period from 2015–2020 (Question 5, Appendix A). When assessed across all states and years, 90% of responses (n = 278) indicated that methods did not change from the previous year. Among AFWA regions, consistency in variable estimation techniques was ≥85%. Notably, estimation techniques changed most in the Midwest and Northeast regions, but in both cases, respondents indicated that these changes did not significantly affect estimate quality. Across years (2015–2020), biologists’ responses regarding consistency of estimation techniques varied little through 2019 (Table 6). In 2020, the number of states in which techniques changed increased from 10% in 2019 to 23%; however, 17% of respondents indicated these changes did not significantly impact estimate quality.

A final regulatory question concerned the annual consistency of spring turkey hunting regulations from 2015–2020 (Question 6, Appendix A). Respondents were given 7 possible responses with all but one (i.e., Shooting Hours Contracted Compared to Previous Year) chosen by at least one respondent (Table 7). Whereas 4 respondents combined responses, most responses (90%, n = 232) indicated there was no change.

FIGURE 4 Change in number of active resident spring wild turkey hunters between the 3-year average for 2017–2019 and 2020 during the COVID-19 pandemic. Open circles indicate states either with no COVID-19 restrictions or those which did not relate to turkey hunting. Solid circles indicate states with COVID-19 restrictions related directly to turkey hunting and/or access. The x-axis abbreviations represent Association of Fish and Wildlife Agencies regional associations: NE = Northeast, SE = Southeast, MW = Midwest, and W = Western. State abbreviations follow U.S. Postal Service standards.
Because short-term turkey population trajectory could be an important factor in determining potential effects of the COVID-19 pandemic on turkey populations and turkey hunting, we asked respondents to use their best available information and indicate whether the population in their jurisdiction has increased, decreased, or stayed the same from 2015–2020 (Question 1, Appendix A). Responses varied considerably among states and regions when classifying 2015–2020 trends in state turkey populations (Figure 1, Table 8). In general, perceived trends in Western states were that populations stayed the same or decreased. Perceived trends in Midwest states were that populations stayed the same or increased. Perceived trends in Southeast states (except for North Carolina) were that populations stayed the same or decreased. Responses from Northeast states indicated all 3 trends, but the majority (64%) of respondents indicated that turkey populations had been stable from 2015–2020.

Questions concerning turkey hunting variable estimates (Question 3a and 3b, Appendix A) and reported turkey harvest (Questions 2a and 2b, Appendix A) yielded considerable information to complete the COVID-19
scenario evaluations. With the high variability in turkey population characteristics across the country (Figure 1, Table 8), we compared the 2017–2019 average for each variable for resident and non-resident hunters to estimates for 2020.

In most states, sales of spring turkey hunting licenses (Question 2a, Appendix A) increased in 2020 compared to the 2017–19 average (Figure 3). Based on survey responses, some exceptions reflected reductions in non-resident hunting opportunities during 2020 due to restrictions on interstate travel or limits on non-residents license sales (e.g., Kansas, K. Fricke, Kansas Department of Wildlife and Parks, personal communication). More states had increased hunting license sales when their COVID-19 restrictions were in place before the spring hunting season opened than states that enacted restrictions after the season opened.

Similar to the number of eligible turkey hunters, estimated active turkey hunters in 2020 was greater than the 2017–2019 average in almost all states, and in some cases up to 30% greater (Figure 4). The number of active hunters was greater in states where the time between implementation of COVID-19 restrictions and the subsequent opening date of turkey hunting seasons was greatest. Although fewer states provided data, turkey hunting effort—expressed as total hunter days per season—also increased in 2020 compared to the 2017–2019

**FIGURE 6** Change in turkey hunting effort expressed as average days per hunter between the 3-year average for 2017-2019 and 2020 during the COVID-19 pandemic. Open circles indicate states either with no COVID-19 restrictions or those which did not relate to turkey hunting. Solid circles indicate states with COVID-19 restrictions related directly to turkey hunting and/or access. The x-axis abbreviations represent Association of Fish and Wildlife Agencies regional associations: NE = Northeast, SE = Southeast, MW = Midwest, and W = Western. State abbreviations follow U.S. Postal Service standards.
mean in most states (Figure 5). Hunters in states with seasons opening after implementation of COVID-19 restrictions expended more hunting effort, indicating that restrictions provided hunters with more free time and the ability to spend more time afield. In addition to a respondents' estimates of hunting effort, we used responses to calculate an additional effort variable expressed as days hunted per individual hunter (i.e., hunter-days). Trends across the country in hunter-days mimicked other hunting-related variables; hunter-days increased in 2020 from the previous 3-year average (Figure 6), mostly in states with hunting seasons opening after COVID-19 restrictions were implemented.

Reported turkey harvest is the population and hunting variable most often of interest to managers and turkey hunters. This is especially true in areas where populations may be stable or declining. Similar to other variables, reported total harvest was greater in most states in 2020 when compared to the previous 3-year average (Figure 7). Even though 60% of respondents reported an increased harvest in their state, 40% of states indicated that reported harvest decreased, in one case by >40%. Although hunting effort and total reported harvest increased in most states in 2020, take-per-unit-effort (i.e., harvest per hunter-day, which controls for changes in participation and effort) decreased in 93% of jurisdictions from which data were available (Figure 8).

