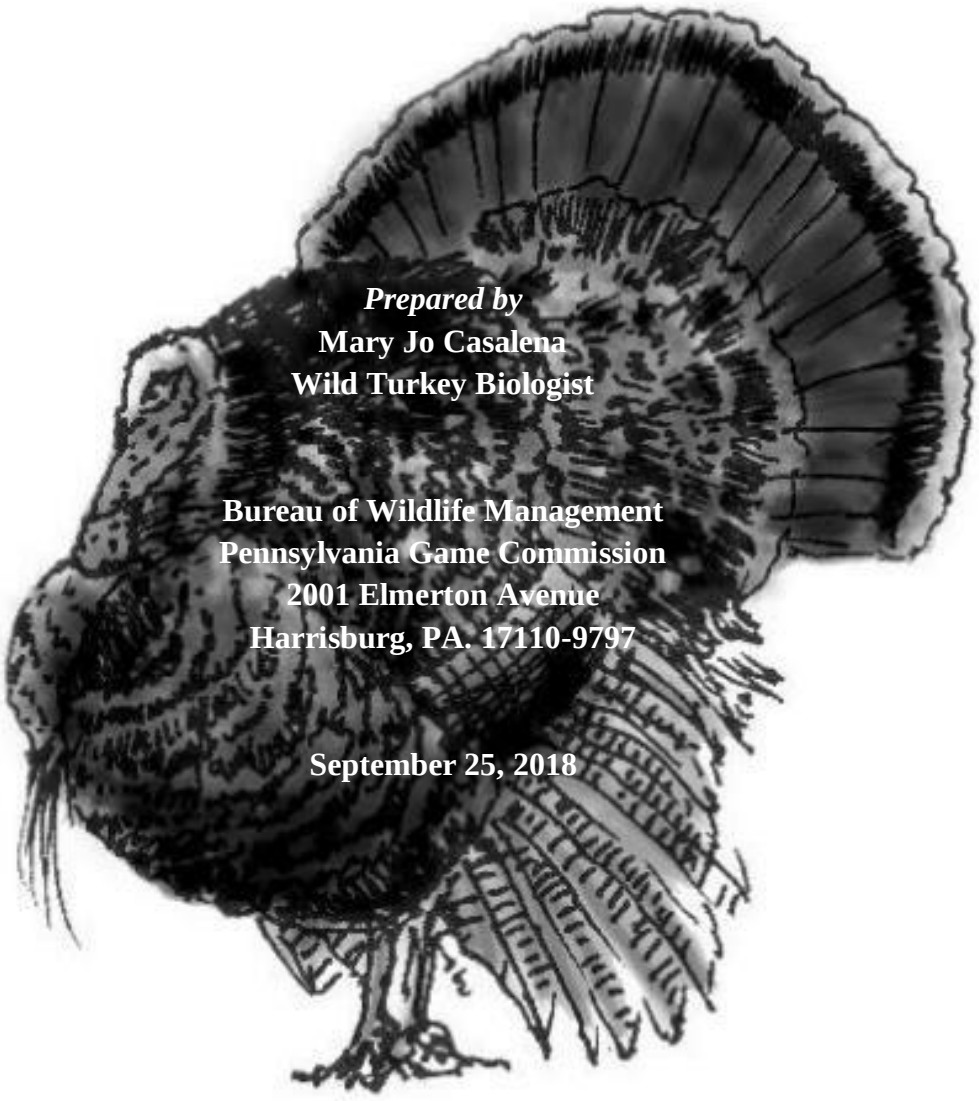
PENNSYLVANIA
WILD TURKEY
MANAGEMENT PLAN
2018-2027



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EXECUTIVE SUMMARY

Overview

Within the Pennsylvania Game Commission's (PGC's) mission to manage Pennsylvania's wild birds, wild mammals and their habitats for current and future generations (as directed under Pennsylvania's Consolidated Statutes Title 34), and vision to champion all wildlife resources and Pennsylvania's hunting and trapping heritage (as directed under Title 58 of the Pennsylvania Code), this document is a continuation and revision of the first two management plans for the wild turkey in Pennsylvania.

During the first management plan, 1999-2005, the PGC completed wild turkey restoration and built partnerships with other groups, agencies and organizations. The 2006-2017 plan focused on acquiring more detailed harvest and population data; conducting research on harvest and survival rates for population modeling and informing harvest strategies; minimizing and abating human-turkey conflicts; quantifying and acquiring turkey habitat throughout the Commonwealth; developing more efficient, long-term and landscape-level habitat management methods; developing a habitat suitability model; assisting and educating land owners regarding turkey populations and habitat management; improving hunter safety through increased educational opportunities and law enforcement; increasing fines for Game and Wildlife Code violations; and maintaining and enhancing cooperative partnerships (see Accomplishments of Turkey Management in Pennsylvania, 2006-2017).

This Pennsylvania Wild Turkey Management Plan (2018-2027) builds upon the information gained during the two previous plans (e.g., harvest and survival rate data, and other population parameters that are now annually collected such as poult recruitment, age/sex of harvested birds, annual food abundance, etc.). The plan revision process, which began in 2015, included input from all PGC Bureaus, the Board of Commissioners, conservation organizations, and the public. During the public review process (2 July – 31 August 2018) we received 180 comments from 82 individuals outside the agency plus an in-depth review by the PANWTF, NWTF and Board of Commissioners. Comments were summarized, reviewed and, where applicable, incorporated into the final plan (Appendix 2).

The strategic goal for wild turkey management remains the same as in the 2006-2017 plan: To provide optimum wild turkey populations in suitable habitats throughout Pennsylvania for hunting and viewing opportunities by current and future generations. This goal is to be achieved by completing 60 strategies under 6 objectives (see Section I):

1. **Population** - monitor wild turkey populations in each Wildlife Management Unit (WMU) and sustain or enhance populations within the limits of social and biological carrying capacities (19 strategies; lead Bureau responsibility - Wildlife Management);
2. **Habitat** - monitor, maintain, and improve the quality and quantity of wild turkey habitat throughout the state (12 strategies; lead Bureau responsibility – Wildlife Habitat Management);
3. **Information and Education** – assess and improve the public's knowledge, awareness and understanding of the wild turkey resource and its management (7 strategies; lead Bureau responsibility – Information and Education, and Wildlife Management);
4. **Hunting/Hunter Safety** - promote and improve the knowledge, safety, and participation of wild turkey hunters without diminishing the quality of spring and fall hunting experiences (10 strategies; lead Bureau responsibility – Information and Education, Wildlife Management);
5. **Wild Turkey Protection** - maintain high ethical standards of hunters and nonhunters, and improve hunter compliance with laws and regulations regarding wild turkey management (6 strategies; lead Bureau responsibility – Wildlife Protection); and
6. **Cooperative Partnerships** - maintain and enhance partnerships in all aspects of wild turkey management (6 strategies; lead Bureau responsibility - Wildlife Management, Executive Office).

A list of strategies accompanies each objective. Some strategies are to be accomplished within this 10-year span, while others are ongoing. This plan ties in directly with the agency's Strategic Plan (2015-2020), which calls for species management plans to guide management decisions, and is the foundation for program, project, and budget development. A summary of important issues and key strategies for each objective is presented below; for more extensive background information and discussion on specific topics, refer to the relevant portion(s) of sections I – VIII in the plan's main body.

Population

During the last decade, declining trends in turkey abundance and productivity have been observed across much of the species' range, including Pennsylvania. These trends are likely driven by changes in landscape-scale habitat, weather patterns, and predator communities, possibly in combination with unsustainable levels of fall hunting mortality. Compared to large mammal populations, wild turkeys have much more dramatic annual fluctuations in reproduction and survival. As a result, wildlife managers cannot precisely control turkey population change over the short-term, but can facilitate desired trends over the longer term through a combination of both proven and new approaches in habitat management (see bolded Habitat section below) and harvest management, as well as the use of effective population monitoring techniques to assess the effectiveness of management actions. PGC research findings during the previous two management

plans provided valuable information for harvest and population management, including more detailed information on turkey life history which we strive to implement during this cycle.

Turkey hunting is among the most challenging outdoor activities. While the PGC endeavors to emphasize the experiences and challenges gained in turkey hunting, not the harvest, Pennsylvania consistently leads the country in combined spring + fall turkey harvests, as well as number of turkey hunters. The 10-year (2007-2016) average harvests were 38,641 (spring) and 17,602 (fall). Spring turkey hunter numbers have remained fairly stable in recent years and averaged 226,700 from 2012-2014, compared to the next closest state, Missouri with 148,900 spring turkey hunters in 2014. Fall turkey hunters have declined over time, similar to the decrease in general hunting license sales, but still averaged 200,000 from 2012-2014, compared to the next closest states, Wisconsin (57,800) and Texas (54,800) in 2013. The general hunting license includes tags to harvest 1 fall (either-sex) and one spring (bearded) turkey. Hunters may separately purchase one additional spring turkey tag (daily harvest limit of one). The potential impacts of high hunter numbers and harvests on Pennsylvania turkey populations requires careful attention to setting both fall and spring hunting seasons appropriately.

***Fall harvest management*:**

Fall turkey hunting is a Pennsylvania tradition highly desired by stakeholders, and the PGC is continually striving to maintain this opportunity. At the same time, fall hunting is known to result in additive mortality especially now that populations are not experiencing the exponential growth observed during population restoration. Moreover, for logistical reasons fall seasons are established prior to knowledge of the outcome of the spring breeding season. Therefore, under this management plan the PGC will continue its proven approach of maintaining a conservative fall either-sex harvest via season length in Wildlife Management Units (WMUs) that can sustain a fall harvest, and opening the season separate from other small- and big-game hunting seasons, to regulate harvest of female turkeys (the driving force of the population via nesting and brooding of young). In those WMUs where turkey populations can support a fall season, season length will likely continue to range from 3 days to 3 weeks in early November, plus a Thanksgiving season in WMUs with at least a one-week regular season.

Although the overall approach to fall harvest management and the options for fall seasons will remain similar to those under previous turkey management plans, an important improvement that will be pursued under the 2018-2027 plan is the development of turkey population dynamics models for each WMU. These models will predict turkey population responses to changes in harvest regulations and will be integrated into a stochastic dynamic programming (SDP) framework that will allow the PGC to identify optimal harvest regulations that optimize both turkey populations and hunting opportunities for Pennsylvania's large turkey hunter population. Results of a PGC 2010-2014 hen harvest and survival rate study showed that a one-week change

in fall season length can effectively change hen harvest rates for population management purposes. During that period on average 158,000 fall hunters harvested 2-10% of the female turkey population. During years of low poult reproduction (i.e., low recruitment), the percentage of adult turkeys in the fall harvest increases, providing a smaller carry-over of adult hens into the spring breeding population, and thus, lower reproductive output the following spring. Several consecutive years of this cycle significantly decreases local turkey populations. Because recruitment and female survival are the driving forces for turkey populations monitoring these are important aspects of turkey population management. Also, during years of abundant acorn mast production the fall turkey harvest declines (likely due to the abundance of food dispersing flocks making them more difficult for hunters to find). These variables, other biological and harvest data collected annually, and results from other recent studies are being incorporated into the turkey population model and structured decision protocol to better predict turkey populations for establishing population and harvest management strategies. Once finalized these models will be appended into this plan. The result will be a quicker, more adaptive response to turkey population trends: liberalizing seasons when populations increase to take advantage of additional opportunity, and restricting harvest when populations decline.

***Spring harvest management*:**

As with fall hunting, spring turkey season structures require managers to balance the provision of opportunity desired by hunters against potential negative biological impacts. The 2018-2027 plan continues the successful approach of maintaining a spring gobbler season running from the Saturday closest to 1 May through 31 May (except when the 31st is a Sunday, in which case the season ends the 30th); a youth season the Saturday prior to the regular season opener; and hunting hours closing at noon during the youth season and the first two weeks of the regular season, then at one-half hour after sunset from the third Monday to the close of the regular season. These parameters provide harvest of males after the majority of breeding has occurred and, on average, when most hens are incubating nests. Hens are less prone to disturbance, nest abandonment and accidental harvest while incubating a nest. The season opening date is a compromise between maximum gobbling activity and minimum hen nesting disturbance, and the limitation to morning hunting in the first half of the season further limits hen disturbance.

All-day hunting is possible toward the end of the season because hunting pressure is largely reduced for various reasons; hunting methods used in the afternoon/evening usually involve less moving on the part of hunters, affording less hen disturbance; and most hens are in their later stages of nest incubation making them less likely to abandon their nests if disturbance does occur. Harvest during these extra hours comprises a small portion (6.3%) of the total season reported harvest and mainly occurs between 4:00-8:00 p.m. However, the extra hours provide opportunity for hunters.

The second spring tag also provides additional recreation. The 2014-16 second-bird harvest averaged 3,787, 8% of the total statewide harvest, with no documented negative effects to the turkey population.

Due to Pennsylvania's large turkey hunter base, many spring turkey hunting opportunities and an adult gobbler harvest rate of 38%, additional season liberalization is not advised as it may cause declines in hunter satisfaction (by removing too many adult gobblers) and/or turkey populations. Juvenile males' low spring harvest rate (27%) combined with their high annual survival rate (65% compared to that of adult males, 41%) provide sufficient carry-over into the adult male population such that Pennsylvania's high adult male harvest rate is sustainable. Annual data collection is essential for monitoring trends in these parameters.

Population monitoring:

The PGC maintains several long-term monitoring programs for turkey populations and harvest, including summer sighting surveys, harvest reporting, and post-season hunter surveys. These traditional tools, along with the more recently implemented public turkey sighting survey to obtain additional information on annual recruitment, will continue in the 2018-2027 plan. Improving harvest reporting, particularly during the fall hunting season, will be a priority. Resources permitting, the PGC will begin turkey harvest rate monitoring for each WMU and expand assessments of turkey diseases and how they may relate to population management. The PGC will also work cooperatively with other agencies and organizations to conduct research on emerging issues affecting turkey populations.

Habitat

In a general sense, Pennsylvania's large size, mix of temperate hardwood forests and fertile agricultural land (58% forest and 26% farmland) and diversity of landscape physiographic features allow for dense turkey populations. A diverse landscape provides year-round habitat needs including nesting, brood-rearing, roosting, and wintering within a relatively small home range; and increases complexity of patches, thus decreasing predator foraging efficiency and negative effects of harsh weather. However, composition and juxtaposition of habitats are not always ideal, and at least 3 equally important negative changes in landscape-level habitat quality in Pennsylvania and throughout the Northeast are evident over the past 25 years. First has been a decline in amount of interspersion and juxtaposition of different habitat types, (e.g., loss of fence rows in agricultural areas). Second, a percentage of forests composed of mast-producing oaks (*Quercus* spp.) has been declining while non-mast-producing species like red maple (*Acer rubrum*) have increased in biomass, leaving less food resources for turkeys. Third, forest maturation has reduced amount of young forest/early successional habitat conditions important for turkey nesting, feeding, loafing, and other activities. Single-aged forests lack alternative foods that are typically found on landscapes with a diversity of forest age classes and therefore exhibit great annual variation for

fall and winter food availability for turkeys. On landscapes interspersed with agriculture, crop lands had been reliable alternative sources of food, but now produce less waste grains for turkey winter foraging due to progressively more efficient crop harvesting systems, fewer insects during the growing season or loss of farms outright due to economic pressures. Additionally, losses of early successional vegetation communities and young forests have reduced quality and quantity of nesting and brood-rearing cover.

Fortunately, active habitat management can maintain and improve habitat quality for all turkey life stages. An important initial step in targeting habitat management is identifying habitat inadequacies that may be limiting populations. During the previous management plan the Habitat Suitability Index (HSI) model output (scores of 0.0-1.0, with 1.0 being the highest quality) showed wide variation in turkey habitat quality by WMU. Habitat suitability scores ranged from 0.524 in the largely forested WMU 2G to 0.922 in the very diverse landscape of WMU 2D. Each WMU has its own capacity as to the achievable habitat suitability score. Applying the HSI to harvest and hunter effort provided a means to identify WMUs in need of additional management actions (habitat improvement, season adjustments, etc.). The intention of the HSI is to help determine where management actions are needed and where they are reasonable. During this plan cycle the habitat suitability model will be revised/updated to more fully reflect not only current habitat and turkey populations, but also their potential, and in turn determine holistic priority areas for habitat management/improvements at the WMU and State Game Lands levels.

Once key areas in need of habitat management are identified, appropriate techniques to address the identified deficiencies will be implemented. These will include creating a better distribution of forest age classes, utilizing prescribed fire, etc. A concerted effort will be made to influence landscape-scale habitat quality through increasing the acreages of habitat management projects. With approximately 85% of Pennsylvania privately owned, appropriately managing wild turkey habitat, is a challenge, especially given that turkey habitat suitability is lower on some public lands than on some private lands. At the local level, private land owners make the most positive impact by working cooperatively, with adjacent land owners. Federal and state educational efforts and landowner incentive programs will continue to help facilitate habitat management, and the PGC will continue to acquire turkey habitat throughout the Commonwealth as resources permit.

Information and Education

As turkey populations continue to thrive in human-populated portions of Pennsylvania, the public's knowledge of their presence and appreciation for their attributes continues to grow and change. Only 25% of Pennsylvanians reported that at least one person in their household hunted during a 2017 telephone survey of 610 Pennsylvania residents, and 14.5% of Pennsylvanians indicated they were hunters. An important goal during this plan cycle will be surveying non-hunters to gain insight on social carrying capacity and perceptions regarding the turkey population.

Informing and educating interested non-hunting stakeholders regarding wild turkey population and management needs is an important aspect of this plan and will benefit from surveys directed to the general public. Providing opportunities for the non-hunting public to take ownership in wild turkey population management through citizen science projects, such as the annual public summer turkey sighting survey, and via assistance with managing habitats is imperative. Other opportunities for public involvement and cooperative partnerships with traditional and nontraditional partners will be pursued during this plan cycle. For example, creating a public road-kill index may be an effective method of monitoring social carrying capacity of turkey populations and nuisance situations.

Hunting/Hunter Safety

Current statistics show fewer young hunters entering hunting pastime than the number of older hunters leaving the pastime. A key goal of this plan is to develop a more precise method of annually determining participation rates of the various age segments of turkey hunters to recommend ways to increase hunter participation, retention, recruitment and reactivation. Hunter surveys conducted under the Information and Education objective will also assist with these efforts. Previous surveys revealed the top 3 factors that would influence interest in starting to participate annually in fall turkey hunting were more free time to hunt, higher turkey populations, and having a place to hunt. The PGC Hunter Access Program has enrolled >13,000 landowners providing >2.6 million acres of hunting land to licensed hunters as of 2017, along with the >4 million acres of public lands in the Commonwealth. However, convenient accessibility of these properties is not always available for hunters (mainly due to lack of free time). The PGC hunting outreach and access programs strive to break down barriers for hunters.

According to PGC turkey hunter surveys overall turkey hunter satisfaction with turkey management has decreased somewhat over the last two management plan cycles. Although hunting regulations are not considered a major barrier to turkey hunting participation, in some cases sportsmen may want changes in regulations. However, surveys show no clear consensus as to which changes are desired, making future regulation changes difficult. Hunter surveys during this cycle will attempt to determine how to adequately satisfy most hunters while protecting the resource. Any changes will require appropriate management justification and hunter education to ensure support.

A positive aspect of turkey hunting since the last management plan cycle has been the decrease in hunting-related shooting incidents (HRSIs) during turkey seasons, below management goals of less than 2 per 100,000 turkey hunters during the spring and less than 0.5 per 100,000 turkey hunters in the fall. Turkey hunting incident rates declined from highs of 8.9 during the spring 1991 season and 16.2 during the fall 1990 season. These declines are mainly due to improved hunter education on safety, hunter anticipation and excitement, appropriate use of fluorescent orange,

improved hunter knowledge of turkey hunting, and possibly lower hunter densities during key hunting days (i.e., Saturdays, opening /closing days). Educational efforts to maintain and further improve the safety of turkey hunting in Pennsylvania will continue during this plan cycle.

Wild Turkey Protection

The objectives of improving hunter safety and ethics are additionally supported via two programs that simultaneously assist the PGC find/prosecute violators: Operation Game Thief, 1-888-PGC-8001, https://pgcdatacollection.pa.gov/operationgamethief, and the PANWTF reward program, www.panwtf.org. These provide monetary rewards to the individual/s who provide information that leads to a conviction. Additionally, since 2010 when Pennsylvania joined the Interstate Wildlife Violator Compact (IWVC), wildlife violation conviction data are shared among member states, allowing member states to honor license suspensions in each member state. These programs will continue through this management plan cycle as part of an active program of enforcement of regulations established to protect the turkey resource, promote fair chase, and provide equitable recreational opportunities.

Cooperative Partnerships

The strategies in this plan are comprehensive, involving all aspects of wild turkey management. Thus, implementation of the strategies involves the entire agency and cooperators; they are not solely implemented by the Bureau of Wildlife Management. To assist with implementation planning, Appendix 1 summarizes suggested target dates. Implementing the 60 strategies will require personnel and budget commitments, yet resources are always limited. Additional revenue and resources will be needed to complete some strategies, so developing, maintaining, and enhancing cooperative partnerships with organizations, institutions and agencies will be a key component of this plan.

The number of institutions, agencies and organizations cooperating with the PGC in turkey management efforts is large. However, the Pennsylvania Chapter National Wild Turkey Federation (PANWTF) deserves special recognition as the lead agency partner for wild turkey management. An annual turkey management meeting of PGC Bureaus and PANWTF will continue, using the plan implementation schedule (Appendix 1) as a basis to update the agency and PANWTF on accomplishments to date, ensure implementation of strategies remains on schedule, and discuss areas where adjustments and /or additional support/cooperation are needed.

Wild turkey management is a complex and ever-changing endeavor, but setting clear objectives and priorities allows for maximum effectiveness in application of limited resources. Through this planning tool the PGC strives to maintain wild turkeys as a resource treasured by all.

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I. MANAGEMENT GOAL, OBJECTIVES, AND STRATEGIES

Pennsylvania Wild Turkey Management Plan (2018-2027)

GOAL: Provide optimum wild turkey populations in suitable habitats throughout Pennsylvania for hunting and viewing recreation by current and future generations.

Six objectives have been identified to accomplish the goal. A set of strategies (how to accomplish the objective) is outlined under each objective.

- The 60 strategies identified below may appear to be unattainable. However, many strategies (30) are ongoing throughout the year or accomplished annually to ensure proper management of wild turkeys, the resources they require, and recreational heritage.
    - Annual strategies have the word 'annually' underlined, and in red.
    - *Strategies (or portions) in italics, represent those where successful implementations likely will be contingent on new and / or reallocated personnel and financial resources.*
- Target timeframes for completion are included with each strategy, and work is to be completed by the end of the year specified, otherwise for strategies that are continuous or repeated annually, timeframes are not necessary.
    - Appendix 1 summarizes suggested target dates for each strategy to assist with implementation planning.
- The lead Bureau/s and/or Regions responsible for implementation of each strategy follows each strategy in (): Bureau of Wildlife Management (BWM); Bureau of Automated Technology Services (BATS); Bureau of Wildlife Habitat Management (BWHM); Executive Office (EO); Training Division (Training); Bureau of Wildlife Protection (BWP); Bureau of Administrative Services (BAS); Bureau of Information and Education (BIE); and National Wild Turkey Federation Regional Biologist (NWTF-RB).
- Strategy accomplishments are reviewed annually during the PGC/PANWTF Cooperative meeting to ensure implementation remains on schedule and / or address areas where adjustments and /or additional support are needed.

Population Objective: Monitor wild turkey populations in each Wildlife Management Unit (WMU) and sustain or enhance populations within the limits of social and biological carrying capacities.

Strategies

1.1 Annually provide a statewide spring turkey season that is biologically timed to open during

the median peak of nest incubation initiation. (BWM)

1.2 Annually use the fall season length as the primary means for managing populations in each WMU by annually providing a conservative fall season in WMUs that can sustain a fall harvest, while maintaining or enhancing the experience of the fall turkey season commensurate with turkey populations at or below social carrying capacity. (BWM)

1.3 Annually collect age, sex, sporting arm used, date and time of turkey harvest by township and county, which are necessary for monitoring trends in turkey populations and help inform management decisions. (BWM, BATS)

1.4 Annually conduct harvest surveys (e.g., spring turkey hunter, mentored youth spring turkey hunter and Game-Take Survey) to estimate hunter effort, success and harvest data (by sex and age) at the WMU scale in time for providing seasons and bag limits recommendations for the following hunting license year. (BWM, BATS)

1.5 Annually assess WMU turkey population status and trends via population modeling, and/or by analyzing spring harvest densities (from reported harvest and agency conducted harvest surveys) and summer turkey sighting survey data, and other variables identified as important for modeling the spring, and possibly fall population. (BWM, BATS, Regions)

1.6 By 2018, assess the current correlation between summer turkey sighting survey data and predictions of fall turkey harvests to determine if the R-value is still approximately 0.92. Investigate the feasibility of potential improvement in the R-value by including PGC Food and Cover staff and/or Foresters to the surveys as well as Bureau of Forestry personnel (like the current Michaux State Forest turkey surveys). (BWM, BATS, Regions, BWHM)

1.7 Annually offer a volunteer turkey sighting survey during August, with evaluation after 2020 (5 years), to assess its effectiveness of enhancing the State Game Warden (SGW) turkey sighting data for obtaining poult to hen ratios to determine recruitment and comparing to similar data from other Northeast states to determine recruitment trends and fall harvest predictions across the Northeast region. (BWM, BATS)

1.8 By 2018, develop a proposal and implement annual harvest rate monitoring in each WMU via winter leg-banding. (BWM, Regions, BWHM)

1.9 After the Northeast regional project, to identify potential causes of the trends observed in wild turkey populations in the Northeast, evaluate the proposed cost-effective regionally unified data collection protocols *and implement those that are realistic for Pennsylvania*. (BWM)

1.10 By 2018 complete analyses of the 5-year (2010-2014) hen turkey harvest and survival rates study to be used for population modeling and recommending fall season lengths. (BWM)

1.11 By 2019, create wild turkey population models for each WMU and implement in 2020, incorporating where appropriate, population trends and potential driving factors, from the Northeast regional database. (BWM)

1.12 By 2020 determine if the new population models require additional data, *and by 2021*

develop and initiate research project(s) and / or monitoring program(s) to collect data to fully implement the model and improve outputs. (BWM)

1.13 Continue working with the U.S. Geological Survey (USGS) to create Structured Decision Protocols (SDP) for each WMU for recommending fall turkey hunting season structure before implementation, but after completion of, the turkey population model. Until the SDP is complete continue to use the criteria specified in the 2006-2017 plan. (BWM)

1.14 By 2021, incorporate the agency GIS, turkey habitat suitability models and estimated turkey abundance into the turkey population models to develop population management objectives for each WMU. (BWM, BWHM)

1.15 By 2022, identify WMUs with unique population management problems (e.g., inexplicably low populations, marginal habitats, Strategy 2.1); *develop and implement possible solutions; monitor and evaluate outcomes of habitat management on populations*. (BWM, BWHM, Regions)

1.16 By 2020, and on a 5-year basis, assess the two-bird bag limit for the spring season and all-day spring hunting in each WMU to determine if either has had any negative effect on the age structure of the turkey population; recommend regulatory changes if needed. (BWM, BWP, EO, BAS)

1.17 Conduct research to assess reproductive patterns in association with habitat suitability. (BWM, BWHM, Regions)

1.18 Annually continue passive disease surveillance and maintain a database of wild turkey disease occurrence/distribution to identify potential outbreaks and/or threats to populations. (BWM, Regions)

1.19 *In cooperation with the Northeast Upland Game Bird Technical Committee, develop a regional study to determine if diseases (e.g., West Nile Virus, Blackhead, Lymphoproliferative Disease Virus) have affected juvenile survival/recruitment.* (BWM, NWTF-RB)

Habitat Objective: Monitor, maintain, and improve the quality and quantity of wild turkey habitat throughout the state.

Strategies

2.1 Utilize the agency GIS, turkey habitat suitability model and suite of other PGC wildlife species management plans (Deer, Elk, Grouse/Woodcock, Wildlife Action Plan, etc.), to determine holistic priority areas for habitat management and improvements at the WMU level. (BWHM, BWM, Regions, NWTF-RB).

2.2 Utilize the agency GIS, turkey habitat suitability model and suite of other PGC wildlife species management plans as part of the scheduled 5-year State Game Lands (SGLs)

Comprehensive Management Plan updates, to identify those SGLs with the most highly skewed forest age class distributions, and if WMUs that contain those SGLs show low turkey population densities, then prioritize them for management. (BWM, BWHM, Regions)

2.3 Monitor if habitat improvement at the SGL level correlates with changes in turkey population densities at the WMU level. *If a correlation cannot be detected, then develop a program to monitor correlation between habitat improvements and turkey population densities at the SGL level. Utilize partnerships with NGOs and other volunteers to conduct the monitoring.* (BWM, BWHM, Regions, NWTF-RB)

2.4 *Annually collect data on mast production, including PGC mast surveys and the Northeast Regional Oak Mast Survey, and weather conditions for each WMU, to help explain and predict fall harvests and variations in trends in turkey populations, and help inform harvest management decisions.* (BWM, Regions, BWHM)

2.5 Increase SGL forest management acres (combined regeneration harvests and TSI) to 15,000 acres annually by ensuring permanent (i.e., forest technicians), and temporary (i.e., interns, limited term technicians) staffing levels and necessary budgets for preparatory and non-commercial treatments. (EO, BWHM, Regions)

2.6 Increase PGC-supported habitat improvements via prescribed burning (from fields to oak forest) to sustain 30,000 acres annually by 2020 and increase where feasible by 2027. Support continuing education requirements to maintain qualifications for PGC staff involved in the program. (BWHM, Regions, Training)

2.7 Annually continue partnerships with other agencies and non-governmental organizations to sustain or exceed 2,500 acres of habitat improvement on private lands annually. (BWHM, EO, Regions)

2.8 Annually quantify, in the implementation report, PGC-supported habitat management practices being conducted on SGLs and other PGC-managed lands to benefit wild turkeys, through the PGC GIS and annual work plans. (BWHM, Regions)

2.9 Annually conduct at least one demonstration or workshop on SGLs per PGC Region to promote, to other public agencies, NGOs and private landowners, commercial and noncommercial forestry, herbaceous and other vegetation management practices beneficial to wild turkeys. (BWHM, Regions, NWTF-RB)

2.10 Annually maintain PGC/PANWTF partnership to allocate NWTF Hunting Heritage habitat funds for high-priority land acquisitions, easements, priority cooperative habitat enhancement projects and habitat demonstration areas on SGLs and other lands open to public hunting and develop similar partnerships where possible. (NWTF-RB, Regions, BWHM, BWM)

2.11 Annually provide technical information and assistance regarding turkey habitat management (especially for nesting, brood-rearing and wintering habitat) to private

landowners and other public land managers through the PGC website, public workshops, internal field days (workshops), printed materials, the Regional Wildlife Management Program, the Hunter Access Program, and other outreach venues and outlets. (NWTF-RB, Regions, BWHM, BIE, BWM)

2.12 Annually pursue funding for habitat management and hunter access through all available sources including, Farm Bill programs, State Wildlife Grants, U.S. Forest Service grants, other NGO funding opportunities, and continued funding of habitat restoration and access improvements through designated Pittman-Robertson funding. (EO, BWHM, BWM, NWTF-RB)

Information and Education Objective: Assess and improve the publics' knowledge, awareness and understanding of the wild turkey resource and its management.

Strategies

3.1 Beginning in 2018, and at 10-year intervals, conduct surveys to determine knowledge, attitudes, characteristics and levels of satisfaction of hunters toward wild turkey populations and management issues. (BIE, BWM, BATS, NWTF-RB)

3.2 Beginning in 2019, and at 10-year intervals, conduct surveys of the non-hunting public to determine social carrying capacity of turkey populations for each WMU, and to investigate these stakeholders' knowledge, perceptions, and nonconsumptive use of the wild turkey resource. (BIE, BWM, BATS, NWTF-RB, private survey company)

3.3 Annually report research and management findings and conclusions to the public through all forms of media, including annual reports posted to the PGC website, social media posts, and articles in lay publications, and via meetings with stakeholders. (BIE, BWM, BATS, NWTF-RB)

3.4 Annually provide educational information through all forms of media and speaking engagements on various aspects of wild turkey biology, habitat management, and population management. (BIE, BWM, Regions, NWTF-RB)

3.5 Annually provide educational information through all forms of media and speaking engagements regarding the importance of increasing forest management acreages. (BIE, BWHM, BWM, Regions, NWTF-RB)

3.6 Annually update agency "frequently asked questions" information sheets on various aspects of wild turkey management addressing common questions and misunderstandings and create new fact sheets as necessary; maintain on PGC website, and in the *Hunting and Trapping Digest* and *Game News* as appropriate. (BIE, BWM, NWTF-RB)

3.7 Annually continue to work with the PA Prescribed Fire Council, and other groups, to provide outreach on the benefits of prescribed burning for wildlife habitat and improved hunting opportunities. (BWHM, BIE, Regions, NWTF-RB)

Hunting/Hunter Safety Objective: Promote and improve the knowledge, safety and participation of wild turkey hunters without diminishing the quality of spring and fall hunting experiences.

Strategies

4.1 Develop a turkey hunter license, or another reliable method, to more precisely determine participation rates of the various age segments of turkey hunters, track recruitment, retention and reactivation, improve harvest reporting rates, and recommend ways of increasing participation of those various segments. (EO, BAS, BATS, BWP, BWM)

4.2 Annually develop and distribute educational and hunter safety materials directly to turkey hunters via social media and other electronic methods, *as well as via direct mailing if/when resources are available*. (BIE, BWM, NWTF-RB)

4.3 Annually assess and explore opportunities for continued development and promotion of the turkey hunting aspect of the youth and adult mentored hunting programs in Pennsylvania, and train adult hunters through the National Hunter Mentor Program to expand mentoring opportunities for new turkey hunters. (BIE, BWM, NWTF-RB)

4.4 Annually consider implementation of expanded turkey hunting opportunities by WMU in a manner consistent with the population objective and the quality of the hunting experience. (BWM)

4.5 Annually maintain and expand the PGC's Hunter Access programs to help promote and protect these privately-owned lands open to public hunting. (BWHM)

4.6 *Annually acquire turkey habitat into the SGL system and Hunter Access programs to expand hunting opportunities and protect/enhance habitat*. (BWHM)

4.7 Annually monitor hunter success to quantify hunter participation, habitat quality and hunter satisfaction. (BWM, BATS)

4.8 Annually strive to maintain average turkey hunting-related shooting incident rate below 2 per 100,000 hunters for spring season and below 1.5 per 100,000 hunters for fall season through education, season structure and other methods. (BIE, BWP, Regions, BWM, NWTF-RB)

4.9 Annually create, update and promote programs (online, classroom and field oriented) within the agency and with partners to expand and promote turkey hunter knowledge, safety and ethics, such as the Successful Turkey Hunter curriculum. (BIE, BWP, Regions, BWM, NWTF-RB)

4.10 Annually ensure that complete information on turkey hunting-related shooting incidents are included in all International Hunting Education Association reports. (BIE, BWP, Regions)

Wild Turkey Protection Objective: Maintain high ethical standards of hunters and nonhunters and improve hunter compliance with laws and regulations regarding wild turkey management.

Strategies

5.1 Annually assess hunter compliance with laws and regulations to protect the wild turkey resource and seek changes where necessary. (BWP, EO, BAS)

5.2 Annually use wild turkey decoys and other appropriate law enforcement tools to discourage road hunting and poaching. Utilize partnerships to assist with purchasing equipment. (BWP)

5.3 Annually seek legislation to increase penalties for serious violations where and when necessary. (BWP, EO)

5.4 Annually monitor hunter compliance with fluorescent orange turkey hunting regulations. (BWP)

5.5 Update/finalize Standard Operating Procedure 40.13, Guidelines for Handling Nuisance Wild Turkey Conflicts. (BWM, BWP, NWTF-RB)

5.6 Individually address nuisance and negative consequences upon affected stakeholders from conflicts caused by wild turkeys through shared public and private responsibility and in a manner consistent with population, habitat, and hunting and hunter safety objectives. (BWP, Regions)

Cooperative Partnerships Objective: Maintain and enhance partnerships in all aspects of wild turkey management.

Strategies

6.1 Annually maintain partnerships with other public landowners, NGOs (including the NWTF, PANWTF and local chapters), and private landowners via PGC Hunter Access Programs to foster support for and implementation of all aspects of the wild turkey management plan in Pennsylvania. (EO, BWHM, BWP, BWM, NWTF-RB)

6.2 Annually maintain the Memorandum-of-Understanding with the NWTF and continue annual financial support of the NWTF regional biologist's position that is dedicated to work directly with the PGC and its citizens for the benefit of the wild turkey resource. (EO, BWM, NWTF-RB)

6.3 Annually participate in the Northeast Upland Game Bird Technical Committee, National Wild Turkey Technical Committee, National Wild Turkey Symposia, and other regional and national initiatives for the benefit of the wild turkey resource. (BWM, NWTF-RB)

6.4 Annually continue the WMU 5A Wild Turkey Task Force, in place since 1995, to closely monitor the turkey population in relation to fall season structure and habitat management, *and initiate Task Forces in other WMUs where deemed necessary and resources permit.* (BWM, Regions, NWTF-RB)

6.5 When requested, assist states and Canadian provinces with their wild turkey restoration or range expansion programs by trapping and transferring turkeys, if biologically, socially and economically feasible. (BWM, Regions, NWTF-RB)

6.6 Annually engage a broad range of partners, some seemingly "non-traditional" to turkey management, such as the American Bird Conservancy, Audubon, Joint Ventures, Quality Deer Management Association, American Chestnut Foundation, etc., to address the common goal of improved forest health and forest age diversity in WMUs with poor quality habitat due to single-aged forest structure. (EO, BWHM, BIE, BWM, NWTF-RB)

II. BACKGROUND

Physical Description

The following poster, available on the agency website, http://www.pgc.pa.gov/Wildlife/WildlifeSpecies/Turkey/Documents/Sopchick%20Turkey%20Poster.pdf, provides an excellent illustration of wild turkey identification by sex and age (Fig. 1).

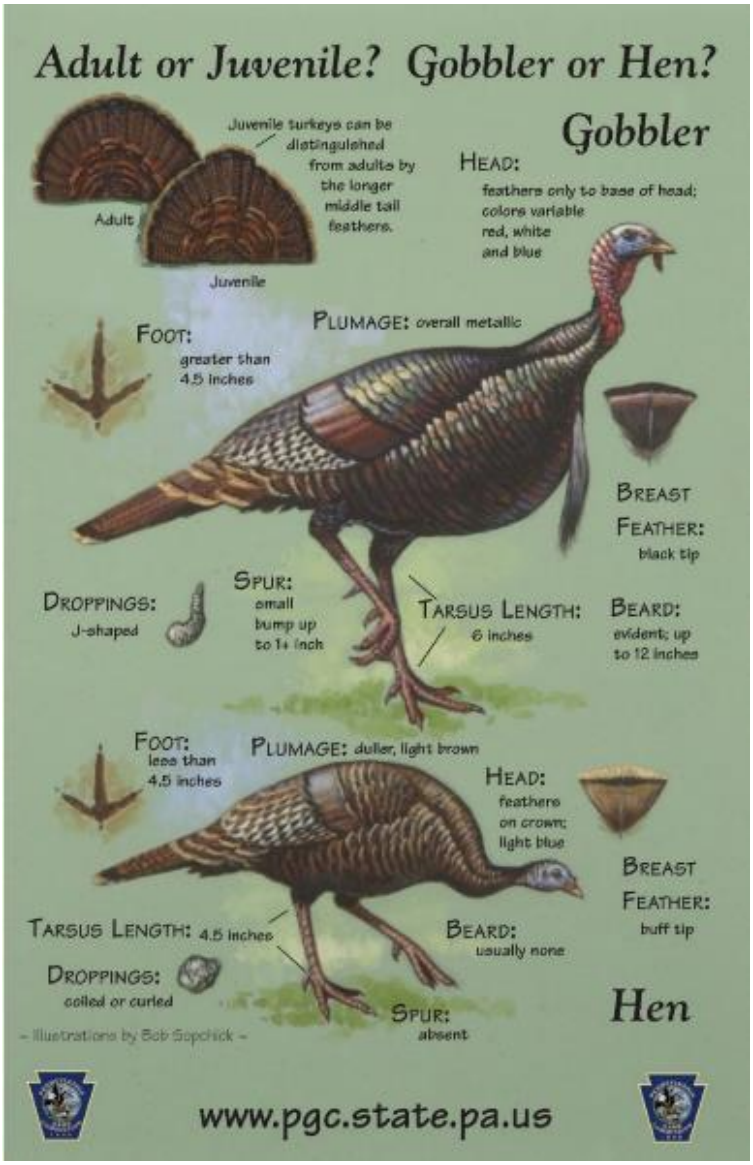

Figure 1. Eastern wild turkey identification by sex and age, courtesy of the Pennsylvania Game Commission, 2003.

