Gobbling Chronology Project Update
Summarizing Information for 2016 – 2018

February 11th, 2019

BACKGROUND

Wild turkeys are a valuable public trust resource in North Carolina. They are beloved by hunters and non-hunters alike. In recent years, more than 60,000 hunters pursued turkeys each spring and annually harvested more than 15,000 birds. The North Carolina Wildlife Resources Commission (NCWRC) seeks to emphasize spring gobbler hunting, allow the population to grow in numbers and distribution, and to satisfy the public to the extent possible.

The NCWRC's regulatory management of wild turkeys in North Carolina takes into account many factors, including turkey ecology, hunter effort, turkey population density, habitat and landscape attributes, and hunting traditions. Principal among these factors is the need for an understanding of turkey reproductive ecology. There are several facets to reproductive ecology, including gobbling activity, egg laying, incubation, nest predation, and nesting success rates. Gobbling activity, and patterns of gobbling activity through the spring, attracts the interest and attention of turkey hunters. The timing of gobbling activity, the timing of the spring turkey season, hunter success, and hunter satisfaction are all intertwined. As such, an understanding of gobbling chronology is paramount to successful turkey management.

Science-based gobbling chronology data in North Carolina have been lacking. Furthermore, the chronology of gobbling activity may vary across the state. It is generally recognized that gobbling activity varies with respect to latitude in North America, with gobbling occurring earlier in southern latitudes. In some cases, peak gobbling activity may vary by as much as two weeks within individual states (Palumbo 2010). Gobbling activity is generally thought to follow a bimodal pattern, with peaks at two specific times during spring. Peaks are expected to occur before the primary breeding period (prior to hens being receptive to breeding) and again after that period when hens are incubating nests. However, this pattern, and presumably other aspects of reproductive behavior, may not always occur (Miller et al.

1997). Therefore, in this project we seek to collect gobbling chronology data specific to North Carolina to make better informed regulatory decisions about turkey management.

We began this project in 2016 to evaluate new technologies and equipment and to determine if patterns of gobbling activity exist in two parts of the state (southeast and northwest) where factors thought to influence the timing of gobbling are most different. We were encouraged by our results in 2016 and therefore expanded the project statewide and plan to continue through 2019.

OBJECTIVES

This project has several specific objectives:

1. Determine the best methods for using acoustic recorders to research gobbling chronology in North Carolina.

2. Use acoustic recorders to collect baseline gobbling chronology data in southeastern and northwestern North Carolina.

3. Collect gobbling chronology data statewide in order to better understand turkey reproductive ecology and to inform management decisions.

METHODS

Equipment

We purchased and deployed 51 Song Meter SM3 Acoustic Recorders (Wildlife Acoustics, Inc., Maynard, MA 01754) in the course of this project. We purchased and evaluated two different data processing software programs: Song Scope V4 (Wildlife Acoustics, Inc., Maynard, MA 01754) and RavenPro Version 1.4 (The Cornell Lab of Ornithology, Ithaca, NY 14850). After briefly evaluating both programs, we have processed our data via the RavenPro software.

Site Selection

We deployed the acoustic recorders on large properties that had high numbers of turkeys and little or no hunting pressure (Figures 1 - 3). Sites have included many North Carolina State Parks and Natural Areas as well as privately-owned properties. We selected locations on the properties that we expected to be frequently used by turkeys. Recorders were housed in security boxes and bolted to trees.

In 2016, we deployed 25 recorders in northwestern North Carolina, 25 recorders in southeastern North Carolina, and used one recorder for testing and practice. This allowed staff to operate efficiently and provided preliminary data from two regions where factors thought to influence the timing of gobbling chronology are most different. Based on results in 2016, we deployed all 51 acoustic recorders statewide in 2017. We placed at least 5 acoustic recorders in each WRC district. We reused the best six sites (i.e., the highest numbers of gobbles) in each of the two regions (District 7 – northwest region and District 4 – southeast region) that had been part of the project in 2016. As in 2016, we selected large properties, with abundant turkeys, where little to no turkey hunting occurred. We deployed the 51 recorders again in 2018, using the same locations as in 2017 except that we selected new locations for 5 recorders (0.4 to 18 miles from previous locations) were we expected to record substantially more gobbling activity.

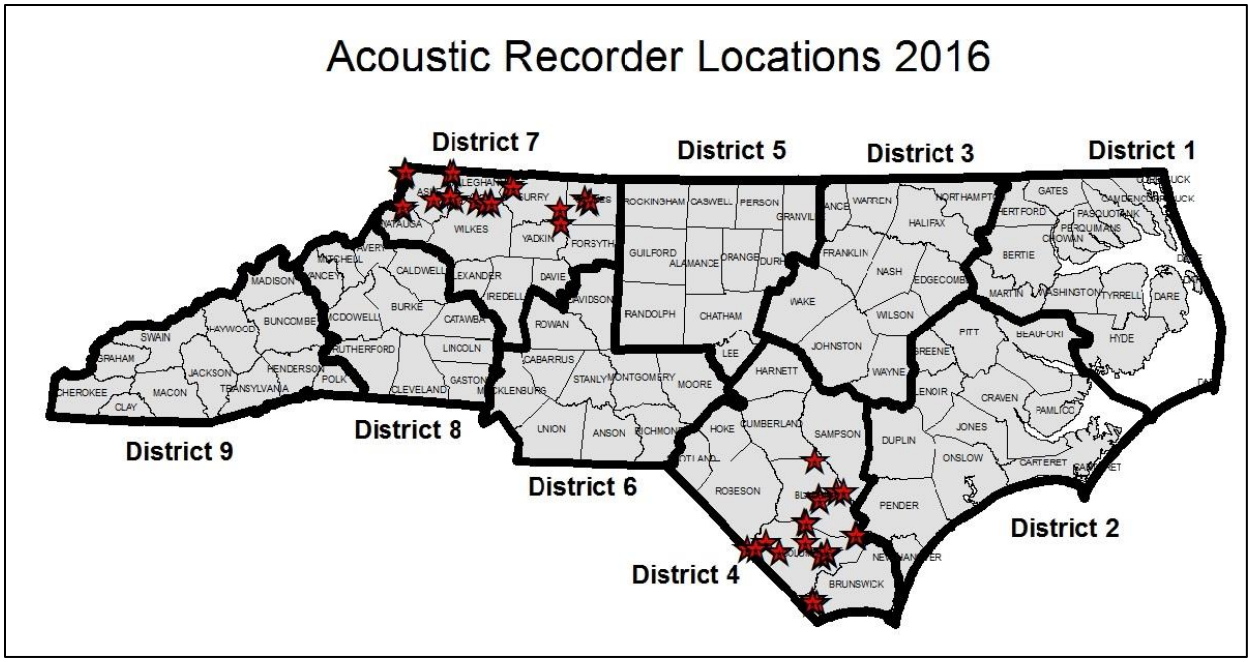

Figure 1. General locations of acoustic recorders, March 1 – May 31, 2016.