**FIGURE 7** Change in reported wild turkey harvest between the 3-year average for 2017-2019 and 2020 during the COVID-19 pandemic. Open circles indicate states either with no COVID-19 restrictions or those which did not relate to turkey hunting. Solid circles indicate states with COVID-19 restrictions related directly to turkey hunting and/or access. The x-axis abbreviations represent Association of Fish and Wildlife Agencies regional associations: NE = Northeast, SE = Southeast, MW = Midwest, and W = Western. State abbreviations follow U.S. Postal Service standards.
DISCUSSION/MANAGEMENT IMPLICATIONS

Our results establish a series of reference points for turkey hunting and hunter dynamics before and during the COVID-19 pandemic. Our study was not designed to demonstrate direct cause and effects of the 2020 COVID-19 pandemic on turkey populations. Although we cannot assess impacts on turkey populations, there is evidence that hunting participation and effort increased in 2020 compared to previous years, and the increases or decreases observed in harvest were not necessarily in response to increasing turkey numbers. Our results quantitatively address many questions raised before and during the 2020 spring turkey hunting season, will inform future evaluations, and could be used to design direct management-oriented research to evaluate the concepts raised by our work at local, state, regional, and range-wide scales. Whether the levels of turkey hunting participation and effort will be sustained in 2021 and beyond is unknown. Spring 2020 was an important reference point that will have to be viewed in the context of COVID when compared to years before and after.

Our results also indicate that hunting license sales, the number of hunters afield, reported harvest, total hunter days afield, and the number of days individual hunters were afield all increased in most states during the spring 2020 wild turkey hunting season. For numerous reasons, more individuals had more available time...
to hunt. In addition, many state governments and agencies, including state fish and wildlife agencies, promoted getting outdoors during the pandemic. Our results show that those efforts, or others, were successful. We could not measure directly whether or not increased license sales, hunters afield, and reported harvest reflected the entry of new hunters into turkey hunting or the return of lapsed turkey hunters, but we suggest either is possible. The pandemic effect on longer term Recruitment, Retention, and Reactivation (R3) efforts—across all outdoor activities, including turkey hunting—is fertile ground for future research.

Changes in hunting and hunter variables were not consistent in all states. Arguably, the most useful measure of potential effects of hunting on a wildlife population—take-per-unit-effort—decreased in all but one state from which responses were collected. Viewed nationally (Figure 9) our results support many trends that wild turkey
managers predicted. Importantly, results also demonstrate that because wild turkeys are a state-trust resource and populations and hunting dynamics vary among states (sample units in this study), there are many exceptions to generalities about the variables we measured during 2020.

Although surveys of this type do not allow us to determine the impact of changes in hunting participation and effort on turkey population density or distribution within or among states, they do suggest that broadened and standardized monitoring and research is needed. Because wild turkeys are a priority game species of most state fish and wildlife agencies in their range, we believe continued and expanded monitoring will inform questions about hunting participation and changes in turkey populations. Monitoring efforts should be designed and standardized with specific goals allowing the interaction of variables on turkey population dynamics and hunter demography to be examined. In all cases, monitoring efforts should include wildlife population and habitat evaluations and study of hunter dynamics in a social science framework. Additionally, there should be on-going evaluations of harvest estimate reliability to improve accuracy and non-reporting bias.

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CONFLICTS OF INTEREST
The authors declare no conflicts of interest.

ETHICS STATEMENT
Our protocol for conducting this study followed the North Carolina Wildlife Resources Commission's policies for human subjects research specified in the agency's “Statement of Principals Governing Human Subjects Research.”

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APPENDIX A

Spring 2015–2020 Wild Turkey Hunting Season Survey

This survey will be available until April 9, 2021. Your answers will help us learn more about changes in turkey hunting and harvest during the 2020 COVID-19 pandemic. Thank you in advance for your time and participation. Please select the ">>>" button to begin.

Your Information

- Your Name ________________________________
- Position Title ________________________________
- Agency Name ________________________________
- State ________________________________
- Email address ________________________________

Q1. Wild Turkey Population Change From 2015 through 2020, has the wild turkey population in your state...