History of Wild Turkeys

Wild turkeys are native only to North America, with two species occurring; the wild turkey (*Meleagris gallopavo*), found in 49 states (all but Alaska), 6 Canadian provinces, and Mexico; and the ocellated turkey (*M. ocellata*), found in Mexico, Belize and Guatemala. Five subspecies of the wild turkey, each with distinct biological characteristics and unique management requirements, are widely distributed across the continent (Fig. 2; Eriksen et al. 2015, Virginia Department of Game & Inland Fisheries 2014). The most widely distributed and common subspecies is the eastern wild turkey *(M. g. silvestris*), found in Pennsylvania. The 2014 population of wild turkeys in the United States was estimated to be 6.0-6.2 million turkeys (Eriksen et al. 2015). For a complete history of the wild turkey in Pennsylvania see Latham (1941, 1956), Mosby (1959) and Casalena (2006).

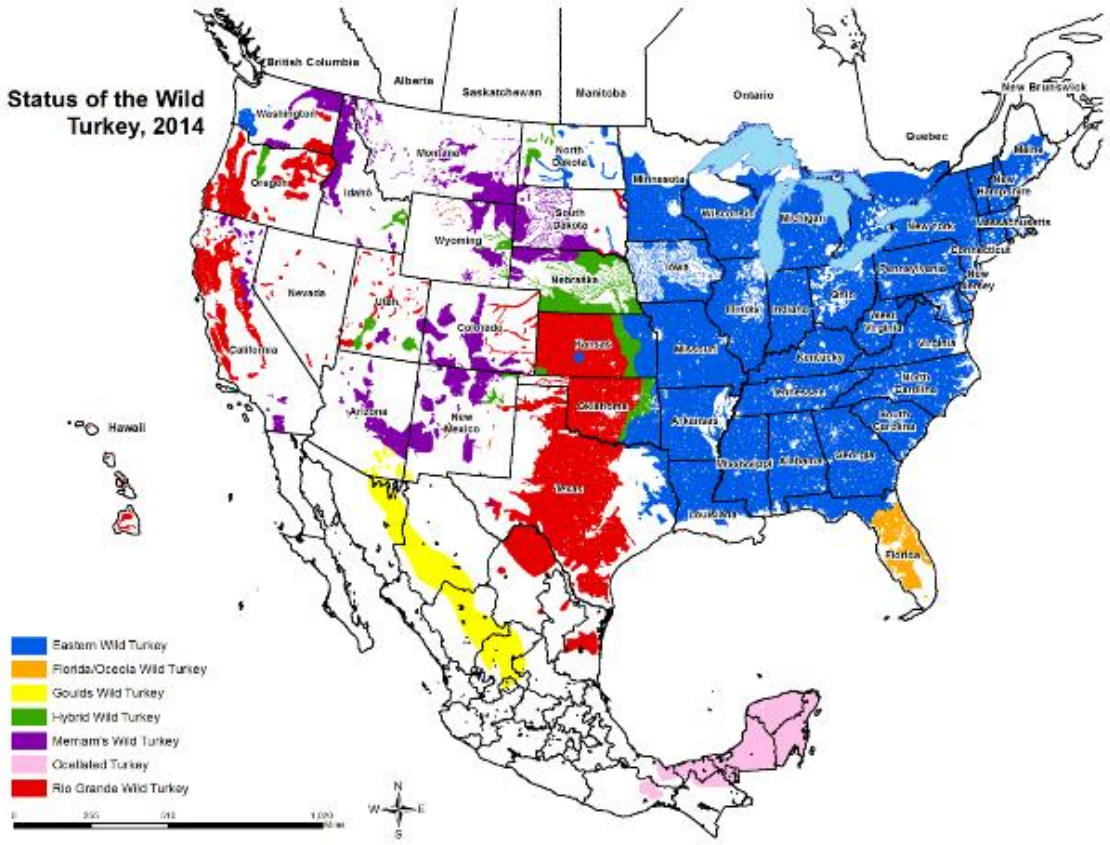

Figure 2. Estimated distribution of wild turkeys (*Meleagris gallopavo*) by subspecies and ocellated turkeys (*M. ocellata*) in 2014 (Eriksen et al. 2015). Data from the United States based on survey data submitted from state wildlife agencies. Distribution of wild turkeys and ocellated turkeys in Mexico is based on Lafon and Schemnitz (1996) and Gonzales et al. (1996).

Accomplishments of Turkey Management in Pennsylvania, 2006-2017

1) 2006 – Regulation legalized use of crossbows beginning with the 2006 fall and 2007 spring turkey seasons.
2) 2007 – Mentored youth permitted to harvest a spring gobbler.
3) Turkey data collection needs were identified after testing the Northeast turkey population model:
    a. 2007 – began collecting age and sex information of harvested turkeys by WMU;
    b. 2008 – Wildlife Conservation Officers began collecting productivity data during annual summer turkey sighting surveys.
4) 2006-2009 – Conducted a 4-year gobbler study in cooperation with New York and Ohio, partially funded by NWTF and PANWTF to determine gobbler harvest and survival rates by age-class.
    a. Male harvest rates were higher for adults (39%) than juveniles (27%);
    b. Annual survival rates were higher for juveniles (87%) than adults (30%);
    c. The high adult harvest rate was offset by greater recruitment of juveniles into the adult age class the following year, allowing a relatively high, but sustainable, adult harvest rate;
    d. Harvest rates declined as the proportion of forested area within 6.5 km of capture location increased.
5) 2006 – A framework was established to develop State Game Land comprehensive management plans, providing for more effective and efficient management of PGC-managed lands.
6) 2007 – Regulation legalized use of dogs in fall wild turkey hunting.
7) 2008 – Transferred 44 wild turkeys from nuisance flocks in the Pittsburgh metropolitan area to North Dakota to assist with turkey restoration in that state.
8) 2008 – Spring season extended to Memorial Day.
9) 2008 – Updated the prosecution database by adding a wild turkey species code to the prosecution list to annually track turkey-specific violations.
10) 2008 – Regulatory change removed the fluorescent orange requirements for hunters participating in spring gobbler seasons.
11) 2009 – The Pennsylvania Prescribed Burn Practices Act (HB 262) was passed, providing statewide standards for prescribed fire and liability protection for burn managers.
12) 2009 – Automated Licensing System began, making harvest data collection quicker and more accurate.
13) An increase in available Pittman-Robertson funding was earmarked for habitat projects

with a focus on oak forest restoration, invasive plant control, native openings, and native shrublands, establishing PGC's "P-R Project" program.

14) 2009 – Using 4 years of data (2006-09), determined the two-bird spring bag limit has no effect on the turkey age structure, and regulation changes were not necessary.
15) 2010 – Revised the turkey population model to incorporate gobbler harvest rates obtained during gobbler study.
16) 2010 – Pennsylvania joined the Interstate Wildlife Violator Compact, SB 1200.
17) 2010 – Fall turkey season opened in WU 5A after 7 years of a closed fall turkey season and intensive population monitoring, as per criteria established in the wild turkey management plan.
18) 2010 – Mentored youth hunting program was expanded allowing a mentor to transfer their fall turkey tag to a mentoree.
19) 2010 – Three-day Thanksgiving turkey season initiated, in WMUs with 1+ week regular fall turkey seasons.
20) 2010-2014 – Conducted a 5-year hen survival and harvest rate study.
21) 2010-2014 – Annually conducted a fall turkey hunter survey to evaluate hunter satisfaction, turkey hunter recruitment, and reactivation of former fall turkey hunters, particularly due to fall season changes in 2010 and 2011.
22) 2011 – P-R projects were expanded to include infrastructure improvements that improve access for hunters and management purposes, resulting in over 75 bridge replacements and hundreds of miles of road improvements on SGLs and other PGC managed properties.
23) 2011 – Spring season extended to May 31.
24) 2011 – All-day spring turkey season during the second half of the spring season, closing one-half hour after sunset.
25) 2011 - An elective 'Successful Turkey Hunting' course started as an advanced course, separate from the mandatory Hunter Trapper Education course.
26) 2011 – Annual spring gobbler hunter surveys implemented to acquire participation and harvest results immediately following the season instead of the one-year delay when data were obtained via the annual Game-Take Survey, increasing data accuracy.
27) 2011 – House Bill 97 passed which increased the penalty structure for big-game violations of Game and Wildlife Code.
28) 2011 – PGC successfully applied for the first Voluntary Hunter Access and Habitat Improvement (VPA-HIP), receiving $3M for private lands habitat work from the federal Farm Services Agency (the highest award nationally).
29) 2012 – Determined the WMU system provides data sufficient for reliably analyzing trends in populations by WMU.
30) 2012 – National Resources Conservation Service established the Working Lands for

Wildlife – Golden-Winged Warbler Initiative, providing resources to create over 13,000 acres of early successional habitat important for turkey nesting and brood-rearing.

31) 2012-2015 – Due to Lymphoproliferative disease (LPDV) being diagnosed in a Pennsylvania wild turkey in 2012 (wild leg-banded hen found dead in Clearfield County by a landowner, while the first case in North America was diagnosed in 2009, Arkansas), LPDV surveillance study was conducted across Pennsylvania for wild turkeys, ruffed grouse (*Bonasa umbellus*) and wild ring-necked pheasants (*Phasianus colchicus*), with wild turkey the only species infected (76% prevalence rate), consistent with prevalence rate across the Northeast.
32) 2014 – PGC wildlife veterinarian began a standard turkey disease documentation process for necropsied turkeys to formally monitor turkey disease occurrence throughout the Commonwealth.
33) 2014 – Northeast Wildlife DNA Laboratory at East Stroudsburg University completed a genetic analysis of wild turkeys in Michaux State Forest (in WMU 5A) compared to that in other areas of the state and determined the MSF turkeys were genetically diverse and not related to game farm turkeys that were once released there, which verified that suboptimal game farm genetics was not the reason for the population decline.
34) 2015 – The 1.5 millionth acre was added to the State Game Lands system with a 2,109-acre addition to SGL 195 in Jefferson County.
35) 2015 – PGC received an additional $3M from VPA-HIP for private lands habitat work on properties enrolled in the Hunter Access Program.
36) 2015 – A Regional Conservation Partnership Program (RCPP) was established in Pennsylvania, focusing on oak forest habitat improvements. Although the RCPP was established to mainly benefit cerulean warblers, oak forest habitat improvements also are important turkey habitat.
37) 2015 – PGC wildlife veterinarian experimentally determined the most effective and cost-efficient method for diagnosing avian pox in wild turkeys.
38) 2015 – Determined, via telemetry data from 254 hen wild turkeys, opening spring gobbler season the Saturday closest to 1 May continues to be biologically appropriate as the median nest incubation initiation date is 4 May.
39) 2016 – Initiated a web-based volunteer turkey sighting survey during August to compare turkey productivity with that of other states that also use citizen science.
40) 2016 – In cooperation with the Northeast Upland Game Bird Technical Committee, initiated a regional turkey population trend study to understand the factors driving changes in population abundance, productivity and harvest within the region.
41) 2016 – PGC used prescribed fire to improve 10,683 acres of habitat during the calendar year, surpassing the 10,000-acre annual benchmark.

42) 2016 – With habitat partners including the American Bird Conservancy, Indiana University of Pennsylvania, and DCNR, the PGC successfully applied for 4 major habitat grants including National Fish & Wildlife Foundation Delaware River, NFWF Central Appalachians, U.S. Forest Service Landscape Restoration, and U.S. Forest Service/NRCS Joint Chiefs, providing for ~10,000 acres of habitat improvement on private and public land.
43) 2006-present – Established several turkey habitat management demonstration areas on State Game Lands, and created or maintained 1,000s of acres of wild turkey habitat, much of which involved cooperative projects with conservation organizations, sportsmen clubs, and federal, state and local agencies.
44) 2006-2017 – Acquired 37,178 acres of State Game Lands.
45) 2006-2017 – Accomplished 45,200 acres of prescribed burns to enhance wildlife habitat.
46) 2006-present – Best management practices from minimal maintenance of openings to forest structure improvements were adopted using a landscape scale approach.
47) 2006-present – Continued the cooperative agreement with the NWTF to partially fund a NWTF Regional Biologist to work closely with agency staff on wild turkey research, population management, and habitat management, and provide technical assistance to private landowners.
48) 2006-present – Regularly updated the wild turkey web page on the PGC web site, published many articles on wild turkey biology and management in both popular and scientific publications, and regularly gave public presentations.
49) 2006-present – Maintained regulations requiring a PGC permit prior to releasing game-farm turkeys, to help eliminate their release into the wild.

III. PENNSYLVANIA WILD TURKEY LANDSCAPE

Pennsylvania's large size compared to other northeastern states (46,058 mi^2) and position in the mid-Atlantic region in the temperate eastern hardwood forest provides a rich diversity of landscape types due, in part to the diversity of geographic features; 6 ecoregions, or physiographic provinces (Appalachian Plateaus, Central Lowlands, Ridge and Valley, New England, Piedmont and Atlantic Coastal Plain; Fig. 3; www.dcnr.pa.state.us/topogeo). Even though these provinces have only a modest elevational range from sea level in the Piedmont Province of Delaware County, to 3,213 feet in the Appalachian Plateaus Province of Somerset County, these variations dictate habitat type, soil fertility and land use, which in turn dictate turkey population densities (Wilson et al. 2012).

Soils along narrow ridges and steep slopes of the Appalachian Plateaus, Central Lowlands, Ridge and Valley, and New England provinces are usually shallow and low in fertility. However, the valley soils in these provinces, derived from shale and limestone, are relatively fertile and deeper. Piedmont soils are characterized by sandy loam soils with red clay subsoil. They are generally acidic and low in organic material, phosphorus, and nitrogen. Coastal Plain soils are typically sandy and low in fertility (Virginia Department of Game and Inland Fisheries 2014). The steep slopes and higher elevations remain predominately forested, while flatlands, wide valleys, and lower elevations are dominated by farmland and human development (Wilson et al. 2012).

Temperature trends closely follow the topography more than latitude, but the coldest winter temperatures are in northern Pennsylvania in the Deep Valleys and Glaciated Plateau, while the warmest are in the lowlands in the southeast along the Delaware River and the northwest near Lake Erie (Wilson et al. 2012). These aspects, along with extensive drainage systems (more than 86,000 miles of waterways) of 5 major rivers provide ample habitat for wild turkeys in Pennsylvania. Additionally, the diversity of Pennsylvania's landscape (58% forested and 26% farm land) provides a suitable mix of habitats (USDA 2012, Widmann 2016). However, composition and juxtaposition of these habitats is not always ideal. With approximately 15% of Pennsylvania publicly owned and 85% privately owned, the challenge of appropriately managing wild turkey habitat is still high, especially considering habitat suitability for turkeys is lower on some public lands than on some private lands (explained in Habitat Model section).

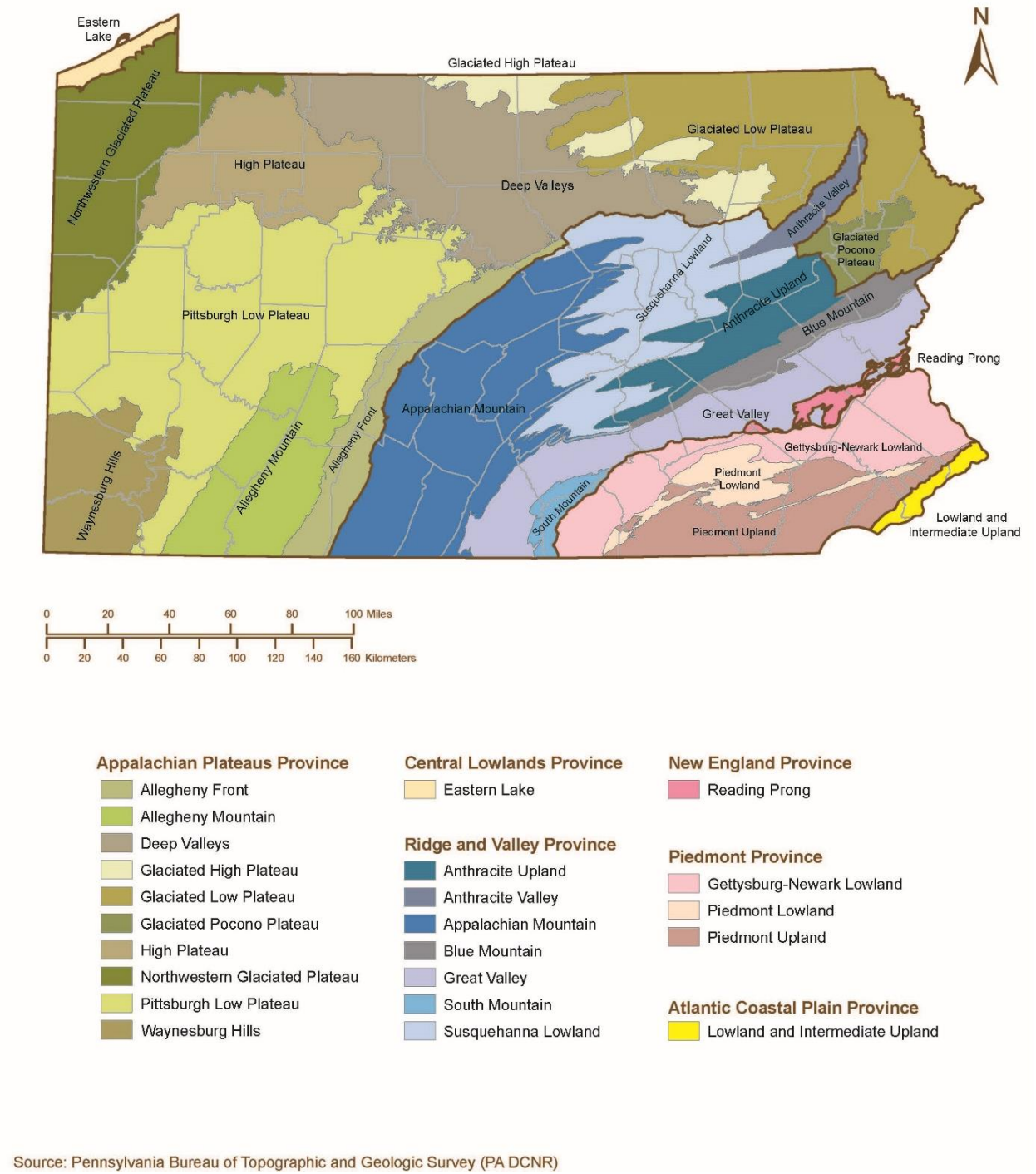

Figure 3. Physiographic provinces and sections of Pennsylvania (Source: Map 13, Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, www.dcnr.pa.state.us/topogeo).

Wildlife Management Units

Wild turkey populations, along with most other game species, are managed via Wildlife Management Units (WMUs) in Pennsylvania (Fig. 4). Adopted in 2003, and revised most recently in 2017, the 23 WMUs are grouped and identified within 5 large physiographic provinces, or sections therein, with similar physical attributes, i.e., geological structure, elevation, soils, vegetation, and climate (Rosenberry and Lovallo 2002). Units within each physiographic province or section were determined based on homogeneous habitat, wildlife population densities, hunter participation, hunter access, land use, major land ownership, and human demographics. Boundaries for each WMU were created to be easily identifiable, that is, they follow major highways and/or waterways.

Figure 4. Pennsylvania Wildlife Management Units (WMUs), as of April 2017.

Wild Turkey Habitat Model

During the 2006-2017 management plan, the PGC adapted a wild turkey habitat model developed in Virginia (Morris 2014) as a standardized, quantitative way of assessing turkey habitat suitability. The model will be updated during this cycle (Strategies 2.1-2.3). Available geographic information system (GIS) datasets are used to evaluate turkey habitat quality over time to determine how current conditions compare to previous. It incorporates a 2-step comprehensive habitat assessment for turkeys, which allows us to identify management needs for specific WMUs and SGLs: 1) at the landscape-level (home-range of a wild turkey, approximately 5,200 ac.), and 2) at <1,000 ac for on-site habitat assessment using a rapid habitat appraisal tool that uses aerial imagery (Morris 2014).

For the aerial imagery we used readily available 2011 National Land Cover Database (NLCD) data with a 30-m spatial resolution (Fry et al. 2011), and NLCD data from 1992, 2001 and 2011 to assess habitat suitability changes over time. Habitat components were forested, open land and edge, such that an optimum mixing of diverse forests, interspersed with openings and agriculture characterized the best turkey habitats (Homer et al. 2015; https://www.mrlc.gov/nlcd2011.php). Less diversity of land cover and land use was characterized as lower quality habitat (Morris 2014, Virginia Department of Game and Inland Fisheries 2014). Habitat not suitable for wild turkeys (i.e., developed, open, barren, water and emergent herbaceous wetlands) were not incorporated into the habitat calculation ("Unsuitable Habitat as No Data"), but a layer featuring water bodies was used for visual reference (Morris 2014). These components were modeled as a function of adult food and cover life requisites ($LRSI_A$) and reproduction and recruitment life requisites ($LRSI_B$) for the final habitat suitability index (HSI), ranging from 0.0 – 1:

$$LRSI_A = (\text{percent of area forested})^2 * (\text{percent of area open})^{1/3}$$

$$LRSI_B = ((\%\text{ of area in edge}) * (\%\text{ of area that is open} \leq 150\text{m from forest})^{1/2})^{1/2}$$

$$HSI = (LRSI_A * (LRSI_B^2))^{1/3}$$

The main function of the model output was to produce a map of habitat suitability for current (2011) and previous (1992) NLCD data to determine if and how habitat suitability has changed over time (Morris 2014). Data output for Pennsylvania showed wide variation in turkey habitat quality by WMU, with the highest suitability in WMU 2D (HSI = 0.922) and the least in 2G (HSI = 0.524; Table 1). The mean HSI was 0.737, with 14 WMUs above this value and 9 below (Fig. 5). Wildlife Management Unit 2D also had the highest value in 1992; WMU 2G declined from the second lowest in 1992 to the lowest value in 2011 (WMU 5A had the lowest value in 1992 at 0.560). The mean HSI in 1992 was 0.773 with the overall average percent decline during the 19-year period of 4.8%. Most (17) WMUs declined in overall habitat suitability with the largest decline in WMU 3D (-18.5%), most likely due to the tremendous increase in human population

and associated development. Suitability improved in 2 WMUs (5B at 4.9% improving from the 5th lowest suitability to the 7th lowest, and 1A at 2% improving from the 7th highest suitability to 4th highest), and remained relatively unchanged in 4 WMUs (5A, 2A, 2H and 2E).

Table 1. Wild turkey habitat suitability by Pennsylvania Wildlife Management Unit (WMU), based on Virginia's turkey habitat suitability model (Morris 2014), in 1992 and 2011, using National Land Cover Database Data (Fry et al. 2011), and percent change (%) in suitability, sorted by highest to lowest suitability in 2011.

WMU	1992 HSI	2011 HSI	% Change
2D	0.934	0.922	-1.3
2A	0.915	0.915	0.0
1B	0.909	0.889	-2.2
1A	0.864	0.881	2.0
3C	0.923	0.873	-5.4
2E	0.876	0.868	-0.9
2B	0.867	0.819	-5.5
3A	0.816	0.790	-3.2
5C	0.805	0.787	-2.2
4A	0.821	0.768	-6.5
5D	0.828	0.761	-8.1
4E	0.788	0.757	-4.0
2C	0.793	0.757	-4.5
4B	0.799	0.744	-6.8
3B	0.766	0.694	-9.3
4C	0.763	0.667	-12.6
5B	0.625	0.656	4.9
4D	0.724	0.641	-11.5
2H	0.591	0.588	-0.6
2F	0.603	0.565	-6.2
5A	0.560	0.561	0.2
3D	0.645	0.526	-18.5
2G	0.570	0.524	-8.1
Mean HSI	0.773	0.737	-4.8

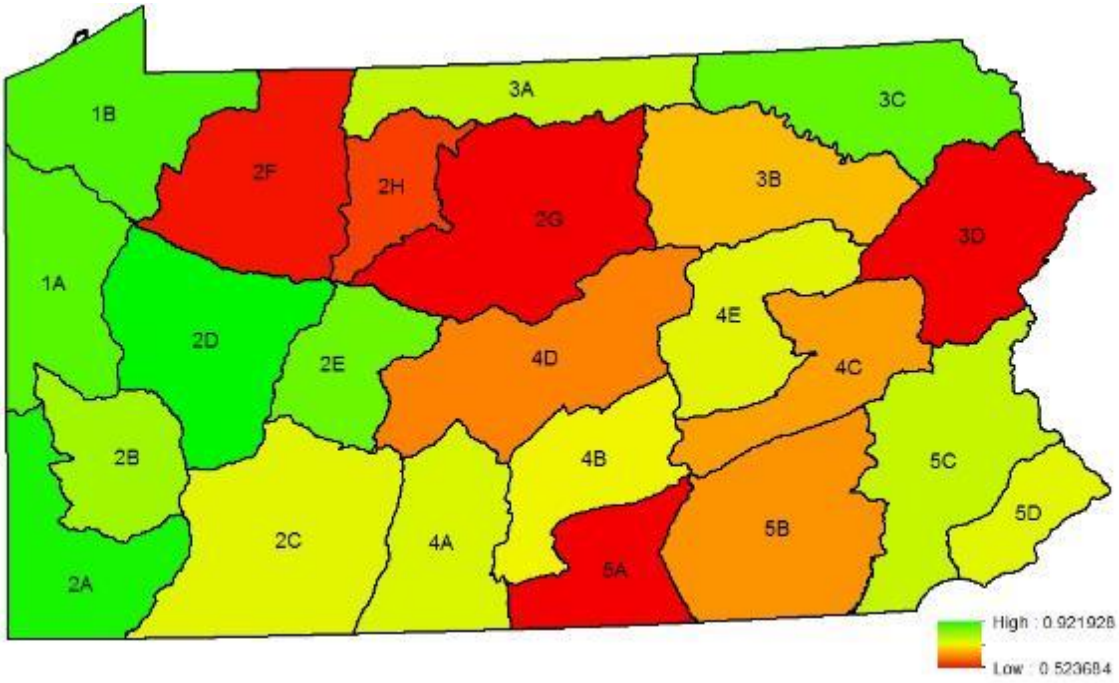

Figure 5. Average 2011 Habitat Suitability Index by Wildlife Management Unit, Pennsylvania.

Additionally, private lands had a substantially higher HSI than public lands (0.78 and 0.49, respectively), with SGLs showing an overall HSI value 0.56. That of U.S. Fish and Wildlife Service (USFWS) lands, mainly Erie National Wildlife Refuge, had the highest value of all land ownership evaluated, 0.83 (Table 2).

The overall outcome of this model showed the largely forested WMUs have the lowest quality turkey habitat. However, the model clumps all forested lands into one classification and, clearly, forested habitats grade in quality as turkey habitat.

Table 2. Turkey habitat suitability index by public land ownership, Pennsylvania, based on 2011 NLCD (Homer et al. 2015).

Land Ownership	HSI
PA Bureau of Forestry (State Forest)	0.435
US Forest Service	0.454
PGC State Game Lands	0.564
US National Park Service	0.571
US Department of Defense	0.751
US Fish and Wildlife Service	0.835
Public Land	0.49
Private Land	0.78

The WMUs with the lowest model-estimated habitat suitability were those with the greatest proportion of contiguous forest and public land ownership. This makes sense as large forested blocks are penalized by the HSI model. However, such large areas are vitally important for wild turkeys and other wildlife as refugia. These forests can be improved while maintaining their forest character by active management that creates a greater diversity of forest age classes at landscape scales. Habitat management can be focused on public lands with the most skewed age class distributions (i.e., those most heavily weighted toward the 90+ year age classes). Such lands can be gleaned from Comprehensive Game Lands Plans, DCNR District Forest Plans, and other inventory and planning documents (Strategies 2.2-2.3, 2.5).

The PGC recognizes that habitat in the more forested WMUs, such as 2F, 2G, 2H and 3D will never reach highest suitability even with habitat management. Each WMU has its own capacity as to the achievable habitat suitability score. Improvement in habitat suitability and any associated improvement of turkey population density/harvest density will be monitored. This suitability index has limitations and may not always reflect turkey population density. For example, the U.S. Fish and Wildlife Service land scored the highest at 0.835 due to the diversity of habitat, but turkey population density there is not very high. These limitations which will be addressed during this management plan cycle and revised/updated to more fully reflect turkey populations and population potential.

In general, private land scored higher than public land because of several factors: abandonment of agricultural areas has created more young forest habitat on private lands, managing at a smaller scale creates more patchworks of habitats, with more opportunities for timber harvests across the landscape, and change in land ownership often necessitates different management of land.

Habitat Model in Association with Spring Harvest

Applying this model to harvest (Table 3) and hunter effort (Table 4) provides a means to identify WMUs in need of additional management actions (habitat improvement, season adjustments, etc.).

Table 3. Matrix of spring harvest density (harvest per square mile) population index and habitat suitability index (HSI), by Pennsylvania Wildlife Management Unit (WMU), 2009-2013.

		HSI of each WMU			
		Low: <0.65	**Moderate-Low: 0.65-0.76**	**Moderate-High: 0.76-0.84**	**High: >0.84**
Relative Population Density (Spring Harvest per square mile suitable habitat)	Low: <0.60	2G, 2H, 5A	5B	5C, 5D	
	Moderate-Low: 0.60-0.85	2F, 3D	2C, 4B		2E
	Moderate-High: 0.85-1.23	4D	3B, 4C	3A, 4A	3C
	High: >1.23			2B, 4E	1A, 1B, 2A, 2D

Table 4. Matrix of spring harvest effort population index and habitat suitability index (HSI), by Pennsylvania Wildlife Management Unit (WMU), 2009-2013.

		HSI of each WMU			
		Low: <0.65	**Moderate-Low: 0.65-0.76**	**Moderate-High: 0.76-0.84**	**High: >0.84**
Relative Population Density (Harvest per hunter day)	Low: <0.031	2F, 2G, 2H, 5A	4B	5C	
	Moderate-Low: 0.031-0.033	3D, 4D	2C	3A	2E
	Moderate-High: 0.033-0.041		3B, 4C, 5B	2B, 4A	1B
	High: >0.041			4E, 5D	1A, 2A, 2D, 3C

Tables 3 and 4 illustrate that WMUs 2F, 2G, 2H and 5A are in most need of habitat and turkey population management. However, the PGC acknowledges these WMUs will never achieve the rating of 'high', such as WMUs 1A, 2A, 2D and 2C.

During this management plan cycle, HSI values for each WMU will be updated using current NLCD data to determine which WMUs are in specific need of turkey habitat and population improvements, and which have potential habitat features (e.g., brood habitat) that may be limiting

or enhancing turkey populations (Strategies 2.2-2.3; Morris 2014). This information will be used to help inform habitat management and harvest regulations (Strategies 1.1- 1.5, 1.8-1.15, 2.2-2.3, 2.7, 2.8) and will be reported to the public (Strategies 3.3 and 3.4). Additionally, the model output on habitat suitability and estimates of turkey abundance will be incorporated into the new turkey population model, which is being developed during this plan cycle, to help identify population management objectives for each WMU (Strategy 1.14, Fig. 6). For example, WMUs with low turkey abundance relative to the HSI may be designated for population increase (depending on output of the other model variables); WMUs with moderate to high turkey abundance and habitat suitability may be designated for maintaining the current population (Morris 2014, Fig. 6).

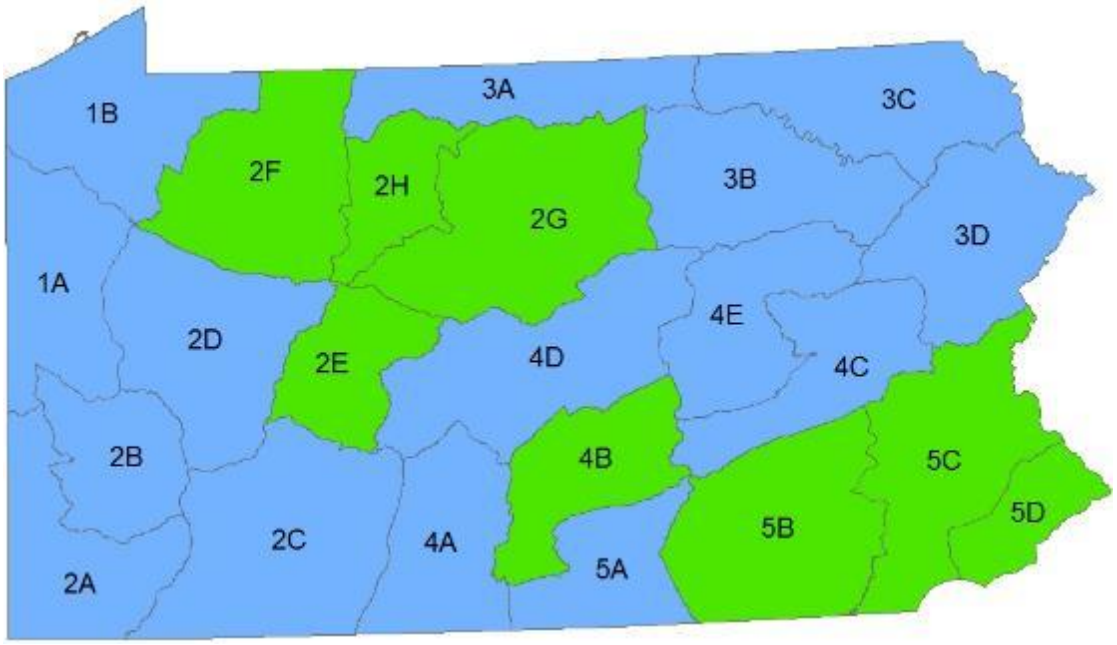

Figure 6. Pennsylvania turkey population management objectives in the 23 Wildlife Management Units, based on turkey habitat suitability (as of 2011) and estimate of turkey abundance (as of 2013). Blue = maintain similar population. Green = increase population.

IV. ECOLOGICAL CONTEXT OF WILD TURKEY POPULATIONS

Dynamics of Pennsylvania's wild turkey populations depend on reproduction (gains) and mortality (losses). Pennsylvania's turkey population exhibited rapid expansion during restoration, particularly from approximately 100,000 in 1990 to its peak of approximately 280,000 in 2001 (Fig. 7). Higher reproduction and survival rates were facilitated by a combination of factors, including ongoing trap and transfer, suppressed predator populations, shorter hunting seasons, and a more diverse landscape than exists today (Dickson 1992, Lewis 2001, Tapley et al. 2001). This resulted in rapid population expansion, not only in Pennsylvania, but across the Northeast. The ecological context in which wild turkeys in the northeastern United States exist has shifted dramatically since then, which could explain recent turkey population declines to the low seen in 2005 (185,500), and nearly annual fluctuations through 2016 (Casalena et al. 2015*a*, Eriksen et al. 2015, Hughes et al. 2007, Nowacki and Abrams 2008, Backs 2009, Porter et al. 2011, New York State Department of Environmental Conservation [NYSDEC] 2014, McShea et al. 2015). Whether current population levels are what is to be expected into the future is unclear. Therefore, Pennsylvania's research and management during this management plan cycle focuses on determining and understanding the potential "new normal" of turkey population trends by gathering and applying information on interactions of turkey habitat, weather, predation, disease, hunting mortality, and survival and incorporating this new understanding of a changing ecological context into population models, season setting protocol and landscape level habitat management at the WMU level.

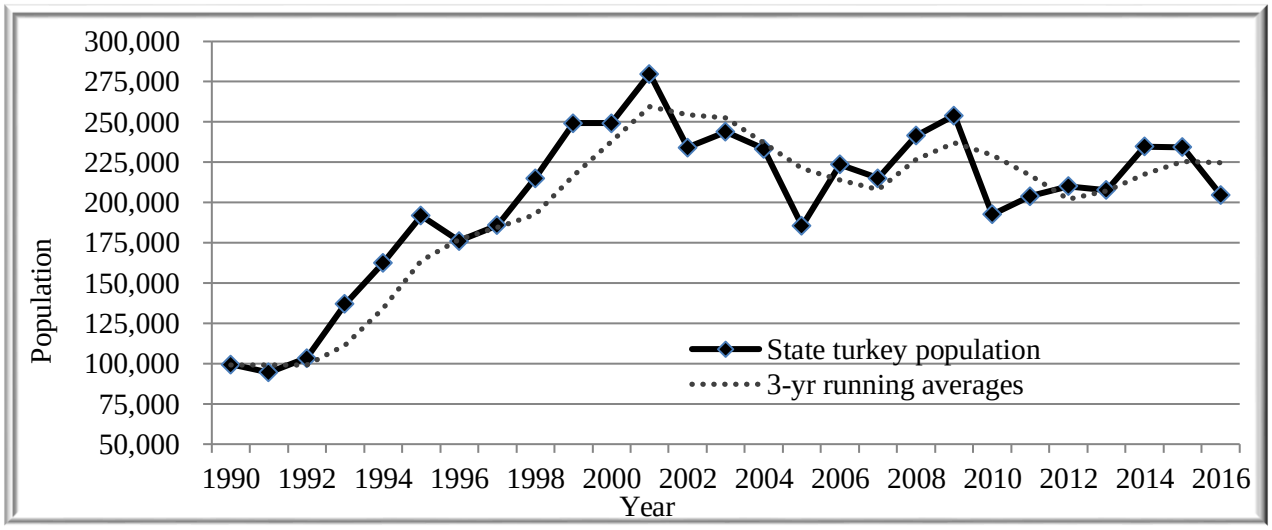

Figure 7. Pennsylvania spring wild turkey populations and 3-year running averages, from turkey survey data, 1990-2016, based on adult male harvest rates of 37.6% and juvenile male harvest rates of 27.5% (Diefenbach et al. 2012).

This section contains a summary of current scientific understanding of turkey population and management issues, particularly trends in turkey abundance and productivity in Pennsylvania and the Northeast from 1990-2016, major factors that have been found to influence turkey populations (habitat, weather, predation, disease, hunting mortality, and survival), and how these factors may interact. How these factors have changed in Pennsylvania and the Northeast in recent decades and are projected to change in the future are summarized. Additionally, summarized here are the objectives and strategies within this management plan cycle that address approaches to most effectively manage turkey populations in Pennsylvania given current and potential future ecological contexts (Strategies 1.1-1.5, 1.8-1.15, 2.1-2.3, 2.7-2.9). Most material in this section is based on the paper, "*Understanding the new normal: wild turkeys in a changing northeastern landscape*" (Casalena et al. 2015*a*), with adaptations specifically for Pennsylvania.

Trends in Turkey Abundance

Turkey population trends have changed significantly across the northeast US since population restoration. To describe trends in turkey abundance in Pennsylvania and across the Northeast region, Casalena et al. (2015*a*) used a standardized spring harvest density, i.e., spring harvest per km^2 of land area, averaged over 3 years to account for annual variations. Although there are limitations of using harvest density data as an index of population size, these were the only standard data available across the entire region and researchers believed harvest density trends generally reflected changes in turkey populations (Byrne et al. 2015, Casalena et al. 2015*a*).

During 1990-1992 through 1999-2001, spring harvest per km^2 increased 121% in the mid-Atlantic states (Pennsylvania, New Jersey, Maryland, West Virginia, Virginia, Delaware, and New York) and 150% in Pennsylvania alone. These were facilitated by a combination of: restoration (trap & transfer), suppressed predator populations (much more trapping than today and rabies was more evident), more fall turkey hunters, and a more diverse landscape than exists today. Then, during 1999-2001 through 2011-2013, spring harvest per km^2 declined about 25% throughout the Mid-Atlantic States and 16% in Pennsylvania (NYSDEC 2014; Fig. 8).