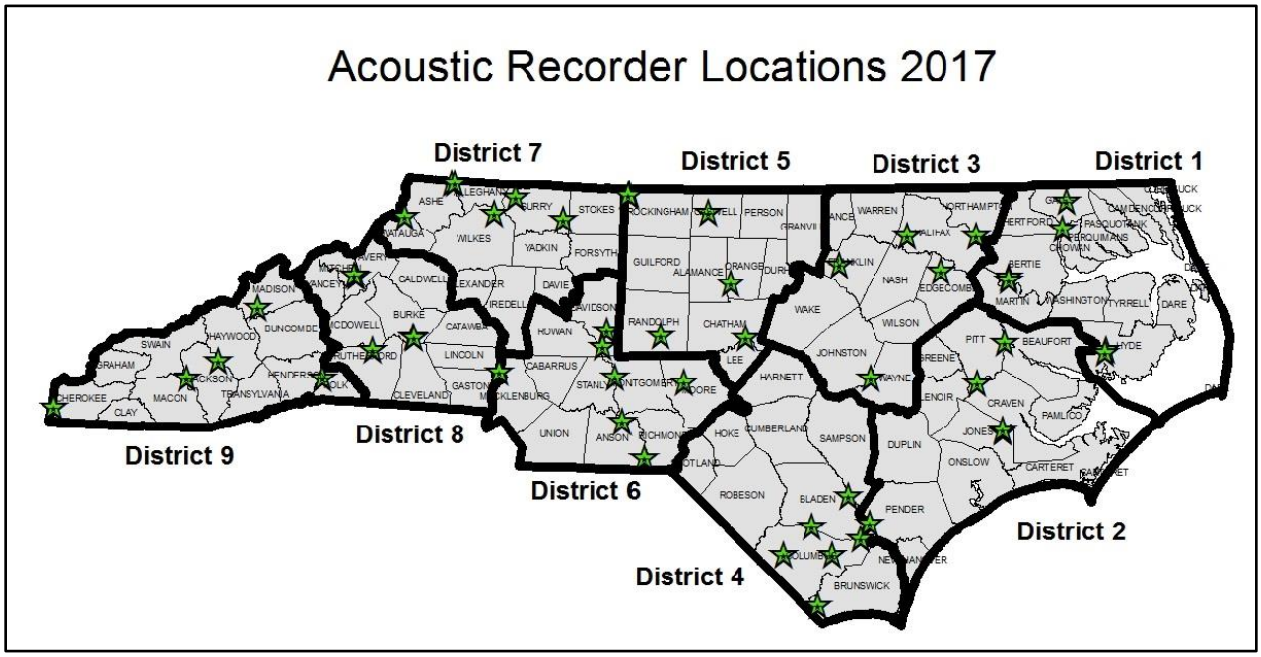

Figure 2. General locations of acoustic recorders, February 24 – June 3, 2017.

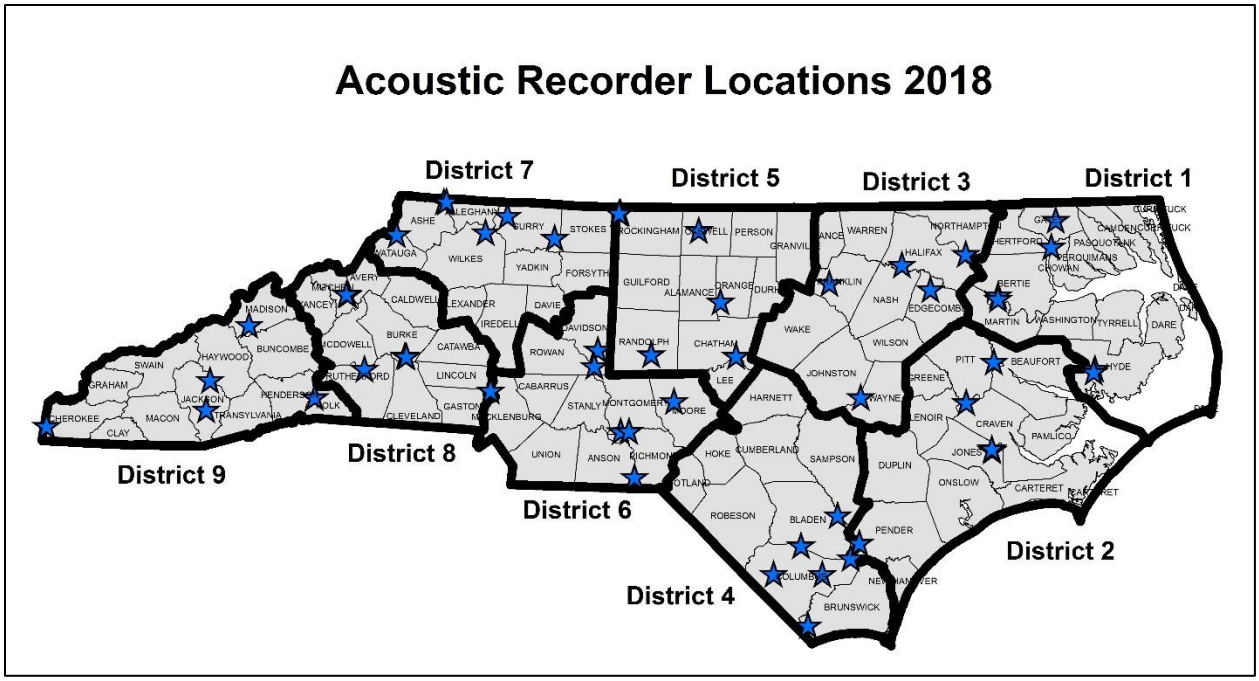

Figure 3. General locations of acoustic recorders, February 24 – June 2, 2018.

Sampling Period and Recording Time

2016: Our primary period of interest was March 1st through May 31st, 2016, though we recorded data at some sites beginning in the last week of February. Field biologists deployed the acoustic recorders in February 2016. Each recorder was visited in mid-April to replenish SDHC cards and replace batteries. Recorders were removed from the field locations in June 2016. The recorders were programmed to record 5 hours each day beginning 1 hour before sunrise.

2017: We adjusted our sampling period and recording time based on 2016 results. Our primary period of interest was from February 24th through June 3rd, 2017, though we recorded data at some sites beginning on February 23rd. Field biologists deployed the acoustic recorders in mid-February 2017 and did not return until June 2017 to remove them as the programming schedule was adjusted so that the entire time could be recorded with one set of batteries and SDHC cards. Each recorder was programmed to record 2.5 hours each day beginning 30 minutes before sunrise.

2018: The process for this season was very similar to our 2017 procedure. Our primary period of interest was from February 24th through June 2, 2018. Recorders were deployed in mid-February 2018 and were set to record 2.5 hours each day beginning 30 minutes before sunrise. Five recorders were improperly deployed, with four recording no data during the sampling period and one recording only one hour per day rather than 2.5 hours per day

Data Processing

We accomplished data processing aspects of this project by hiring full-time temporary employees. In 2016, we hired 3 full-time temporary employees that worked a combined total of 1,696 hours. In 2017, we hired 2 full-time temporary employees that worked a combined total of 1,200 hours. In 2018, we hired 2 full-time temporary employees that worked a combined total of 1,200 hours. These temporary employees, along with Chris Kreh (Upland Game Bird Biologist) and Allison Medford (Wildlife Diversity Biologist), handled all aspects of processing and analyzing data. We evaluated software options, backed up files to external hard drives, manually tallied the number of gobbles on a subset of the recordings, developed/evaluated procedures for automatically detecting gobbles on the recordings, processed all files from the acoustic recorders, and prepared appropriate notes and spreadsheets as needed. The bulk of data processing was accomplished using Band Limited Energy Detectors in Raven Pro software (versions 1.4 and 1.5).