- Increased
- Decreased
- Stayed the same

Q2a. Estimated Harvest by Age Class—Resident Hunters

| Year | Jake | Adult | TOTAL | Source of Harvest Estimate [Examples could include: mandatory reporting, voluntary reporting, post-season surveys, other (specify)] |
|------|------|-------|-------|---------------------------------------------------------------------------------------------------------------|
| 2015 |      |       |       |                                                                                                               |
| 2016 |      |       |       |                                                                                                               |
| 2017 |      |       |       |                                                                                                               |
| 2018 |      |       |       |                                                                                                               |
| 2019 |      |       |       |                                                                                                               |
| 2020 |      |       |       |                                                                                                               |
Q2b. Estimated Harvest by Age Class—Nonresident Hunters

| Year | Jake | Adult | TOTAL |
|------|------|-------|-------|
| 2015 |      |       |       |
| 2016 |      |       |       |
| 2017 |      |       |       |
| 2018 |      |       |       |
| 2019 |      |       |       |
| 2020 |      |       |       |

Source of Harvest Estimate [Examples could include: mandatory reporting, voluntary reporting, post-season surveys, other (specify)]

Q3a. Turkey Hunting Estimates—Residents

| Year | Number of licenses held that allow for turkey hunting | Estimated number of active turkey hunters | Turkey hunting effort (total hunter days/season) |
|------|------------------------------------------------------|------------------------------------------|-----------------------------------------------|
| 2015 |                                                      |                                          |                                               |
| 2016 |                                                      |                                          |                                               |
| 2017 |                                                      |                                          |                                               |
| 2018 |                                                      |                                          |                                               |
| 2019 |                                                      |                                          |                                               |
| 2020 |                                                      |                                          |                                               |

Q3b. Turkey Hunting Estimates—Nonresidents

| Year | Number of licenses held that allow for turkey hunting | Estimated number of active turkey hunters | Turkey hunting effort (total hunter days/season) |
|------|------------------------------------------------------|------------------------------------------|-----------------------------------------------|
| 2015 |                                                      |                                          |                                               |
| 2016 |                                                      |                                          |                                               |
| 2017 |                                                      |                                          |                                               |
| 2018 |                                                      |                                          |                                               |
| 2019 |                                                      |                                          |                                               |
| 2020 |                                                      |                                          |                                               |
Q4. Harvest Estimate Reliability Please rate your confidence in the harvest estimate for each year as “Poor,” “Good,” or “Excellent.”

| Year | Poor | Good | Excellent |
|------|------|------|-----------|
| 2015 | ○    | ○    | ○         |
| 2016 | ○    | ○    | ○         |
| 2017 | ○    | ○    | ○         |
| 2018 | ○    | ○    | ○         |
| 2019 | ○    | ○    | ○         |
| 2020 | ○    | ○    | ○         |

Q5. Consistency of Turkey Hunting Estimates Did the way you estimate harvest, participation, or effort change from 2015 through 2020? (If only one or two of these variables changed, indicate which variables changed in the Comments box for Q5.)

| Year | Methods did not change from previous year | Changed but did not significantly affect estimate quality | Changed and significantly changed estimate quality |
|------|------------------------------------------|--------------------------------------------------------|--------------------------------------------------|
| 2015 | ○                                        | ○                                                      | ○                                                 |
| 2016 | ○                                        | ○                                                      | ○                                                 |
| 2017 | ○                                        | ○                                                      | ○                                                 |
| 2018 | ○                                        | ○                                                      | ○                                                 |
| 2019 | ○                                        | ○                                                      | ○                                                 |
| 2020 | ○                                        | ○                                                      | ○                                                 |

Q6. Consistency of Spring Turkey Hunting Regulations Did the amount of spring turkey hunting opportunity change from 2015 through 2020?

| Year | No change from previous year | Hunting season length expanded compared to previous year | Shooting hours expanded compared to previous year | Bag limit increased compared to previous year | Hunting season length contracted compared to previous year | Shooting hours contracted compared to previous year | Bag limit decreased compared to previous year |
|------|-----------------------------|--------------------------------------------------------|-------------------------------------------------|---------------------------------------------|--------------------------------------------------------|---------------------------------------------|---------------------------------------------|
| 2015 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
| 2016 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
| 2017 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
| 2018 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
| 2019 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
| 2020 | ○                           | ○                                                      | ○                                               | ○                                           | ○                                                      | ○                                           | ○                                           |
Q7. Status of Your State During the 2020 Spring Turkey Season Relative to the COVID-19 Pandemic (check all that apply)

- No restrictions
- Stay-at-Home Orders–Statewide
- Stay-at-Home Orders–by County
- Restrictions on Public Gatherings of >10 people
- Restrictions on Turkey Hunting (including license sales restrictions)
- Restrictions on Public Access to Turkey Hunting Areas

Q8. Approximate start date of COVID-related travel restrictions in your state in 2020?

________________________________________________________________________________________________________

Q9. Opening and closing dates of the 2020 spring wild turkey hunting season in your state

- Opening Date (mm/dd) ________________________________
- Closing Date (mm/dd) ________________________________

Q10a. In your opinion, how did COVID-19 affect resident participation in turkey hunting during the spring 2020 season in your state? (check all that apply)

- More people turkey hunted
- Less people turkey hunted
- Individual turkey hunters hunted more
- Individual turkey hunters hunted less
- None of the above

Q10b. In your opinion, how did COVID-19 affect nonresident participation in turkey hunting during the spring 2020 season in your state? (check all that apply)

- More people turkey hunted
- Less people turkey hunted
- Individual turkey hunters hunted more
- Individual turkey hunters hunted less
- None of the above

Thank you for taking the time and effort to complete this survey.
Please click the '>' button to submit your responses or '"' to go back and make changes.