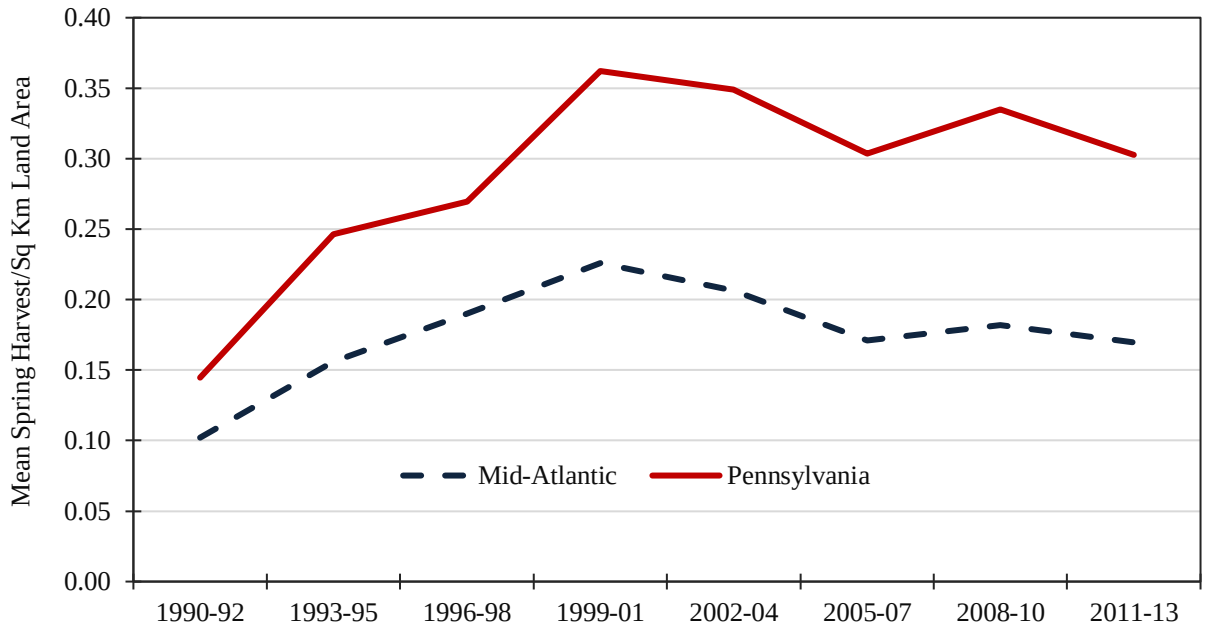

Figure 8. Three-year average spring wild turkey harvest per km^2 of land area in the Mid-Atlantic states (New York, New Jersey, Pennsylvania, Maryland, Delaware, West Virginia, and Virginia), and Pennsylvania, 1990-2013.

Trends in Turkey Productivity

Productivity, as measured by the 3-year mean number of poults per all hens observed during August from annual summer productivity surveys in each state, declined from 1999-2001 to 2011-2013, which may help explain the population declines across the Mid-Atlantic region (Casalena et al. 2015*a*; Fig. 9). The PGC began collecting productivity data after restoration was complete (2008), but it can be assumed that productivity in Pennsylvania also declined during this period, which would help explain Pennsylvania's turkey population decline (Fig. 9).

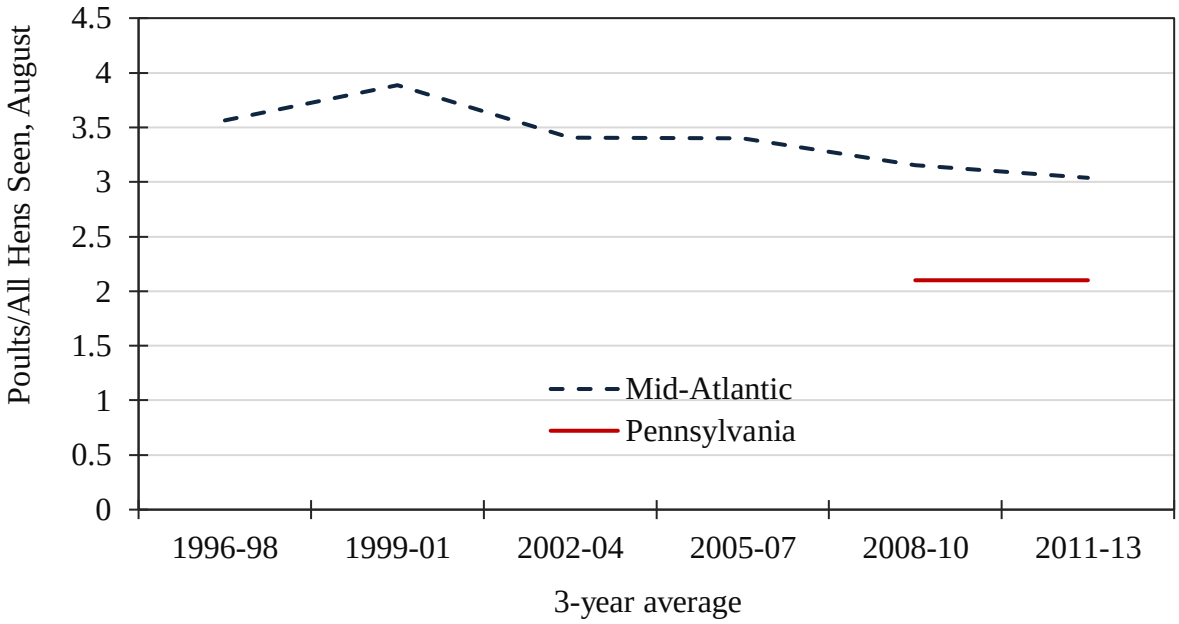

Figure 9. Three-year average poults per all hens seen in August across Mid-Atlantic states (New York, New Jersey, Pennsylvania (2008-13), Maryland, Delaware, West Virginia, and Virginia), and Pennsylvania, 1996-2013.

Population Influences

Habitat

Habitat quality grades along a continuum, and increasing quality supports survival of individuals, then reproduction, and then population persistence (Hall et al. 1997). Focusing habitat management at the landscape level supports wildlife at the population level. Studies have postulated that aspects of habitat condition (e.g., mast abundance, interspersion and juxtaposition of cover types) may be used as a proxy for population numbers and expected harvest of turkeys (Glennon and Porter 1999, Norman and Steffen 2003, Diefenbach et al. 2012). In Virginia, Norman and Steffen (2003) found that below-average oak-mast production increased fall harvest. In southwestern New York, Glennon and Porter (1999) found that proportions of open lands and agriculture, density of edges among different cover types, i.e., interspersion and juxtaposition of cover types, were positively associated with fall wild turkey abundance. Diefenbach et al. (2012) found in New York, Pennsylvania, and Ohio, that the proportion of forested habitat on the landscape was negatively associated with spring harvest rates.

Other studies investigated effects of habitat features, measured at multiple scales, on nest predation, dispersal and habitat use (Fleming 2003, Fleming and Porter 2007, Jones et al. 2007, Fuller et al. 2013). In southeastern Connecticut, Fuller et al. (2013) found that nest sites with sparse understory cover (i.e., cover that provided concealment without obscuring the hen's ability to

detect a predator) had increased daily nest survival. Across New York in 2001, Fleming (2003) found, in fragmented landscapes, decreased nest predation with increased distance from the edge, cover and forest age, i.e., interspersion and juxtaposition of cover types. High edge densities between forest types and agriculture classes within 5 km of a nest increased nest predation, while the mean shape of those combined class patches decreased nest predation. Habitat configuration within 5 km was the most important predictor of nest predation. Therefore, she suggested managing at the landscape level was of primary importance but did not refute the importance of the effects of variables at all scales. Fragmented landscape structure (e.g., high edge density) also facilitated dispersal ability of wild turkeys in New York (Fleming and Porter 2007). A diverse landscape provides year-round habitat needs including nesting, brood-rearing, roosting, and wintering within a relatively small home range; increases complexity of patches, thus decreasing predator foraging efficiency (Glennon and Porter 1999, Fleming 2003); and provides a diversity of food sources to help mitigate severe spring and winter conditions (Porter et al. 1983, Vander Haegen et al. 1988). However, factors such as expanding urbanization, energy development, invasive plant species, and agricultural consolidation threaten the quality of habitat for turkeys (Porter et al. 2015).

Studies demonstrate turkey populations are sustainable in contiguous forest landscapes, but perhaps not at the densities that can be reached in heterogeneous landscapes with a mix of forest patches, shrublands and agriculture (Glennon and Porter 1999, Porter 2007). Pennsylvania's HSI model paired with hunter harvest lends support to this point, with lowest estimated population densities in predominantly forested WMUs in central parts of the state and the northern tier. However, it must be clearly noted these areas represent some of the largest remaining contiguous forested blocks in eastern United States. As such they have tremendous habitat value for wildlife, particularly many species of special concern, as well as their overall water quality and ecosystem benefits. Additionally, these extensive forests are important for wild turkeys and other wildlife as refugia, and could potentially harbor them from extirpation, as they previously did for wild turkey and served as the seed source of today's populations statewide.

At least 3 equally important changes in landscape-level habitat quality in Pennsylvania and the Northeast are evident over the past 25 years. First, there has been a decline in amount of this interspersion and juxtaposition of different habitat types, i.e., the forest and agricultural types. During this management plan cycle, 7 of the 12 strategies within the habitat objective focus on landscape level habitat management (Strategies 2.1-2.7, 2.9).

Second, percentage of forests composed of mast-producing oaks (*Quercus* spp.) has been declining while non-mast-producing species like red maple (*Acer rubrum*) have increased in biomass (Table 5; Nowacki and Abrams 2008, McShea et al. 2015, Widmann 2016). Change in forest composition

has been driven by lack of forest management, forest fire suppression policies beginning around the 1920s, browsing by over-abundant white-tailed deer (*Odocoileus virginianus*), mortality caused by gypsy moth (*Lymantria dispar*) since the 1980s (Wunz and Pack 1992, McShea and Healy 2002, Nowacki and Abrams 2008, McShea et al. 2015), and other introduced exotic pathogens, such as oak blight (Abrams 1992, Porter et al. 2011, Jones et al. 2015). With little to no regeneration on the ground, oak-dominated forests are being converted to maple and other non-mast producing hardwood species that are shade-tolerant and fire-sensitive (Nowacki and Abrams 2008, McShea et al. 2015). Simultaneously, micro-environmental conditions have improved for shade-tolerant species (i.e., cool, damp, shaded conditions), which have created less flammable fuel beds and deteriorated ability of shade-intolerant, fire-adapted oaks to persist. As Nowacki and Abrams (2008) stated, cost and effort to restore fire-adapted ecosystems will escalate rapidly if this process continues at the current rate.

Table 5. Aboveground biomass on forest land of top ten tree species and percent increase by net volume, within Pennsylvania forests, 2015 (Widmann 2016).

Species	Aboveground biomass on forest land (million tons)	Sampling error (%)	Percent increase since 2010 (%)
Red maple	193	2.4	5.3
Black cherry	105	3.7	6.7
Northern red oak	121	3.7	9.1
Sugar maple	89	4.6	6.9
Chestnut oak	86	4.3	3.7
Hemlock	37	5.7	8.7
Yellow-poplar	39	7.4	9.3
White ash	53	5.0	3.6
Sweet (black) birch	61	4.0	10.9
White Oak	54	5.2	1.5
Other softwoods	33	6.6	7.5
Other hardwoods	225	2.3	5.4
All species	1,096	1.0	6.3

According to the 2015 Forest Inventory Analysis in Pennsylvania, red maple is now the most voluminous species (measured as million cubic feet of live trees on forest land), followed by black cherry (*Prunus serotina*), northern red oak (*Quercus rubra*), and sugar maple (Table 5; Widmann 2016). However, sweet birch (*Betula lenta*) had the largest percentage increase in volume since 2010, 10.9%, and white oak (*Quercus alba*) the smallest, 1.5%. American beech (*Fagus grandifolia*), ranked eleventh by volume, decreased by 2%. Additionally, harvest rate slightly

exceeds growth of oak species, whereas the opposite is true with red maple. During this management plan cycle all 12 strategies within the habitat objective involve oak regeneration either directly or indirectly.

Third, forest maturation has reduced amount of young forest/early successional habitat conditions important for turkey nesting, feeding, loafing, and other activities (Fig. 10; Dessecker et al. 2006, Jones et al. 2007, King and Schlossberg 2014, Widmann 2016). The single-aged, 85-125-year-old age class is a product of the widespread clearing for agriculture and timber during the late 1800s through early 1900s (Nowacki and Abrams 2008, Albright et al. 2017). Forest Inventory Analysis data in Pennsylvania show the area of timberland in large diameter stands (≥11.0 inches d.b.h. for hardwoods and 9.0 inches for softwoods) has steadily increased since the 1950s, such that the current composition is 69% in large diameter trees, and only 9% in small diameter (dominated by trees <5.0 inches d.b.h.; Widmann 2016). The declining percentage of small diameter forests has become more dramatic since 1980 (Fig. 10; Widmann 2016). The northern red oak, chestnut /black /scarlet oak and chestnut oak types each have < 1% of their area in small diameter stands, whereas the cherry/white ash/yellow-poplar and black cherry types each have >10% of their area in small diameter stands. The lack of small diameter stands in oak forest types illustrates the difficulty in regenerating oak forest types in Pennsylvania (Widmann 2016; Fig. 10a). Due to litigation and lengthy public comment periods, federal forest lands are not harvested as heavily as private lands. However, much private lands harvests are not done so sustainably by removing only the most productive genetic stock, and leaving the inferior stock (Albright et al. 2017).

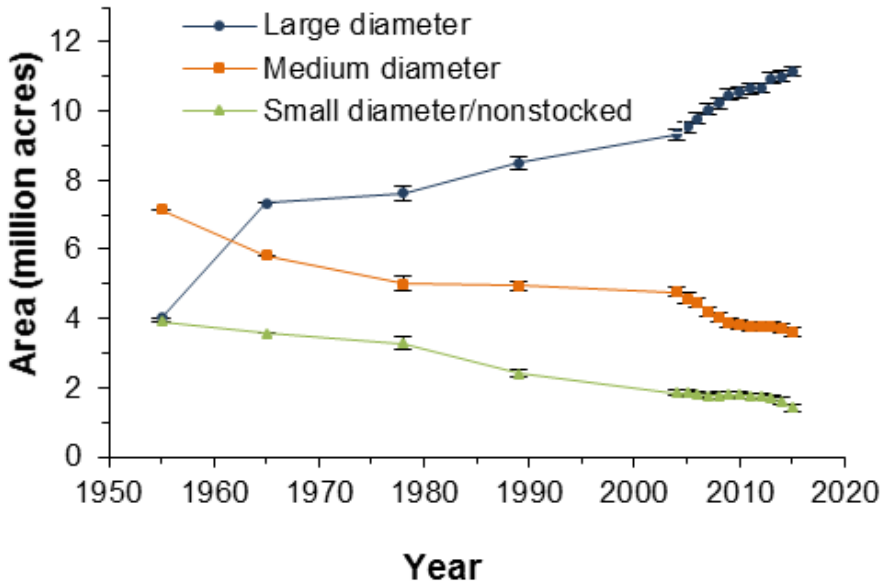

Figure 10. Area of timberland by stand-size class and inventory year, Pennsylvania. Error bars represent a 68 percent confidence interval around the estimated mean. (Widmann 2016).

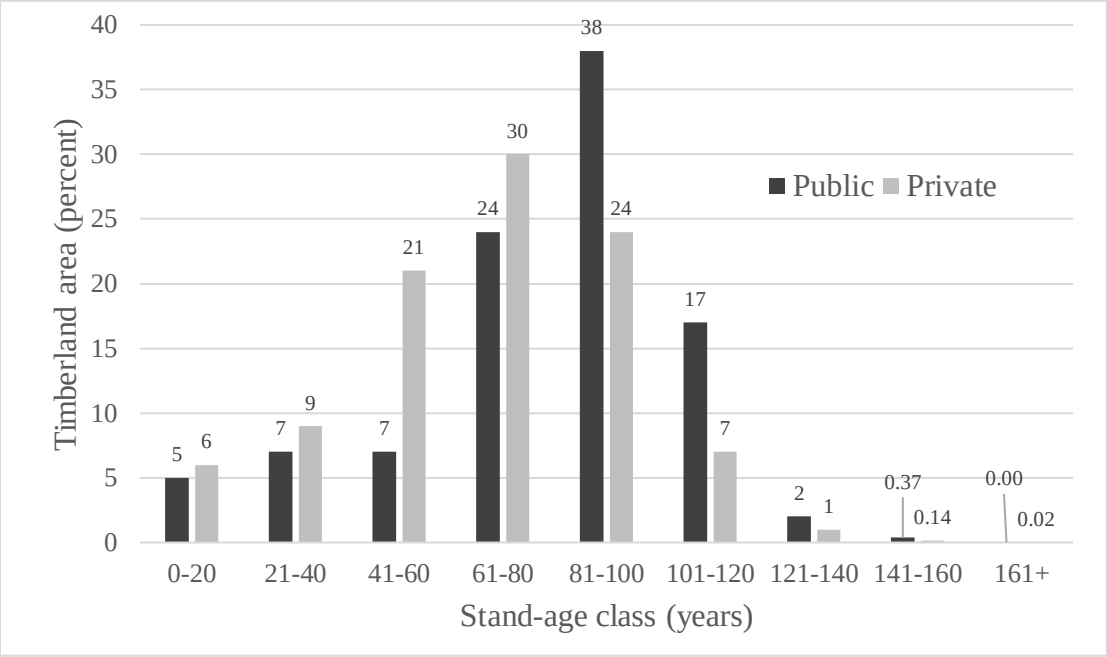

Figure 10a. Percent of each Pennsylvania forest stand-age class in public and private ownership, 2014 (Albright et al. 2017).

Single-aged forests lack alternative foods that are typically found on landscapes with a diversity of forest age classes and, therefore, exhibit great annual variation for fall and winter food availability for turkeys (McShea and Healy 2002, Nowacki and Abrams 2008, Porter et al. 2011, McShea et al. 2015). Due to the unpredictable nature of acorn production, and the absence of the steady annual American chestnut (*Castanea dentata*) nut production, wild turkeys must rely on other food resources during years of mast failures. However, those alternatives are becoming less abundant and more scattered across a more homogenous landscape, and may greatly impair winter food availability.

The American Chestnut Foundation's years of bioengineering to develop blight resistant American chestnut hybrids is advancing. Partnerships with ACF will be important for establishing these trees which were annual reliable mast producers (Strategy 6.6).

In landscapes interspersed with agriculture, crop lands had been reliable alternative sources of food, but now produce less waste grains for turkey winter foraging due to progressively more efficient crop harvesting systems or loss of farms outright due to economic pressures. Wild turkeys have become more dependent on silage storage areas, becoming nuisances to the agricultural community in some locales (Porter et al 2011). Additionally, losses of early successional vegetation communities and young forests have likely reduced quality and quantity of nesting and

brood-rearing cover (Glennon and Porter 1999, Porter 2007). Loss of landscape-scale habitat complexity may be a significant contributing factor in the trends observed in turkey harvest and productivity. Recommendations for improving oak forest resiliency and sustainability include creating a better distribution of forest age classes and utilizing prescribed fire (Brose et al. 2014). During this management plan cycle 9 of the 12 strategies within the habitat objective focus either directly, or indirectly, on the change in forest species composition and age class. (Strategies 2.4-2.7, 2.9, 2.10, and 2.12).

Weather

Weather is an important factor affecting populations. Severe weather, as well as variations from averages, can affect survival, reproductive success, food abundance/accessibility, and hormonal changes, which affect reproduction. Climate change has already become apparent with definable variations in weather patterns since 1980 (Wilson et al. 2012).

Winter and spring weather particularly affect wild turkey demographics and knowledge of their effects can aid management decisions (Healy 1992). Winter severity has been shown to reduce survival in northern climates but has not been found to have long-term effects on population growth (Wunz and Hayden 1975). A few severe winters from 1963 through the 1970s, with extended low temperatures, excessive snow depths, and sudden deep snowfalls caused turkey survival to be reduced in newly established populations (Austin and DeGraff 1975, Wunz and Hayden 1975). These newly established populations, unfamiliar with the habitat and terrain might not have been able to adapt for severe winter survival, such as moving to stream valleys, adjacent farmland and overgrown brush land. Flocks that did make these movements exhibited increased survival. Telemetry data from more than 440 female wild turkeys in Pennsylvania from 1999-2014 showed that seasonal survival was highest during winter when turkeys persist in winter flocks, and lowest during breeding/nesting seasons (Lowles 2002, Casalena 2015). Negative impacts of winter severity for established populations appear to act through reduced access to food, such that during winters with high nutritional intake requirements when snow eliminates availability of ground diets high in nutritional value (Pekins 2007), a hen's spring reproductive success is negatively impacted (Casalena 2015). Conversely, agricultural food sources (e.g., manure spreads, silage pits) have been shown to mitigate winter severity effects, particularly during periods of persistent deep snow and absence of other beneficial habitats such as spring seeps (Vander Haegen et al. 1989, Hamel 2002, Timmins 2003, Healy and Casalena 1996). Agricultural areas had been reliable alternative sources of food, but much has either been lost outright due to development or reduced in habitat quality due to modern farming practices (e.g., less waste grain, more intensive crop production methods, restriction on manure spreading; Porter et al. 2011). In some situations, this forces more turkey dependency on silage storage areas, which creates a nuisance to the agricultural community (Pekins 2007, Porter et al. 2011).

Although nest incubation initiation is controlled primarily by photoperiod, weather also has been shown to affect it, with higher March temperatures correlated with earlier incubation and deeper March snow postponing incubation initiation (Norman et al. 2001, Casalena et al. 2015*b*). Nest success and daily survival also are affected by weather, as they are positively correlated with average to below average rainfall, negatively correlated with number of rain events, and daily nest survival is positively associated with heating degree days (Priest 1995, Roberts et al. 1995, Roberts and Porter 1998*b*). Roberts and Porter (1998*a*) found that poult survival was negatively correlated with lower than average temperatures and greater than average rainfall. These studies also demonstrated links between nest success and poult survival and abundance. More research on this is needed. Similarly, annual change in fall harvest has been negatively correlated with annual change in May rainfall (Roberts and Porter 2001). These resarchers were able to use spring weather data as a surrogate to reproductive success to predict annual poult survival and assess trends in fall populations and oak mast production. These in turn affect fall harvest success (Norman and Steffen 2003), such that predictions in fall harvests can be made (Roberts et al. 1995, Roberts and Porter 1996, Norman and Steffen 2003). We will determine if spring weather can be successfully used as a variable in the structured decision protocol (Strategy 1.13).

Climate change has begun to show some effects with more extreme minimum and maximum precipitation since 1980 (Wilson et al. 2012). Average annual rainfall in the Northeast since 1991 has increased 8% relative to 1901-1960, with more winter and spring precipitation (U.S. Global Change Research Program 2014). Additionally, there has been an increase in amount of precipitation falling in heavy events in the Northeast, which is projected to continue due to a warmer atmosphere and associated changes in large scale weather patterns (U.S. Global Change Research Program 2014). These changes in climate most likely will impact turkey annual recruitment due to more spring-time precipitation negatively affecting nest success and poult survival, and possibly increasing disease transmission (Casalena et al. 2015*b*).

Several studies have investigated importance of the interactions between weather and habitat conditions on turkey populations in the Northeast. Porter and Gefell (1996) showed importance of multiple land cover types and spring and early summer temperatures on fall harvest across southern New York. Vander Haegen et al. (1989) found that agricultural food sources buffered effects of winter severity in southwest Massachusetts. Roberts et al. (1995) suggested that improvements to winter habitat in areas with frequent, severe winters would provide greatest benefit to turkey populations, whereas improvements to nesting habitat would be more beneficial in areas with infrequent severe winters, such as Pennsylvania. During this management plan cycle 5 strategies within the population objective focus either directly, or indirectly, on mitigating weather effects on turkeys (Strategies 1.6, 1.9, 1.11, 1.13, and 1.17).

Climate change also will affect forest composition and function such that tree species occupying cooler, moister habitats like sugar maple, black cherry, northern red oak and American beech will become less prominent, being forced northward or to higher elevations (Price and Sprague 2012). This may affect wild turkeys because the likely forest type to replace these, oak/hickory, may not succeed as well as anticipated because they are being replaced by red maple/birch. type forests will take their place. However, summer droughts could become more common (Price and Sprague 2012), which in turn will affect mast production and overall tree health. The combination of late frosts which damage/kill the trees' flowers, heavy spring rains which cause fungus outbreaks, and summer droughts, which cause abortion of fruit and/or tree mortality are increasing challenges. Negative affects to wild turkeys and other wildlife can be somewhat mitigated by appropriate forest management.

Disease

While direct mortality is the most obvious negative impact of disease on individual animals or wildlife populations, disease can also negatively influence reproduction, immunity, energy assimilation, and resource allocation. Fewer disease problems occur in the Northeast than the Southeast US, and disease outbreaks have not had discernible long-term, large-scale impacts on populations to date (Weinstein et al. 1996, Jones et al. 2015). Wild turkeys commonly experience bacterial and parasitic infections and harbor many nematode species that do not usually cause death or even clinical symptoms (Davidson and Wentworth 1992). The blood parasite *Haemoproteus meleagridis* is widely distributed and causes episodes of lameness and depression. Histomoniasis (blackhead) is a severe parasitic disease caused by a protozoan transmitted by ingestion of earthworms, but regardless of what its common name suggests, does not cause a black looking head. Blackhead occurs only sporadically in Pennsylvania (typically 1-3 diagnoses annually within Pennsylvania since surveillance began in 2014), but is often confused with three other common diseases, that cause proliferative skin lesions on the head, neck and/or legs, and, once ulcerated, become covered by black crust. Diagnoses of skin lesions cannot be made macroscopically. Rather, they require laboratory testing, such as examining the skin under a microscope or specific tests for infectious agents.

Elsmo et al. (2016) found the most common skin disease in the eastern US is avian poxvirus, a virus transmitted among wild birds primarily by arthropods, especially mosquitoes, or direct/indirect contact with virus-contaminated objects (Davidson 2006). Avian pox weakens birds, making them vulnerable to predation. It is not feasible to control avian pox, but transmission through a population can be dampened by culling birds with lesions to control virus spread (Davidson and Wentworth 1992).

The second most common cause of skin lesions is bacterial dermatitis, such as from *Staphylococcus* spp, *Escherichia coli* and *Bacillus* spp. (Elsmo et al. 2016). Anatomic distribution and seasonal occurrence of cutaneous lesions may offer helpful clues as to the cause. Lesions on the head and neck area are most frequently caused by avian poxvirus, whereas lesions restricted to the feet are more likely bacterial infections (Elsmo et al. 2016). Skin lesions observed in the fall and winter are more likely to be caused by avian pox, whereas bacterial dermatitis is more frequently observed in the spring and summer (Elsmo et al. 2016).

The third common cause of skin lesions is an exogenous, oncogenic retrovirus, lymphoproliferative disease virus (LPDV), first recognized in 1972 in domestic turkeys from the United Kingdom, and later reported in domestic turkeys in Austria, Netherlands and Israel (Thomas et al. 2015, Allison et al. 2014). It has not been found in domestic poultry in the United States, but little research has been done. The first diagnosis of LPDV in a wild turkey was from Arkansas in 2009 by PGC wildlife veterinarian, Dr. Justin Brown, while he worked at the Southeastern Cooperative Wildlife Disease Study, University of Georgia (Allison et al. 2014). LPDV occurs widely, but may only produce clinical disease when a turkey's immune system is weakened from presence of other parasites and diseases (Allison et al. 2014, Thomas et al. 2015). The disease was confirmed in Pennsylvania in 2012 in a wild, leg-banded hen found dead in Clearfield County. Subsequent surveillance between 2012-16 from hunter harvested turkeys across 26 counties in Pennsylvania showed LPDV prevalence in 50 of 66 (76%) turkeys, none of which showed clinical symptoms of the disease (Brown et al. 2016). These results are consistent with another study that examined hunter-harvested turkeys from 17 other states, where 47% of those turkeys tested positive for LPDV, but statewide prevalence ranged from 26% in Oklahoma to 82% in Maine and 83% in New Hampshire (Thomas et al. 2015). Currently, there is little information on the host range of LPDV, but experimental data indicates chickens and turkeys are susceptible to infection while domestic ducks and geese are resistant. In wild birds, LPDV has only been reported from wild turkeys (Eastern, Osceola and Rio Grande subspecies); throughout Pennsylvania ruffed grouse and wild ring-necked pheasants were tested for LPDV with no detection, suggesting the natural LPDV host range is relatively restricted (Brown et al. 2016).

Avian influenza has never been confirmed in wild turkeys. Additionally, passive surveillance for West Nile virus (WNV; i.e., testing sick and dead birds found on the landscape) across Pennsylvania has shown no WNV affected wild turkeys. Only two states (Michigan and Missouri) have reported any mortality of wild turkey due to WNV (M.J. Casalena, Pennsylvania Game Commission unpublished data). This suggests wild turkeys may be slightly, but not highly, susceptible to the virus. Being large, visible birds, if they were susceptible and experienced high mortality one would expect to see many sick turkeys on the landscape, just as sick and dead crows are found on the landscape during active WNV seasons. A challenge study conducted on domestic

turkey poults documented only one of 10 poults died after being inoculated with (*n*=8) or exposed to (*n*=2) WNV and concluded WNV lacked the potential to be a major new disease for turkeys (Swayne et al. 2000). However, this study may not be directly related to wild turkeys. Therefore, the pathogenic potential of WNV in wild turkey poults requires further research.

While uncommon, ectoparasitic dermatitis and fungal infections also sporadically cause skin lesions in wild turkeys (Elsmo et al. 2016). The PGC wildlife veterinarian intensified the passive surveillance program in 2014 to increase sampling (from an average of 2 submissions annually to 25-30), and create a tissue repository to provide "samples in hand" for future research or testing of new diseases or outbreaks (J. Brown, personal communication).

Many diseases that affect turkeys are influenced by anthropogenic processes, including spillover from domestic poultry (e.g., histomoniasis), toxicoses (e.g., zinc phosphide from rodenticide applications, particularly in orchards), trauma, and intentional movement of captive-bred and wild animals (Leighton 2002, Caudell et al. 2015). While wild turkeys are susceptible to diseases common to domestic turkeys, wild turkeys do not seem to be carriers. They have never been linked to disease outbreaks in domestic poultry or cattle (Davidson and Wentworth 1992). To date disease outbreaks have not had discernible long-term, large-scale impacts on populations. However, the potential for more subtle impacts of disease on productivity, immunity, energy assimilation and resource allocation are poorly understood. Research is needed to understand potential impacts of emerging or recently identified diseases, and how disease may interact with other population influences such as habitat, weather, predation, and harvest management (Strategy 1.19). Our ability to measure and define the full diversity of disease impacts in wildlife, particularly on a population level, is hindered by a lack of sensitive techniques for detection, various logistical hurdles (e.g., our inability to follow sick turkeys and monitor their response to disease, and the difficulty of monitoring causes of death in young turkeys), and our lack of understanding the effects of disease on wild turkeys (e.g., possible vertical transmission of disease from hen to poult). Our passive surveillance, which allows continual diagnostic monitoring for, and identification of, new emerging diseases such as LPDV and WNV, allow us to identify potential hazards before population-wide impacts are observed (J. Brown, personal communication). During this management plan cycle 2 strategies within the population objective focus either directly, or indirectly, on wild turkey diseases (Strategies 1.18 and 1.19).

Predation

Predation is a complex process that involves predator-prey interactions and a suite of factors that influence these interactions including habitat, weather, disease, and presence and abundance of other prey species (Miller and Leopold 1992). Turkeys, across all life stages, are preyed upon by a suite of predators. Omnivorous mammalian meso-predators (e.g., raccoons [*Procyon lotor*],

skunks [*Mephitis mephitis*], and opossums [*Didelphis virginiana*]) and snakes are prolific nest predators, depredating nesting hens and eggs, thus making these life stages the most vulnerable for the wild turkey (Martin et al. 2015, Hughes et al. 2007). As ground nesters, eggs of nesting hens are subject to other, opportunistic, predation such as a variety of birds (particularly crows [*Corvus brachyrhynchos*]), small mammals (particularly chipmunks [*Tamias striatus*]), house cats (*Felis domesticus*), and occasionally black bears (*Ursus americanus*; M. J. Casalena, pers. comm.). In fact, a 2004 study in southern Georgia found opossum to be the most frequent nest predator (42% of predated nests), with the median time of predation 2:19am, followed by American crows, predating nests in the afternoon (median time was 4:36pm), bobcats (*Lynx rufus*) and rat snakes took the same percentage, 8% (median time was 8:02pm and 2:54pm, respectively) with only one nest predated by a coyote (*Canis latrans*, 9:24pm; Martin et al. 2015). Larger mammalian predators (e.g., bobcats, foxes [*Vulpes vulpes*, *Urocyon littoralis*] and coyotes), avian predators (e.g., hawks and owls), also prey on nesting hens and eggs, and kill poults and adult birds (Miller and Leopold 1992).

Although the PGC has received much speculation from hunters regarding fisher (*Martes pennanti*) predation on wild turkeys, research on fishers shows that fishers are omnivorous and capable of exploiting diverse prey resources (Lovallo 2008). McNeil et al. (2017) examined 91 fisher stomachs from carcasses collected throughout Pennsylvania (2002-2014) and found their diet was more diverse compared to most populations studied elsewhere and had the highest diversity value ever reported for fishers. They attributed this to the diversity of terrain, plants and animals in Pennsylvania which provide the ideal setting for fishers to employ generalist feeding behavior. Pennsylvania hosts 66 species of terrestrial mammals, 190 species of breeding birds, and an abundance of squamate reptiles, amphibians, invertebrates, and plants that fishers can incorporate into their diets. A study in the Sierra Nevada Mountains of California, which sampled 201 fisher feces over a 3-year period, attributed their highly diverse diet to the absence of their "normal" prey (porcupines and rabbit species), and included small mammals, reptiles, insects, birds (identified as passerines with no mention of wild turkey or other galliforms, such as grouse), fruits, and fungi (Powell et al. 1997, Zielinski et al. 1999). Zielinski et al. (1999) further noted that no single family of animal or plant group was identified in more than approximately 22% of feces. In Pennsylvania, McNeil et al. (2017) found that while porcupines and rabbit species were common prey items, fishers also consumed 30 different species of prey and 11 species of plants. Mammalian prey species were found in 82% of the stomach contents (rodents, carnivores [including other fishers], deer, rabbits, opossum, shrews). Avian prey species were found in 11% (only 3 avian eggs: black-capped chickadee and downy woodpecker - species that seek tree cavities, and ring-necked pheasant). Foliage, fruit/seeds and a few species of reptile, amphibians and insects also were detected. Because of their diverse prey base, Pennsylvania fishers are opportunistic feeders and do not target wild turkeys.

Predation rates are influenced by habitat quality (on local and landscape scales), weather, disease, and predator diversity and density. High quality habitat for wild turkeys is also beneficial to numerous other prey species and increases their populations, which increases predator numbers. However, high prey diversity keeps predator pressure low on any one species (e.g., wild turkeys), but could also have a negative affect by increasing predator populations thereby increasing predation rate on all prey (Miller and Leopold 1992).

Habitat quality, as previously mentioned, affects risk of nest predation (Fleming 2003). Many studies have linked spring rainfall to nest success through the moisture-facilitated nest depredation hypothesis (Roberts et al. 1995; Roberts and Porter 1996; Roberts and Porter 1998*b*; Lowrey et al. 2001), which postulates that wet turkeys and nest sites are more easily located by mammalian predators that rely heavily on their olfactory senses (i.e., the "wet hen syndrome"). Also, prolonged periods of deep snow during winter decreases physiological health of turkeys (Pekins 2007) and may increase their vulnerability to predation. High population densities of turkeys may increase transmission of diseases like avian pox, weakening them and thus increasing their vulnerability to predation (Davidson and Wentworth 1992). Predation alone is not known to be a direct threat to turkey populations, but interactions with other factors increase its potential effects (Hughes et al. 2007).

Populations of species that prey on turkeys have increased in number and distribution (AFWA 2014, Pardieck et al. 2014; Pennsylvania Game Commission unpublished data). For example, populations of avian predators common to the Northeast that prey on turkeys (red-tailed hawk [*Buteo jamaicensis*]) have experienced significant increases since 1990 (Pardieck et al. 2014; Fig. 11). Rabies swept through the Northeast in the 1990s, suppressing populations of meso-predators (e.g., raccoons; Smith et al. 2002, Dyer et al. 2013). Since then, three-year furbearer harvest per km^2, an index of furbearer abundance, substantiate the observations of the PGC furbearer biologists that most mammalian predator numbers have increased over the past decade (4 of 6 species; i.e., raccoon, red fox, Virginia opossum, and coyote; pers. com T, Hardisky and M. Lovallo, Pennsylvania Game Commission unpublished data; Fig. 12). Although harvests of bobcat and fisher have been highly conservative to date, other metrics of estimating population trends substantiate increased populations, up to the mid-2010s (pers. com T. Hardisky and M. Lovallo, Pennsylvania Game Commission unpublished data).

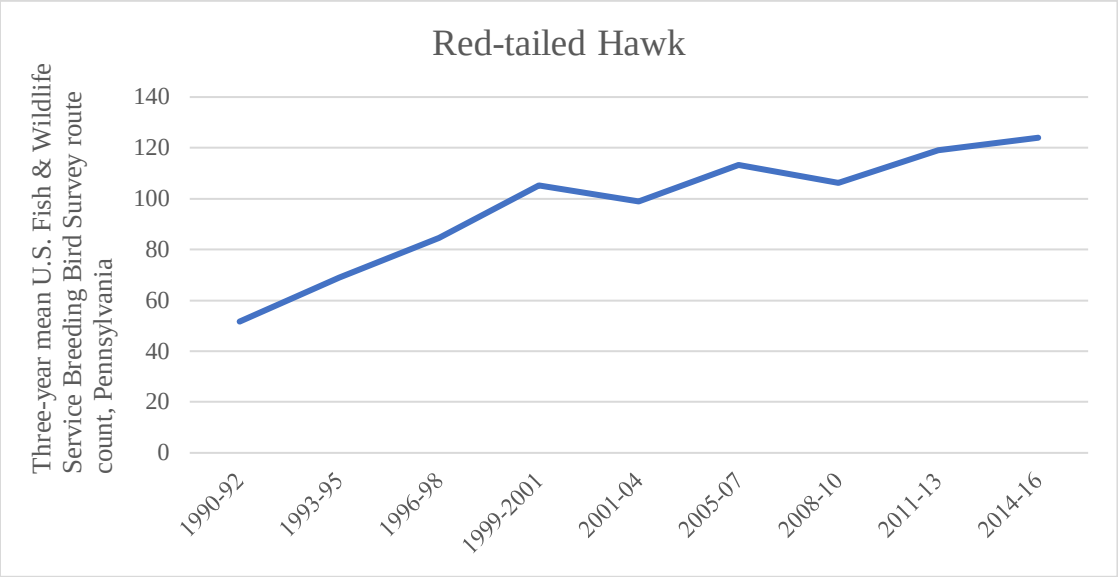

Figure 11. Three-year mean route count of red-tailed hawks, from US Fish and Wildlife Service Breeding Bird Surveys, Pennsylvania, 1990-2016.

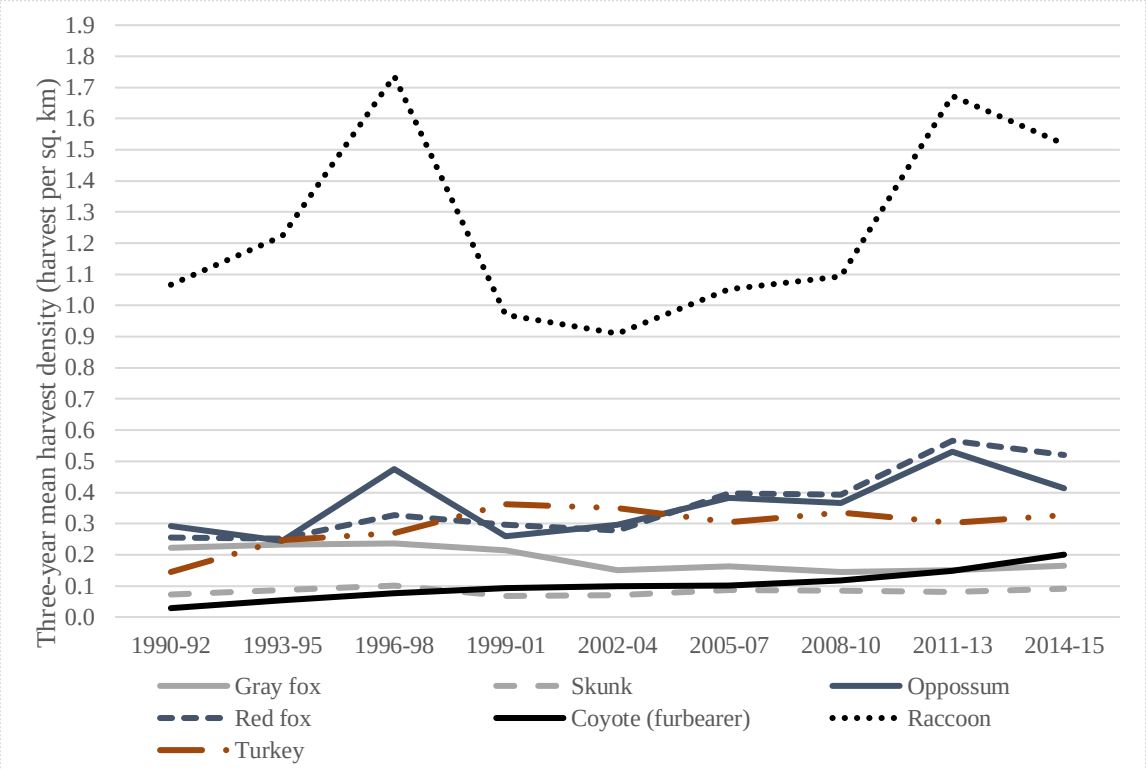

Figure 12. Three-year mean furbearer and wild turkey harvest density (harvest per square kilometer of land area) in Pennsylvania, 1990-92 to 2014-15, as determined from agency annual furbearer hunter survey.