RESULTS

Hours Recorded and Data Processing

Overall performance of the acoustic recorders has been good and we recorded a total of 22,105 hours from March 1 - May 31, 2016 (Table 1), 12,320.5 hours from February 24 – June 3, 2017 (Table 2), and 10,844 hours from February 24 – June 2, 2018 (Table 3). We processed all these recording with Raven Pro software (versions 1.4 and 1.5). In 2016, efficiency of our data processing improved greatly after initial training. Using Raven Pro's automated detection procedures, we were able to process approximately 175 hours of recordings in an eight-hour work day. In 2016, we established specific input parameters for using Raven Pro's automated detectors. In 2017 and 2018, to have comparable results to the first year, we continued to use the same input parameters that we used in 2016. The acoustic recorders have two external microphones and each microphone separately records an audio file. However, we noticed that gobbles would sometimes be detected on only one of the recorder's two external microphones and sometimes on both microphones. Therefore, we adjusted our procedures in 2017 and 2018 so that the software could detect a gobble on either of its two external microphones (and not be double counted), rather than relying on only the first microphone, as we did in 2016.

Table 1. Location, hours recorded, and number of gobbles detected by acoustic recorders, March 1 – May 31, 2016.

Acoustic Recorder Number	Year	Region	County	Site	Hours Recorded	Number of Gobbles Detected
SM304671	2016	NW	Wilkes	Stone Mountain State Park (Horse Trailer Parking Area)	460	0
SM304668	2016	NW	Stokes	Hanging Rock State Park (Drain Fields)	450	1
SM304495	2016	NW	Watauga	Elk Knob State Park (Summit Trailhead)	460	3
SM304662	2016	NW	Ashe	Mt. Jefferson State Natural Area	460	3
SM304664	2016	NW	Alleghany	Stone Mountain State Park (Traffic Island)	460	6
SM304667	2016	NW	Stokes	Hanging Rock State Park (Camp Sertoma)	450	11
SM304666	2016	NW	Stokes	Hanging Rock State Park (Reservoir)	450	12
SM304652	2016	NW	Ashe	New River State Park (Oliver Tract #2)	460	34
SM304650	2016	NW	Ashe	NCDA Upper Mountain Research Station	460	37
SM304657	2016	NW	Ashe	Pond Mountain (Loflin Tract #1)	460	40
SM304659	2016	NW	Ashe	Pond Mountain (Braun Tract Near Gap)	460	40
SM304475	2016	NW	Ashe	New River State Park (Wagoner Rd #2)	460	43
SM304663	2016	NW	Wilkes	Private Property	450	45
SM304656	2016	NW	Surry	Camp Raven Knob (Endicott Springs)	460	62
SM304670	2016	NW	Ashe	Pond Mountain (Braun Tract Cemetery)	460	73
SM304489	2016	NW	Surry	Pilot Mountain State Park (River Section)	455	95
SM304669	2016	NW	Alleghany	Stone Mountain State Park (Ranger Residence)	455	108
SM304661	2016	NW	Ashe	New River State Park (Wagoner Rd #1)	460	158
SM304655	2016	NW	Surry	Camp Raven Knob (Weather Station)	460	159
SM304665	2016	NW	Watauga	Elk Knob State Park (Elk Horn Gap)	460	164
SM304653	2016	NW	Alleghany	New River State Park (Alleghany Access Area #1)	460	182
SM304658	2016	NW	Ashe	Pond Mountain (Loflin Tract #2)	460	188
SM304660	2016	NW	Surry	Pilot Mountain State Park (Shoals Rd)	460	349
SM304654	2016	NW	Alleghany	New River State Park (Alleghany Access Area #2)	460	988
SM304651	2016	NW	Ashe	New River State Park (Oliver Tract #1)	460	1,862
				Northwest Region Subtotal	**11,450**	**4,663**
SM304625	2016	SE	Columbus	Private Property	460	1
SM304641	2016	SE	Columbus	L. Waccamaw State Park (Pine Woods Trail)	330	16
SM304626	2016	SE	Bladen	Elkton Rod and Gun Club (Slades Swamp)	275	48
SM304642	2016	SE	Columbus	L. Waccamaw State Park (Dam Fire Line)	460	98
SM304643	2016	SE	Columbus	L. Waccamaw State Park (Dam Trail)	460	123
SM304623	2016	SE	Columbus	Private Property	460	126
SM304638	2016	SE	Bladen	Elkton Rod and Gun Club (Runway Field)	460	158
SM304634	2016	SE	Brunswick	Private Property	460	214
SM304622	2016	SE	Bladen	Corporate CURE Farm	305	219
SM304624	2016	SE	Columbus	Private Property	460	228
SM304647	2016	SE	Columbus	Private Property	330	228
SM304636	2016	SE	Bladen	Private Property	460	253
SM304627	2016	SE	Columbus	Private Property	435	278
SM304628	2016	SE	Columbus	Private Property	285	336
SM304630	2016	SE	Bladen	Private Property	445	394
SM304644	2016	SE	Columbus	L. Waccamaw State Park (Behind Residence)	460	402
SM304629	2016	SE	Bladen	Private Property	460	410
SM304635	2016	SE	Brunswick	Private Property	460	588
SM304645	2016	SE	Columbus	Private Property	460	629
SM304631	2016	SE	Bladen	Private Property	460	786
SM304640	2016	SE	Bladen	Elkton Rod and Gun Club (New Ground Field)	460	864
SM304632	2016	SE	Brunswick	Private Property	460	915
SM304648	2016	SE	Columbus	Private Property	430	955
SM304646	2016	SE	Columbus	Private Property	460	996
SM304637	2016	SE	Columbus	Private Property	460	1,607
				Southeast Region Subtotal	**10,655**	**10,872**
				Grand Total	**22,105**	**15,535**

Table 2. Location, hours recorded, and number of gobbles detected by acoustic recorders, February 24 – June 3, 2017.