Hunting Pressure

Considerable research has been conducted to understand the effects of hunting on turkey populations in the Northeast. While turkey populations were expanding (1960-2003), there is no evidence hunting pressure affected populations; rather, biologists hypothesize that high annual reproductive capacity offset any possible negative effects of hunting mortality (Porter et al. 1990). Now that turkey populations have declined after restoration and reproductive output has decreased, recent studies have shown that conservative hunting season structures are important for maintaining turkey populations.

Spring harvest is the single greatest mortality factor of adult male wild turkeys (Godwin et al. 1991, Paisley et al. 1996, Wright and Vangilder 2005, Thogmartin and Schaeffer 2000, Holdstock et al. 2006, Moore et al. 2008, Diefenbach et al. 2012) and is considered additive to other mortality sources because natural survival during the remainder of the year is high, providing little opportunity for compensating increases in survival to offset hunting mortality (Little et al. 1990, Vangilder and Kurzejeski 1995, Healy and Powell 1999). Moore et al. (2008) demonstrated significantly lower annual male survival rates in an area with a spring season (54%) versus that with no spring season (71%), during 1998-2000 in South Carolina, and concluded that spring gobbler harvests are additive mortality. However, they also concluded that even in years of low reproductive rates the spring-only harvest appeared to have minimal effect on turkey populations. In northern New Jersey from 2000−04, spring adult harvest rates (29%) were greater than those for juveniles (10%; Eriksen et al. 2011). Comparatively, spring harvest rates were substantially higher in New York, Pennsylvania and Ohio, for both adults (35%, 38% and 39%, respectively) and juveniles (18%, 27% and 17%, respectively; Diefenbach et al. 2012). Additionally, Ohio estimated, via radio-tagged males, illegal kills of 14% (M. Reynolds, Ohio Department of Natural Resources unpublished data). Consequently, Diefenbach et al. (2012) concluded the additional mortality from illegal kills and crippling loss could result in an overall spring hunting mortality rate (legal harvest, illegal kills, and crippling loss) of 30-35% in New York and Ohio and >40% in Pennsylvania.

High spring harvest rates of adult males were sustainable for two reasons. First, season opening dates were set to generally correspond with hen nest incubation such that hen harvest and disturbance by hunters were minimized because most hens were occupied with incubating nests. Therefore, spring hunting is not thought to affect nest rates or nest success. Second, juvenile male harvest rates were significantly lower than that of adults (18% in New York, 27% in PA and 17% in Ohio). Juvenile male survival rates (64% in NY, 65% in PA and 87% in OH) were 20-40% greater than that of adults such that high recruitment of juveniles into the adult population the following year was sufficient to maintain populations (Diefenbach et al. 2012). However, if

multiple years with high harvest rates on adult males change age structure such that juvenile males comprise a larger portion of the spring population, hunter satisfaction may be negatively affected (Healy and Powell 1999, Diefenbach et al. 2012). If high gobbler harvest is coupled with a season structure whereby the season opens prior to mating activity, enough gobbler harvest could occur to impact hen nesting rates and egg fertility (Miller et al. 1997, Healy and Powell 1999, Moore et al. 2008). Regulating hunting pressure via season structure places great responsibility on managers to forecast the effects of harvest on populations at various densities and on hunter satisfaction. However, the PGC does not express spring harvest goals in terms of desired harvest rates. Rather, the PGC sets conservative spring seasons according to the timing of the breeding season to ensure minimal biological impacts to the population.

As PGC studies have shown, fall hunting can affect turkey populations now that they are no longer experiencing exponential growth rates. In WMU 5A, population decline from 1999−2001 was partially due to mortality from fall harvest (Casalena et al. 2007). A 7-year fall season closure, accompanied by several consecutive years of above average recruitment, and targeted habitat improvements, assisted population recovery such that a short fall season has had no additive effects on the turkey population (Casalena 2016). Further, a PGC study from 2010-2014, showed that a longer fall season length in northern Pennsylvania compared to a shorter season length in southcentral Pennsylvania increased fall hen harvest rates by 1.7%, which represented a 20% or more relative change in absolute hen harvest rate (Casalena and Diefenbach 2016). Studies in Virginia and West Virginia showed similar results to ours (Norman and Steffen 2003), as well as fall harvest affecting populations, and subsequent spring harvest due to the subsequent decrease in nesting/brood rearing, i.e., hen, population (Pack et al. 1999, Alpizar-Jara et al. 2001). Population models have shown that harvesting 5-10% of the fall population will allow continued population growth (Vangilder and Kurzejeski 1995, Healy and Powell 1999), but these studies were conducted when turkey populations were increasing with high reproductive output. Current turkey populations generally have more numerous consecutive years of low poult recruitment, and in these cases may warrant more restrictive fall season regulations.

Establishing fall seasons is inherently more complex than establishing spring seasons because, in the fall, all age and sex classes are harvested, population size varies annually according to WMU, and food resources/weather affect hunting vulnerability; therefore, wildlife managers typically set regulations conservatively (i.e., season length, season timing, bag limits, permit allocations; Healy and Powell 1999). During this management plan cycle, 17 strategies within the population objective (1.1-1.6 and 1.8-1.16), 1 strategy within the habitat objective (2.4), 2 strategies each within the information and education (3.1 and 3.7) and cooperative partnerships (6.2 and 6.4) objectives, and all strategies within the hunting heritage/hunter safety and wild turkey protection objectives focus either directly, or indirectly, on turkey harvest.

Interactions of Factors

The above environmental factors affect turkey populations both individually and interactively. They have challenged us to reexamine our expectations for turkey abundance and productivity and identify where and how limited resources can best be applied for maximum benefit to turkeys. High quality habitat remains the key to productive wildlife populations, such that optimal habitat conditions may buffer negative effects of weather, predation, disease, and hunting. However, with the decline in landscape-scale habitat quality, this buffering effect will not function as effectively. While predation can play a role in limiting local turkey populations, higher than average predation rates may be symptomatic of a landscape with poor habitat quality causing turkeys and their young to be more vulnerable to predation, particularly during extreme weather events. For example, poor habitat for a hen with her brood in rainy conditions limits her ability to effectively keep her brood dry, warm and quiet, thus, making the brood more susceptible to dying from exposure, and/or all of them to be more susceptible to predation.

Research is showing the connection between reproductive success and habitat heterogeneity at various scales may be predator abundance and behavior, demonstrating new complexity in our understanding of predation (Brautigam et al. 2015, Byrne and Chamberlain 2015, Porter et al. 2015). For example, in agricultural landscapes with a high density of edges (i.e., many agricultural fields mixed with woods) predation rates of turkey nests are higher than that in more homogenous forested landscapes (Fleming and Porter 2015). Fleming and Porter (2015) found that turkey nest predation is influenced at three scales: nest, patch and landscape levels. At the nest level, the predator's ability to locate a nest is dependent on the amount/quality of cover. At the patch level, the predator's behavior (search pattern) is affected by the amount of edge, forest age, and distance to edge. At the landscape level, predator population density is related to the diversity of the landscape such that in highly diverse agricultural landscapes, predator populations are most dense due to the abundance of prey foods, and that density affects nest success. Fleming and Porter (2015) found lower nest predation in more homogenous forested landscapes. Additionally, negative effects of unpredictable severe weather conditions (winter and spring; U.S. Global Change Research Program 2014) and potential disease occurrences amplify effects of poor habitat quality and predation. Weather affects poult survival directly and indirectly through predation and food availability, and quality habitat is essential for escape cover and poult nutritional requirements (Porter 1992, Harper et al. 2001, Backs and Bledsoe 2011).

Nest success and poult survival are essential for recruitment and population growth, and overharvest during the fall season, combined with low recruitment over time, will decimate a population. Regional differences in habitat and weather likely affect populations such that habitat/weather/harvest interactions are more evident in poorer quality habitat whereas higher

quality habitat can sustain higher harvests given the same effects of weather. Conversely, low quality habitat has lower recruitment potential and, thus, more conservative harvest management must be maintained. This is especially important with declining wild turkey populations, which are more vulnerable to harvests, as hunter harvests may have a more detrimental impact where population densities are low (Healy and Powell 1999, Norman et al. 2001b, Norman and Steffen 2003, Casalena et al. 2015b).

While successive years with above-average reproductive success can allow turkey populations to temporarily increase, the apparent overall downward trend in populations over the past 15 years may be indicative of a larger, systemic problem that is not being counteracted by good production years. This downward trend is likely being intensified due to the interaction of the various environmental factors, and harvest. The PGC sets fall turkey hunting seasons in April, prior to knowing the effect of the winter on breeding conditions and the effects of weather, habitat quality and predation on annual recruitment (see Turkey Season Setting section). This time lag-induced information gap on current population trends prevents us from quickly adjusting hunting seasons. The time lag is exacerbated by the current method of fall hunting season setting which requires comparing current population trend indices to the previous three-year average. This was in place because when turkey populations were expanding, their annual population fluctuations could reach 50%. However, population increases do not occur as often, and declines now occur more often than increases, which makes the current reactive approach to population trends inadequate to avoid negative impacts of harvest mortality. Future turkey populations likely will not reach the same densities as during their peak of restoration due to irreversible changes in landscape-scale habitat, increased density and diversity of predator communities, and unknown effects of disease and weather. The structured decision protocol for hunting season recommendations being developed during this management plan cycle (Strategy 1.13) will allow for a more proactive season-setting approach that provides maximum hunting opportunity while protecting the population from significant declines.

Population Dynamics

Reproduction

Historical nesting and recruitment rates, while turkey populations were being restored and exhibiting exponential population growth, likely differed from current levels because current populations exhibit lower reproductive rates likely due to less favorable conditions than existed during restoration (i.e., habitat, weather, predation, disease, hunting pressure, and interactions of these factors, as previously discussed). Therefore, population dynamics data presented here are from research conducted since the completion of restoration; unfortunately, relatively few studies of population dynamics have been conducted since restoration has been completed. Historical and

current research have shown that both recruitment and female survival are important factors impacting the growth of wild turkey populations, and monitoring both continue to be important (Warnke and Rolley 2007). The PGC can positively influence recruitment and female survival via habitat management, and female survival via harvest management and education.

Reproductive effort and presumed incubation success of radio-tagged hens vary considerably among years and between age-classes (Casalena 2016). In Pennsylvania, nest incubation rates from satellite transmittered hens from 2010-2015 varied from 60-98% for adults, and 45-60% for first-year hens (Casalena in prep). The low incubation rates were during a cold, wet spring after a harsh winter with low mast crop supplies, while nearly all adult hens incubated at least one nest during a normal spring followed by a warm winter with abundant mast crops. Swanson and Reynolds (2011) reported that Ohio turkeys showed higher than average reproductive rates from 2002-2006. Initial nesting rate did not differ between adults (91%) and first-year hens (85%), although all renest attempts were by adult hens. Adult hens exhibited a higher incubation completion rate (71%) than first-year hens (49%), and no first-year hens that completed incubation were observed with poults 3-4 weeks post-hatch. Total recruitment (number of poults alive 3-4 weeks post-hatch per female alive on 1 April) was 3.0 and ranged 1.9-3.6 (Swanson and Reynolds 2011). They explained these higher than normal reproductive rates for an established turkey population could have resulted from a larger proportion of adult versus first-year hen turkeys in the population (due, in part from the most successful turkey reproductive season on record 3 years prior to the study) and the mast supply in this oak-hickory forest dominated landscape being average to above average all 5 years of the study (Swanson and Reynolds 2011). They concluded that female turkey age structure is important to recruitment (Swanson and Reynolds 2011). Additionally, Badyaev et al. (1996) found that female turkeys that nested earlier in the spring had higher nesting survival than did females that nested later in the spring.

While there are current reproductive data for 7 WMUs, these data are lacking for the remaining 16, including the 5 WMUs that exhibit the highest habitat suitability. Obtaining a comprehensive estimate of turkey reproduction merits additional research as time and resources permit (Strategy 1.17). This information is important for modeling current populations by WMU, for determining how reproduction is related to Pennsylvania's habitat quality, and for understanding the population structure by WMU and how Pennsylvania's turkey populations differ from those in other states.

Recruitment is determined annually across the Northeast states, including Pennsylvania, via summer turkey sighting surveys. Recruitment (poults per all hens seen during August) is a measure of young entering the fall population based on the number of hens in the population. By August, most poult mortality has occurred; those seen in August are representative of the fall population and are correlated with fall harvest (Wunz and Shope 1980, Wunz and Ross 1990, Healy and

Powell 1999). The 2008-13 average poult to hen ratio in Pennsylvania was 2.1, but averaged 3.1 across the entire Mid-Atlantic States, and 3.5 across the New England states (Casalena et al. 2015*b*). Lobdell et al. (1972), using population simulations determined that a mean of 3.03 young per adult female (range 2.28-3.78) was needed to maintain a population of 1,000 eastern wild turkeys for a 100-year period. These conclusions might be outdated because their modeling was based on expanding turkey populations. The variability of productivity in Pennsylvania demonstrates that interactions of multiple factors - weather, food supply, habitat, predation, and potentially disease – can impact annual recruitment (Casalena et al. 2015*a*).

Survival

Diefenbach et al. (2012) determined male survival rates via leg band returns in Pennsylvania, New York and Ohio (2006-09). In all 3 states, annual survival rates of juvenile males were approximately twice that of adult males (juvenile survival: 63.5% in New York, 65.3% in Pennsylvania and 77.0% in Ohio; adult survival: 30.2% in Ohio, 34.0% in New York and 40.9% in Pennsylvania). In New Jersey, annual survival rates (2000-04) were slightly higher for both age classes but remained significantly higher for juveniles (81% juvenile and 39% adult; Eriksen et al. 2011). Also, male survival rates in South Carolina from 1999-2000 were significantly higher in an area with no turkey hunting (71%) versus an area with a spring gobbler season (54%; Moore et al. 2008). Several studies have noted most natural mortality of male turkeys occurs during spring, when they are at greatest risk of predation due to being focused on attracting and mating with hens (Thogmartin and Schaeffer 2000, Moore et al. 2008)

From 2010-2014 in southcentral/southwest Pennsylvania (WMUs 2C, 2E, 4A, 4B and 4D), female turkey survival rates varied annually and increased from 34%-71%. In northcentral Pennsylvania (WMUs 2F, 2G and 2H) during the same years, female turkey survival rates also increased, from 19%-56%, which suggested these populations were increasing (Casalena et al. 2016). Juvenile survival (17%-60%) generally was lower than adult survival (37%-73%), but 95% confidence intervals overlapped, and sample sizes of juveniles were too low to determine differences between study areas (Casalena et al. 2016). In southeastern Ohio, female survival was 59% for juveniles and 71% for adults, but 95% confidence intervals overlapped (Reynolds and Swanson 2011). In New York, survival of females (juveniles and adults) was 34% from January-September 2013-2015 (Diefenbach 2015).

Survival rates in the remaining 15 WMUs are unknown, but likely are like those from the 2010-2014 hen study. However, additional data collection to document those rates is desirable (Strategy 1.9). Fall hunting season length varies among WMUs, and, therefore, annual survival rates also vary. Wild turkey survival, by sex and age, in WMUs without fall seasons is an area needing

additional research in Pennsylvania, especially as it relates to recruitment the next summer (Strategy 1.17).

Harvest Rates

As shown in the previous section, spring harvest rates differ between juvenile and adult males (Vangilder 1992, Vangilder and Kurzejeski 1995, Diefenbach et al. 2012, Eriksen et al. 2011). Spring harvest rates in Pennsylvania averaged 38% for adults and 27% for juveniles (Diefenbach et al. 2012). Harvest rates may change as the turkey population and hunter densities change. Therefore, strategy 1.8 (winter leg-banding to obtain harvest rate data in each WMU) is in place to obtain harvest rate data to provide more in-depth knowledge of harvest rates for more precise harvest management in the future (see also next section regarding harvest rates in each WMU).

Estimated fall hen harvest rates in New York ranged 1-3% from 2013-2015 (Diefenbach 2015). Average female harvest rates during fall in southeastern Ohio (legal + illegal kills) ranged 0-5% (Reynolds and Swanson 2011). In comparison, harvest rates in Pennsylvania ranged 2-10% during 2010-2014 (Table 6; Casalena and Diefenbach 2016). Harvest rates changed when season length changed in Pennsylvania such that harvest rates were lower during 2-week seasons and higher during 3-week seasons (Fig. 3). Harvest rates generally decreased throughout the study even though the number of fall hunters increased each year, suggesting the populations in both study areas were increasing. Additional data on fall harvest rates are needed in the northeast and southeast regions of Pennsylvania. Spring and fall harvests are believed to be additive for hens; illegal taking of hens during the spring season will reduce the available fall take (Vangilder and Kurzejeski 1995). In Ohio, illegal hen kill exceeded the legal harvest and were distributed throughout spring and fall hunting seasons (Ohio's spring season opened prior to the median date of nest incubation initiation), such that Ohio biologists cautioned further lengthening of the fall turkey season as it could increase hen hunting mortality (Reynolds and Swanson 2011). Illegal spring kill is of less concern in Pennsylvania because the spring season opens in conjunction with nest incubation such that most hens are incubating and therefore unavailable to come to a hunter's call and be mistakenly/illegally shot. For example, illegal hen kill during the spring season was 1.4% in Pennsylvania (2010-2014), compared to 6.0% in Virginia (1989-1994) where the spring season opens during turkey mating period, and 2.5% in West Virginia (1989-1994) where the season opens during turkey hen egg-laying period (Casalena et al. 2015, Norman et al. 2001).

Table 6. Estimated harvest rates for satellite-transmittered or leg-banded hen wild turkeys, Pennsylvania, by study area and year, 2010-2014. Year 2010 was an experimental year. In 2011 and 2012, fall season length was 2 weeks + 3 days in Study Area 1, and 3 weeks (closed on Friday) + 3 days in Study Area 2. Season length was switched between Study Areas in 2013 and 2014.

	Study Area 1 (WMUs 2C, 2E, 4A, 4D)				Study Area 2 (WMUs 2F, 2G, 2H)			
Year	Harvest Rates	SE (Hˆ)	LCL	UCL	Harvest Rates	SE (Hˆ)	LCL	UCL
2010	6.8%	0.029	0.031	0.151	6.4%	0.027	0.029	0.142
2011	7.9%	0.028	0.040	0.157	9.0%	0.045	0.036	0.226
2012	2.0%	0.012	0.007	0.058	4.3%	0.020	0.018	0.102
2013	4.8%	0.022	0.021	0.113	3.9%	0.016	0.018	0.087
2014	3.7%	0.019	0.014	0.096	1.7%	0.010	0.006	0.051

Harvest Rate by WMU

Not only do fall harvest rates vary among WMUs due to fall season length, but both spring and fall harvest rates vary due to differences in turkey-habitat relationships, weather, interspecific interactions with predators and hunter pressure (Parent et al. 2015). During the gobbler harvest rate study from 2006-09 Diefenbach et al. (2012) constructed models in which spring harvest rates varied among management zones (combinations of WMUs and physiographic regions) within New York, Pennsylvania and Ohio. Although the models did not show significant differences between management units, differences in spring harvest rates among management zones may have been large enough to have biological and management significance, but sample sizes were not sufficient. Therefore, additional research is needed to determine spring harvest rates in each WMU, or by groupings of WMUs (Strategy 1.8).

Home Ranges

Recent studies on turkey home ranges are limited. During the gobbler harvest rate study, the average distance male turkeys moved from winter trapping to spring harvest was 4 miles, but distance traveled was greater for juvenile males (4.8 miles) than adult males (2.9 miles) (Diefenbach et al. 2012). Similarly, for hens, the average distance traveled from trapping location to recovery location (i.e., harvest location, or where carcass or leg-band/transmitter was found) was greater for juvenile hens (5.7 miles) than adult hens (3.3 miles; Pennsylvania Game Commission unpublished data).

Home ranges of male wild turkeys in West Virginia during April-May (2006-07) averaged 1,014 acres for adult males (n=7) and 404 acres for juvenile males (n=12; Rauch et al. 2011). Although not statistically different because sample size was low, home ranges of 2-year-old males were 904 acres compared to 1,124 acres for 3+ year-old males. Also, adult males were dispersed randomly,

whereas juvenile males were clustered in the study area, as expected. Only males that were not harvested were used for calculations (harvested males didn't have enough telemetry locations). No female turkeys were transmittered. The researchers found larger male home ranges where turkey populations were larger, possibly due to more hens available.

Male home ranges in New Jersey were similar between juveniles (1,688 acres; n=14) and adults (1,683 acres; n=12; Vollmer 2001). Home ranges were affected by habitat type and quality and human interference, as would be expected.

Female wintering home ranges in southwestern Virginia averaged 553 acres in agricultural areas and 618 acres in forested areas, where no baiting occurred (baiting wildlife is legal in Virginia; Burhans 1996).

V. WILD TURKEY POPULATION MANAGEMENT

Harvest Management

Pennsylvania's wild turkey harvest strategies are to maintain both a statewide spring season (bearded turkeys only) that is biologically timed to open during the median peak of nest incubation initiation (to protect nesting hens), and a conservative fall either-sex season in WMUs that can sustain a fall harvest, while maintaining or enhancing the tradition/heritage of the fall turkey season commensurate with turkey populations at or below social carrying capacity, i.e., at a population density that causes little to no human conflicts. Pennsylvania typically leads the country in spring turkey hunters with 226,700 (2012-2014 average), compared to the next closest state, Missouri with 148,900 spring turkey hunters in 2014. Pennsylvania typically ranks third in spring turkey harvests, with the 2012-2014 average of 38,200 (<7% were estimated to be hens), compared to Missouri's and Georgia's 2014 harvest of 47,600 and 44,100, respectively (Eriksen et al. 2015). Pennsylvania typically leads the country in fall turkey hunters (200,000 average from 2012-2014), compared to the next closest state, Wisconsin (57,800) and Texas (54,800) in 2013. Pennsylvania's fall harvest (16,800 in 2013) typically is second only to Texas (19,100 in 2013; Eriksen et al. 2015), when most turkeys harvested are females. Pennsylvania consistently leads the country in combined spring + fall turkey harvests, as well as hunters.

Annual statewide total (spring + fall) harvests, determined from surveys, increased steadily from the 1930s until the early 2000s (Fig. 13). Nearly 700,000 turkeys were harvested from 2000-2010, averaging nearly 70,000 turkeys per year. Since then, harvests during the 2010s have declined to approximately 52,000 per year. Even though harvests have declined since their peaks of 2000-2001, Pennsylvania continues to lead the country in total harvests (spring + fall). During the 2008-

2009 hunting seasons Pennsylvania's total harvest of 70,425 turkeys comprised 8.3% of the total nationwide harvest of 845,559, and 2013-2014 total harvest of 58,015 comprised 7.5% of the total nationwide harvest of 769,625 (Eriksen et al. 2015).

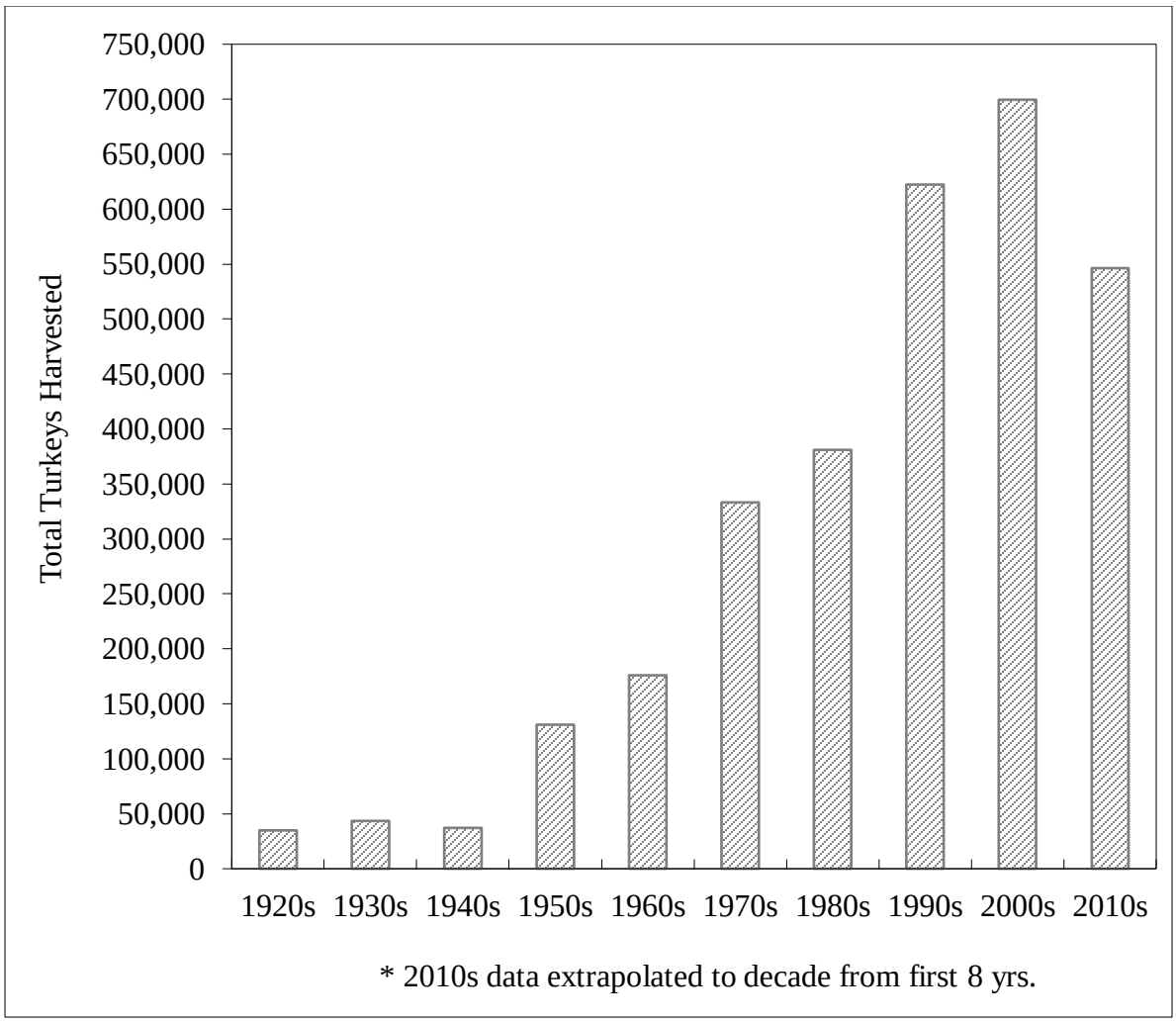

Figure 13. Pennsylvania total (spring + fall) turkey harvest trends in each decade (as of 2017.)

Turkey Season Setting

Turkey season lengths are proposed each January to the Board of Commissioners in conjunction with all game species season/bag limits. The Board reviews the staff recommended seasons as well as public comments to incorporate both scientific and social aspects of population management. Following a 60-day public comment period, the Commission adopts, each April, final seasons and bag limits for the next hunting year, which begins 1 July. Fall season lengths are established prior to knowledge of the outcome of the spring breeding season, and the spring season is established over one year in advance. This is an additional reason that seasons are set conservatively.

The general hunting license (valid July 1-June 30) permits hunters to harvest 1 turkey (either-sex) during the fall season and 1 bearded turkey during the spring season. Since 2006 spring turkey hunters may purchase a second spring tag, which permits harvest of an additional bearded turkey, with one per day bag limit. Turkeys are a big-game species in Pennsylvania and, therefore, hunters are required to report their harvest to the PGC within 10 days, via internet, phone or harvest report card, or 5 days for Mentored hunters.

As a result of research demonstrating the timing of the spring hunting season minimizes hen turkey disturbance and harvest, thus having minimal effect on the turkey populations (Healy and Powell 1999, Norman et al. 2001, Casalena et al. 2015*b*), the PGC expanded spring opportunities by implementing a youth hunt (2004), mentored youth hunter program (2006), 2-bird bag limit (with purchase of a second tag; 2006), extension of the season until May 31 (2011), and all-day hunting during the second half of the spring season (2011).

The fall season had been more traditional in Pennsylvania, being closed statewide only 3 years (1914, 1915 and 1926) since turkey seasons were established in 1897. Conversely, the spring season was closed from 1914-1967 (Kosack 1995). However, the spring season has gradually become more popular than fall; since 2000 spring hunters have annually exceeded fall turkey hunters, and since 2001, spring harvests have annually exceeded fall harvests. This shift toward a larger spring harvest of gobblers and a smaller hen harvest in the fall is in line with our population objective of sustaining or enhancing populations, because of the research that has revealed fall harvest can depress population growth, and turkey populations are particularly sensitive to adult hen mortality; thus, fall harvest is additive mortality (Healy and Powell 1999, Casalena and Diefenbach 2016). Because all licensed hunters in Pennsylvania can participate in turkey hunting, the PGC manages fall turkey harvests by season length within WMUs (Tables 7-8). Results of the 2010-2014 hen harvest and survival rate study showed that a one-week change in fall season length can effectively change hen harvest rates for management purposes (Casalena and Diefenbach 2016). Due to higher turkey populations from 1995-2003, the PGC expanded fall turkey hunting opportunities with longer fall seasons in most WMUs. However, since 2004, fall seasons have mainly been shortened in accordance with declining population trends in each WMU (Tables 7 and 8). During this management plan cycle (2018-2027), the hen harvest and survival rate study results are being used to create a turkey population model and a structured decision protocol for recommending fall season lengths (Strategies 1.10-1.13).

Table 7. Pennsylvania fall turkey hunting season lengths in each Wildlife Management Unit, (WMU), 2003-2009.

	Fall turkey hunting season length[a]						
WMU	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1A (Sh,B&A)[b]	3	3	2	2	2	2	2
1B (Sh,B&A)[b]	2	2	2	2	2	2	2
2A (Sh,B&A)[b]	3	3	3	3	2	2	2
2B (Sh,B&A)[b]	3	3	3	3	3	3	3
2C	3	2	2	2	2	2	2
2D	3	3	3	3	3	3	2
2E	3	2	2	2	2	2	2
2F	3	3	3	3	2	2	2
2G	3	3	3	3	3	3	3
2H[c]							
3A	3	3	3	3	3	3	3
3B	3	3	3	3	3	3	3
3C	3	3	3	3	3	3	3
3D	3	3	3	3	3	3	3
4A	3	2	2	2	2	2	2
4B	3	2	2	2	2	2	2
4C	3	3	3	3	3	3	3
4D	3	2	2	2	3	3	3
4E	3	3	3	3	3	3	3
5A	Closed	Closed	Closed	Closed	Closed	Closed	Closed
5B	Closed	Closed	Closed	Closed	Closed	Closed	Closed
5C (Sh,B&A)[b]	1	1	6d	6d	6d	6d	4d
5D (Sh,B&A)[b]	1	1	6d	6d	6d	6d	4d

[a] Lengths recorded in weeks, unless otherwise specified; d=days. [b] Sh,B&A = Shotgun or bow and arrow only.
[c] 2H created in 2013 when 2G was split into 2 WMUs.

Table 8. Pennsylvania fall turkey hunting season lengths (weeks, days) in each Wildlife Management Unit, (WMU), 2010-2018. In 2010, a second season was added (Thanksgiving, plus the following 2 days).

	Fall turkey hunting season length[a]								
WMU	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
1A[b]	6d + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	1 + 3d	1 + 3d	1 + 3d
1B[b]	6d + 3d	2 + 3d	2 + 3d	1 + 3d	1 + 3d	1 + 3d	1	1	1
2A[b]	6d + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	1 + 3d	1 + 3d	1 + 3d
2B (Sh,B&A)[c]	12d + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d
2C	6d + 3d	2 + 3d	2 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d
2D	6d + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
2E	6d + 3d	2 + 3d	2 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
2F	12d + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
2G	12d + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
2H				2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
3A	12d + 3d	3 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
3B	12d + 3d	3 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
3C	12d + 3d	3 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
3D	12d + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
4A	6d + 3d	2 + 3d	2 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	1 + 3d	1 + 3d
4B	6d + 3d	2 + 3d	2 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	1 + 3d	1 + 3d
4C	12d + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d
4D	6d + 3d	2 + 3d	2 + 3d	3 + 3d	3 + 3d	2 + 3d	2 + 3d	2 + 3d	2 + 3d
4E	12d + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d	3 + 3d
5A	3d,Tu-Th	3d,Tu-Th	3d,Tu-Th	3d,Tu-Th	3d,Th-Sa	3d,Th-Sa	3d,Th-Sa	3d,Th-Sa	3d,Th-Sa
5B	Closed	Closed	Closed	Closed	Closed	Closed	Closed	3d,Tu-Th	3d,Tu-Th
5C (Sh,B&A)[c]	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
5D (Sh,B&A)[c]	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

[a] Lengths recorded in weeks, unless otherwise specified; d=days.

[b] Sh,B&A = Shotgun or bow and arrow only in WMUs 1A, 1B and 2A until 2012 when rifles were again permitted.

[c] Sh,B&A = Shotgun or bow and arrow only in WMUs 2B, 5C, and 5D.

Spring Turkey Hunting Season Management

The annual statewide spring, bearded bird only, hunting season opens the Saturday closest to 1 May, which is, on average, the median peak of nest incubation as determined by Rinell et al. (1965) and confirmed by Casalena et al. (2015*b*). Even though bearded hens are legal to harvest, the

emphasis is harvest of male turkeys after they have bred females, and protecting nesting hens from harvest. The PGC publicizes for hunters to consider, before harvesting a known bearded hen, bearded hens are adults that have high probability of nest success due to their previous experience and size. Bearded hens may add substantially to the local population if not harvested.

Timing of Spring Season

A common request from spring turkey hunters is to open the season earlier to hunt during the first peak of gobbling. Timing of spring hunting season is one area where biologically informed management can potentially reduce negative effects on the population (Healy and Powell 1999, Norman et al. 2001).

The PGC seeks to structure spring hunting season early enough to maximize hunter satisfaction, but late enough to reduce hen kill (i.e., legal + illegal harvest) and nest abandonment. The most important determinants of spring hunter satisfaction, according to hunter surveys are hearing, seeing and calling to male turkeys (Little et al. 2000, Swanson et al. 2007, Casalena et al. 2011, Isabella and Reitz 2015). Therefore, hunter satisfaction is maximized by seasons that coincide with peak of gobbling activity (Strategy 3.1; Norman et al. 2001, South Carolina Department of Natural Resources 2009). Gobbling activity in unhunted populations has a short peak during winter break-up of flocks and a longer, more consistent, peak near median date of nest incubation initiation (South Carolina Department of Natural Resources 2009). The longer peak in gobbling is due to increased efforts of male turkeys to locate receptive hens as fewer hens are receptive to gobbling once they begin incubation (Bevill 1974, Miller et al. 1997, Norman et al. 2001, South Carolina Department of Natural Resources 2009). However, spring turkey hunters have generally been interested in hunting males during the entire gobbling period, which covers mating, egg-laying, and incubation periods (Vangilder et al. 1990, Norman et al. 2001, Swanson et al. 2007, Casalena et al. 2011). Hunting during mating and egg-laying have potential negative biological effects, such as removing dominant males before they have bred hens, legal/illegal harvest of females, and nest abandonment (Gloutney et al. 1993, Palmer et al. 1993, Norman et al. 2001, Whitaker et al. 2007, South Carolina Department of Natural Resources 2009).

Pennsylvania and several other states have attempted to balance hunter satisfaction and hen protection by setting spring hunting season in accordance with median date of initiation of nest incubation (Strategy 1.1; Healy and Powell 1999, Casalena 2006, Whitaker et al. 2007, South Carolina Department of Natural Resources 2009, New York State Department of Environmental Conservation 2015). This hunting season timing should also maximize hunter satisfaction because of the second gobbling peak and increased response of male turkeys to hunters' calls during peak of initiation of nest incubation (Strategy 3.1; Bevill 1974, South Carolina Department of Natural Resources 2009). Pennsylvania's spring turkey season opening date (Saturday closest to 1 May)

is based on data collected 1953-1963, which showed that 53% of hens initiated incubation by 4 May (Rinell et al. 1965). The opening date coincides with incubation initiation dates of 5-9 May in the Mid-Atlantic States (Whitaker et al. 2007). Because >50 years have passed since Rinell et al. (1965), Casalena et al. (2015*b*) studied current incubation timing to determine if incubation initiation has changed due to a warming climate in the northern hemisphere and weather becoming more variable, which would warrant an earlier spring turkey season opener (Easterling et al. 2000, Magnuson et al. 2000, Coumou and Rahmstorf 2012). Research from 52 bird species (European and North American) demonstrated that egg-laying date is advancing an average 0.13 days per year (SE = 0.03, range -0.8 to 0.51), and egg-laying is occurring 2.4 (SE = 0.27, range -10.3 to -0.01) days earlier for every degree increase in centigrade (Dunn and Winkler 2010).

Although many bird species lay earlier when spring temperatures are warmer in any given year (Dunn 2004), a variety of other proximate factors are hypothesized to influence start of breeding for turkeys and other bird species, including precipitation, food abundance, breeding density, photoperiod, hormones and body condition (Porter et al. 1983, Vander Hagen et al. 1988, Blankenship 1992, Thogmartin and Johnson 1999, Pekins 2007, Porter 2007, Dawson 2008, Dunn and Winkler 2010). For most temperate-breeding birds, these factors are thought to act in a hierarchy, with increasing photoperiod as the primary cue for gonadal maturation and release of hormones during spring (Blankenship 1992, Dunn and Winkler 2010). Photoperiod is fixed at the same latitude but likely interacts simultaneously with these other environmental cues to set the physiological window during which egg-laying will occur (Dawson 2008, Schoech and Hahn 2008, Dunn and Winkler 2010). Mean annual temperatures in Pennsylvania have increased 1°C since the 1960s (Ross et al. 2013). Of the 254 hen turkeys with satellite transmitters monitored from 2010-2014, median incubation initiation date was 2 May, which was 2 days earlier than median date during the 1953-1963 study (Rinell et al. 1965, Casalena et al. 2015*b*). However, during both studies, incubation initiation varied greatly among years and individual hens. It is uncertain if the 2-day advancement in incubation initiation was due to annual variations in winter/spring weather and food resources or climate change. From 2010-2014, the maximum proportion of hens beginning incubation typically varied by several days (2010 and 2012) to >1 week (2011, 2013 and 2014; Fig. 14; Casalena et al. 2015*b*). During 4 of those 5 years the spring season opened 3 to 8 days prior to median date of incubation initiation. Due to the spring season structure of opening on a Saturday and annual variation in incubation initiation, a constant season opening date set near the long-term median date of incubation initiation exposes few additional hens to risk and hunter satisfaction is likely maintained at greater levels than would be seen with a more conservative approach of opening the season later (Casalena et al. 2015*b*). Of possibly greater concern than warming temperatures, climate change has resulted in increased annual variability in weather (Magnuson et al. 2000, Ross et al. 2013), which could lead to greater variation in nest initiation dates and more years when the season opening date may be suboptimal

for hunter satisfaction.

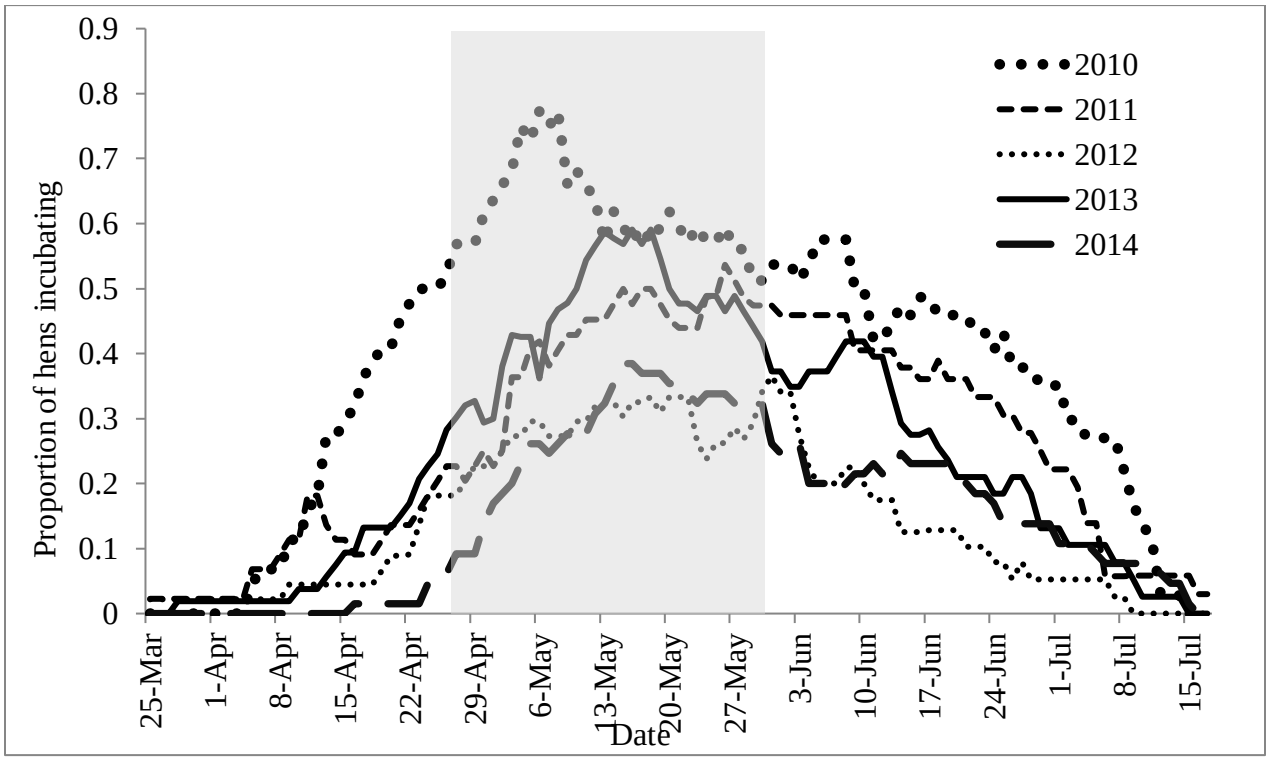

Figure 14. Proportion of satellite-transmittered eastern wild turkey hens incubating eggs by day in Pennsylvania, 2010-2014. Shaded area represents duration of spring turkey hunting season (not including youth season), from earliest season opening date of the 5 years represented, 27 April, to latest closing date of 31 May (Casalena et al. 2015).

Opening spring season prior to median date of incubation initiation has potential to increase hen harvest (both legal and mistaken). Norman et al. (2001) concluded that the high (6.0% ± 1.3 SE, *n* = 383) rate of illegal hen kill in Virginia during 1989-1994 was related to spring hunting season opening during peak mating season rather than during peak incubation. Females were more vulnerable to illegal kill during mating due to their tendency to associate with gobbling males, which increased likelihood of hens being harvested. Illegal hen kill in West Virginia was less during the same study at 2.5% (± 0.80 SE, *n* = 596) and their spring season generally opened during the hen egg-laying period (Norman et al. 2001). Illegal hen kill in Pennsylvania during 2010-2014 was 1.4% (SE = 0.56, *n* = 254, D. Diefenbach, U.S. Geological Survey unpublished data). Norman et al. (2001) concluded that likelihood of illegal female kill is probably highest during mating, intermediate during egg-laying (as observed with opening of West Virginia's season) and least during nest incubation initiation (as observed with opening of Pennsylvania's season).

Mississippi (Miller et al. 1998) and Iowa (Hubbard et al. 1999) have earlier spring seasons, lower

rates of hen kill, and lower hunter densities (Eriksen et al. 2015). Whether their lower rates of hen kill were due to lower hunter densities or hunter attitude (i.e., not wanting to shoot a hen) is unknown. However, spring hunter density (2.0 hunters/km^2; Casalena 2015*a*) and male harvest rates in Pennsylvania (0.35-0.39; Diefenbach et al. 2012) are the highest in the mid-Atlantic region (New York State Department of Environmental Conservation 2014). Therefore, an earlier spring season could have potential negative effects on population dynamics if hen kill increased, which could lead to negative effects on future harvests and hunter satisfaction. High hunter density could also increase risk of nest abandonment due to disturbance if the season began earlier. Research on this topic is lacking for turkeys, but research on waterfowl has shown risk of nest abandonment due to human disturbance is greater during egg-laying than during incubation (Gloutney et al. 1993). Additionally, Norman et al. (2001) and Healy and Powell (1999) noted illegal hen kill during spring may be more important for states that offer a fall either-sex season. Due to additive effect of harvest in turkey populations, Vangilder and Kurzejski (1995) and Healy and Powell (1999) cautioned that small changes in illegal female kill during spring have potential to limit a population's capacity for sustained fall harvest.

Youth Season

A statewide youth season is held the Saturday prior to the regular season opener. Therefore, it opens prior to the peak of nest incubation. The 2014-16 average harvest was 2,536 bearded turkeys, approximately 6 percent of the total spring harvest. However, the opportunity this provides Pennsylvania youth (average of 20,200 youth and mentored youth hunters) and potential hunter recruitment/retention outweigh the small harvest and risk of hen kill and disturbance incurred (Strategies 4.3 and 4.4). Youth season hunting closes at noon, and hunters are asked to be out of the woods by 1pm to protect nesting hens from disturbance. There could be potential negative effects with an all-day youth season, especially in areas where the turkey population is not increasing.

All-Day Spring Hunting

As with the youth season, hunting hours close at noon during the first two weeks of the regular spring season. From the third Monday in May through 31 May hunting hours close one-half hour after sunset. Sunday hunting is prohibited, and only shotguns and archery equipment may legally be used. All-day hunting is possible toward the end of the season because hunting pressure is largely reduced for various reasons, most hens are in their later stages of nest incubation making them even less likely to abandon their nests if disturbed, and hunting methods used in the afternoon/evening usually involves less moving on the part of hunters.

Assessment of 6 years of afternoon harvest data show this extra hunting time has consistently comprised a small portion (6.3%) of the overall season's reported harvest (Fig. 15). During the all-

day portion of the spring season, afternoon harvests comprised an average 19% of harvests (Fig. 16). For the afternoon segment, most of the harvest occurred between 4:00-8:00 pm. The latest reported harvests were between 8:30pm (2013) and 9:30pm (2015). Hunting hours closed from 8:40-9:16 pm depending on location and week.

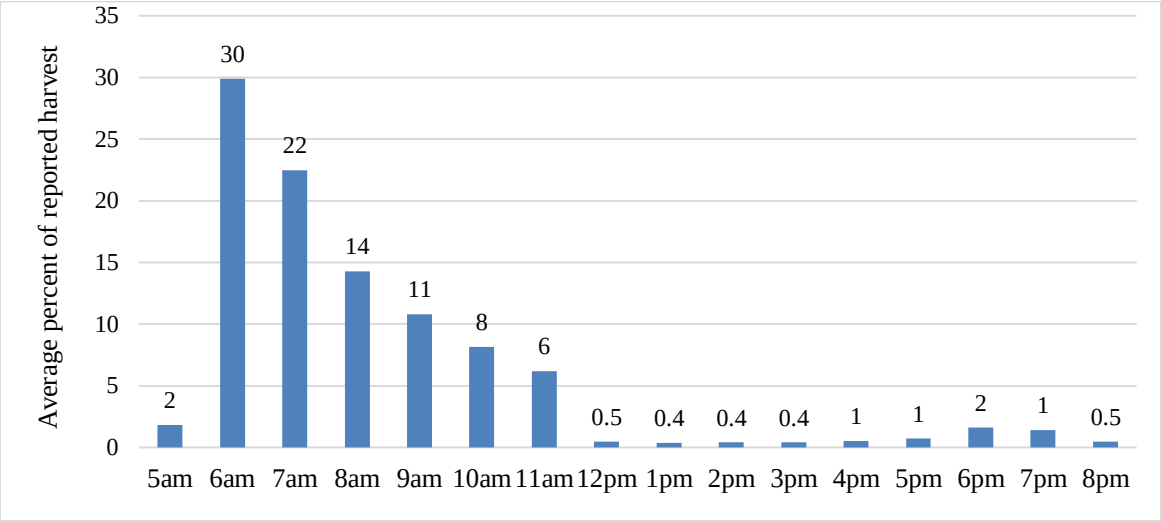

Figure 15. Percent of turkey harvest by hour throughout the entire Pennsylvania spring season, 2011-2016 average.

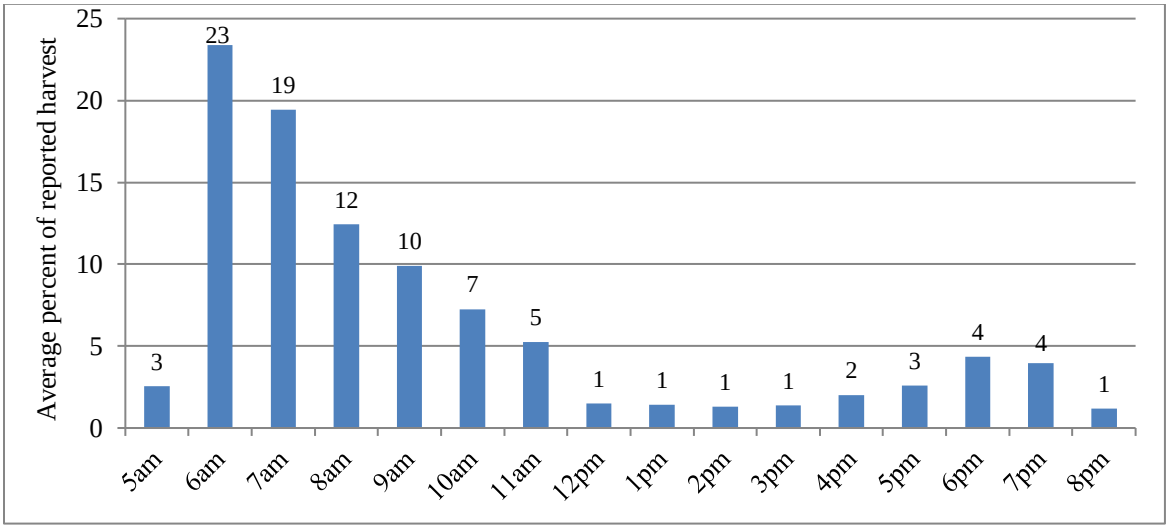

Figure 16. Percent of turkey harvest by hour during the all-day portion of the Pennsylvania spring season, 2011-2016 average.

Two-bird Spring Bag Limit

Since 2006, a two-bird spring bag limit has been an option for hunters who purchase the special spring license. Unlike the regular spring turkey hunting license that comes with the general license and reporting is required only if the hunter harvests a bird, the special spring license has mandatory reporting regardless of success or use within 10 days of the season ending. Sales of the special spring license continues to grow, particularly since 2010 when the license became available for purchase over the counter as soon as general hunting license sales begin (mid-June) until the day before the regular season opens. Previously sales were restricted to 1 January-1 April for administrative purposes. Average annual sales during the more restricted period (2006-2009) was 8,785, and from 2010-2016 was 16,336, an increase of 86%.

From 2006 to 2010 the PGC mailed reminder letters to 1,000 randomly selected special spring license holders who did not report. On average 5% of non-reporters harvested a second turkey. To account for non-reporting, 5% is added to harvest estimates to account for the non-reported harvest. The PGC will conduct the survey every ≥5 years, beginning 2018, to determine if the non-reporting average remains the same. For the 5-year period, 2012-16, an average 34% of second license purchasers hunted for a second bird with a 43% success rate, far exceeding the 16% success for spring turkey hunters harvesting their first turkey (Table 9).

Table 9. Percent of second spring license purchasers who hunted for a second turkey in Pennsylvania, 2012-2016, success rate, and the 5-year average.

Year	Percent hunted for second turkey	Success Rate (95% CI)
2016	31%	44% (30-59%)
2015	31%	43% (28-58%)
2014	37%	45% (36-59%)
2013	39%	41%
2012	30%	45%
Average	34%	43%

The 2014-16 second-bird harvest averaged 3,787, 8% of the total statewide harvest. There have been no negative effects to the turkey population from the two-bird spring bag limit. Second harvests and age structure of each WMU are monitored annually to provide continual assessment of any potential impact of the two-bird spring bag limit (Strategies 1.3, 1.4, 1.5, 1.16, and 4.4).

Thirty-four states, and the province of Ontario, have spring limits of more than one turkey (season limits of 2-5; mode is 2). Fifteen states have a one-turkey spring limit (Alaska does not have a wild turkey season). Many of the states that limit the harvest to one turkey per hunter have low turkey

population densities or hunting permit quotas that limit the number of turkey hunters (e.g., Delaware, Rhode Island, New Hampshire and Arizona).

Properly timed and implemented multiple-bird, spring limits have not caused turkey population declines (Casalena and Eriksen 2003). In Pennsylvania, there is a large turkey hunter base, a two-turkey season limit (with appropriate license), all-day hunting during the second half of the season, a season that runs until 31 May, and an adult gobbler harvest rate of 37.6% (which is about the maximum desired for maintaining hunter satisfaction and population objectives); all of which indicate further liberalization may cause declines in hunter satisfaction and turkey populations.

Fall Turkey Hunting Season Management

The traditional fall either-sex turkey season opens 4 Saturdays before Thanksgiving so that it does not overlap with the statewide rifle bear and deer seasons. Moreover, the timing is intended to avoid hunter conflicts and opportunistic turkey harvest, particularly with high-powered rifles. Harvest is regulated by season length varying from a closed season to 3 weeks and is annually set according to the population trend within each WMU. Since 2010, there is an additional 3-day Thanksgiving turkey season in WMUs where population data demonstrate the WMU can sustain additional harvest (Tables 7-8). Harvest during the Thanksgiving season equates to that of a one-week season (due to these days exhibiting high participation). Therefore, WMUs with a 3-week season and the Thanksgiving season essentially have a 4-week fall season; this exceeds the fall season length recommended in previous wild turkey management plans. The addition of the fall turkey mentored youth program in 2010 has not resulted in any harvest increase as the mentor must transfer their fall turkey tag to their mentored youth.

Opening day of the fall turkey season is separate from other big game and small game seasons. Pack (1986b) suggested that scheduling the opening of fall turkey season to not coincide with that of other game seasons has been effective at reducing harvest rates in West Virginia. During opening days, much of the turkey harvest was associated with opportunistic taking by hunters pursuing other species.

A challenge for the PGC is setting fall hunting seasons considering the biological and social tradeoffs involved (Strategies 1.2-1.4, 1.6, 1.10, 1.13, 1.14 and 1.15). Fall hunting opportunity is a tradition that is highly desired by stakeholders, but results in additive mortality especially now that populations are not exhibiting the exponential growth like that during population restoration (Little et al. 1990, Vangilder 1992, Healy and Powell 1999, Pack et al. 1999). Thus, fall hunting may decrease future turkey abundance and, in turn, ability of the agency to maximize other aspects of stakeholder satisfaction (e.g. spring hunting opportunity and success, viewing opportunities). The lower recruitment levels of current turkey populations may warrant using a lower threshold

for acceptable fall harvest rates than was previously used when setting fall seasons. These tradeoffs have become more pronounced as weather, habitat quality, and other external influences on populations have become less favorable, and in the face of our nascent ability to understand the complex interactions of these ecological factors, which tends to force us to manage reactively rather than proactively.

Also, during years of poor reproduction, the percentage of adult turkeys in the fall harvest increases (few juveniles available), providing a smaller carry-over of adult hens into the spring breeding population. When fall harvests approach or exceed spring harvests, population growth slows (Healy and Powell 1999, Pack et al. 1999). However, during population expansion it is believed the larger fall than spring harvests were sustainable due to tremendous turkey reproductive rates. Since 2001, once populations leveled off and then decreased, Pennsylvania's spring harvests consistently exceed fall harvests. The 2014-16 average spring harvest was 39,500 and the average fall harvest was 14,700. On average, from the hen study data of 2010-2014, 158,000 fall hunters harvested 2-10% of the female turkey population (D. R. Diefenbach, U.S. Geological Survey unpublished data).

Potential Future Fall Harvest Strategies

A possible strategy to reduce fall harvest of females is to establish a male-only fall season. An alternative is to establish a male-only season only during the Thanksgiving season, which would possibly allow for a longer regular fall season. Alabama and Florida have male-only fall seasons, but no northeast states use this regulation. This regulation change may not be popular with traditional fall turkey hunters, and may require considerable public education for acceptance, as was necessary in Florida.

Another possible future harvest strategy is to issue fall turkey season permits for each WMU, like the antlerless deer tag system. This, however, would be a major regulation change as a fall turkey tag currently is issued with every general hunting license.

Hunter surveys (strategy 3.1) will be used to obtain data on hunter opinion on various regulatory options. Human-dimensions data can be used by decision makers to select fall season structures that optimize the balance of biological and social concerns.

Fall Turkey Dogs

Use of dogs for fall turkey hunting has been legal since 2007. In 2007, 1% of respondents to the 2007-08 Pennsylvania Turkey Hunter Survey indicated hunting with a dog during the fall season; 33% succeeded in harvesting a turkey (Casalena et al. 2011). Since then, fall harvests have declined such that it is unlikely that use of dogs during fall turkey hunting has caused any significant

increase in fall hunter success. Questions about fall turkey dogs will be included during the 2018 turkey hunter survey.

Harvest Analyses

Harvest Trends

Preliminary harvest data have been collected since 1973 via mandatory harvest reporting by successful hunters within ten days of harvesting a turkey during each season via 3 options: postage-paid report cards issued with each license (or found in the Hunting and Trapping Digest); on-line; and telephone. Hunters report date, time, location (WMU, County, Township), sporting arm used, and age and sex of harvest.

Final harvest and hunter effort estimates are derived from annual surveys which collect data on WMU hunted, number of days hunted, number of turkeys harvested, and beginning the 2002-03 license year, sex and age of harvested turkeys at the statewide and WMU scales (Fig. 17; Tables 10-11). The Game-Take Survey (GTS), initiated in 1971, is annually distributed (mailed, and web-based since 2012) to 2% of Pennsylvania hunters after small game seasons end each March and finalized each July (Johnson 2016). Since 2012, a Mentored Youth Hunter Survey (MYHS) has been conducted annually and is implemented concurrently with GTS. Both surveys were used to estimate spring turkey harvest until a separate Spring Turkey Hunter Survey (STHS) and Mentored Youth Spring Turkey Hunter Survey (MYSTHS) were initiated in 2012 and 2013, respectively. Separate spring surveys were initiated to acquire more timely data and eliminate previous errors in data collection and hunter memory bias as the GTS and MYHS distribution is in March well after the previous spring turkey season. Each June the STHS is distributed (mail and web-based response options) to all GTS respondents (ca.10,000 hunters). The MYSTHS is distributed to ca. 1,000 respondents to the MYHS.

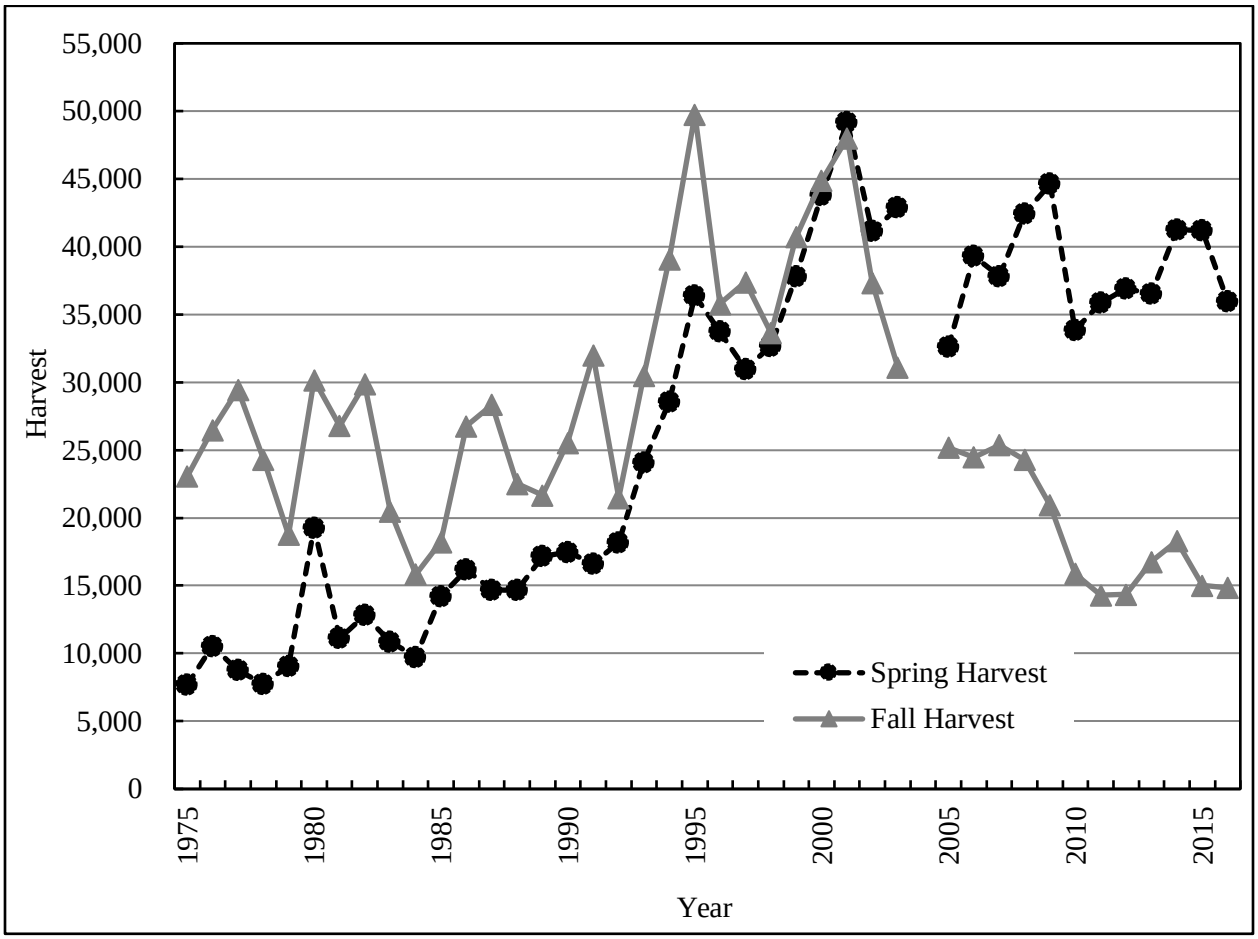

Figure 17. Statewide spring and fall Pennsylvania wild turkey harvests, 1975-2016, from annual hunter surveys. No data for 2004. Spring harvests beginning 2006 include second bird harvests from hunters who purchased a second bird license.

Table 10. Pennsylvania spring wild turkey harvests, by Wildlife Management Unit (WMU), as determined from hunter surveys, 2006-2016, and the 2006-15 average. Harvests include first and second turkey harvests. Second turkey harvest was allowed with purchase of special spring license beginning 2006. Beginning 2011, spring season was open through May 31, and all-day hunting was permitted during last two weeks of season. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev 10-yr Avg
1A	1,523	1,988	1,180	1,956	2,196	1,582	2,381	1,885	3,038	2,144	1,390	1,974
1B	2,103	2,896	2,605	3,050	2,515	2,316	1,502	2,677	3,039	2,564	1,731	2,489
2A	2,444	1,539	2,078	3,004	1,318	2,593	2,376	2,950	2,069	2,063	2,894	2,288
2B	1,687	1,261	1,967	1,452	943	1,343	1,180	2,044	2,069	1,582	2,102	1,594
2C	2,151	2,147	1,985	1,585	2,114	1,892	2,509	1,772	2,408	3,736	2,899	2,305
2D	2,566	2,264	2,868	3,758	2,164	2,998	2,613	2,700	3,126	2,864	3,475	2,883
2E	1,032	303	1,053	936	538	1,076	1,293	662	1,400	1,439	1,021	972
2F	1,502	1,530	1,327	1,375	1,280	1,839	1,713	1,222	1,024	2,599	1,255	1,516
2G	1,655	1,583	2,105	1,758	1,267	1,580	1,966	1,668	1,890	3,372	1,326	1,852
2H	522	510	670	563	398	507	633	536	494	1,020	400	573
3A	1,876	1,100	892	1,390	1,603	1,416	1,557	716	974	1,592	1,155	1,240
3B	2,064	1,980	2,294	2,830	2,136	1,406	1,695	1,369	1,873	2,712	831	1,913
3C	2,179	1,842	3,335	2,703	1,763	2,574	2,808	2,063	3,075	2,348	3,078	2,559
3D	1,981	2,246	1,819	2,284	1,206	1,323	926	1,529	1,625	2,297	678	1,593
4A	1,791	1,370	1,155	1,767	1,198	1,054	1,216	1,535	1,414	1,810	1,587	1,410
4B	1,881	1,271	993	1,400	1,279	929	1,084	899	1,007	1,735	1,455	1,205
4C	2,257	2,445	2,487	2,136	1,317	1,478	2,277	1,523	1,749	2,130	1,660	1,920
4D	1,331	1,984	2,564	2,231	2,583	2,242	1,770	1,889	1,785	2,997	1,429	2,147
4E	1,727	2,332	2,777	2,503	2,070	1,983	2,002	2,441	2,407	1,878	2,075	2,247
5A	375	706	661	283	426	598	343	468	1,589	1,406	560	704
5B	292	447	385	460	255	662	798	849	1,113	2,993	1,335	930
5C	861	725	1,126	751	934	899	582	1,109	601	2,258	782	977
5D	63	74	93	177	35	52	31	35	124	837	184	164
Unknown	3,435	3,261	4,017	4,287	2,314	1,510	1,666	1,969	1,365	1,405	662	2,245
TOTAL	39,299	37,801	42,437	44,639	33,849	35,852	36,920	36,507	41,258	51,782	35,966	39,701

Table 11. Pennsylvania fall wild turkey harvests, by Wildlife Management Unit (WMU), as determined from hunter surveys, 2006-2016, and the 2006-15 average. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev 10-yr Avg
1A	927	735	649	1,237	481	399	426	1,162	764	703	1,002	748
1B	1,484	919	1,391	1,413	1,203	639	768	649	983	502	501	995
2A	1,206	1,103	464	530	802	320	682	738	683	904	704	743
2B	1,020	735	278	618	241	639	565	559	901	402	701	596
2C	835	1,195	927	1,413	722	799	938	1,007	764	703	605	930
2D	2,411	1,471	1,854	1,325	882	1,358	965	1,543	1,365	1,004	1,002	1,418
2E	556	919	927	795	722	639	682	268	1,092	703	624	730
2F	1,113	735	556	707	882	399	1,109	1,454	1,201	1,030	324	919
2G	1,755	1,600	1,544	1,070	1,154	1,209	1,098	1,722	873	703	702	1,273
2H	564	514	496	344	371	388	352	179	0	301	101	351
3A	1,020	1,379	834	265	1,043	719	821	649	683	502	401	791
3B	649	1,287	834	1,148	722	639	853	828	1,229	703	948	889
3C	1,391	2,390	2,596	1,767	963	559	821	984	1,556	829	401	1,385
3D	649	643	834	442	642	639	283	130	574	402	100	524
4A	1,669	2,114	1,020	1,413	722	879	426	167	873	1,105	401	1,039
4B	1,206	919	927	442	642	399	512	447	655	829	400	698
4C	927	552	834	442	562	559	853	1,073	437	502	403	674
4D	1,391	2,114	2,688	1,237	802	1,438	453	761	1,120	1,406	401	1,341
4E	1,206	1,655	1,391	1,413	802	559	938	784	655	554	223	996
5A	Closed	Closed	Closed	Closed	176	85	85	314	328	100	101	181
5B	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	0	-
5C	371	184	93	88	Closed	Closed	Closed	Closed	Closed	Closed	0	184
5D	0	0	0	0	Closed	Closed	Closed	Closed	Closed	Closed	0	0
Unknown	2,133	2,206	3,152	2,827	1,348	1,033	711	1,337	1,556	1,131	801	1,743
TOTAL	24,481	25,369	24,288	20,934	15,884	14,300	14,339	16,755	18,292	15,018	10,844	18,966

Reporting rates are calculated by cross-referencing reported harvest and what was reported on the GTS, MYHS, STHS and MYSTHS. A three-year rolling statewide average reporting rate is used. Statewide 2014-16 average reporting rates were 32% for fall and 56% for spring. Spring survey changes and improvements in data cleansing since 2010 resulted in reporting rate increases of 187% (i.e., 20% reporting rate in 2009, and lower during previous years; Fig. 18). Fall reporting rates improved temporarily due to a large-scale, intense advertisement campaign that stressed big-

game harvest reporting. Fall reporting rates have since declined to the prior average of 33%. Further work is needed to determine how to maintain fall reporting rates above 50% (Strategy 4.1).

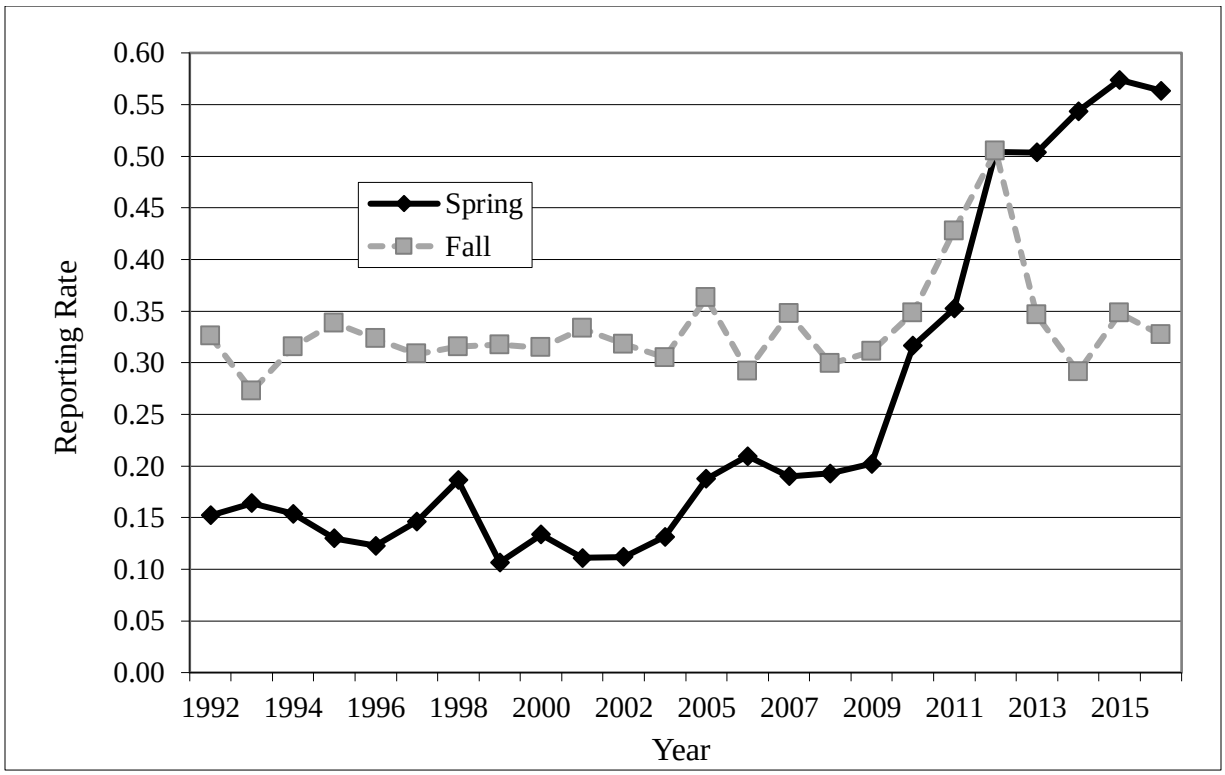

Figure 18. Annual spring and fall turkey hunter harvest reporting rates calculated by cross-referencing reported harvest with what was reported on Game-Take, Mentored Youth and Spring Turkey Hunter Surveys. Concerted media outreach to hunters on the importance of reporting temporarily improved spring and fall reporting rates. Separate, Spring Turkey Hunter and Spring Mentored Youth Turkey Hunter Surveys in 2012 and 2013, respectively, continued the improvement to spring reporting rates.

Trends in harvest and harvest density (harvest per square mile) for each WMU, and state total, are determined by comparing the current year's data with the previous short-term (3-year) and long-term (10-year) averages (Tables 12-13). This is done for preliminary (reported) and final (survey) harvest results.

Table 12. Spring turkeys harvested per square mile, for each Pennsylvania WMU, 2006-2016. Harvest densities were determined from reported harvests corrected for reporting rate (2006-2008), then from Game-Take Surveys and Spring Turkey Hunter Surveys (2009-present). Beginning 2006 hunters could harvest a second spring turkey with appropriate license, but data include only first harvests for comparison with previous years. The previous 10-year average is provided for comparisons with the current year. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev. 10-yr Avg
1A	1.23	0.97	1.17	1.00	1.14	0.81	1.25	0.98	1.44	1.15	0.61	1.11
1B	1.44	1.22	1.37	1.37	1.11	1.05	0.66	1.21	1.20	0.59	0.67	1.12
2A	1.38	0.96	1.21	1.60	0.67	1.33	1.27	1.57	1.07	0.92	1.43	1.20
2B	1.45	1.14	1.07	1.03	0.65	0.85	0.83	1.46	1.43	1.23	1.42	1.11
2C	0.74	0.67	0.67	0.48	0.65	0.61	0.79	0.54	0.78	1.03	0.83	0.70
2D	1.30	0.96	1.22	1.45	0.81	1.13	1.00	1.03	1.16	1.03	1.25	1.11
2E	0.76	0.77	0.75	0.70	0.38	0.85	0.99	0.47	1.01	0.98	0.63	0.77
2F	0.53	0.54	0.55	0.55	0.50	0.69	0.69	0.48	0.37	0.67	0.45	0.56
2G	0.61	0.60	0.66	0.53	0.37	0.44	0.61	0.51	0.57	0.32	0.35	0.52
2H	0.50	0.50	0.55	0.53	0.37	0.44	0.61	0.51	0.37	0.17	0.35	0.46
3A	1.06	0.78	0.93	0.87	1.02	0.88	1.01	0.44	0.56	1.24	0.68	0.88
3B	0.95	0.97	1.11	1.21	0.90	0.62	0.72	0.58	0.72	1.06	0.29	0.89
3C	1.17	1.07	1.22	1.18	0.75	1.15	1.27	0.92	1.25	1.14	1.22	1.11
3D	1.06	0.90	1.02	1.01	0.52	0.56	0.40	0.68	0.63	0.98	0.25	0.78
4A	0.91	0.72	0.88	0.96	0.65	0.61	0.67	0.85	0.74	0.59	0.81	0.76
4B	1.19	0.87	1.05	0.83	0.76	0.47	0.66	0.54	0.56	0.91	0.82	0.78
4C	1.54	1.24	1.39	1.12	0.67	0.76	1.22	0.80	0.90	0.70	0.84	1.03
4D	0.77	0.67	0.74	0.77	0.88	0.72	0.61	0.66	0.52	0.91	0.45	0.73
4E	1.54	1.19	1.48	1.37	1.12	0.98	1.10	1.37	1.17	1.49	1.11	1.28
5A	0.44	0.45	0.42	0.20	0.31	0.32	0.25	0.34	1.03	0.29	0.33	0.41
5B	0.32	0.25	0.28	0.16	0.09	0.24	0.28	0.30	0.40	0.46	0.45	0.28
5C	0.74	0.52	0.57	0.32	0.41	0.41	0.26	0.50	0.28	0.35	0.34	0.44
5D	0.07	0.09	0.07	0.21	0.04	0.06	0.04	0.04	0.15	0.27	0.14	0.10
State Average	0.94	0.79	0.90	0.94	0.70	0.74	0.77	0.75	0.82	0.82	0.69	0.82

Table 13. Fall turkeys harvested per square mile, for each Pennsylvania WMU, 2005-2016, as determined from annual Game-Take and Mentored Youth Hunter Surveys. The previous 10-year average is provided for comparisons with the current year. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev. 10-Year Average
1A	0.52	0.48	0.50	0.62	0.67	0.26	0.22	0.23	0.63	0.41	0.38	0.54	0.45
1B	0.72	0.66	0.74	0.62	0.67	0.57	0.30	0.36	0.31	0.46	0.24	0.24	0.54
2A	0.61	0.46	0.39	0.47	0.29	0.44	0.18	0.38	0.41	0.38	0.50	0.39	0.40
2B	0.77	0.55	0.48	0.53	0.45	0.18	0.47	0.41	0.41	0.66	0.29	0.51	0.49
2C	0.47	0.45	0.54	0.47	0.46	0.23	0.26	0.30	0.32	0.25	0.23	0.19	0.38
2D	0.85	0.62	0.72	0.81	0.53	0.35	0.55	0.39	0.62	0.55	0.40	0.40	0.60
2E	0.62	0.65	0.64	0.76	0.63	0.57	0.51	0.54	0.21	0.87	0.56	0.49	0.60
2F	0.47	0.33	0.40	0.32	0.29	0.37	0.17	0.46	0.60	0.50	0.43	0.13	0.39
2G	0.59	0.49	0.56	0.59	0.34	0.37	0.39	0.35	0.55	0.28	0.23	0.23	0.45
2H	0.55	0.56	0.51	0.50	0.34	0.37	0.39	0.35	0.18	0.00	0.30	0.10	0.38
3A	0.73	0.54	0.97	0.70	0.18	0.69	0.48	0.54	0.43	0.45	0.33	0.27	0.57
3B	0.75	0.62	0.80	0.58	0.51	0.32	0.28	0.38	0.37	0.55	0.31	0.42	0.52
3C	0.66	0.51	0.84	0.62	0.82	0.45	0.26	0.38	0.46	0.72	0.38	0.19	0.57
3D	0.52	0.44	0.44	0.35	0.20	0.29	0.29	0.13	0.06	0.26	0.18	0.05	0.30
4A	0.58	0.73	0.81	0.77	0.81	0.42	0.51	0.25	0.10	0.50	0.64	0.23	0.55
4B	0.78	0.80	0.70	0.55	0.28	0.40	0.25	0.32	0.28	0.41	0.52	0.25	0.48
4C	0.80	0.66	0.77	0.80	0.24	0.31	0.31	0.47	0.59	0.24	0.28	0.22	0.52
4D	0.58	0.63	0.78	0.96	0.45	0.29	0.52	0.16	0.28	0.41	0.51	0.15	0.51
4E	0.91	0.91	0.89	0.95	0.81	0.46	0.32	0.54	0.45	0.38	0.32	0.13	0.66
5A	Closed	Closed	Closed	Closed	Closed	0.14	0.07	0.07	0.24	0.25	0.08	0.08	0.15
5B	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	
5C	0.16	0.13	0.13	0.12	0.04	Closed	Closed	Closed	Closed	Closed	Closed	Closed	
5D	0.00	0.02	0.01	0.01	0.00	Closed	Closed	Closed	Closed	Closed	Closed	Closed	
State Average	0.56	0.49	0.56	0.54	0.46	0.35	0.32	0.32	0.37	0.40	0.33	0.24	0.44

Population Model

The current wild turkey population model is based on spring harvest densities (harvest per total square miles) for each WMU multiplied by adult and juvenile male harvest rates, based on data from the 2006-2009 gobbler harvest rate study (Diefenbach et al. 2012). A population sex ratio of 50% is used; higher natural mortality level of females is offset by spring harvest mortality of gobblers (Healy and Powell 1999). During this management plan cycle (2018-27), the PGC will develop a more robust population model (statewide and WMU specific; Strategies 1.5, and 1.10-

1.14 using data acquired during the last two management plan cycles to estimate the effect of changing fall season length on harvest rates, and a variety of annually collected population parameters (e.g., sex and age of harvest, poult:hen ratios, abundance indices) by WMU. These data are used to develop recommendations for setting fall hunting seasons but have not been explicitly used in a population model that can be incorporated into a decision framework to predict the effect of management decisions. Catch per unit effort may be added to integrate WMU-level and annual changes in hunter effort (assuming catchability remains constant), and to provide a more comprehensive assessment of turkey status across the state (via Strategy 1.4; Parent et al. 2015).

Currently only the spring turkey population is estimated because this is the minimum population, which has experienced mortality from fall harvest and natural predation. Also, unlike the fall turkey-hunting season, which varies among WMUs from 0 – almost 4 weeks, the spring season is a consistent statewide season, beginning the Saturday closest to 1 May and ending 31 May. Therefore, annual variation in spring harvest is more a reflection of population fluctuations than other factors (Healy and Powell 1999). Two liberalizations to the spring season framework in 2011, all-day hunting during the second half of the season and extending the season from Memorial Day to 31 May, may have increased harvest rates slightly, but should not have significantly affected the population model. Harvest data collection includes sex and age, but ages of female harvests currently are not collected for the fall season; female age structure data are needed.

The PGC and hunters would benefit from a population model that would predict population levels prior to the fall hunting season to aid in predicting the outcome and effect of various options for fall turkey season on the population for each WMU, and to obtain better insights regarding factors influencing population fluctuations (Strategies 1.3, 1.5, 1.9-1.13 and 1.16).