Acoustic Recorder Number	Year	District	County	Site	Hours Recorded	Number of Gobbles Detected
SM304662	2017	1	Bertie	Private Property	247.5	134
SM304666	2017	1	Bertie	Private Property	247.5	930
SM304653	2017	1	Gates	Merchants Millpond State Park	247.5	599
SM304659	2017	1	Hertford	Private Property	222.5	292
SM304668	2017	1	Hyde	Private Property	247.5	340
SM304638	2017	1	Hyde	Private Property	247.5	2,035
SM304661	2017	2	Craven	Private Property	247.5	2,613
SM304671	2017	2	Jones	Private Property	237.5	1,224
SM304489	2017	2	Jones	Private Property	247.5	2,635
SM304670	2017	2	Pender	Private Property	247.5	631
SM304663	2017	2	Pitt	Private Property	247.5	306
SM304627	2017	3	Edgecombe	Private Property	247.5	337
SM304647	2017	3	Franklin	Private Property	247.5	128
SM304625	2017	3	Halifax	Medoc Mountain State Park	247.5	6
SM304656	2017	3	Johnston	Private Property	247.5	1,275
SM304643	2017	3	Northampton	Private Property	247.5	388
SM304640	2017	4	Bladen	Elkton Rod and Gun Club	247.5	311
SM304631	2017	4	Bladen	Private Property	247.5	1,400
SM304632	2017	4	Brunswick	Private Property	225.0	1,289
SM304624	2017	4	Columbus	Private Property	247.5	179
SM304644	2017	4	Columbus	L. Waccamaw State Park	247.5	236
SM304637	2017	4	Columbus	Private Property	222.5	2,237
SM304652	2017	5	Caswell	Private Property	247.5	311
SM304626	2017	5	Chatham	Deep River Trail State Park	247.5	140
SM304646	2017	5	Orange	Cane Creek Reservoir	247.5	181
SM303721	2017	5	Randolph	NC Zoo	247.5	432
SM304629	2017	5	Rockingham	Mayo River State Park	247.5	372
SM304495	2017	5	Rockingham	Mayo River State Park	247.5	531
SM304667	2017	6	Anson	Private Property	247.5	636
SM304658	2017	6	Davidson	Private Property	103.0	567
SM304648	2017	6	Davidson	Private Property	247.5	2,044
SM304622	2017	6	Moore	Boy Scout Camp	247.5	178
SM304645	2017	6	Richmond	Pee Dee NWR	305.0	29
SM304635	2017	6	Stanly	Morrow Mountain State Park	247.5	17
SM304669	2017	7	Alleghany	Stone Mountain State Park	247.5	30
SM304654	2017	7	Alleghany	New River State Park	115.0	404
SM304651	2017	7	Alleghany	New River State Park	247.5	4,283
SM304660	2017	7	Surry	Pilot Mountain State Park	247.5	192
SM304655	2017	7	Surry	Camp Raven Knob	247.5	243
SM304665	2017	7	Watauga	Elk Knob State Park	247.5	366
SM304636	2017	8	Burke	South Mountain State Park	247.5	426
SM304641	2017	8	Burke	South Mountain State Park	247.5	483
SM304650	2017	8	Gaston	Mountain Island Educational State Forest	247.5	2,313
SM304642	2017	8	Mitchell	Private Property	247.5	24
SM304623	2017	8	Mitchell	Private Property	247.5	60
SM304664	2017	8	Rutherford	Private Property	247.5	990
SM304475	2017	9	Cherokee	Private Property	247.5	323
SM304657	2017	9	Jackson	Private Property	247.5	0
SM304630	2017	9	Jackson	Private Property	247.5	297
SM304634	2017	9	Madison	Private Property	247.5	108
SM304628	2017	9	Polk	Private Property	247.5	344
				Total	**12,320.5**	**35,849**

Table 3. Location, hours recorded, and number of gobbles detected by acoustic recorders, February 24 – June 2, 2018.

Acoustic Recorder Number	Year	District	County	Site	Hours Recorded	Number of Gobbles Detected
SM304662	2018	1	Bertie	Private Property	247.5	1469
SM304666	2018	1	Bertie	Private Property	235.0	683
SM304653	2018	1	Gates	Merchants Millpond State Park	247.5	337
SM304659	2018	1	Hertford	Private Property	247.5	313
SM304668	2018	1	Hyde	Private Property	247.5	854
SM304638	2018	1	Hyde	Private Property	247.5	1125
SM304661	2018	2	Craven	Private Property	247.5	1710
SM304671	2018	2	Jones	Private Property	247.5	731
SM304489	2018	2	Jones	Private Property	247.5	1949
SM304670	2018	2	Pender	Private Property	247.5	866
SM304663	2018	2	Pitt	Private Property	247.5	234
SM304627	2018	3	Edgecombe	Private Property (Improperly Deployed)	0.0	0
SM304647	2018	3	Franklin	Private Property (Improperly Deployed)	0.0	0
SM304625	2018	3	Halifax	Private Property (Improperly Deployed)	0.0	0
SM304656	2018	3	Johnston	Private Property (Improperly Deployed)	99.0	60
SM304643	2018	3	Northampton	Private Property (Improperly Deployed)	0.0	0
SM304640	2018	4	Bladen	Elkton Rod and Gun Club	247.5	793
SM304631	2018	4	Bladen	Private Property	212.5	817
SM304632	2018	4	Brunswick	Private Property	247.5	1104
SM304624	2018	4	Columbus	Private Property	247.5	1759
SM304644	2018	4	Columbus	L. Waccamaw State Park	247.5	35
SM304637	2018	4	Columbus	Private Property	247.5	1874
SM304652	2018	5	Caswell	Private Property	247.5	986
SM304626	2018	5	Chatham	Deep River Trail State Park	247.5	27
SM304646	2018	5	Orange	Cane Creek Reservoir	247.5	165
SM303721	2018	5	Randolph	NC Zoo	247.5	8
SM304629	2018	5	Rockingham	Mayo River State Park	230.0	487
SM304495	2018	5	Rockingham	Mayo River State Park	247.5	152
SM304667	2018	6	Anson	Private Property	97.5	250
SM304658	2018	6	Davidson	Private Property	247.5	1337
SM304648	2018	6	Davidson	Private Property	247.5	2900
SM304622	2018	6	Moore	Boy Scout Camp	167.5	198
SM304645	2018	6	Montgomery	Private Property	247.5	502
SM304635	2018	6	Montgomery	Private Property	245.0	827
SM304669	2018	7	Alleghany	Stone Mountain State Park	247.5	16
SM304654	2018	7	Alleghany	New River State Park (Equipment malfunction)	10.0	97
SM304651	2018	7	Alleghany	New River State Park	230.0	1545
SM304660	2018	7	Surry	Pilot Mountain State Park	195.0	113
SM304655	2018	7	Surry	Camp Raven Knob	247.5	64
SM304665	2018	7	Watauga	Elk Knob State Park	232.5	649
SM304636	2018	8	Burke	South Mountain State Park	247.5	243
SM304641	2018	8	Burke	South Mountain State Park	232.5	493
SM304650	2018	8	Gaston	Mountain Island Educational State Forest	247.5	1686
SM304642	2018	8	Mitchell	Private Property	247.5	0
SM304623	2018	8	Mitchell	Private Property	242.5	22
SM304664	2018	8	Rutherford	Private Property	247.5	1505
SM304475	2018	9	Cherokee	Private Property	247.5	120
SM304657	2018	9	Jackson	Private Property	247.5	495
SM304630	2018	9	Jackson	Private Property	247.5	105
SM304634	2018	9	Madison	Private Property	247.5	163
SM304628	2018	9	Polk	Private Property	247.5	7
				Total	**10,844.0**	**31,875**

Accuracy of Automated Detection

We determined the number of gobbles in our data largely with automated detection procedures in Raven Pro software. We set specific parameters for the procedures which the software then used to identify sound events in the data that might be gobbles. We then evaluated each of these events to determine whether they were truly gobbles. Thus, automated detection procedures invariably missed some gobbles (false negatives) and also misidentified some sound events that are not gobbles (false positives). Though time consuming, false positives were removed by our procedures of manually checking all potential gobbles identified by the software.

To better understand the number of false negatives (i.e., missed gobbles) we manually identified gobbles in a subset of our data in all three seasons. In 2016, we manually processed a total of 62 hours of data spread across 3 recorders. Manual procedures essentially involved listening and looking at the entire time period and tallying the number of gobbles that could be identified. We compared the results of manually processing this 62 hours of data with results from automated detection procedures of the same 62 hours of data. With manual procedures we identified 2,988 gobbles. Automated detection procedures identified 887 sound events as potential gobbles, with 539 of these being verified as actual gobbles (348 sound events were crows, woodpeckers, or various other sounds). Thus, our automated procedures detected 18% of the total gobbles that occurred in this subset. In general, the software tended to miss faint gobbles (presumably from turkeys that were farther away) and sound events when multiple turkeys gobbled simultaneously.

In 2017 we spent more effort in manually processing a subset of the data. For 34 recorders we manually reviewed a 5-minute period just before sunrise in each day's recording and manually identified all gobbles occurring during that time period. In total, this time span comprised 275.3 hours containing 7,244 gobbles and exhibited a pattern that generally aligns with our understanding of gobbling chronology (Figure 4). Automated procedures detected 31% (2,256 gobbles) of the total number of gobbles. This was substantially better than the 18% detection rate we estimated in 2016, which was likely due to adjusting our procedures such that the software could detect gobbles from either of the two external microphones, instead of relying solely on one microphone as we did in 2016.

In 2018, for each recorder, we manually reviewed a 2-minute period just before sunrise in each day's recording and manually identified all gobbles occurring during that time period (Figure 5). In total, this comprised 146.8 hours containing 2,522 gobbles. Automated procedures detected 31% (785 gobbles) of the total number of gobbles during this time period, which was identical to our 2017 detection rate.

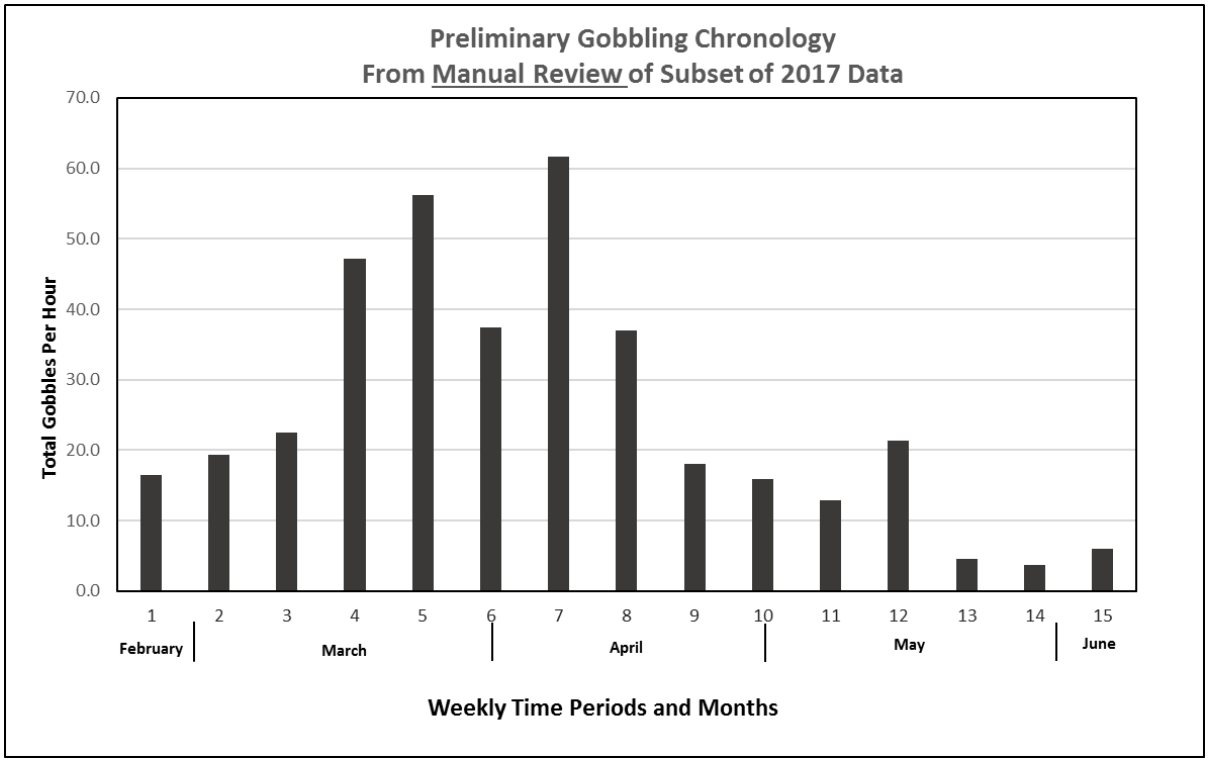

Figure 4. Number of gobbles identified per hour by weekly time periods from a manual review of a subset of data from February 24 through June 3, 2017. The subset compiled 5-minute sections before sunrise of each day's recording from 34 sites across North Carolina. The total number of gobbles was divided by the number of hours of acoustic recording time in each week. In total, 7,244 gobbles were detected.

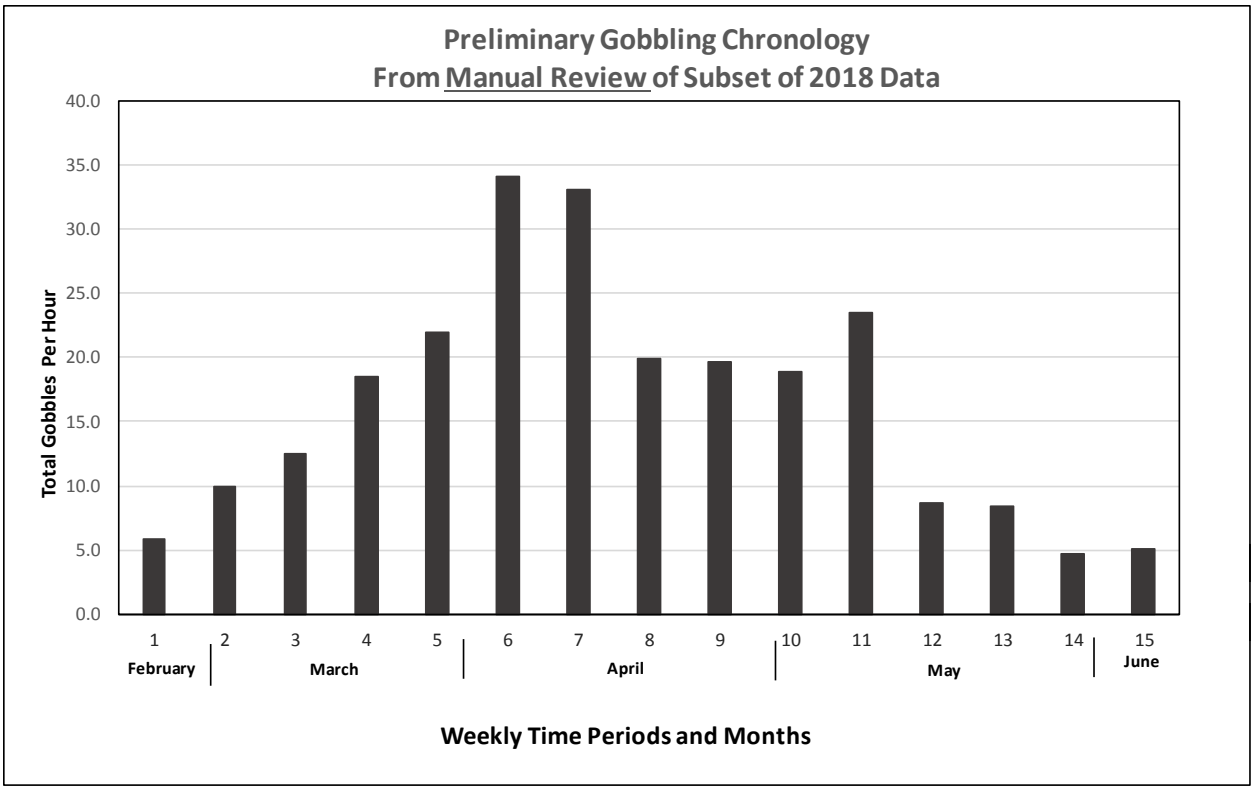

Figure 5. Number of gobbles identified per hour by weekly time periods from a manual review of a subset of data from February 24 through June 2, 2018. The subset compiled 2-minute sections before sunrise of each day's recording from 47 sites across North Carolina. The total number of gobbles was divided by the number of hours of acoustic recording time in each week. In total, 2,522 gobbles were detected.