Population Trend Indices for Fall Season Recommendations

Trends in turkey populations are annually assessed (Strategy 1.6) via final spring harvest densities (harvest per square mile) for each WMU, and summer turkey population indices.

Spring Harvest density

Spring harvest density (harvest per square mile) is calculated from the STHS and MYSTHS (statewide and for each WMU).

Annual Summer Turkey Sighting Surveys

Summer population trends are determined via annual State Game Warden (SGW) (formerly Wildlife Conservation Officer [WCO]) summer turkey sighting surveys, which provides a summer population trend index for each WMU (Table 14, Casalena 2016). Annually, since 1953, from Jun-Aug SGWs record their daily mileage and the number of wild turkeys seen each day while

conducting routine business during daylight hours in their assigned patrol vehicles. Total turkeys seen per 1,000 miles driven is calculated for each district, and a weighted average is calculated for turkeys seen per 1,000 miles driven within each WMU.

Spring harvest density calculations and summer sighting indices are independent of each other, and we assume their trends are indicative of the trend in the turkey populations (Strategy 1.6). Also, previous research has shown a correlation between summer turkey sighting survey data and predictions of fall turkey harvests (Wunz and Ross 1990), and during this management plan this correlation will be tested (Strategy 1.7). A concern, however, is conditions have changed over the past 65 years which may be contributing sources of bias that negatively impact the summer sighting index – more traffic and distracted drivers mean SGWs spend less driving-time scanning for turkeys, workloads (time, miles) are not distributed evenly across districts. This may have negatively impacted the turkey sighting index. A possible solution is to extend the survey to PGC Food and Cover Crews and/or Foresters and Department of Conservation and Natural Resources Bureau of Forestry staff (while driving on State Forests). This would assist implementation of Strategies 1.6 and 1.7.

Table 14. Pennsylvania turkey summer sighting index values (average number of wild turkeys seen/1,000 mi driven by State Game Wardens [SGW]) in each Wildlife Management Unit (WMU) and the state average, 2006-2016. For comparisons with the current year, the previous 3-year average is provided (2015-15). Prior to 2005, if a SGW district contained >1 WMU all data were assigned to the 1 WMU that comprised the largest amount of the district. Since 2005 mileage and turkey sighting data were reported for each WMU, up to 3 WMUs per SGW district. SGW districts were re-aligned slightly in 2011 for administrative purposes and differ slightly from previous years. WMU 2H was created in 2013, as a section of the western region of WMU 2G. Previous data could not be re-assigned because data were collected at the WMU level.

WMU	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev. 3-yr Avg.
1A	37.6	18.2	12.4	16.3	13.8	33.1	11.4	19.5	11.4	10.5	12.2	13.8
1B	37.2	30.7	46.5	32.3	33.7	9.7	20.0	21.2	13.1	15.9	30.3	16.8
2A	37.9	40.0	23.5	27.2	28.5	28.7	34.1	35.8	27.0	37.1	69.5	33.3
2B	31.7	24.9	16.4	16.7	7.4	47.1	13.7	16.3	10.1	14.4	22.3	13.6
2C	17.1	16.9	15.9	15.5	15.7	34.5	19.0	20.0	16.7	15.7	17.9	17.5
2D	13.0	11.7	8.9	12.9	13.2	17.2	13.3	11.2	16.4	14.0	24.3	13.9
2E	32.4	44.5	18.1	45.1	32.1	12.6	26.4	15.4	21.4	19.0	31.2	18.6
2F	24.4	24.3	37.0	30.7	35.3	19.0	35.0	30.5	28.2	21.3	29.8	26.7
2G	32.0	40.5	23.3	32.9	26.4	24.0	21.8	20.8	18.8	38.7	25.8	26.1
2H								29.8	23.2	26.0	16.9	26.3
3A	66.7	71.0	40.8	27.7	43.8	29.7	35.8	17.6	29.7	22.3	19.5	23.2
3B	19.2	20.7	39.1	25.7	13.2	24.0	12.4	8.0	16.8	15.8	21.5	13.5
3C	67.5	77.5	44.3	40.6	52.8	24.6	20.1	13.2	21.5	20.7	40.3	18.4
3D	36.1	31.2	35.1	27.9	32.6	17.4	12.9	34.1	29.9	29.5	26.3	31.2
4A	29.2	57.1	39.0	37.3	12.4	19.6	13.8	11.4	14.3	14.4	9.9	13.4
4B	9.6	11.8	5.8	2.5	3.7	8.9	8.6	13.4	6.0	9.1	4.4	9.5
4C	11.7	7.5	16.1	19.6	18.2	13.6	13.7	48.0	28.8	16.0	16.0	30.9
4D	13.0	19.9	33.8	17.7	14.1	16.2	22.2	18.1	16.6	18.3	7.4	17.7
4E	25.3	23.1	36.9	29.8	20.9	19.9	17.0	18.8	12.9	12.0	5.8	14.6
5A	3.2	3.0	5.1	1.5	7.2	5.9	2.8	11.5	1.8	6.2	8.0	6.5
5B	2.8	1.7	2.8	7.4	2.8	3.8	5.1	6.2	5.5	5.9	4.2	5.9
5C	7.7	5.5	2.1	2.0	6.3	4.9	2.9	3.8	4.3	2.4	2.4	3.5
5D	0.0	9.5	8.2	1.2	2.0	2.1	0.0	1.6	1.7	0.8	0.3	1.3
State Average	24.7	25.3	24.0	21.6	20.9	17.8	16.5	18.8	17.2	17.7	19.5	17.9

Annual Productivity

Since 2008, the summer turkey surveys include observations of poults (young turkeys) seen with and without hens, hens seen with broods, hens seen without broods and adult gobblers from June through August (Table 15). This allows calculations of productivity via brood size (poults per hen)

and recruitment ratio (poults per all hens, i.e., hens with broods plus lone hens) for estimating overall reproductive success and fall population trend. Both will be incorporated into the new population model (Strategies 1.11 and 1.12). Recruitment ratio is a measure of young entering the population based on the number of hens in the population. In compliance with the Northeast Upland Gamebird Technical Committee and its 13 cooperating states, turkey recruitment data was standardized into a regional database using only August sightings of poults and all hens because this was the month that all 13 states collect brood data. The Best Management Practice stated in Byrne et al. (2014) is to collect data during the months of July and August.

Table 15. August wild turkey recruitment ratio, poults seen per all hens (hens with poults and without poults), by Wildlife Management Unit (WMU) in Pennsylvania, 2008-2016, the state average (excluding WMU 5D), and previous 3-year average (2013-2015), from SGW summer turkey sightings. WMU 2H was created in 2013, as a section of the western region of WMU 2G. Previous data could not be re-assigned because data were collected at the WMU level.

WMU	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev 3-yr Avg
1A	1.9	2.2	2.8	0.6	3.3	0.7	0.9	3.6	2.4	1.7
1B	1.4	1.7	2.4	1.6	0.5	2.9	2.2	1.3	1.8	2.1
2A	3.3	1.2	2.6	1.2	1.1	2.5	2.2	1.9	2.6	2.2
2B	0.9	2.5	0.9	1.0	2.6	1.2	1.6	1.7	1.9	1.5
2C	2.1	0.8	1.1	3.2	3.7	2.8	2.2	2.2	2.0	2.4
2D	1.6	2.0	1.0	2.0	1.4	1.9	1.1	2.2	3.1	1.7
2E	1.7	2.5	1.0	2.2	3.8	3.5	3.6	1.9	3.5	3.0
2F	4.0	2.2	2.1	2.8	2.3	2.7	2.5	2.7	3.0	2.6
2G	3.4	3.5	1.2	1.2	2.7	2.9	2.0	3.5	1.5	2.8
2H						5.0	2.9	2.3	2.2	3.4
3A	2.5	1.8	0.9	2.5	4.2	2.3	3.0	2.7	2.6	2.7
3B	3.5	2.9	2.2	2.5	2.4	2.0	2.7	2.3	2.0	2.4
3C	3.4	3.0	2.7	2.6	3.2	2.3	3.0	1.9	1.9	2.4
3D	2.5	0.7	2.3	1.4	0.9	2.4	2.8	2.4	1.5	2.5
4A	2.4	0.7	2.8	1.0	0.5	1.9	1.3	1.3	1.4	1.5
4B	2.7	2.3	4.3	3.8	3.6	3.3	2.7	1.0	5.5	2.3
4C	4.2	2.0	3.7	2.8	3.5	3.2	3.6	2.3	1.6	3.0
4D	2.4	1.5	1.1	1.3	1.9	2.8	3.5	4.5	0.9	3.6
4E	3.3	4.0	0.8	2.1	4.3	1.2	2.9	3.6	0.0	2.6
5A	3.7	6.0	0.0	0.0	3.0	3.0	0.6	3.0	3.7	2.2
5B	1.7	1.7	5.0	0.3	2.0	4.0	3.4	2.6	1.3	3.3
5C	0.9	0.0	0.9	2.8	0.1	1.9	0.7	0.0	0.8	0.9
5D	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	1.3
State Avg.	2.6	2.2	1.7	1.7	2.1	2.5	2.3	2.5	2.5	2.4

Volunteer-based August Turkey Sighting Survey

A volunteer-based August turkey sighting survey was launched in 2016 to acquire turkey productivity data comparable to that of other Northeast states for tracking regional trends, and provide the public an opportunity to contribute to "citizen science" (Table 16). The data are not used to establish turkey hunting seasons and bag limits because the public survey lacks a

standardized unit of effort, ability to ensure annual consistency, and long-term data set, all of which are provided by SGW annual summer turkey surveys. However, the public survey provides an independent source of data to assist in predicting fall harvest potential. As per Strategy 1.7, the survey will be evaluated after 5 years (2020) to assess its effectiveness of enhancing the SGW turkey sighting data for obtaining recruitment data, and for comparing to similar data from the Northeast states to determine regional recruitment and fall harvest predictions.

Table 16. Pennsylvania August volunteer turkey sighting survey results, for each Wildlife Management Unit (WMU) and state total, 2016. Reports are from the public. August wild turkey recruitment ratio is the proportion of juveniles entering the population per total number of hens (hens with and without poults).

WMU	Hens With Poults	Poults	Hens Without Poults	Males	Unknown Sex/Age	Total Sightings	Poults/All Hens (Recruitment Ratio)
1A	128	358	63	56	75	680	1.87
1B	185	595	125	146	100	1151	1.92
2A	299	1277	111	171	380	2238	3.11
2B	476	1896	262	657	346	3637	2.57
2C	148	564	78	75	172	1037	2.50
2D	157	530	110	126	106	1029	1.99
2E	74	311	42	59	50	536	2.68
2F	175	714	68	73	89	1119	2.94
2G	185	807	119	126	71	1308	2.65
2H	43	205	57	34	36	375	2.05
3A	142	592	32	60	72	898	3.40
3B	183	731	117	157	249	1437	2.44
3C	282	1216	211	325	326	2360	2.47
3D	328	1059	168	215	269	2039	2.14
4A	90	380	74	77	122	743	2.32
4B	101	343	36	79	103	662	2.50
4C	170	682	174	132	216	1374	1.98
4D	223	847	124	154	269	1617	2.44
4E	139	651	92	120	146	1148	2.82
5A	105	359	111	82	133	790	1.66
5B	236	898	165	120	202	1621	2.24
5C	240	861	176	186	314	1777	2.07
5D	33	118	54	46	84	335	1.36
Unknown	39	152	34	19	29	273	
State Total	4181	16146	2603	3295	3959	30184	2.38

The volunteer-based survey, and results, can be accessed via a mobile app (search Turkey Sighting Survey in the Google Play Store or Apple's App Store), or on the Turkey page of the agency website: http://www.pgc.pa.gov/Wildlife/WildlifeSpecies/Turkey/Pages/default.aspx.

Regional Acorn Mast Survey

The strong relationship between acorn crops and ecology of big game species is summarized for turkey, white-tailed deer, and black bear in McShea and Healy (2002). Year-to-year variation in acorn crops can influence fluctuations in reproduction, survival, dispersal, seasonal movements, or over-winter body condition of these 3 important game species. In addition, research in West Virginia has shown hard-mast conditions have a strong influence on annual variations in big game harvests. Based on more than 20 years of hard-mast survey data, when hard-mast decreased, turkey, archery black bear, and archery, antlerless and total deer harvest increased while black bear gun harvest (which occurs later in the fall) decreased. Reasons are speculated to include, game concentrate around areas of food including open agricultural areas, making them easier to find and to pattern. Gun harvest of black bears decreases because the lack of food influences bears to hibernate earlier. Heavy hunting pressure may magnify poor mast conditions. Therefore, average hunter density must be taken into consideration when fall seasons are set (Steffen et al. 2002). Conversely, in areas with abundant mature oaks, beech, and black cherry, the opposite is true during bumper mast years. Hunters have difficulty pinpointing flocks because turkeys are not concentrated around a specific food source, and tend to be more 'nomadic'. The strong correlations between hard-mast survey data and harvest in these various seasons facilitated prediction of harvest levels prior to opening of seasons.

To provide a powerful assessment of the impact of acorns on annual harvest dynamics within states and the Northeast region, in 2007, the Northeast Upland Game Bird Technical Committee developed a quantitative, but rapid, assessment technique for mast crops for state wildlife agencies to use throughout the Northeast. Prior to this, not all states collected mast data and methods differed among states that did. Pennsylvania has participated since 2007, monitoring 3 survey sites from 2007-2013. In 2014 the PGC expanded survey efforts with at least 1 survey site in 22 of our 23 WMUs (n=28 sites total), to survey all physiographic regions of Pennsylvania with substantial forested land (no survey in suburban WMU 5D). The 3 original survey sites were too few to accurately predict harvest. Due to budget constraints and reprioritizations in 2016 and 2017, only 10 sites were surveyed (including the original 3). Beginning 2018 all sites will be surveyed annually (Strategy 2.1). During this management plan (2018-2027), mast data also will be a potential variable in the turkey population model (Strategies 1.11-1.13).

Population Objectives for each WMU

Population objective strategies 1.10-1.15 refer to developing and using wild turkey population

models specifically for Pennsylvania. During the 2006-2017 management plan cycle the Northeast Wild Turkey Technical Committee (now the Northeast Upland Game Bird Technical Committee) commissioned development of a regional wild turkey population model (McGhee 2004), which was completed in 2006 and funded by each state agency and each state chapter of the NWTF. The model provided a good first-step in turkey population modeling and identified data gaps, which are now collected. The model, however, contained assumptions not applicable to Pennsylvania and lacked state-specific adjustments. Since 1999 the PGC has obtained a wealth of data to develop more robust, data-driven population models for each WMU, including the HSI model. These models will allow us to predict population responses to various changes in hunting season options. Because there is much uncertainty in knowing the optimum hunting season recommendations from year to year, a stochastic dynamic programming (SDP) framework is being incorporated (Marescot et al. 2013; Fackler et al. 2017), which is a powerful tool for identifying optimal decisions in the presence of uncertainty about biological systems (Strategy 1.13). For example, wild turkey hunting regulations for fall 2017 and spring 2018 were finalized in April 2017. With this necessary time-frame to the decision process, hunting seasons are finalized prior to knowledge of, and data for, 2017 reproduction, mast supply and winter 2018 severity. Stochastic dynamic programming is a means of incorporating variability in reproduction and survival into the structured decision framework to identify a decision that best meets management objectives to maximize hunting opportunity and the turkey population. This transparent, structured, data-driven and adaptive SDP process for hunting season recommendations will allow all stakeholders to more fully understand the mechanisms that drive turkey populations, thus reducing the political aspect of decision setting, such that support for the optimal decision is straightforward. This is particularly important with the current fall season structure with options of none, one or both seasons and accompanying variations in season length. Once the SDP process is adopted by the agency it will be appended into this management plan (Strategies 1.11 and 1.13).

Fall Turkey Management in each WMU

Fall season length varies among the 23 WMUs depending on turkey population trends, which are related to many factors including habitat quality, harvest density, harvest vulnerability hunter density and hunter accessibility to the area (e.g., large expanse of forest versus wood-lots).

Decision-making guidelines for recommending fall turkey-hunting seasons

During this management plan cycle the PGC will develop and implement a new structured decision-making process for recommending fall turkey-hunting seasons (Strategies 1.11 and 1.13). Until then the following guidelines will continue, as established in the 2006-2017 management plan, in preparing staff recommendations for wild turkey seasons. These recommendations use 3-year trends in spring harvest density and summer sighting indices:

1) Recommend opening fall turkey seasons in WMUs that have been closed to fall turkey hunting:
    a. When spring harvest densities have exceeded 1.0 turkey per square mile for 3 consecutive years, or
    b. When population indices indicate no population growth after 5 years.
2) Maintain fall season length if trend indices for 3 years are not consistently higher or lower than the population index values when the most recent season length change occurred.
3) Extend the fall season length up to a week at a time, not to exceed a 3-week season, if the previous 3 years of population trend indices are above the population index values when the most recent season length change occurred. However, if a turkey population in a WMU demonstrates a repeated pattern of adverse effects from a longer season, season length increases should be delayed until the population grows to a higher level, or until research indicates that fall harvest rates are not suppressing the population.
4) Decrease gradually, or eliminate, the fall season in a WMU if:
    a. The previous 3 years of population trend indices are consistently below population index values when the most recent season length change occurred, or
    b. The previous 3 years of trend indices show a consistent declining trend if no recent season length change has occurred, or
    c. Additional research indicates that harvest rates or other factors are suppressing the population.
5) Do not increase the fall bag limit unless/until research supports such action.
6) Maintain the opening day of the fall turkey season separate from other big game and small game seasons to minimize the opportunistic taking of turkeys by hunters pursuing other species during opening day.

In WMUs where population trends are not increasing and fall season lengths have remained the same, the turkey population most likely has either reached biological carrying capacity or fall harvest rates are limiting population growth. In these areas, the wild turkey harvest likely will fluctuate annually and will be dependent on year-to-year production, because population expansion is no longer compensating for high harvest rates or production variability due to interactions among weather, habitat, predation, etc. Future gains in Pennsylvania's wild turkey populations largely depend on wise fall harvest management. Development of the structure decision protocol for fall seasons will greatly assist in this endeavor.

VI. PUBLIC INFORMATION & EDUCATION

Public Surveys

Strategies 3.1 and 3.2 call for surveys to be conducted at 10-year intervals, beginning in 2018, to determine hunter and non-hunter knowledge, attitudes and satisfaction regarding wild turkey populations and management. Prior turkey hunter surveys were conducted in 1995, 2001 and 2008. From 2010-2014 the PGC conducted an annual survey of turkey hunters to evaluate hunter satisfaction, turkey hunter recruitment, and reactivation of former fall turkey hunters, particularly due to fall season changes in 2010 and during the hen survival and harvest rate study. No surveys asking specifically about wild turkeys have been conducted of the non-hunting public.

Pennsylvania Chapter National Wild Turkey Federation Spring Turkey Hunter Cooperator Survey

Since 2009 the Pennsylvania Chapter NWTF has conducted a spring turkey hunter cooperator survey to reach out to the grassroots hunters regarding specific information on each season's observations, acquire a long-term database for tracking trends, and as a means of getting NWTF members and non-members interested and involved with wild turkey management. Although the sample size of respondents is low (average = 41), data from this survey include information not acquired by PGC surveys, such as participation by hours of scouting and hunting, misses, gobbling activity, turkeys seen, success of hunter partner and time of shot/s, and provides additional anecdotal data regarding the spring harvest and hunter participation.

Quality Hunting and Hunter Satisfaction

Per the Pennsylvania General Turkey Hunter Surveys, overall turkey hunter satisfaction with turkey management decreased from 77% in 1995 to 70% in 2001 and 63% in 2008 (Diefenbach 1996, Pennsylvania Game Commission 2002, Casalena et al. 2011). Results from the Fall Turkey Hunter Surveys (2010-14) illustrate a similar decreasing trend in overall satisfaction with the fall turkey season, with lowest satisfaction in 2014 (Fig. 19; Casalena and Johnson 2015).

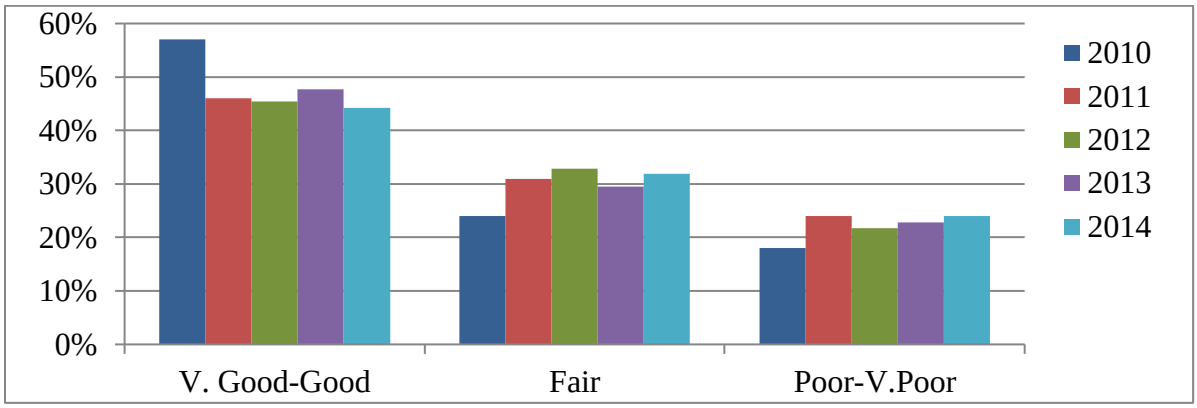

Figure 19. Rating of survey respondents' fall wild turkey hunting experience in Pennsylvania, 2010-2014.

In view of recent decreasing turkey harvests, populations, and hunter success, a decrease in satisfaction was not surprising. However, during the 2008 general turkey hunter survey, most hunters considered turkey populations to be "about right" where hunters did most of their hunting (spring population: 64%; fall population: 63%; Casalena et al. 2011). Turkey hunters may not relate hunting success directly to satisfaction. For many, a large turkey population may be more important than harvesting a turkey. For example, overall harvest success of fall hunter survey respondents (for both fall season segments) ranged from 8% in 2013 to 12% in 2012, but hunter satisfaction was higher in 2013 than 2012, demonstrating that harvest success was not the driving force to satisfaction. PGC surveyed fall hunters how important harvesting a turkey was to their satisfaction; 51% responded not important, 32% responded somewhat important, and 7% responded very important. Similarly, during our 2013 and 2014 Fall Turkey Hunter Surveys, 47% were satisfied when they saw, but did not harvest a turkey, 37% had no opinion, and 16% were dissatisfied, during both years. This aspect of seeing but not harvesting turkeys may affect hunters' overall hunting experience and will be examined in more detail during future surveys (Strategy 3.1). Seeing turkeys, however, is dependent on a variety of factors other than turkey population size, such as poult recruitment, food supply, and weather during the season, which are challenging for wildlife agencies to manage. Management approaches that promote large turkey populations may be more valuable than those maximizing harvest and addressing hunter behavior/safety (quotas, shot size, etc.). However, these factors seem to be related (Williams and Austin 1988, Vangilder 1992, Casalena and Johnson 2015).

Regarding fall hunting impacts to the population, 31% of survey respondents in 2001 and 35% in 2008 thought fall turkey harvests "need to be controlled to prevent overharvest of hens" (the question was not asked in 1995 or during the 2010-2014 surveys). However, from 1995-2008, a growing percentage of turkey hunters were willing to sacrifice one week of fall turkey hunting if future turkey populations, harvests and season lengths would increase (47% in 1995, 51% in 2001,

54% in 2008); but, only slightly more than half of respondents. The potential impact of the fall hen harvest on future turkey populations continues to be an educational challenge.

Overall, there is room to improve turkey hunting management approaches and regulations in Pennsylvania. In some cases, sportsmen may want changes in regulations, although there appears to be no clear consensus if changes are desired. Future regulation changes will require appropriate management justification and hunter education to ensure their continued support. Therefore, conducting turkey hunter surveys every 10 years to document changes in hunter knowledge, attitudes and opinions is vital (Strategies 3.1 and 3.2).

Non-consumptive Use

The non-hunting public generally appreciates wild turkeys and values their presence, perhaps due to their typically less abundant numbers than deer and their general wariness, which makes viewing them less frequent and, perhaps, a more valued type of wildlife viewing (in most situations). Their unique spring courtship rituals, summertime brood flocks in agricultural fields and forest openings, and their winter flock behavior afford the public ample viewing opportunities year-round.

Nuisance turkey issues were minimal during the 2006-2017 turkey management plan for two reasons: turkey population densities were lower, and the PGC and public have learned how to handle various nuisance situations. During turkey population peaks throughout much of the 1999-2005 management plan, the population likely exceeded social carrying capacity, particularly in WMUs with nuisance complaints. As turkey populations continue to fluctuate throughout Pennsylvania, and as part of the Information and Education Objective, the PGC will conduct surveys each decade (beginning 2019) to determine social carrying capacity of turkey populations in each WMU, to ensure nuisance issues remain minimal (Strategy 3.2). These surveys also will provide information regarding other aspects of nonconsumptive stakeholders' knowledge, perceptions and enjoyment of wild turkey populations to identify additional educational needs. Additionally, these surveys will help identify additional opportunities to pursue for public involvement in turkey population and habitat management.

Another indicator of the turkey population exceeding social carrying capacity is an increase in road-killed turkeys, as anecdotally noted during the 2006-2017 turkey management plan. The PGC will determine if tracking road-killed turkeys and creating a road-kill index can be another effective method of monitoring social carrying capacity of turkey populations. Information gained from the surveys and road-kill index will be used to help complete Strategies 5.5-5.6 regarding nuisance wild turkeys.

Wildlife viewers have the opportunity every August to participate in citizen-science with the PGC by submitting their wild turkey sightings via the PGC's turkey sighting survey mobile application or on the agency website. This survey provides turkey productivity data like that collected in other Northeastern states, such that annual productivity can be compared across the region and fall harvest predictions can be generated (Strategy 1.7). Additional public involvement opportunities will be pursued this management cycle, as well as opportunities for the public to manage their land for quality habitat through landowner incentive programs.

The Wild Turkey Page on the PGC website, http://www.pgc.pa.gov/Wildlife/WildlifeSpecies/Turkey/Pages/default.aspx, provides a tremendous amount of educational resources for the hunting and non-hunting public, in addition to turkey habitat management suggestions, seasons, bag limits and regulations, information on life history, history of Pennsylvania's turkey population, how to identify turkeys by sex and age, the turkey management plan, tables and figures regarding trends in the population, answers to frequently asked questions, explanations of how/why the agency sets hunting seasons, hunting safety and tips, research conducted in Pennsylvania, and related links. The Wild Turkey Page will be updated regularly throughout this plan cycle (Strategies 3.3-3.6).

Education of hunters and non-hunters, hunting and civic organizations, school groups, and others regarding all aspects of wild turkey life history, research and management is an agency priority and will continue to be accomplished across all Bureaus, Regions, the NWTF Regional biologist, and countless volunteers (Strategies 3.4-3.5).

Educational Needs

All Pennsylvania turkey hunter surveys identified areas of the wild turkey management program that require additional educational efforts (Diefenbach 1996, Pennsylvania Game Commission 2002, Casalena et al. 2011, Casalena and Johnson 2015). Strategies 3.3-3.7, 4.2 and 4.9 involve all bureaus of the PGC and NWTF partnership, to provide research and educational information to the public via all forms of media and speaking engagements. Some turkey hunters continue to misunderstand: turkey harvest reporting for proper population management; the importance of properly timing the opening of our spring season; turkey population control and the role of fall harvests in population management; illegal hen mortality during spring season; consideration spring hunters can give to bearded hens, which have high probability of nest success due to their previous experience and size and, therefore, may add substantially to the local population if not harvested; and the general role of wild turkeys within the landscape.

Knowing that Pennsylvania hunters tend to be very traditional and resistant to change is helpful to the PGC when considering changes to hunting regulations or expanding opportunities. However, the large pool of new turkey hunters reported by recent PGC turkey surveys may not yet be committed to tradition and may offer new opportunities for education and regulation changes (Casalena et al. 2011, Casalena and Johnson 2015). Additional management-related data and life history studies will be required to meet these challenges. The PGC also must educate hunters and non-hunters on the importance of their providing valuable data, and of the need for their support of the necessary research that will allow the PGC to keep pace with change. Educational efforts will continue and will be further pursued regarding the need for regular habitat management at both the landscape and local scales to maintain and improve turkey populations. Habitat management goes hand-in-hand with harvest management.

VII. HUNTING/HUNTER SAFETY

Hunter Recruitment, Retention and Reactivation

Paid Wild Turkey Hunting License

Pennsylvania has traditionally chosen to restrict turkey-hunting participation through season lengths rather than quotas on numbers of hunters. A separate turkey-hunting license is often proposed by turkey hunting enthusiasts, but currently one spring and one fall turkey harvest permit are included in the cost of a general hunting license. Most states require a paid permit to hunt turkeys. In the northeast U.S., only Maryland and Pennsylvania allow turkey hunting without a permit or special license. Since 2006, hunters may purchase an additional spring turkey-hunting license to harvest a second spring bird. Pennsylvania turkey hunters continue to favor our tradition of unlimited participation, at least during the fall season; 76% of respondents to the 2008 Turkey Hunter Survey disagreed with restricting the number of fall turkey hunters to increase safety and satisfaction of turkey hunters (Pennsylvania Game Commission 2010).

However, completing portions of Strategies 4.1 and 4.2 of Hunting Heritage/Hunter Safety Objectives (such as tracking recruitment, retention and reactivation, improving harvest reporting, and conducting direct mailings to turkey hunters) would be more efficient with a turkey-hunting license (also Strategy 4.1). The database of turkey hunters would be maintained such that the PGC could track recruitment, retention and reactivation, and would simplify dissemination of educational and hunter safety materials via email and postal mail. Additionally, this strategy specifies to more precisely determine participation rates of turkey hunters and recommend ways of increasing participation of turkey hunters. Participation rates are currently estimated via annual GTS, MYHS, STHS, and MYSTHS. Sample sizes of these surveys will be increased to provide more precise WMU level data. We currently sample a portion of general license purchasers. A turkey-hunting license would assist with identifying turkey hunters for surveying.

The negative aspect of a turkey hunting license is the potential decrease in participation during this general declining trend in turkey hunters. Our hunter surveys show only 4% of spring turkey hunters and 2% of fall turkey hunters buy their general hunting licenses solely to hunt during these seasons; they hunt other species available with the general license. These general hunters may not be interested in paying for an additional license.

Hunting Participation

Current hunter participation data are derived from the annual spring turkey hunter and fall game-take surveys, which are distributed to license purchasers after the seasons have concluded. Even though turkey hunting participation has declined in Pennsylvania since its peak in 1981, turkeys

remain the second most popular game species, next to white-tailed deer (Fig. 20). Spring hunter numbers have remained stable since 1983 (average 223,200, range 179,200 in 1991 to 256,000 in 1983), but fall hunter numbers have decreased approximately 43% (from the 1983-86 average of 329,400 to the 2013-15 average of 186,400). Total number of license purchasers declined 22% during the same time. Since 2000 spring turkey hunters have outnumbered fall turkey hunters. The 2013-15 average total hunters for other highly popular species were approximately 735,240 deer (*Odocoileus virginianus*), 127,940 squirrel (*Sciurus sp.*), 126,940 bear, 86,240 pheasant and 39,930 coyote hunters (Johnson 2016).

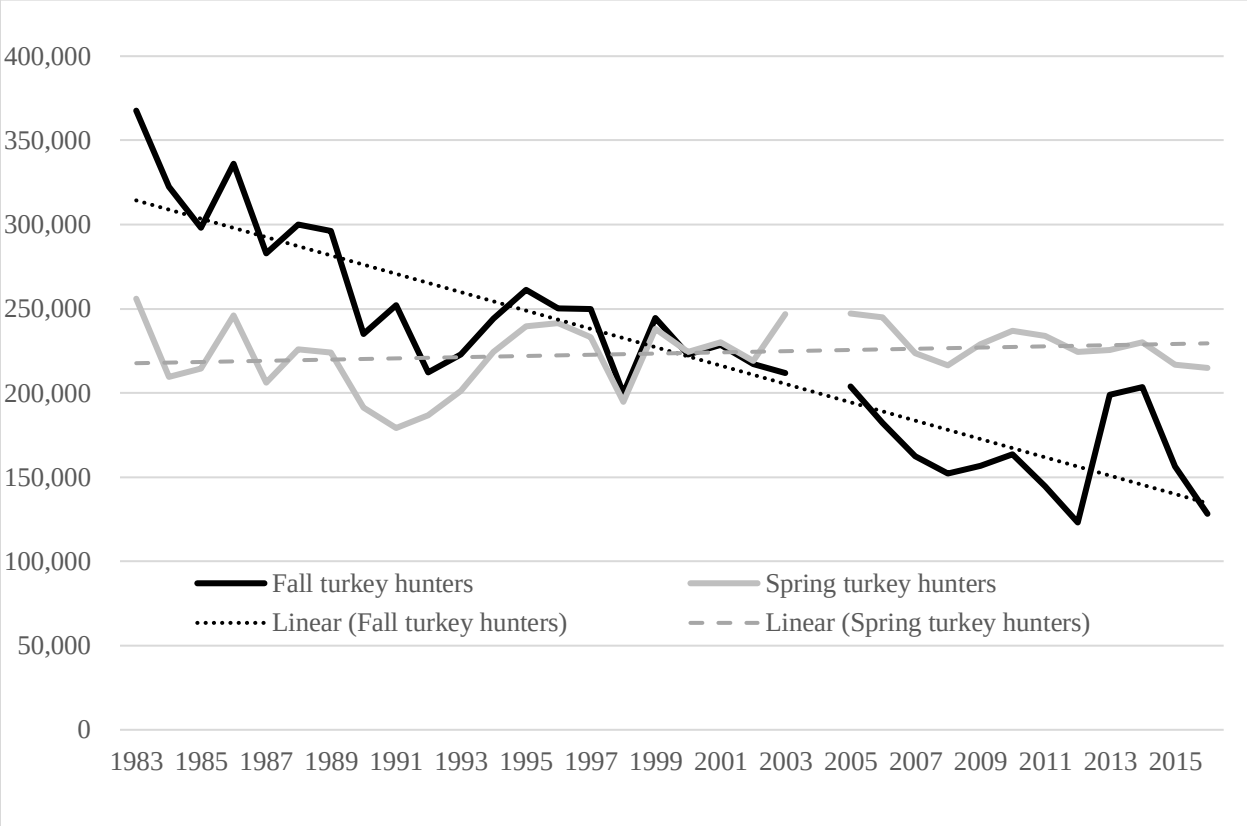

Figure 20. Number of Pennsylvania fall and spring turkey hunters, 1983-2016, and trend lines.

As Figure 20 suggests, not all turkey hunters hunt both seasons. On average, according to our hunter surveys from 2011-2016, 46% of spring turkey hunters also hunted fall turkey and 42% of fall turkey hunters also hunted spring turkey during the same license year (J. Johnson, Pennsylvania Game Commission unpublished data). This compares to 60% hunting both seasons during the 2007-08 seasons and 50% during the 1994-95 seasons (Diefenbach 1996, Casalena et al. 2011). However, Pennsylvania turkey hunters hunt many other species. On average, from 2011-2016, 93% of all our turkey hunters also hunted deer during the same license year, 30% hunted

bear, 27% hunted squirrel, 20% hunted rabbit (*Lepus americanus, Sylvilagus floridanus*), and less than 20% hunted other game species. Very few hunters, from 2011-2016, hunted solely turkeys (i.e., hunted no other seasons); 2% hunted only fall turkey season, and 4% hunted only spring turkey season (J. Johnson, Pennsylvania Game Commission unpublished data).

The 2012-15 average Pennsylvania turkey hunter age increased to 51.0 from 45.5 in 2009-11 (Johnson 2016, Casalena et al. 2011). This is consistent with the general hunter age increase for the same time. Responsive Management (2004) reported the main factor that affects general hunting participation in Pennsylvania was an aging hunting population, with aging hunters no longer able to hunt, or hunt less frequently. The same is likely true for turkey hunters. During the 2008 and 2009 hunter surveys, female hunters comprised 3% of fall turkey hunters and 4% of spring turkey hunters. Females comprised 7% of the general hunting license purchasers. Percentages increased slightly in 2014 for turkey hunters: 4% of fall turkey hunters and 5% of spring turkey hunters, but to 10% of the general hunting license purchasers (J. Johnson, Pennsylvania Game Commission unpublished data).

Throughout the 5-year survey period of fall turkey hunter surveys (2010-2014), the percentage of those who fall turkey hunted at least one of the last 3 years declined from 37% in 2010 to 28% in 2014, while the percentage of respondents who never hunted turkeys in Pennsylvania (fall or spring) increased from 32% to 37%, surpassing those who fall turkey hunted. However, the majority of fall turkey hunters consistently did so each year. Approximately 46% of survey respondents participated in the Thanksgiving season demonstrating that turkey hunters took advantage of the extra opportunity. Participation in the regular and Thanksgiving seasons fluctuated annually, which further demonstrated the benefit of multiple season opportunities. The majority (81%) of hunters were satisfied with the two-season segment structure or had no opinion. Hunting success did not drive satisfaction, but only about half of respondents had overall satisfaction with the seasons (ranged 57% in 2010 to 44% in 2014). Seeing turkeys, even without harvesting one, may have positively affected hunters' overall hunting experience (Casalena and Johnson 2015).

During the 5 years of fall turkey hunter surveys non-turkey hunters were asked how likely 10 factors (5 related to length and timing of fall turkey season) would influence their interest in starting to participate annually in fall turkey hunting. The top 3 factors remained the same all 5 years, along with order of importance. On average, 58% responded that more free time to hunt would influence their interest, 47% responded higher turkey populations, and 43% responded having a place to hunt; all factors not related to season structure (Casalena and Johnson 2015). The top reason mimicked that of nationwide surveys for the need of more free time to hunt (U.S. Department of the Interior et al. 2011). Although having more free time to hunt was the most

important factor that would influence initiating participation in fall turkey hunting, one factor that would provide flexibility to potential hunters, a longer season, became less important over the 5 years. Therefore, providing the flexibility of two fall seasons, managing for higher turkey populations, and maintaining hunter access were the most important aspects of recruiting and maintaining fall turkey hunters in Pennsylvania.

Programs to increase hunter recruitment, retention and reactivation have been developed within the PGC Bureau of Information and Education's Divisions of Marketing, Merchandising and Outreach as well as Research and Education. The Research and Education Division also conducts surveys to track program successes, strengths and failures to improve each program. Surveys of turkey hunters and non-hunting stakeholders, conducted at 10-year intervals beginning in 2018, will continue to be coordinated between the Bureau of Wildlife Management and Bureau of Information and Education (Strategies 3.1-3.2). Cooperative partnerships with other agencies and private organizations are crucial for these programs to be successful. More data are needed on hunter effort, how it affects hunter success rates and overall harvests, as well as how hunter efficiency affects turkey vulnerability (Strategies 3.1, 4.1 and 4.7).

Mentored Hunt Programs

Mentored hunt programs were initiated to improve hunter recruitment with the goal of retaining these hunters into the future. In 2006 Pennsylvania became the first state in the nation, under the Families Afield Initiative, to create a mentored youth hunting program. The mentor (licensed hunter 21 years or older) serves as guide to one mentored youth (an unlicensed person no older than 11 years of age accompanied by the mentor). As of the 2017-18-license year, a mentored youth may hunt: squirrels, cottontail rabbits, doves (*Columbidae* family; migratory game bird license required), woodchucks (*Marmota monax*), coyotes, deer, and turkeys in any of their respective seasons, and must follow daily and field possession bag limits for each species. The Mentored Adult Hunting Program began with the 2014-15 license year to allow first-time hunters 18 years and older who have never held a prior Pennsylvania hunting license, or one in another state or nation, to participate and learn about hunting through the experience of a licensed mentor, for three consecutive, unbroken, license years. As of the 2017-18-license year, a mentored adult may hunt: squirrels, ruffed grouse, cottontail rabbits, hares, pheasants (pheasant permit required), bobwhite quail (*Colinus virginianus*), porcupines (*Erethizon dorsatum*), woodchucks, crows (*Corvus* sp.), coyotes, antlerless deer, and turkeys in any of their respective seasons, and must follow daily and field possession bag limits for each species. Harvest tags for antlered deer and spring turkeys are provided with the mentored individual's permit. Although harvest tags are not provided for fall turkey season, a mentor can transfer their one fall turkey harvest tag to their mentored youth/adult if the mentored individual harvests a fall turkey, and the mentor is to check

the “taken by mentored youth/adult” box on the harvest report card or when reporting the harvest via phone or online.

Survey results from the 2014 fall wild turkey hunter survey showed 9% of respondents during the fall 2014 season took a mentored youth fall turkey hunting. Of those, 14% harvested a turkey (in 2013, 7% mentored a youth with an 8% success rate, in 2012, 10% mentored a youth with an 11% success rate). These success rates are like those of adult hunters and may increase mentored youth hunter recruitment and retention rates.