Gobbling Activity by Time of Day

Gobbles were identified as to the time (i.e., specific minute) within the daily recording period in which they occurred. In all three study years, a distinct peak of gobbling activity occurred approximately 15 minutes before sunrise (Figure 6).

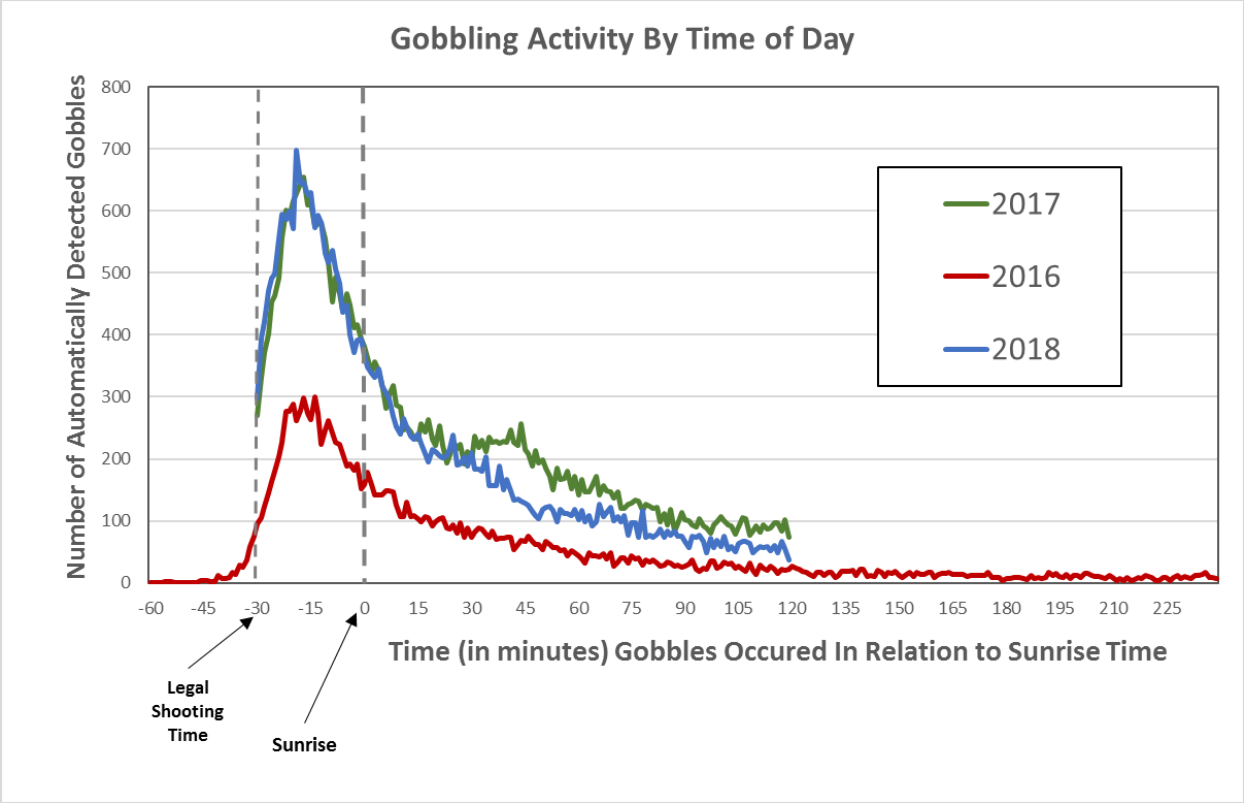

Figure 6. Gobbling activity by time of day. From acoustic recordings beginning 1 hour before sunrise until 4 hours after sunrise, March 1 – May 31, 2016 and beginning 30 minutes before sunrise until 2 hours after sunrise February 24 – June 3, 2017 and February 24 – June 2, 2018.

Gobbling Chronology

Gobbles were identified by the date on which they occurred and then summarized by pooling into weekly time periods. We established the weekly time periods beginning with February 24 of each year in order to retain consistency across fluctuations in calendar dates, hunting season dates, and leap years (Table 4).

Table 4. Weekly time periods and number of hours recorded for 2016, 2017, and 2018.

	2016			2017			2018		
Week	Dates	Hours Recorded	Number of Gobbles Detected	Dates	Hours Recorded	Number of Gobbles Detected	Dates	Hours Recorded	Number of Gobbles Detected
1	Feb 24 - Mar 1, 2016 (includes Feb 29th)	220.0	63	February 24 - March 2, 2017	763.0	700	February 24 - March 2, 2018	804.5	790
2	March 2 - 8, 2016	1,730.0	506	March 3 - 9, 2017	882.0	2,456	March 3 - 9, 2018	794.5	1,025
3	March 9 - 15, 2016	1,750.0	1,069	March 10 - 16, 2017	884.5	2,321	March 10 - 16, 2018	794.5	1,117
4	March 16 - 22, 2016	1,685.0	1,450	March 17 - 23, 2017	882.0	3,745	March 17 - 23, 2018	794.5	2,648
5	March 23 - 29, 2016	1,680.0	1,712	March 24 - 30, 2017	882.0	5,433	March 24 - 30, 2018	794.5	2,230
6	March 30 - April 5, 2016	1,680.0	1,358	March 31 - April 6, 2017	882.0	3,601	March 31 - April 6, 2018	787.0	3,895
7	April 6 - 12, 2016	1,685.0	1,660	April 7 - 13, 2017	882.0	4,926	April 7 - 13, 2018	777.0	3,568
8	April 13 - 19, 2016	1,655.0	1,838	April 14 - 20, 2017	882.0	3,749	April 14 - 20, 2018	777.0	2,812
9	April 20 - 26, 2016	1,640.0	1,635	April 21-27, 2017	892.0	1,882	April 21-27, 2018	777.0	3,279
10	April 27 - May 3, 2016	1,645.0	1,457	April 28 - May 4, 2017	864.5	1,869	April 28 - May 4, 2018	769.5	3,216
11	May 4 - 10, 2016	1,645.0	1,168	May 5 - 11, 2017	864.5	1,990	May 5 - 11, 2018	759.5	3,180
12	May 11 - 17, 2016	1,645.0	953	May 12 - 18, 2017	864.5	2,176	May 12 - 18, 2018	744.5	1,917
13	May 18 - 24, 2016	1,695.0	385	May 19 - 25, 2017	859.5	700	May 19 - 25, 2018	727.0	1,640
14	May 25 - 31, 2016	1,750.0	281	May 26 - June 1, 2017	807.0	238	May 26 - June 1, 2018	657.0	505
15	June 1 -7, 2016	0.0	0	June 2 - 8, 2017	229.0	63	June 2 - 8, 2018	92.0	53
	Total	**22,105.0**	**15,535**	**Total**	**12,320.5**	**35,849**	**Total**	**10,844.0**	**31,875**

Gobbles were detected every week of the spring seasons in all three years (Figures 7 - 9). The only exception was in Week 15 in 2016 when no acoustic recorders were still deployed. The preliminary graphs of gobbling chronology patterns depicted in Figures 7 - 9 should be interpreted with caution, but they do seem to exhibit patterns that we expect to provide insight into turkey reproductive ecology and we plan to examine them more fully once additional years of data are available.

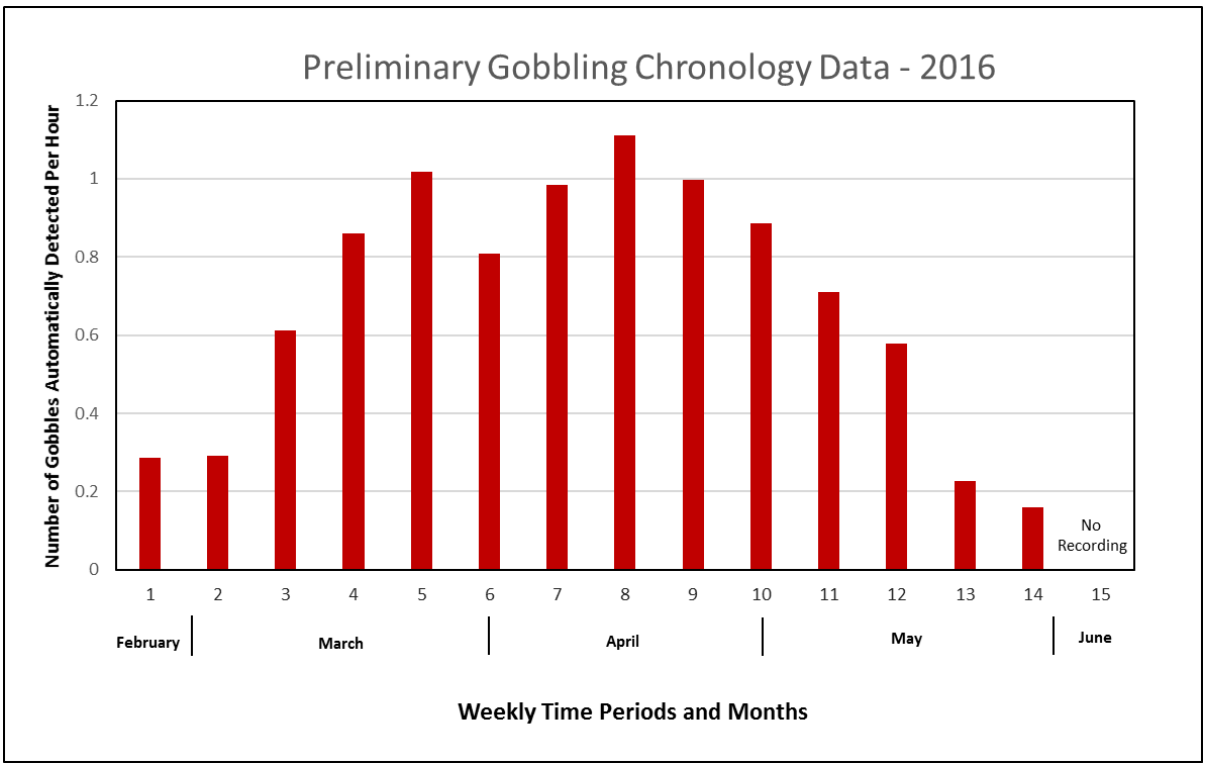

Figure 7. Number of gobbles automatically detected by Raven Pro software per hour by weekly time periods from late February through May 2016. These data come from 50 sites where acoustic recorders were deployed in southeastern and northwestern North Carolina, with the number of gobbles automatically detected divided by the number of hours of acoustic recording time in each week. In total, 15,535 gobbles were detected in 22,105 hours. North Carolina youth and regular turkey hunting seasons occurred during portions of weeks 6-11, though hunting was prohibited or very limited on the 50 sites where acoustic recorders were deployed.

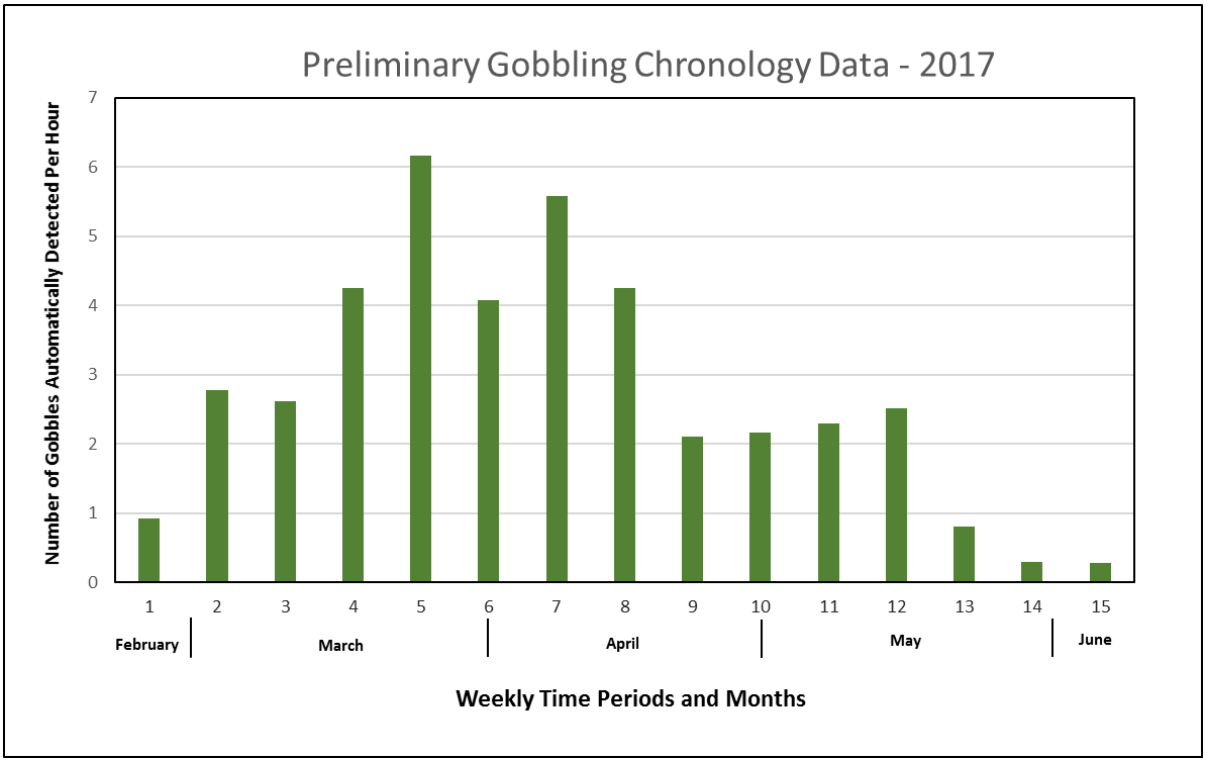

Figure 8. Number of gobbles automatically detected by Raven Pro software per hour by weekly time periods from late February through early June 2017. These data come from 51 sites where acoustic recorders were deployed across North Carolina, with the number of gobbles automatically detected divided by the number of hours of acoustic recording time in each week. In total, 35,849 gobbles were detected in 12,320.5 hours. North Carolina youth and regular turkey hunting seasons occurred during portions of weeks 6-11, though hunting was prohibited or very limited on the 51 sites where acoustic recorders were deployed.