Hunter Access

Pennsylvania offers several million acres of public and private hunting lands. Public lands include: >1.5 million acres of State Game Lands, purchased for managing wildlife habitat and to provide hunting and trapping opportunities; approximately 2 million acres of state forest land; 200,000 acres of state parks; 500,000 acres of the Allegheny National Forest and U.S. Army Corps of Engineers and Department of Defense properties; and many county and municipal parks and recreational areas. Additionally, since 1936 the PGC has managed a Hunter Access Program to provide; hunting and trapping on private farms and forests (especially areas near large population centers), protection to landowners from violators, and an incentive for landowners to cooperate actively with the PGC and conservation organizations to improve habitat to increase wildlife populations,
http://www.pgc.pa.gov/HuntTrap/Hunting/HunterAccessProgram/Pages/default.aspx. As of 2017, >13,000 landowners and tenants were enrolled in the program providing hunting access to >2.6 million acres, of which 2.19 million acres were accessible for turkey hunting. In exchange, landowners receive extra law enforcement patrols, relief from damage by wildlife, free seedlings to plant on their property, free signage and free assistance on soil conservation and habitat improvement. The Hunter Access Program is to be maintained and expanded, as resources permit, throughout this management plan (Strategy 4.5). Private land accessible for turkey hunting in the Hunter Access Program comprises 9% of all the private land in Pennsylvania. According to the 2007-08 turkey hunter survey finding a place to turkey hunt was only difficult for hunters around the metropolitan areas of Philadelphia and Pittsburgh, where 56% and 51% of respondents had difficulty finding a place to hunt, respectively. In WMUs where most of the land is public (e.g., WMU 2G is 55% public, WMU 2F is 51% public) most fall turkey hunters hunted public land (67% of turkey hunters in WMU 2G and 66% of turkey hunters in WMU 2F), according to the 2007-08 turkey hunter survey. Conversely, more fall hunters in WMUs 5C (53%), 3C (52%), and 4E (40%) than in other WMUs hunted posted, privately owned land where private land comprised 97-99% of the land. Results were similar for the spring 2008 season (Casalena et al. 2010). Acquiring, and maintaining, hunter access in areas dominated by private land has the greatest benefit for hunters. At a statewide level, 65% of respondents to both the 2001 and 2008 surveys

did not have trouble finding a place to hunt, even though Pennsylvania has more turkey hunters and higher turkey hunters per square mile than most states (Tapley et al. 2007, Casalena et al. 2011). Respondents also did not believe there were too many hunters (63%), although opinions differed according to season. Approximately 63% of spring turkey hunters in 2001 and 2008 did not think there were too many turkey hunters, compared to about 49% of fall hunters. Approximately 28% were undecided for both seasons. Although a large percent of the 2001 and 2008 survey respondents would feel safer if fewer hunters were in the woods during either the fall or the spring season, 57% of respondents preferred regulating hunting pressure themselves rather than to have limits placed on hunter numbers. Thus, maintaining land open to hunting will continue to be an important aspect of self-regulating turkey hunting pressure. Although hunter interference and ease of access to hunting lands do not appear problematic currently, an increase in frequency of leasing land for hunting could make the Hunter Access Program even more important for wildlife managers in the future (Isabella and Reitz 2015).

Hunter Success

Spring turkey hunter success rates, calculated as percent of hunters who harvest a spring turkey (Table 17), fluctuate annually in Pennsylvania, depending on multi factors, including turkey age structure and population density, hunter density, access and habitat. Spring hunter success rates, for each WMU, are obtained by dividing regular harvests (excluding harvests from the special turkey license) by the number of participants according to the STHS. The 2007-2016 average statewide hunter success rate was 17% (Table 17). During this period the annual success rates among WMUs ranged from an average of 10% in WMUs 2F, 2G and 2H to 25% in WMU 2B and 29% in WMU 2A (the 39% in WMU 5D lacks precision due to low sample size). Variability likely is not associated with hunter density because the 3-year average hunter densities were similar between WMUs 2G and 2A (4.6 hunters /square mile, and 4.5, respectively). Habitat quality is much higher in WMU 2A than in 2G (Table 1 and Fig. 5).

Table 17. Spring turkey hunter success rates (%) by Wildlife Management Unit (WMU) in Pennsylvania, 2006-2016, determined from Spring Turkey Hunter Surveys, and the previous 3-year (2013-15) average. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2006	2007	2008	2009	2010	2011	2012[a]	2013	2014	2015	2016	Prev 3-yr Avg
1A	16.3	20.9	16.6	18.7	22.2	15.2		21.5	23.5	20.2	11.1	21.7
1B	20.3	27.1	25.3	29.1	20.9	18.2		24.5	24.0	12.9	13.4	20.5
2A	22.8	18.0	30.0	31.0	15.0	27.1		36.2	26.9	25.0	29.6	29.4
2B	17.2	15.9	21.2	16.3	9.6	13.9		27.3	22.1	25.5	24.5	25.0
2C	17.8	18.7	17.1	12.1	17.7	15.9		12.1	19.8	24.9	29.6	19.0
2D	16.1	13.8	23.3	23.0	14.9	20.1		18.4	25.5	22.7	27.3	22.2
2E	15.3	4.4	18.0	13.4	7.9	17.9		10.1	17.7	19.9	11.0	15.9
2F	12.3	16.4	13.4	12.9	12.5	15.7		9.6	9.3	12.2	9.2	10.4
2G	10.5	10.6	14.6	12.8	8.0	10.1		11.5	11.0	7.7	8.0	10.1
2H	10.5	10.6	14.6	12.8	8.0	10.1		11.5	12.8	5.6	14.2	10.0
3A	18.1	14.0	11.7	18.4	17.2	12.8		7.8	8.4	22.9	15.1	13.0
3B	14.8	15.1	17.7	21.6	17.4	10.6		9.2	10.9	16.8	1.7	12.3
3C	19.8	17.4	25.5	25.0	13.6	18.8		15.9	22.4	21.8	24.8	20.0
3D	19.2	20.4	20.0	21.9	13.2	13.5		15.4	13.7	28.4	7.1	19.2
4A	19.9	13.1	13.1	17.0	12.5	11.5		15.8	12.4	13.6	11.5	13.9
4B	17.0	13.1	10.8	14.2	13.4	8.5		12.0	6.2	15.4	12.3	11.2
4C	19.6	22.2	19.6	18.3	12.8	12.4		11.1	13.6	14.1	13.4	12.9
4D	11.0	15.3	17.6	15.9	17.6	14.3		11.9	11.1	18.4	9.2	13.8
4E	17.7	24.5	28.2	25.6	19.0	21.0		19.7	21.9	30.7	21.7	24.1
5A	11.3	25.0	16.7	8.9	13.9	14.5		13.0	25.1	9.2	6.7	15.8
5B	13.4	17.1	12.4	15.2	8.1	24.4		16.0	23.6	19.2	15.4	19.6
5C	15.0	12.1	16.6	10.3	14.4	18.1		15.6	8.7	11.9	18.5	12.1
5D[b]	36.7	22.5	21.0	45.1	11.1	68.7		33.4	38.5	83.2	30.2	51.7
State Average	15.4	16.2	18.7	18.6	13.5	15.1		15.4	16.2	17.9	15.1	16.5

[a] Data not available.

[b] Inadequate sample size.

Fall turkey hunter success rates are calculated by dividing the GTS harvest by the number of hunters (Table 18). Success in fall is more variable than in spring due to varying fall season lengths, mast supply (hard and soft), recruitment and weather during the season (Wunz and Ross 1990). The 2007-2016 statewide average hunter success rate was 10% (range 8-16%). During this period

the success rates among WMUs ranged from an average of 8.6% in WMU 4B to 15.2% in WMU 2A (Table 17).

The PGC does not maintain success rate data at the landownership level (i.e., private and public). According to the 2001 and 2008 Pennsylvania Turkey Hunter Surveys, approximately 71% of hunters, during both seasons consistently hunted non-posted land; i.e., either public (40%) or non-posted private land (31%; Casalena et al. 2011). In 2008, public land comprised 15% of Pennsylvania. Therefore, public and Hunter Access Program hunting areas remain important destinations for turkey hunters. The PGC strategies of improving habitat quality, conserving existing habitat and maintaining hunter access will be maintained through this plan cycle, which also may result in maintained and improved hunter success (Strategy 4.7).

Table 18. Fall turkey hunter success rates (%) by Wildlife Management Unit (WMU) in Pennsylvania, 2006-2016, and the 2013-15 average, determined from Game-Take Surveys, and the previous 3-year (2013-15) average. WMU 2H was created in 2013, as a section of the western region of WMU 2G and harvest data were back-calculated for prior years.

WMU	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Prev 3-yr Avg
1A	16.6	14.5	19.6	19.0	8.7	9.1	9.2	13.8	9.9	8.8	18.2	10.8
1B	21.4	15.1	24.0	24.1	16.5	9.9	13.7	7.6	12.4	7.3	9.6	9.1
2A	19.1	21.0	11.0	12.5	15.8	8.8	24.9	11.0	13.1	19.7	13.9	14.6
2B	18.9	15.5	6.7	14.0	4.9	16.0	18.2	7.4	15.3	6.7	17.3	9.8
2C	9.3	13.3	10.3	14.4	7.3	11.8	13.3	9.0	6.2	8.5	7.8	7.9
2D	20.4	14.2	19.8	12.6	9.2	19.1	14.5	15.1	12.1	10.2	14.1	12.5
2E	10.3	14.9	21.0	13.9	12.8	14.6	13.9	3.6	15.4	12.3	15.5	10.5
2F	11.6	11.1	7.5	9.3	11.0	5.2	13.4	11.8	9.9	10.7	3.6	10.8
2G	13.1	15.4	12.2	10.1	9.5	11.0	9.5	11.2	6.7	6.1	6.3	8.0
2H	13.1	15.4	12.2	10.1	9.5	11.0	9.5	5.8	0.0	13.9	5.5	6.5
3A	14.0	21.7	16.8	5.3	16.9	13.9	16.1	6.8	8.3	8.8	7.9	8.0
3B	6.0	11.3	9.4	13.5	9.5	8.9	11.3	6.1	11.3	7.6	12.3	8.4
3C	20.1	28.5	28.2	25.6	13.3	9.0	16.1	12.5	15.7	9.3	6.5	12.5
3D	10.2	11.9	19.7	7.6	15.4	14.4	6.7	1.5	8.7	6.6	2.9	5.6
4A	24.1	25.2	13.9	17.1	10.8	14.4	7.2	2.4	12.2	13.7	6.4	9.4
4B	15.2	11.1	14.2	6.2	10.6	6.8	7.9	4.5	8.6	9.4	6.8	7.5
4C	12.6	8.3	10.8	6.5	9.6	10.7	15.2	12.5	5.9	7.1	7.0	8.5
4D	13.7	19.0	23.8	9.9	8.7	13.9	5.4	5.5	7.0	13.3	4.3	8.6
4E	14.4	25.4	20.1	19.3	11.6	12.0	14.0	8.6	9.0	9.5	4.3	9.0
5A	Closed	Closed	Closed	Closed	13.8	6.2	9.9	9.3	13.9	6.1	5.5	9.8
5B	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
5C	17.2	8.7	5.3	4.40	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
5D	17.3	2.4	6.9	3.90	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
State Average	13.4	15.6	15.9	13.4	9.7	9.9	11.8	8.4	9.2	9.8	8.55	9.1

Sunday Hunting

In 2017, the PGC Board of Commissioners passed a position statement agreeing with the concept of Sunday hunting. Regulation requires State Legislation enactment.

Sunday hunting is not anticipated to pose biological concerns for spring turkey hunting in Pennsylvania because it would not affect the 3 biological concerns of spring turkey hunting: harvest of males prior to completion of breeding, disturbance of hens, and illegal/accidental hen harvest. Two management strategies alleviate these concerns. First is the biologically set opening date (opening during the median date of nest incubation, on average) such that most of the breeding has occurred, at which point breeding males are now excess to the population, and hen disturbance/harvest is minimized. Second, is the half-day season during the first half of the season, which minimizes disturbance of nesting hens.

Also, the belief that no Sunday hunting provides turkeys a 'rest day' has no biological basis. Vulnerability of gobblers to harvest is multi-faceted, i.e., it is affected by weather, age structure of gobbler population (dominance of each male), nesting stage of hens, hen density and movements, habitat, roost location, hunting pressure, and other possible factors. A 2012-2013 study in Louisiana (Gross et al. 2015) tracked GPS-transmittered gobblers and hunters with GPS units, and found "hunter presence had little effect on male movements". Male turkeys increased movement by 6% on hunted days compared to unhunted days. Turkeys that survived the hunting season tended to more often encounter areas of great hunter presence, suggesting a learned antipredator behavior. Therefore, Sunday hunting may have greater social impact (i.e., very slightly decreasing turkey hunter success) than biological impact.

There may be a minor biological concern with Sunday hunting during the fall season in Pennsylvania, i.e., a possible, but slight, increase in hen harvest rate. Current fall turkey seasons span 0-3 Sundays depending on WMU. Of the 23 WMUs, 2 WMUs incorporate 3 Sundays, 12 include 2 Sundays, 5 include 1 Sunday, 2 include 0 Sundays, and 2 WMUs have closed seasons. Once the Structured Decision Protocol is developed it will be used to evaluate potential impacts of Sunday hunting before recommending it for turkey seasons. Alternatively, potential harvest rate increases could be monitored via monitoring harvest rates (which would require a leg-banding study) or via population trends, and fall hunting season length recommendations could be adjusted accordingly. The slight (likely insignificant) harvest rate increase could occur if a flock was located and broken up late in the day on Saturday, then that flock would be vulnerable to harvest Sunday when it is attempting to re-group. However, this currently is the case for most other days of the season. In fact, hunting a flock that was broken up late the previous day is a current strategy for fall turkey hunting. Sunday hunting may have more positive social impacts than minor negative biological impacts. Sunday hunting may increase hunter recruitment, retention and/or re-activation because of no need to take time off from work or school, students would able to hunt 2 consecutive days, students who are busy with activities Saturday have another weekend day to hunt, and non-residents travelling to Pennsylvania may be more likely to hunt here with 2 weekend days available to hunt turkeys.

The added weekend days would more likely redistribute hunter participation and harvest rather than increase both. Many hunters (not all, due to religious obligations) may hunt Sunday instead of taking off a day during the week to hunt. This is based on our experience with the 3-day Thanksgiving season when many hunters have all or part of those days off school/work. Approximately 20% of the total season harvest occurs during those 3 days, but total fall harvest has not increased.

However, a conservative approach may be warranted to ensure protection of the resource upfront. A possibility is to end the spring season 4-5 days earlier for a 3-year period, assess the Sunday harvest, and determine if days can be added back without affecting harvest. The one- and two-week fall seasons could end on Friday instead of Saturday. WMUs with 3-week seasons end on a Friday, and would end on a Thursday, unless turkey population trends in a given WMU are deemed above social carrying capacity. Similar to spring season, the Sunday harvest would be assessed for a 3-year period to determine if days could be added back without affecting harvest.

Turkey Hunting Ethics and Safety

Turkey hunting is among the most challenging and rewarding types of outdoor recreation available. In its purest form, turkey hunting requires a wide range of skills including locating turkeys, calling ability, hunting strategy, knowledge of turkey behavior, and persistence. The future of turkey hunting depends on the spirit of fair chase, not the size or number of turkeys taken. The emphasis of information and education programs, within the agency and with partners, should continue to be experiences and challenges in turkey hunting - not harvest (Strategy 4.8).

In Pennsylvania, hunting-related shooting incidents (HRSIs) have declined by nearly 80% since hunter education training began in 1959 (Snyder 2006). PGC tracks trends in HRSIs by measuring the accident rate per 100,000 participants (Table 22). Turkey HRSI rates have declined considerably since 2004, but any incidents remain a concern (Strategy 4.8). From 2012-16 there were no fatal turkey-hunting HRSIs, a trend the PGC strives to maintain using continued and additional turkey hunting safety education. Fewer incidents also maintain an ethical and responsible image of turkey hunters for the public. The PANWTF also maintains an educational campaign to sustain this trend. The Wild Turkey Hunting Safety Task Force with the NWTF was re-convened in 2018 (the previous Task Force concluded in 2005; NWTF 2005). The PGC will continue to be involved, particularly because Pennsylvania historically has had the most turkey hunters and, unfortunately, turkey-related HRSIs in the nation. This Task Force also reviews the safety and legality of new hunting products that continually are introduced to the market. Products

that are not a safety concern in one state may be dangerous in another due to more cover, higher turkey hunter density or the interpretation of fair-chase.

Since 2012, turkey-related HRSI rates have been below our management goals for both spring (less than 2) and fall (less than 0.5; Strategy 4.8; Table 22). Additionally, there were no fall turkey HRSIs in 2012 and 2016, with 1 each year in-between. Although fall turkey hunter density continues to average 3.7 hunters per square mile (2012-2016), participation during key hunting days (i.e., Saturdays, opening /closing days) may have declined such that there are fewer turkey hunters in the field during any day of the season. There continues to be more spring than fall HRSIs, possibly related to the higher spring turkey hunter density (2012-2016 average of 4.8). The Turkey Hunter Safety Task Force also concluded that lower hunter densities appear to improve hunter safety. Therefore, the Task Force encouraged agencies to expand hunting opportunity through changes in season length, hunting hours, and access (NWTF 2005).

Hunter anticipation/excitement may also increase HSRIs. Most spring HRSIs tend to occur the first week of the season and result from hunters shooting the victim in mistake of game. Most fall HRSIs are caused by hunters shooting the victim in line of fire. The greatest number of turkey-hunting HRSIs are caused by hunters "failing to properly identify their target, and beyond", caused by premature closure (Pennsylvania Game Commission 2011, Snyder 2006). Premature closure describes the series of acts that occur up to the point when a turkey HRSI offender decides to shoot. The offender typically sees movement, often coupled with hearing sounds thought to be made by a turkey. Before the offender positively identifies these sights and sounds as being a turkey, his/her sensory processes close and the decision is made to shoot. Also, spring season regulations permit harvesting only bearded turkeys. Therefore, hunters must be close enough to see a beard as part of the positive identification process before shooting (rifles are not permitted during the spring season); yet more incidents occur during the spring season than fall. Additionally, most incidents occur during the first week of the spring season. Clearly, hunter anxiety also plays a role in HRSIs. Educational videos, public announcements, news releases via all forms of media are strategies that will be employed by the PGC and partners to alert hunters of the importance of safe hunting (Strategies 4.2, 4.8, and 4.9).

Table 22. Hunting-related shooting incidents (HRSIs) during spring and fall wild turkey seasons (1983-2016), Pennsylvania. Incident rate includes fatal and nonfatal incidents.

	Spring			Fall		
Year	Nonfatal	Fatal	Rate (HRSIs/100,000 hunters)	Nonfatal	Fatal	Rate (HRSIs/100,000 hunters)
1983	7	0	2.7	13	0	3.5
1984	5	1	2.9	10	1	3.1
1985	8	2	3.7	17	1	5.7
1986	10	0	4.1	25	1	7.4
1987	8	0	3.9	25	1	8.8
1988	8	0	3.5	21	3	7.0
1989	4	1	1.8	19	0	6.4
1990	8	1	4.2	38	3	16.2
1991	16	0	8.9	37	2	14.7
1992[a]	8	0	4.3	6	0	2.8
1993[b]	5	0	2.5	6	0	2.7
1994	9	1	4.0	7	0	2.9
1995	16	0	6.7	14	0	5.4
1996	12	0	5.0	11	1	4.8
1997	12	0	5.1	14	0	5.6
1998	10	0	5.1	8	2	4.5
1999	14	0	5.9	16	1	6.5
2000	13	0	5.6	10	0	4.3
2001	7	0	3.0	13	0	5.7
2002	9	1	4.1	15	0	6.9
2003	9	0	3.6	2	0	0.9
2004[c]	9	0	No Data[c]	5	0	No Data[c]
2005	9	0	3.6	2	0	1.0
2006	5	0	2.0	4	0	2.5
2007	5	0	2.2	1	0	0.7
2008[d]	8	0	3.7	2	0	1.3
2009	5	0	2.2	3	0	1.8
2010	10	1	4.6	1	1	1.4
2011[e]	5	1	2.2	2	0	1.6
2012	3	0	1.4	0	0	0.0
2013	1	0	0.4	1	0	0.5
2014	1	0	0.4	1	0	0.5
2015	1	0	0.5	1	0	0.6
2016	4	0	1.4	0	0	0.0
10-yr avg.	4.3	0.2	1.9	1.2	0.1	0.8

[a] Fall fluorescent orange requirement began fall 1992. [b] Spring fluorescent orange requirement began spring 1993 while moving. [c] Annual hunter survey was not conducted in 2004. [d] Fluorescent orange requirement for spring season rescinded. [e] All-day hunting permitted during second half of spring season and season extended to May 31.

The Pennsylvania Game & Wildlife Code requires every person who is involved in an incident resulting in injury by a firearm or bow and arrow while hunting, either as a victim or the person causing injury (including self-inflicted) report it to the PGC within 72 hours. It is unlawful not to submit a report, or to flee, fail, or refuse to render immediate and full assistance to an injured person.

Two programs that support hunter ethics, and simultaneously assist the PGC find/prosecute violators, are the PGC Operation Game Thief (1-888-PGC-8001, https://pgcdatacollection.pa.gov/operationgamethief), and the Pennsylvania Chapter NWTF reward program. These 2 programs provide monetary rewards to the individual/s who provide information that leads to a conviction. These programs continue to help motivate the public to report hunting violations and will continue through this management plan cycle.

VIII. WILD TURKEY PROTECTION

In 2010, via legislation, Pennsylvania joined the Interstate Wildlife Violator Compact (IWVC) which provides reciprocal sharing of information regarding sportsman fishing, hunting, and trapping violations and allows for recognition of suspension or revocation of hunting, fishing, and trapping licenses and permits in all member states. Thus, the IWVC obligates members to report wildlife violation convictions to Compact members, gives the members the capability to honor each other's suspensions, and provides the method to exchange violator data between member states. This Compact facilitates implementation of Strategy 5.1. The PGC will annually continue to seek additional legislation wherever necessary (Strategy 5.3).

Sporting Arms

Legal sporting arms during the spring turkey season are shotgun or archery equipment, including crossbows. During the fall season, hunters in all WMUs except 2B, 5C, and 5D also are permitted to use rifles, muzzle-loading rifles, and handguns.

Crossbows have been legal to use during the spring season for all hunters since 2007. Since 2010, spring harvest via crossbow has consistently comprised about 1% of the total harvest (Table 22). This harvest seems to be shotgun hunters switching to crossbows because other archery harvests (compound and recurve bow) have consistently comprised 1% of spring harvests during the same period, i.e., total archery harvest is 2%.

Archery harvests have traditionally comprised a larger percentage of the fall than spring turkey harvests, likely because part of the season overlaps with archery deer season, in most WMUs (Table 23). Crossbows have been legal for all fall turkey hunters since 2006, but comprised only 1% of the total harvest through 2010, while recurve and compound bow harvests comprised 2% (Table 23). The percentage of harvests via archery tackle significantly increased (p=0.001) from 6% in 2011 to 11% in 2016. Most of this increase is due to crossbow use (3% to 7%). Interestingly, harvest via rifle also increased significantly (p=0.0005), from 19% in 2006 to an average of 23% in 2008-2010, and to an average of 28% in 2012-2016. The increase likely is due to a 2012 regulation change that permitted use of rifles in 3 additional WMUs (1A, 1B and 2A), such that only WMU 2B (Pittsburgh and surrounding areas) is limited to shotguns and archery during the fall season (WMUs 5C and 5D are closed to fall turkey hunting). Harvest via shotgun decreased from 77% in 2006, to 60% in 2016. Handgun and muzzleloader harvests have consistently comprised <1% of the harvest (0.2% for handguns and 0.3% for muzzleloaders).

Table 23. Pennsylvania turkey harvest via sporting arm in each season, 2003-2016. Percentages less than 1% are presented in decimals.

	Spring				Fall						
Year	Shotgun	All Bow	Bow	Crossbow	Shotgun	All Bow	Bow	Crossbow	Rifle	Handgun	Muzzleloader
2016	98%	2%	1%	1.1%	60%	11%	4%	7%	29%	0.2%	0.3%
2015	98%	2%	1%	1.0%	62%	8%	3%	5%	30%	0.2%	0.3%
2014	98%	2%	1%	1.0%	65%	8%	4%	5%	26%	0.2%	0.3%
2013	98%	2%	1%	0.8%	66%	6%	3%	4%	27%	0.2%	0.3%
2012[a]	98%	2%	1%	0.9%	65%	7%	3%	4%	28%	0.2%	0.1%
2011	98%	2%	1%	1.0%	70%	6%	3%	3%	23%	0.4%	0.2%
2010	98%	2%	1%	1.0%	73%	3%	2%	1%	24%	0.2%	0.3%
2009	99%	1%	1%	0.3%	73%	4%	3%	2%	22%	0.2%	0.4%
2008	99%	1%	1%	0.3%	74%	3%	2%	1%	23%	0.2%	0.2%
2007[b]	99%	1%	0.4%	0.1%	76%	3%	2%	1%	20%	0.2%	0.2%
2006[c]	99%	1%	0.4%	0.1%	77%	3%	2%	1%	19%	0.3%	0.2%
2005[d]	99%	1%	1%	0.0%	79%	3%	2%	1%	18%	0.2%	0.4%
2004[e]	99%	0.2%	0.1%	0.1%	79%	2%	2%	0.4%	18%	0.3%	0.3%
2003	99%	1%	0.5%	0.0%	80%	2%	2%	0.3%	18%	0.2%	0.1%

[a] Beginning fall 2012 rifles permitted in Wildlife Management Units 1A, 1B and 2A, i.e., all WMUs open to fall turkey hunting except 2B.

[b] Beginning spring 2007 crossbows permitted during spring season.

[c] Beginning fall 2006 crossbows permitted during fall season.

[d] Beginning spring 2005 crossbows permitted only with authorized crossbow permit.

[e] Beginning fall 2004 crossbows permitted only with authorized crossbow permit.

Although most fall turkey hunters continue to use shotguns, hunter surveys show hunter attitudes regarding use of rifles during fall season have shifted toward maintaining rifles as an option; 39%, 44% and 50% of all hunters during Pennsylvania's 1995, 2001, and 2008 surveys, respectively, disagreed that rifles should be illegal for fall hunting (Casalena et al. 2011). Opposition to regulations on rifles exceeds their use. General speculation is, some of this opposition may arise from concerns regarding the right to bear arms.

Nuisance Turkeys

According to Strategies 5.5-5.6, the PGC will maintain minimal human-turkey conflicts through shared public and private responsibility and in a manner consistent with population and recreation objectives. During the 1999-2005 management plan, turkey population densities were above social carrying capacity in several areas of Pennsylvania as determined by the volume of nuisance complaints to the PGC from residents in suburban and agricultural areas. Although turkeys caused damage to agricultural crops, damage usually was minor, and much was caused by other wildlife species, particularly nocturnal species (Groepper et al. 2015). Occasionally, turkeys damage specialty crops, turf grass, wine grapes or ornamental flowers that may have greater value than

common agricultural crops. However, the perception of agricultural damage caused by turkeys is typically larger than the actual damage caused, as turkeys often are simply moving through the area foraging on insects on the ground and the nocturnal culprits typically are not seen (Groepper et al. 2015, Hughes and Eriksen 2015).

Nuisance wild turkey complaints typically increase when social carrying capacity is exceeded. Therefore, Strategy 3.2 (determining social carrying capacity) and 5.5-5.6 (nuisance wild turkeys) will be completed in conjunction with each other.

WMU 2B (suburban Pittsburgh area) has some of Pennsylvania's densest turkey populations due to high quality habitat and agriculture interspersed with dense human populations. WMU 2B had particularly high nuisance complaints during much of the 2006-2017 management plan, and State Game Wardens and the wild turkey biologist developed educational procedures to handle complaints individually. A draft Standard Operating Procedure (SOP 40.13, Guidelines for handling nuisance urban/suburban wild turkey conflicts) was developed and will be completed this cycle (Strategy 5.5). These guidelines begin with education of landowners regarding turkey behavior and methods to modify this behavior. Where problems persist, field officers are directed to determine whether the turkeys are wild or domestic. Turkeys will be removed by the PGC if they are determined to be pen-reared and the owner cannot be identified. Removal of wild turkeys will occur only in cases where damage/nuisance is severe, behavioral modification is not successful, hunting is not effective, or public safety is an issue. Turkeys either will be relocated at least 10 air miles away (to reduce probability of return) on lands open to hunting or euthanized in accordance with PGC guidelines. Where possible, euthanized turkeys suitable for human consumption are to be made available to local families and/or food banks. Net guns were purchased in several Regions to trap individual nuisance turkeys in suburban areas. An experimental nuisance trap and transfer program in suburban WMU 2B during the 2006-2017 management plan was successful; none of the turkeys (which were trapped from nuisance flocks, leg-banded and released onto public lands) became nuisances again, and several were harvested during hunting seasons (Casalena and Trusso 2011).

Game Farm Turkeys

The NWTF defines a pen-reared "wild" turkey (game farm turkey) as any wild turkey eggs or wild turkeys hatched and/or raised under human control. The difference between game farm and wild turkeys is primarily behavioral. A study on genetic variability and differentiation among wild, game farm and domestic turkeys concluded that heterozygosities of the wild and game farm turkeys were not significantly different, but both were significantly different from domestic turkeys (Stangel et al. 1992). Levels of heterozygosity were significantly lower in domestic turkeys

than in wild and game farm turkeys. Stangel et al. (1992) additionally concluded that, because reduced heterozygosity affects vigor in wild turkeys, the low heterozygosity in domestic and some game farm stock would clearly be reason to prohibit introducing these stocks into wild populations, as these introductions would degrade the overall genetic resource in wild populations.

The importation, sale, and/or release of game farm turkeys in Pennsylvania is addressed in the Pennsylvania Game and Wildlife Code, Title 58, Chapter 137, Sect. 137.2, which states, "It is unlawful to release captive held or captive raised game or wildlife on to any lands, public or private, without first securing a permit from the Commission. The permit applicant shall provide proof the turkeys to be released have been tested using procedures prescribed by the Department of Agriculture in Title 7 Pa. Code Chapter 15 (relating to control and eradication of pullorum disease) and have been found free of disease." Game farm turkeys can be exported to other game farms without a health certificate. However, game farm turkeys pose a potential disease transmission as well as genetic dilution threat to wild populations. Unless properly housed and/or wing-clipped, inadvertent or illegal releases of game farm turkeys to the wild can occur and are difficult to regulate and enforce. Game farm turkeys also can become habituated to humans and become nuisances. However, the number of turkey propagators in Pennsylvania has decreased since the 1990s, such that <50 permitted turkey propagators existed in Pennsylvania in 2018. The main concern the PGC has with propagating turkeys is education of backyard menageries and the potential negative effects to wild turkeys from accidental releases of game farm turkeys. The NWTF developed a brochure and article explaining the problems associated with releasing game farm turkeys, that was featured in the Pennsylvania Game News, and on the PGC and NWTF web sites (Eriksen 2002).

Menagerie owners, hunting preserve owners, and private propagators have vigorously opposed elimination of game farm turkeys in Pennsylvania and other states. Most opposition likely stems from the belief that restrictions on game farm turkeys could lead to future restrictions on other species. Additionally, paid preserve turkey hunting detracts from the public image of turkey hunting and provides fuel for anti-hunters.

The PGC funded a genetics study in 2014 to compare the genetic structure of eastern wild turkeys in the Michaux State Forest (MSF) to that of wild turkeys across the remainder of the state, and to that of turkeys propagated on PGC game farms (PGC game farms closed in 1980). The study objective was to determine if the MSF turkey population may be descendants of PGC game farm turkeys. If so, the lower vigor could partially be the reason for the low MSF turkey population density (Huffman et al. 2014). The study showed the MSF turkey population: 1) did not share alleles with the game farm turkeys; 2) was genetically diverse and; 3) may be a separate

subpopulation of the eastern wild turkey. Wild turkeys in the remaining regions of Pennsylvania shared alleles with the game farm turkeys.

IX. COOPERATIVE PARTNERSHIPS

Cooperative partnerships are necessary to advance landscape-level habitat management and improvement for healthy wild turkey populations, combine resources and expertise in advancing wild turkey research and management, and assist other agencies with wild turkey range restoration (Strategies 2.6, 2.9, 2.11, and 6.1-6.6). Public landowners (e.g., U.S. Army Corps of Engineers, U.S. National Park Service, U.S. Fish and Wildlife Service, Allegheny National Forest, DCNR-Bureau of Forestry, DCNR-Bureau of State Parks, and many county and local governments) have partnered with the PGC to advance wild turkey management in Pennsylvania by providing huntable public land, enhanced habitat, wildlife viewing, and educational programs. These cooperative partnerships will continue and expand as resources permit.

National Wild Turkey Federation

The largest conservation group with a primary stake in the wild turkey resource is the NWTF, which was founded in 1973 with a mission to conserve wild turkeys and preserve the hunting tradition. More than 223,000 volunteers and avid turkey hunters throughout North America were members in 2017. Pennsylvania had >14,000 members; 2nd in membership nationally, behind Missouri. Through fund-raising efforts from 1985-2016, the Pennsylvania Chapter NWTF and partners have spent more than $6 million on projects to benefit the wild turkey. Projects have included all aspects of wild turkey management, such as habitat management, land acquisition, research, information and education, restoration, activities for youth, women and the handicapped, hunting safety, law enforcement, reward payments for reporting turkey-hunting violations that lead to a conviction, and others. The PANWTF's and NWTF's assistance, support, and coordination with PGC wild turkey management have been extremely valuable, with anticipated future growth (Strategies 6.1 and 6.2). PANWTF has funded nearly 2,300 habitat projects in Pennsylvania from 1985-2017. Projects have been conducted on SGLs, state forests, state parks, U.S. Army Corps of Engineers properties, Allegheny National Forest, local municipality properties and private properties open to public hunting. Moreover, projects have involved creating and maintaining early successional habitat; timber stand improvements; perennial wildlife opening creation and maintenance; tree planting; equipment purchase and rental; habitat restoration; annual food plot creation and maintenance; fencing from deer; assisting with prescribed fire management; invasive plant control; and the NWTF's Seed Subsidy Program. This strong partnership between the PGC and PANWTF helps improve habitat for the wild turkey, and a wide variety of wildlife species.

On average the approximately 10,500 PANWTF members account for 6-8% of Pennsylvania turkey hunters. While the views of the Chapter may not always reflect those of the average turkey

hunter, they may provide a more progressive and resource oriented-reflection of the attitudes of the avid turkey hunter (Casalena et al. 2011).

The PGC and NWTF maintain a Cooperative Agreement (current version covers 2014-2019), in which NWTF employs a qualified regional turkey biologist who assists the PGC with implementation of the agency's wild turkey management plan through provision of time, resources and technical expertise. The PGC agrees to pay NWTF $25,000 per year for expenses incurred by NWTF in employing the biologist (Strategy 6.2). During the next agreement period, 2019-2024, the contract will increase to $35,000 per year due to the NWTF biologist's increased time commitments within Pennsylvania. Additionally, the PGC meets annually with PANWTF leadership and NWTF staff based in Pennsylvania to continue this close agency coordination. The PGC wild turkey biologist within the Bureau of Wildlife Management, and turkey biologists from all other states serve as technical representatives to the NWTF National Wild Turkey Technical Committee. This Committee advises NWTF and coordinates nationally on matters that concern wild turkey conservation, research, management, policy, regulations and biology, and ensures a flow of information, cooperation, and mutual support necessary to maximize future wild turkey management progress. The PGC turkey biologist also serves as technical representative to the PANWTF and regularly attends their quarterly board meetings (Strategy 6.3).

Other Partnerships

The PGC upland game bird biologists are members of the Northeast Upland Game Bird Technical Committee, which is comprised of state biologists from Maine to West Virginia to coordinate research, exchange ideas, and assist with problems, needs, or situations relative to management and research of wild turkeys, ruffed grouse, American woodcock, ring-necked pheasants, and bobwhite quail (Strategy 6.3). This Committee was established by the Northeast Wildlife Administrators Association and will continue to maintain its partnership with the PGC at the direction of the Administrators. As the need arises, the PGC also cooperates with other agencies, universities, and state and federal agencies regarding wild turkey restoration and research (Strategy 6.5).

The WMU 5A Wild Turkey Task Force, in place since 1995 to closely monitor that turkey population in relation to fall season structure and habitat management, has been a prime example of the benefits of a cooperative partnership. Task force members work cooperatively to conduct turkey surveys, habitat management, discuss issues, find solutions and funding and provide management recommendations beneficial to the public and wild turkeys. This task force structure can be used in other WMUs if and when deemed necessary and where resources permit (Strategy 6.4).

The PGC has several programs for managing wild turkey habitat on private lands, such as the Private Lands Assistance Program, Forest Wildlife and Farm Game Cooperative Programs, and Regional Wildlife Diversity Program (Strategies 2.6, 2.10, 2.11 and 6.1). Similar programs are provided through the PA DCNR's Forest Stewardship Program, Penn State University's Forest Extension, NWTF's Wild Turkey Woodlands Program, USDA/NRCS programs, and private woodland owners' associations. Private industry can promote wild turkey management while gaining valuable public relations if given proper direction and incentives. Land-use industries (e.g., farming, forestry, energy and mining) readily carry out wildlife practices if given proper and practical direction. In addition, conservation organizations and the public are willing to help. Public outreach, landowner incentive programs, and resources are necessary to involve more public in habitat enhancement projects on private lands.

Trap and Transfer

Trap and transfer of wild turkeys, accompanied by habitat restoration and conservative hunting seasons, are responsible for the restoration of wild turkey populations in Pennsylvania and throughout the United States. From 1958-2008, the PGC transferred 3,709 wild turkeys within Pennsylvania to restore populations. Two primary biological reasons for the program's effectiveness were: (1) good quality wild turkeys rather than the inferior game-farm turkeys originally used, and (2) accelerated establishment of viable breeding populations in suitable but unoccupied habitat rather than depending on the relatively slow process of natural dispersal.

The most recent transfers occurred in 2008, as part of the "Nuisance wild turkey transfer pilot program in Southwestern Pennsylvania" (Casalena and Trusso 2011). Twenty-three wild turkeys were transferred from nuisance urban flocks on private properties within the greater Pittsburgh area to State Game Lands and other lands open to public hunting over 10 air miles away. The program was successful, but the recommendation was to use transfer as a final option for handling future nuisance wild turkey flocks in urban or suburban settings where hunting is not available, artificial feeding is not occurring, and habitat modification is unsuccessful.

Trap and transfer of wild turkeys to augment suppressed wild populations should not be used as a management option. Where viable populations exist, but are at low densities, the factors limiting the population must be determined and corrected. Otherwise those factors suppressing the population will have even greater effect on additional turkeys from other parts of the state that are not adapted to that area. Transfers could increase populations briefly, but without correcting the problem, the population will again decline. Transfers also could confound and delay detection of

limiting factors because transferred turkeys that survive would mask and offset continued high mortality or low recruitment rates.

Private landowners who desire, but do not have, wild turkeys frequenting their property, are encouraged to create suitable habitat for neighboring wild flocks to expand to. Turkeys likely will eventually frequent the area. If the property is geographically isolated and/or the wild turkey population density in the area is not large enough for immigration, turkeys may never frequent the property.

In-state transfers should be used only where viability of wild turkey populations over large areas is threatened. In such instances, fall hunting should be closed until the population reaches a density sufficient for fall hunting, as specified in the section in this management plan, *Decision-making guidelines for recommending fall turkey-hunting seasons*.

From 1958-2008, the PGC transferred 915 wild turkeys to 9 states, the most recent was 53 wild turkeys transferred to South Dakota in 2006 in exchange for wild ring-necked pheasants for the Somerset County Wild Pheasant Recovery Area. Previous out-of-state transfers to other states for restoration or range expansion have been mutually beneficial to the recipient states and the PGC. Future transfers will occur if requested, and not precluded by financial constraints or other priorities (Strategy 6.5). However, because turkey trapping has not occurred since 2014, Regional Wild Turkey Trap and Transfer Crews would require training and possibly equipment, particularly rocket charges. Sources of wild turkeys for out-of-state transfers would first be from nuisance flocks in suburban and urban areas closed to public hunting and/or from private lands. In accordance with PGC Standard Operating Procedures, all wild turkeys transferred out of state are to be tested by a wildlife veterinarian for *Mycoplasma gallisepticum*, *Mycoplasma synoviae*, avian influenza, and *Salmonella pullorum*, via blood tests, to ensure each wild turkey is disease-free prior to shipping (Casalena 2013). According to the PGC 2008 turkey hunter survey, only 40% of respondents supported out of state transfers to assist other states with turkey population restoration. Support increased to 54% if turkeys were trapped on private or unhuntable lands (Casalena 2010). Continued education is necessary to convey the values of assisting other states with wild turkey restoration, and the biological shortcomings of augmenting low populations with in-state transfers.