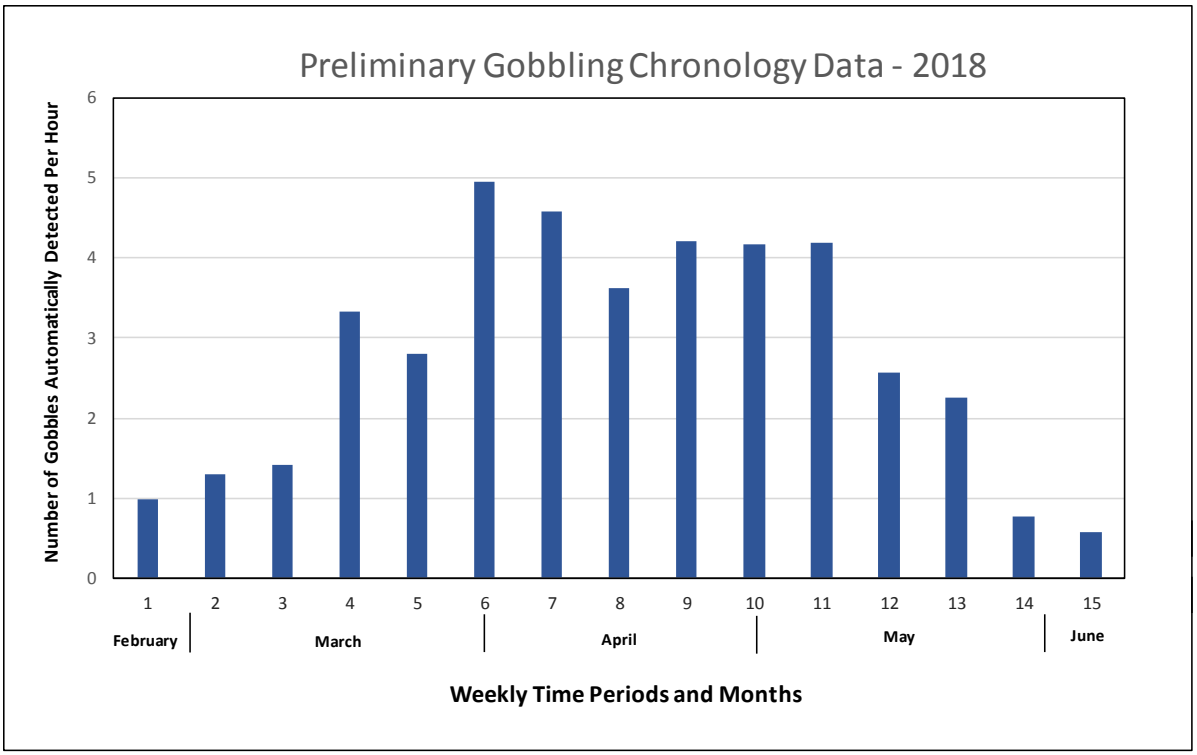

Figure 9. Number of gobbles automatically detected by Raven Pro software per hour by weekly time periods from late February through early June 2018. These data come from 46 sites where acoustic recorders were deployed across North Carolina, with the number of gobbles automatically detected divided by the number of hours of acoustic recording time in each week. In total, 31,875 gobbles were detected in 10,844 hours. North Carolina youth and regular turkey hunting seasons occurred during portions of weeks 7-12, though hunting was prohibited or very limited on the 47 sites where acoustic recorders were deployed.

FISCAL CONSIDERATIONS

In the first year of this project (October 1, 2015 – December 31, 2016) we spent $112,386.29, including expenditures for hours worked, miles driven, and equipment purchased. The largest expenditure was $52,200 for 50 acoustic recorders and security boxes. The second largest expenditure was $24,439.36 for data processing (1,696 hours), which we accomplished using 3 full-time temporary employees. Permanent agency employees worked 975.5 hours ($25,700.91).

In the second year of the project (January 1 – December 31, 2017) we spent $49,401.17. This included expenditures for hours worked (2,103 hours - $43,940.05), miles driven (11,872 miles - $5,461.12), and several relatively small equipment purchases ($439.98). The single largest expenditure in 2017 was for 1,200 hours of time needed for temporary employees to process the acoustic

recordings. Time worked and miles driven by permanent staff were relatively high as biologists deployed the recorders across the entire state of North Carolina.

In the third year of the project (January 1 – December 31, 2018) we spent $43,489.02. This included expenditures for hours worked (1,662.5 - $36,533.02), miles driven (11,686 miles - $5,375.56) and purchase of external hard drives and several other relatively small equipment needs ($1,580.44). The largest single expenditure in 2018 was for 1,200 hours of time needed for temporary employees to process the acoustic recordings.

We anticipate that future years of this project will require resources comparable to the expenditures of 2017 and 2018. The use of acoustic recorders and software for automated detection makes continuation of this project feasible. If we were to collect the same amount of data with traditional techniques (i.e., biologists and technicians in the field daily listening for gobbling turkeys), the cost would likely exceed $1,500,000 annually.

CONCLUSIONS

We are encouraged by the results of our gobbling chronology project in 2016 and 2017. Acoustic recorders appear to be a cost-effective way to assess gobbling chronology patterns. A tremendous amount of data can be collected and analyzed with relatively little effort and can provide accurate insight. We feel that the automated detection procedures are capable of accurately identifying patterns in gobbling chronology, despite the fact that they only glean about 31% of the total gobbles in the recordings. Some of the initial costs (equipment purchases and developing software procedures) were high in 2016, but are not recurring.

The patterns we observed in gobbling chronology in these first three years are informative, but should be interpreted cautiously for several reasons including year-to-year variation, use of many different sites in the two years, the potential effect of various habitat types on the recorders, and the potential effect of spring green-up on the recorders. However, the gobbling patterns appear to provide insight into turkey reproductive ecology and generally follow a pattern we expected of distinct peaks and lulls in activity which may align with changes in breeding season behavior. Also, it should be noted that our data were collected on properties where turkeys experience very little or no hunting pressure. Patterns that hunters observe on heavily hunted properties may vary considerably from these results.

We believe there is considerable merit in continuing our research on gobbling chronology and in taking steps to allow for a thorough statistical examination so that this information can serve as a foundation for regulatory decisions. Specifically, we make the following recommendations:

- Continue to deploy acoustic recorders from February 24 – June 2 in 2019.
- Continue, to the extent practical, to use the 51 sites used statewide in 2018.
- After all recordings from 2019 are processed, perform a complete, statistical examination of gobbling chronology data from 2016-2019.
- Refrain from considering results from this project in making changes to turkey hunting regulations until sufficient data are collected and statistically evaluated.
- Thoroughly test the equipment at field sites to fully understand any limitations and biases. Detailed testing is needed to understand performance in various habitats and the potential impact of spring green-up, such that gobbling chronology data can be interpreted appropriately.
- Continue to hire full-time, temporary employees to handle the bulk of data processing.
- Use results from this gobbling chronology project to design and implement studies to examine other aspects of turkey reproductive ecology.

Our efforts in 2016 - 2018 lead us to conclude that gobbling chronology information collected with acoustic recorders can be extremely useful when making regulatory decisions. We recognize that our data are limited at this point and urge caution in making conclusions at this time. However, continuing this work will ultimately provide a significant component to the knowledge base necessary for wild turkey regulatory management.

PARTNERS

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LITERATURE CITED

Miller, D. A., G. A. Hurst, and B. D. Leopold. 1997. Chronology of wild turkey nesting, gobbling, and hunting in Mississippi. Journal of Wildlife Management 61:840-845

Palumbo, M. D. 2010. Influence of latitudinal and climatic variation, and field observations, on spring gobbling phenology of wild turkey in Mississippi. Thesis, Mississippi State University, Starkville, MS.

Rempel, R. S., C. M. Francis, J. N. Robinson, and M. Campbell. 2013. Comparison of audio recording system performance for detecting and monitoring songbirds. Journal of Field Ornithology. 84(1):86-97