X. LITERATURE CITED

Abrams, M.D. 1992. Fire and the development of oak forests. BioScience 42:346-353.

Albright, T. A. McWilliams, W. H., Widmann, R. H.; Butler, B. J., Crocker, S. J., Kurtz, C. M., Lehman, S., Lister, T. W., Miles, P. D., Morin, R. S., Riemann, R., and Smith, J. E. 2017. Pennsylvania forests 2014**.** Resour. Bull. NRS-111. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 140 p.

Association of Fish and Wildlife Agencies. 2014. National furbearer harvest statistics database. <http://fishwildlife.org/?section=furbearer_management_resources>. Access 11 November 2014.

Alpizar-Jara, R., E. N. Brooks, K. H. Pollock, D. E. Steffen, J. C. Pack, and G. W. Norman. 2001. An eastern wild turkey population dynamics model for Virginia and West Virginia. Journal of Wildlife Management 65:415-424.

Allison, A.B., M.K. Keel, J.E. Philips, A.N. Cartoceti, B.A. Munk, N.M. Nemeth, T.I. Welsh, J.M. Thomas, J.M. Crum, A.B. Lichtenwalner, E.M. Bunting, A.M. Fadley, G. Zavala, E.C. Holmes, and J.D. Brown. 2014. Avian oncogenesis induced by lymphoproliferative disease virus: A neglected or emerging retroviral pathogen? Virology 450-451: 2-12.

Austin, D. E. and L. W. DeGraff. 1975. Winter survival of wild turkeys in the southern Adirondacks. Proceedings of the National Wild Turkey Symposium 3:55-60.

Backs, S. E. and L. W. Bledsoe. 2011. Invertebrate abundance and vegetative structure in forest openings. Proceedings of the National Wild Turkey Symposium 10:51-63.

Backs, S. E. 2009. The other silent spring: disappearing bird of young forests. Ruffed Grouse Society Quarterly 21:40-41.

Badyaev, A. V., W. J. Etges, and T. E. Martin. 1996. Ecological and behavioral correlates of variation in seasonal home ranges of wild turkeys. Journal of Wildlife Management 60:154-164.

Baumann, D. P., Jr., L. D. Vangilder, C. I. Taylor, R. Engel-Wilson, R. O. Kimmel, and G. A. Wunz. 1991. Expenditures for wild turkey hunting. Proceedings of the National Wild Turkey Symposium 6:157-166.

Bevill, W. V. 1974. Some factors influencing gobbling activity among wild turkeys. Proceedings of the Southeast Association of Fish and Wildlife Agencies 27:62-73.

Blankenship, L. H. 1992. Physiology. Pages 84-100 *in* J. G. Dickson, Editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Brautigam, K. J., D. C. Osborne, D. White, Jr., and J. P. Honey. 2015. Effects of supplemental deer feeders on survival of artificial ground nests in southeastern Arkansas. Proceedings of the National Wild Turkey Symposium 11:303-311.

Brose, P.H., D.C. Dey, and T.A. Waldrop. 2014. The fire-oak literature of eastern North America: Synthesis and guidelines. U.S. Forest Service General Technical Report GTR-NRS-135.

Brown, J., C. Cleveland, L. Williams, M. J. Casalena. 2016. Surveillance for lymphoproliferative disease virus in wild upland game birds in Pennsylvania. 2016. *Poster presented at the* 65th Annual Meeting of the Wildlife Disease Association, Cortland, New York, USA.

Burhans, B. J. 1996. Influence of forest clearings on the winter survival, reproduction and movements of wild turkey hens in southwestern Virginia. Thesis. Frostburg State University. Frostburg, Maryland, USA.

Byrne, M. E., and M. J. Chamberlain. 2015. Using behavior and space use of raccoons to indirectly asses the nature of nest predation. Proceedings of the National Wild Turkey Symposium 11:283-293

Byrne, M. E., M. J. Chamberlain, and B. A. Collier. 2015. Potential density dependence in wild turkey productivity in the southeastern United States. Proceedings of the National Wild Turkey Symposium 11:329-351.

Cartwright, M. E., and R. A. Smith. 1990. Attitudes, opinions, and characteristics of a select group of Arkansas spring turkey hunters. Proceedings of the National Wild Turkey Symposium 6:177-187.

Casalena, M. J. 2006. Management plan for wild turkeys in Pennsylvania, 2006-2015. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Casalena, M. J. 2010. 2008 Pennsylvania turkey hunter survey results. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Casalena, M. J. 2013. Wild turkey trap and transfer. Annual Job Report Number 27005. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Casalena, M. J. 2015. Hen turkey fall harvest rates and annual survival rates. Annual Job Report Number 27010, Pennsylvania Game Commission, Bureau of Wildlife Management. Harrisburg, USA.

Casalena, M. J. 2016. Wild turkey productivity and harvest trends. Annual Job Report Number 27001, Pennsylvania Game Commission, Bureau of Wildlife Management. Harrisburg, USA.

Casalena, M. J., M. A. Lowles, and D. R. Diefenbach. 2007. Factors suppressing a wild turkey population in southcentral Pennsylvania. Proceedings of the National Wild Turkey Symposium 9:107-116.

Casalena, M. J., and R. Eriksen. 2003b. Options for spring wild turkey hunting to increase recreational opportunity, December 2003. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Casalena, M. J., and S. Trusso. 2011. Nuisance wild turkey transfer pilot program in Southwestern Pennsylvania. Annual Job Report Number 27005. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Casalena, M. J., C. S. Rosenberry, and R. C. Boyd. 2011. Knowledge, characteristics, and attitudes of wild turkey hunters in Pennsylvania. Proceedings of the National Wild Turkey Symposium 10:41-48.

Casalena, M. J., and J. Johnson. 2015. 2014 Pennsylvania fall wild turkey hunter survey; results. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA. http://www.pgc.pa.gov/Wildlife/WildlifeSpecies/Turkey/Documents/2014%20Fall%20Turkey%20Hunter%20Survey%20Report.pdf

Casalena, M. J., M. V. Schiavone, A. C. Bowling, and I. D. Gregg. 2015*a*. Understanding the new normal: wild turkeys in a changing northeastern landscape. Proceedings of the National Wild Turkey Symposium 11:45-57.

Casalena, M. J., R. Everett, W. C. Vreeland, I. D. Gregg, and D. R. Diefenbach. 2015*b*. Timing of spring wild turkey hunting in relation to nest incubation. Proceedings of the National Wild Turkey Symposium 11:237-247.

Casalena, M. J., and D. R. Diefenbach. 2016. Hen wild turkey fall harvest rates and annual survival rates in Pennsylvania. Pittman-Roberson Program Research Grant Final Performance Report, W-81-R-1, Project 1, Job 1.

Casalena, M. J., D. R. Diefenbach, W. Vreeland, and R. Everett. 2016. Hen wild turkey fall harvest rates and annual survival rates. Annual Job Report Number 27010. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Caudell, J. N., S. E. Backs, R. Rudolph, T. Hooper, T. Bryan, and B. Murphy. 2015. Surveillance of turkey corona virus and other infectious pathogens in eastern wild turkey (*Meleagris gallopavo*) in Indiana. Proceedings of the National Wild Turkey Symposium 11:365-370.

Center for Survey Research. 2017. Fall 2017 Penn State poll; Report of Results. Center for Survey Research Penn State Harrisburg. Harrisburg, PA.

Coumou, D., and S. Rahmstorf. 2012. A decade of weather extremes. Nature Climate Change 2:491-496.

Dawson, A. 2008. Control of the annual cycle in birds: endocrine constraints and plasticity in response to ecological variability. Philosophical Transactions of the Royal Society of London Series B – Biological Sciences 1497:1621-33.

Davidson, W. R. 2006. Field manual of wildlife diseases in the southeastern United States, third edition. The University of Georgia, Athens, Georgia, USA.

Davidson, W. R., and E. J. Wentworth. 1992. Population influences: diseases and parasites. Pages 101-118 *in* J. L. Dickinson, editor. The wild turkey: biology and management. Stackpole, Mechanicsburg, Pennsylvania, USA.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29:456-465.

Dessecker, D. R., G. W. Norman, and S. J. Williamson, editors. 2006. Ruffed grouse conservation plan. Association of Fish and Wildlife Agencies, Resident Game Bird Working Group. Ruffed Grouse Society, Coraopolis, Pennsylvania, USA.

Dickson, J. G., editor. 1992. The wild turkey, biology and management. Stackpole, Harrisburg, Pennsylvania, USA.

Diefenbach, D. R. 1996. 1995 turkey hunter survey. Bureau of Wildlife Management. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Diefenbach, D. R., M. Casalena, M. Schiavone, M. Reynolds, R. Eriksen, W. C. Vreeland, B. Swift, R. C. Boyd. 2012. Variation in Spring Harvest Rates of Male Wild Turkeys in New York, Ohio, and Pennsylvania. Journal of Wildlife Management 76:514-522.

Diefenbach, D. R. 2015. Harvest rates of hen wild turkeys in New York, summary report. 2015. U.S. Geological Survey, Pennsylvania Cooperative Fish and Wildlife Research Unit, Pennsylvania State University, University Park, Pennsylvania, USA.

Dunn, P.O. 2004. Breeding dates and reproductive performance. Pages 67-85 *in* A.P. Møller, W. Fiedler, and P. Berthold, editors. Birds and Climate Change, vol. 35. Elsevier, San Diego, California, USA.

Dunn, P. O., and D. W. Winkler. 2010. Effects of climate change on timing of breeding and reproductive success in birds. Pages 113-148 *in* A. P. Moller, W. Fiedler, and P. Berthold, editors. Effects of climate change on birds. First edition. Oxford University Press, Oxford, United Kingdom.

Dyer, J. L., R. Wallace, L. Orciari, D. Hightower, P. Yager, and J. D. Blanton. 2013. Rabies surveillance in the United States during 2012. Journal of the American Veterinary Medical Association 243:805-815.

Easterling, D. R., G. A. Meehl, C. Parmesan, S. A. Changnon, T. R. Karl, and L. O. Mearns. 2000. Climate extremes: observations, modeling, and impacts. Science 289:2068-2074.

Elsmo, E. J, A. B. Allison, and J. D. Brown. 2016. A review of dermatologic diseases in wild turkeys in the eastern United States from 1975-2013. Journal of Wildlife Diseases 52:582-591.

Eriksen, R. E. 2002. Pen-raised wild turkeys, don't release them! Pennsylvania Game News.

Eriksen, R. E., T. W. Hughes, T. A. Brown, M. D. Akridge, K. B. Scott, and C. S. Penner. 2015. Status and distribution of wild turkeys in the United States: 2014 Status. Proceedings of the National Wild Turkey Symposium 11:7-18.

Eriksen, R. E., A. McBride, and G. W. Norman. 2011. Survival and hunting mortality of male wild turkeys in New Jersey. Proceedings of the National Wild Turkey Symposium 10:173-181.

Fackler, P., D. R. Diefenbach, J. B. Grand, M. J. Casalena, and S. Barnett. 2017. Identifying optimal harvest regulations for fall and spring wild turkey hunting seasons. Research proposal to the National Wild Turkey Federation, Edgefield, South Carolina, USA.

Fleming, K. K. 2003. Scale-explicit spatial determinants of population structure in wild turkeys (*Meleagris gallopavo silvestris*). Dissertation, State University of New York, Syracuse, New York, USA.

Fleming, K. K., and W. F. Porter. 2007. Effect of landscape features and fragmentation on wild turkey dispersal. Proceedings of the National Wild Turkey Symposium 9:175-183.

Fleming, K. K., and W. F. Porter. 2015. Comparision of landscape, atch, and local habitat effects on risk of predation of artificial wild turkey nests. Proceedings of the National Wild Turkey Symposium 11:271-282.

Fry et al. 2011. Need citation.

Fuller, A. K., S. M. Spohr, D. J. Harrison, and F. A. Servello. 2013. Nest survival of wild turkeys, *Meleagris gallopavo silvestris*, in a mixed-use landscape: influences at nest-site and patch scales. Wildlife Biology 19:138-146.

Glennon, M. J., and W. F. Porter. 1999. Using satellite imagery to assess landscape-scale habitat for wild turkeys. Wildlife Society Bulletin 27:646-653.

Gloutney, M. L., R. G. Clark, A. D. Afton, and G. J. Huff. 1993. Timing of nest searches for upland nesting waterfowl. Journal of Wildlife Management 57:597-601.

Godwin, K. D., G. A. Hurst, and R. L. Kelley. 1991. Survival rates of radioequipped wild turkey gobblers in east-central Mississippi. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 45:218-226.

Gonzales, M. J., H. B. Quigley, and C. I Taylor. 1996. Habitat use, reproductive behavior and survival of Ocellated turkeys in Tikal National Park, Guatemala. Proceedings of the National Wild Turkey Symposium 7:193-199.

Groepper, S. R., B. Houck, S. E. Hygnstrom, and S. M. Vantassel. 2015. Real and perceived damage by wild turkeys: a literature review. Proceedings of the National Wild Turkey Symposium 11:371-377.

Gross, J. T., B. S. Cohen, B. A. Collier, and M. J. Chamberlain. 2015. Influences of hunting on movements of male wild turkeys during spring. Proceedings of the National Wild Turkey Symposium 11:259-268.

Hall, L. S., P. R. Krausman, and M. L. Morrison. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173-182.

Hamel, J. P. 2002. Influence of winter supplemtneal feeding on the winter bioengergetics and preproduction of eastern wild turkeys in New Hampshire. Thesis, University of New Hampshire, Durham, New Hampshire, USA

Harper, J. K., Knox, D. C., Guynn, Jr., J. R. Davis and J. G. Williams. 2001. Invertebrate availabilty for wild turkey polts in the southern Appalachians. Proceedings of the National Wild Turkey Symposium 8:145-156.

Healy, W. M. 1992. Population influences: Environment. Pages 129-143 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole, Mechanicsburg, Pennsylvania, USA.

Healy, W. M., and M. J. Casalena. 1996. Spring seep management for wild turkeys and other wildlife. National Wild Turkey Federation, Wildlife Bulletin 21.

Holdstock, D. P., M. C. Wallace, W. R. B. Ballard, J. H. Brunjes, R. S. Phillips, B. L. Spears, S. J. Demaso, J. D. Jernigan, R. D. Applegate, and P. S. Gipson. 2006. Male Rio Grande turkey survival and movements in the Texas panhandle and southwestern Kansas. Journal of Wildlife Management 70:904-913.

Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown, 2015. Completion of the 2011 national land cover database for the conterminous United States-representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing 81:345-354.

Hubbard, M. W., D. L. Garner, and E. E. Klaas. 1999. Wild turkey poult survival in southcentral Iowa. Journal of Wildlife Management 63:199-203.

Huffman, J. E., N. Chinnici, M. Butler, and T. Rounsville. 2014. Genetic analysis of eastern wild turkeys in Michaux State Forest of Pennsylvania. Northeast Wildlife DNA Laboratory, East Stroudsburg University, East Stroudsburg Pennsylvania, USA.

Hughes, T. W., and R. E. Eriksen. 2015. Wild turkey depredation of commercially grown grapes. Proceedings of the National Wild Turkey Symposium 11:379-385.

Hughes, T. W., J. L Tapley, J. E. Kennamer, and C. P. Lehman. 2007. The impacts of predation on wild turkeys. Proceedings of the National Wild Turkey Symposium 9:117-126.

Isabella, J. L. and R. A. Reitz. 2015. Characteristics, attitudes and preferences of spring wild turkey hunters in Missouri. Proceedings of the National Wild Turkey Symposium 11:249-258.

Johnson, J. 2016. Game take and furbearer survey. Annual Report, Project No. 06110, Job No. 11101. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Jones, B. C., J. E. Inglis, and G. A. Hurst. 2007. Wild turkey brood habitat use in relation to prescribed burning and red-cockaded woodpecker management. Proceedings of the National Wild Turkey Symposium 9:209-215.

Jones, J. C., B. N. Hodges, J. Tegt, and A. B. Butler. 2015. Invasive non-native species and wild turkey in the southeastern United States. Proceedings of the National Wild Turkey Symposium 15:89-103.

King, D. I., and S. Schlossberg. 2014. Synthesis of the conservation value of the early-successional stage in forests of eastern North America. Forest Ecology and Management 324:186-195.

Kosack, J. 1995. A look back. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Lafon, A., and S. D. Schemnitz. 1996. Distribution, habitat use, and limiting factors of Gould's turkey in Chihuahua, Mexico. Proceedings of the National wild Turkey Symposium 7:185-191.

Latham, R. M. 1941. The history of the wild turkey in Pennsylvania. Pennsylvania Game News. December 1941:6-8.

Latham, R. M. 1956. Complete book of the wild turkey. The Stackpole Company, Harrisburg, Pennsylvania, USA.

Leighton, F. A. 2002. Health risk assessment of the translocation of wild animals. Revue Scientifique et Technique Office International des Epizooties 21:187-195.

Lewis, J. B. 2001. A success story revisited. Proceedings of the National Wild Turkey Symposium 8:7-13.

Little, T. W., J. M. Keinzler, and G. A. Hanson. 1990. Effects of fall either-sex hunting on survival in an Iowa wild turkey population. Proceedings of the National Wild Turkey Symposium 6:119-125.

Little, D. A., J. L. Bowman, G. A. Hurst, R. S. Seiss, and D. L. Minnis. 2000. Evaluating turkey hunter attitudes on Wildlife Management Areas in Mississippi. Proceedings of the National Wild Turkey Symposium 8:223-231.

Lobdell, C. H., K. E. Case and H. S. Mosby. 1972. Evaluation of harvest strategies for a simulated wild turkey population. Journal of Wildlife Management. 36:493-497.

Lovallo, M. J. Status and management of fisher (*Martes pennanti*) in Pennsylvania, 2008-2017. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Lowles, M. A. 2002. Reproduction and survival of eastern wild turkey hens in south-central Pennsylvania, 1999-2001. Thesis, Pennsylvania State University. University Park, Pennsylvania, USA.

Lowrey, D. K, S. R. Priest, G. A. Hurst, and B.S. Weemy. 2000. Influences of selected weather variables on predation of wild turkey females and nest success. Proceedings of the National Wild Turkey Symposium 8:173-178.

Lowrey, D. K., G. A. Hurst, S. R. Priest, and B. S. Weemy. 2001. Selected weather variables on predation of wild turkey females and nest success. Proceedings of the National Wild Turkey Symposium 8:173-178.

Magnuson, J. J., D. M. Robertson, B. J. Benson, R. H. Wynne, D. M. Livingstone, T. Arai, R. A. Assel, R. G. Barry, V. Card, E. Kuusisto, N. G. Granin, T. D. Prowse, K. M. Stewart, and V. S. Vuglinski. 2000. Historical trends in lake and river ice cover in the northern hemisphere. Science 289:1743-1746.

Marescot, L., G. Chapron, I. Chadès, P. L. Fackler, C. Duchamp, E. Marboutin and O. Gimenez. 2013. Complex decisions made simple: a primer on stochastic dynamic programming. Methods in Ecology and Evolution, 4:872-884.

Martin, J. A., S. M. Juhan, Jr., W. E. Palmer, and J. P. Carroll. 2015. Incubation and predation ecology of wild turkey nests: a cautionary case study regarding video camera surveillance. Proceedings of the National Wild Turkey Symposium 11:295-301.

McGhee, J. D. 2004. Eastern wild turkey modeling project: Annual report 2004. Virginia Polytechnic Institute and State University, Vicksburg, Virginia, USA.

McNeil, D. J., Jr., C. A. Nicks, J. C. Wester and J. F. Larkin. Diets of fishers (Pekania pennanti) and evidence of intraspecific consumption in Pennsylvania. Am. Midl. Nat. 177:200-210.

McShea, W. J. and W. M. Healy. 2002. Oak forest ecosystems: ecology and management for wildlife. The Johns Hopkins Press, Baltimore, Maryland, USA.

McShea, W. J., W. M. Healy, and P. Van Deusen. 2015. Trends in mast availability for wild turkeys in eastern forests. Proceedings of the National Wild Turkey Symposium 11:61-78.

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.

Miller, D. A., Leopold, B. D., Hurst, G. A., 1998. Reproductive characteristics of a wild turkey population in central Mississippi. Journal of Wildlife Management 62: 903-910.

Miller, J. E., and B. D. Leopold. 1992. Population influences: predators. Pages 119-128 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole, Harrisburg, Pennsylvania, USA.

Moore, W. F., J. C. Kilgo, D. C Guynn, Jr., and J. R. Davis. 2008. Is spring wild turkey gobbler harvest additive or compensatory? Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 62:77-81.

Morris, H. N. 2014. Management planning and habitat modeling for wild turkeys in Virginia. Master Degree Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Mosby, H. S. 1959. General status of the wild turkey and its management in the United States, 1958. Proceedings of the National Wild Turkey Symposium 1:1-11.

National Wild Turkey Federation. 2005. The third wild turkey hunting safety task force final report. National Wild Turkey Federation, Edgefield, South Carolina, USA.

New York State Department of Environmental Conservation. 2014. Annual report of the Northeast Upland Game Bird Technical Committee for the Northeast Wildlife Administrators Association, 15-18 September 2014. New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources.

Norman, G. W., J. C. Pack, C. I. Taylor, D. E. Steffen, and K. H. Pollock. 2001. Reproduction in eastern wild turkeys in Virginia and West Virginia. Journal of Wildlife Management 65:1-9.

Norman, G. W., and D. E. Steffen. 2003. Effects of recruitment, oak mast, and fall-season format on wild turkey harvest rates in Virginia. Wildlife Society Bulletin 31:553-559.

Nowacki, G. J., and M. D. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. Bioscience 58:123-138.

Pack, J. C. 1986b. Report on wild turkey hunting regulations, harvest trends and population levels in West Virginia. West Virginia Division of Natural Resources, Elkins, West Virginia, USA.

Pack, J. C., G. W. Norman, C. I. Taylor, D. E. Steffen, D. A. Swanson, K. H. Pollock and R. Alpizar-Jara. 1999. Effects of fall hunting on wild turkey populations in Virginia and West Virginia. Journal of Wildlife Management 63:964-975.

Palmer, W. E., S. R. Priest, R. S. Seiss, P. S. Phalen, and G. A. Hurst. 1993. Reproductive effort and success in a declining wild turkey population. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:138-147.

Paisley, R. N., R. G. Wright, and J. F. Kubisiak. 1996. Survival of wild turkey gobblers in southwestern Wisconsin. Proceedings of the National Wild Turkey Symposium 7:39-44.

Pardieck, K. L., D. J. Ziolkowski, Jr., and M.-A. R. Hudson. 2014. North American breeding bird survey dataset 1966-2013, version 2013.0. Eastern BBS Region - North American breeding bird survey trend results. U.S. Geological Survey, Patuxent Wildlife Research Center <www.pwrc.usgs.gov/BBS/RawData/>. Access 10 November 2014.

Parent, C. J., A. C. Bowling, B. S. Steven, and W. F. Porter. 2015. Wild turkey harvest trends across the Midwest in the 21st century. Proceedings of the National Wild Turkey Symposium 11:211-223.

Pekins, P. J. 2007. Winter bioenergetics of eastern wild turkeys: understanding energy balance and survival in northern populations. Proceedings of the National Wild Turkey Symposium 9:273-280.

Pennsylvania Game Commission. 2010. 2008 Pennsylvania turkey hunter survey results. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Pennsylvania Game Commission. 2011. Successful turkey hunting! Student manual. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Porter, W. F. 1992. Habitat requirements. Pages 202-213 *in* J. G. Dickson, Editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Porter, W. F. 2007. Understanding the ecology of wild turkeys in northern latitudes. Proceedings of the National Wild Turkey Symposium 9:307-313.

Porter, W. F., G. C. Nelson, and K. Mattson. 1983. Effects of winter conditions on reproduction in a northern wild turkey population. Journal of Wildlife Management 47:281-290.

Porter, W. F., and D. J. Gefell. 1996. Influences of weather and land use on wild turkey populations in New York. Proceedings of the National Wild Turkey Symposium 7:75-80.

Porter, W. F., H. B. Underwood, and D. J. Gefell. 1990. Application of population modeling techniques to wild turkey management. Proceedings of the National Wild Turkey Symposium 6:107-118.

Porter, W. F., W. M. Healy, S. E. Backs, B. F. Wakeling, and D. E. Steffen. 2011. Managing wild turkeys in the face of uncertainty. Proceedings of the National Wild Turkey Symposium 10:1-9.

Porter, W. F., C. A. Stewart, and C. J. Parent. 2015. Summary of the 11th national wild turkey symposium. Proceedings of the National Wild Turkey Symposium 11:407-409.

Powell, S. M., E. C. York, and T. K. Fuller. 1997. Seasonal food habits of fishers in central New York. Pp. 279-305, *in* Martes: taxonomy, ecology, techniques, and management (G. Proulx, H. N. Bryant, and P M. Woodard, eds.). Provincial Museum of Alberta, Edmonton, Alberta, Canada.

Priest, S. R. 1995. Relationships between wild turkey hens, environmental factors, and predation during the wild turkey reproductive period on Tallahala Wildlife Management Area. Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Price, W. and E. Sprague. 2012. Pennsylvania's Forests; how they are changing and why we should care. Pinchot Institute for Conservation, Washington, DC, USA.

Rauch, S. E., J. A. Anderson, and A. A Billings. 2011. Spring hunting season home range size of male wild turkeys in north central West Virginia. Proceedings of the National Wild Turkey Symposium 10:157-163.

Reynolds, M. C. and D. A. Swanson. 2011. Survival of female wild turkeys in southeastern Ohio. Proceedings of the National Wild Turkey Symposium 10:149-155.

Rinell, K. T., G. A. Wunz, and R. W. Bailey. 1965. Wild turkey hatch dates in Pennsylvania and West Virginia. 22nd Annual Northeast. Section Wildlife Conference, Harrisburg, Pennsylvania, USA.

Roberts, S. D., J. M. Coffey, and W. F. Porter. 1995. Survival and reproduction of female wild turkeys in New York. Journal of Wildlife Management 59:437-447.

Roberts, S. D., and W. F. Porter. 1996. Importance of demographic parameters to annual changes in wild turkey abundance. Proceedings of the National Wild Turkey Symposium 7:15-20.

Roberts, S. D., and W. F. Porter. 1998*a*. Influence of temperature and precipitation on survival of wild turkey poults. Journal of Wildlife Management 62:1499-1505.

Roberts, S. D., and W. F. Porter. 1998*b*. Relation between weather and survival of wild turkey nests. Journal of Wildlife Management 62:1492-1498.

Roberts, S. D., and W. F. Porter. 2001. Annual changes in may rainfall as an index to wild turkey harvest. Proceedings of the National Wild Turkey Symposium 8:43-52.

Rosenberry, C. R., and M. Lovallo. 2002. A uniform system of management units for managing Pennsylvania's wildlife resources. Pennsylvania Game Commission, Bureau of Wildlife Management, Harrisburg, Pennsylvania, USA.

Responsive Management. 2004. Factors related to hunting participation in Pennsylvania; final report. Responsive Management, Harrisonburg, Virginia, USA.

Ross, A., C. Benson, D. Abler, D. Wardrop, J. Shortle, M. McDill, M. Rydzik, R. Najjar, R. Ready, S. Blumsack, and T. Wagener. 2013. Pennsylvania climate impacts assessment update. Report to the Pennsylvania Department of Environmental Protection, Environment and Natural Resources Institute, The Pennsylvania State University.

Schoech, S., and T. Hahn. 2008. Latitude affects degree of advancement in laying by birds in response to food supplementation: a meta-analysis. Oecologia 157: 369-376.

Smith, D. L., B. Lucey, L. A. Waller, J. E. Childs, and L. A. Real. 2002. Predicting the spatial dynamics of rabies epidemics on heterogeneous landscapes. Proceedings of the National Academy of Sciences 99:3668-3672

Snyder, K. A. 2006. Turkey hunting incident rate report 1983 through 2005. Pennsylvania Game Commission, Bureau of Information and Education, Hunter-Trapper Education Division, Harrisburg, Pennsylvania, USA.

Stangel, P. W., P. L. Leber, and J. I. Smith. 1992. Systematics and population genetics. Pages 18-28 *in* J. G. Dickson, Editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Steffen, D. E., N. W. Lafon, and G. W. Norman. 2002. Turkeys, acorns, and oaks. Pages 241-255 *in* M. J. McShea and W. M. Healy, editors. Oak forest ecosystems: ecology and management for wildlife. The Johns Hopkins Press, Baltimore, Maryland, USA.

South Carolina Department of Natural Resources. 2009. Setting spring hunting seasons by timing peak gobbling, peak breeding and peak incubation. <http://dnr.sc.gov/wildlife/turkey/ springseason09.html>. Access 1 Aug 2014.

Swayne, D. E., J. R. Beck, and S. Zaki. 2000. Pathogenicity of West Nile Virus for turkeys. Av. Dis. 44:932-937.

Swanson, D. A., R. J. Stoll, Jr., and W. L. Culbertson. 2007. Attitudes, preferences, and characteristics of Ohio's spring turkey hunters, 1985 - 2001. Proceedings of the National Wild Turkey Symposium 9:325-330.

Swanson, D. A. and M. C. Reynolds. 2011. Reproductive parameters of wild turkey females in southeastern Ohio. Proceedings of the National Wild Turkey Symposium 10:143-147.

Tapley, J. L, R. K. Abernethy, and J. E. Kennamer. 2001. Status and distribution of the wild turkey in 1999. Proceedings of the National Wild Turkey Symposium 8:15-22.

Thogmartin, W. E., and J. E. Johnson. 1999. Reproduction in a declining population of wild turkeys in Arkansas. Journal of Wildlife Management 63:1281-1290.

Thogmartin, W. E. and B. A. Schaeffer. 2000. Landscape attributes associated with mortality events of wild turkeys in Arkansas. Wildlife Society Bulletin 28:865-874.

Thomas, J.M., A.B. Allison, E. Holmes, J. Phillips, E. Bunting, M. Yabsley, and J.D. Brown. 2015. Molecular surveillance for lymphoproliferative disease virus in wild turkeys (*Meleagris gallopavo*) in the Eastern United States. PLOS ONE 10.137:e0122644.

Timmins, A. A. 2003. Seasonal home range, nesting ecology, and survival of eastern wild turkeys in northern New Hampshire. Thesis, University of New Hampshire, Durham, New Hampshire, USA.

U.S. Department of Agriculture. 2012. Census of Agriculture. https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/Pennsylvania/st42_1_001_001.pdf.

U.S. Department of the Interior. 2003. 2001 National survey of fishing, hunting, and wildlife-associated recreation - Pennsylvania. U. S. Government Printing Office, Washington, DC, USA.

U.S. Global Change Research Program. 2014. 2014 national climate assessment. Washington, DC, USA.

<http://nca2014.globalchange.gov/.> Access 14 July 2015.

Vander Haegen, W. M., W. E. Dodge, and M. W. Sayre. 1988. Factors affecting productivity in a northern wild turkey population. Journal of Wildlife Management 52:127-133.

Vander Haegen, M. W. Sayre, and W. M., W.E. Dodge. 1989. Winter use of agricultural habitats by wild turkeys in Massachusetts. Journal of Wildlife Management 53:30-33.

Vangilder, L. D., S. L. Sheriff, and G. S. Olson. 1990. Characteristics, attitudes and preferences of Missouri's spring turkey hunters. Proceedings of the National Wild Turkey Symposium 6:167-176.

Vangilder, L. D. 1992. Population dynamics. Pages 144-164 *in* J.G. Dickson, Editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Vangilder, L. D., and E. W. Kurzejeski. 1995. Population ecology of the eastern wild turkey in northern Missouri. Wildlife Monograph 130:1-50.

Virginia Department of Game and Inland Fisheries. 2014. Virginia wild turkey management plan (2013-2022). Virginia Department of Game and Inland Fisheries, Richmond, Virginia, USA.

Vollmer, D. L, Jr. 2001. Home range and habitat analysis of eastern wild turkey gobblers (*Meleagris gallopavo silvestris*) in northwestern New Jersey. Thesis. East Stroudsburg University, East Stroudsburg, Pennsylvania, USA.

Warnke, K. D. and R. E. Rolley. 2007. Lessons from wild turkey population dynamics studies. Proceedings of the National Wild Turkey Symposium 9:91-99.

Whitaker, D. M., J. C. Pack, G. W. Norman, D. F. Stauffer, and S. Klopfer. 2007. A range-wide meta-analysis of wild turkey nesting phenology and spring season opening dates. Proceedings of the National Wild Turkey Symposium 9:351-360.

Widmann, R. H. 2016. Forests of Pennsylvania, 2015. Resource Update FS-92. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. Northern FIA: https://www.fs.fed.us/nrs/pubs/ru/ru_fs92.pdf .

Weinstein, M., D. A. Miller, L. M. Conner, B. D. Leopold, and G. A. Hurst. 1996. What affects turkeys? A conceptual model for future research. Proceedings of the National Wild Turkey Symposium 7:135-142.

Williams, L.E., Jr., and D.H. Austin. 1988. Studies of the wild turkey in Florida. Florida Game and Freshwater Fish Commission, Technical Bulletin 10. Gainesville, Florida, USA.

Williams, L., DiBona, M. T., and Burnett, A. 2013. Potential effects of climate change on Northeast upland game bird populations. Report provided by Northeast Upland Game Bird Technical Committee, to the Northeast Wildlife Administrators Association, March 2013.

Wilson, A. M, D. W. Brauning, and R. S. Mulvihill. Second atlas of breeding birds in Pennsylvania. 2012. The Pennsylvania State University Press. University Park, Pennsylvania, USA.

Wright, G. A., and L. D. Vangilder. 2001. Survival of eastern wild turkey males in western Kentucky. Proceedings of the National Wild Turkey Symposium 8:187-194.

Wright, G. A., and L. D. Vangilder. 2005. Survival and dispersal of eastern wild turkey males in western Kentucky. Proceedings of the National Wild Turkey Symposium 9:367-373.

Wunz, G. A., and A. Hayden. 1975. Winter mortality and supplemental feeding of turkeys in Pennsylvania. Proceedings of the National Wild Turkey Symposium 3:61-69.

Wunz, G. A., and A. Hayden. 1981. No more game-farm turkey stocking. Pennsylvania Game News, Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA. March 1981:24-27.

Wunz, G. A., and J. C. Pack. 1992. Eastern turkey in eastern oak-hickory and northern hardwood forests. Pages 232-264 *in* J. G. Dickson, Editor. The Wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Wunz, G. A., and A. S. Ross. 1990. Wild turkey production, fall and spring harvest interactions and responses to harvest management in Pennsylvania. Proceedings of the National Wild Turkey Symposium 6:205-207.

Wunz, G.A., and W.K. Shope. 1980. Turkey brood survey in Pennsylvania as it relates to harvest. Proceedings of the National Wild Turkey Symposium 4:69-75.

Zielinski, W. J., N. P. Duncan, E. C. Farmer, R. L. Truex, A. P. Clevenger, and R. H. Barrett. 1999. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. Journal of Mammalogy 80:961-971.

APPENDIX 1. Implementation schedule for turkey management plan for Pennsylvania, 2018-2027

Objective and Strategies	By End of Fiscal Year (e.g., FY 2018 = July 2018-June 19)									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Population Objective										
Strategy:										
1.1 Provide biologically timed spring hunting season	●	●	●	●	●	●	●	●	●	●
1.2 Use fall season lengths as primary means for managing populations by providing conservative fall hunting seasons	●	●	●	●	●	●	●	●	●	●
1.3 Collect specific harvest information for monitoring trends and directing management	●	●	●	●	●	●	●	●	●	●
1.4 Conduct harvest surveys	●	●	●	●	●	●	●	●	●	●
1.5 Assess turkey population status and trends	●	●	●	●	●	●	●	●	●	●
1.6 Asses summer sighting surveys	●	●	●	●	●	●	●	●	●	●
1.7 Conduct volunteer August survey and assess after 2020	●	●	●	●	●	●	●	●	●	●
1.8 Develop a proposal for, and implement, annual harvest rate monitoring via winter leg-banding by WMU	●	●	●	●	●	●	●	●	●	●
1.9 Evaluate the conclusions of the northeast regional population project. Implement data collection protocols		●	●							
1.10 Complete analyses of hen turkey harvest/survival rate study	●									
1.11 Create/implement turkey population models for each WMU, incorporating where appropriate, population trends and potential driving factors, from the northeast regional database		●	●							
1.12 Determine if population models require additional data; initiate research/monitoring to fully implement/improve		●	●	●						
1.13 Create Structured Decision Protocols for each WMU for fall turkey season recommendations	●	●								
1.14 Incorporate habitat suitability models into population models to develop turkey population objectives for each WMU			●	●						
1.15 Identify WMUs with population management problems, develop solutions and monitor outcomes			●	●	●	●	●	●	●	●
1.16 Determine effects of the two-bird spring bag limit and all-day season on turkey age structure for each WMU. If needed, recommend regulation changes			●					●		

APPENDIX 1. Continued.

Objective and Strategies	By End of Fiscal Year (e.g., FY 2018 = July 2018-June 19)									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Population Objective (continued)										
Strategy:										
1.17 Assess reproductive patterns in northeast, southeast and southwest Pennsylvania in relation to habitat suitability										
1.18 Passive surveillance & maintain database of disease occurrence/distribution to identify outbreaks/threats	●	●	●	●	●	●	●	●	●	●
1.19 In cooperation with the NEUGBTC develop a regional study to determine if diseases have affected juvenile survival/recruitment		●	●							
Habitat Objective										
Strategy:										
2.1 Use GIS and various models to determine holistic priority areas for habitat management & improvements for each WMU	●	●	●							
2.2 Use GIS and various models to identify SGLs in need of turkey habitat improvement		●	●	●	●	●				
2.3 Monitor if habitat improvement correlates with changes in turkey population densities; develop monitoring program for finer-scale population assessment if needed		●	●	●	●	●	●	●	●	●
2.4 Conduct mast surveys in conjunction with the NE Regional Oak Mast Survey, and weather conditions	●	●	●	●	●	●	●	●	●	●
2.5 Increase forest management acreage to 15,000 acres, annually			●	●	●	●	●	●	●	●
2.6 Increase prescribed burning to 30,000 acres, annually, and maintain burn qualifications of PGC staff			●	●	●	●	●	●	●	●
2.7 Sustain or exceed 2,500 acres of habitat management on private lands, annually, through partnerships			●	●	●	●	●	●	●	●

APPENDIX 1. Continued.

Objective and Strategies	By End of Fiscal Year (e.g., FY 2018 = July 2018-June 19)									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Habitat Objective (continued) Strategy:										
2.8 Quantify the habitat management practices conducted for turkeys on SGLs and other PGC managed lands	●	●	●	●	●	●	●	●	●	●
2.9 Conduct at least one workshop or demonstration per PGC Region annually	●	●	●	●	●	●	●	●	●	●
2.10 Maintain PGC/PANWTF partnership to allocate NWTF Hunting Heritage habitat funds	●	●	●	●	●	●	●	●	●	●
2.11 Provide technical information/assistance regarding turkey habitat management to private/public land managers	●	●	●	●	●	●	●	●	●	●
2.12 Maintain current, and pursue other, funding sources for habitat restoration, management and hunter access improvements	●	●	●	●	●	●	●	●	●	●
Information & Education Objective Strategy:										
3.1 Survey hunters and other stakeholders regarding turkey populations and management issues	●					●				
3.2 Survey non-hunters regarding knowledge, perceptions and nonconsumptive recreation of turkey populations		●								
3.3 Report research and management findings to the public through all forms of media	●	●	●	●	●	●	●	●	●	●
3.4 Provide educational information through all forms of media and speaking engagements regarding wild turkeys	●	●	●	●	●	●	●	●	●	●
3.5 Provide educational information through all forms of media and speaking engagements regarding forest management in relation to turkey management	●	●	●	●	●	●	●	●	●	●
3.6 Maintain/create fact sheets through all forms of media	●	●	●	●	●	●	●	●	●	●
3.7 Work with the PA Prescribed Fire Council, and others to promote the wildlife benefits of prescribed burning	●	●	●	●	●	●	●	●	●	●

APPENDIX 1. Continued.

Objective and Strategies	By End of Fiscal Year (e.g., FY 2018 = July 2018-June 19)									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hunting Heritage/Hunter Safety Objective										
Strategy:										
4.1 Develop a turkey hunting license, or similar, to more precisely determine participation rates, track recruitment, retention and reactivation, improve reporting rates, and increase participation		●	●	●						
4.2 Develop and distribute educational and hunter safety materials directly to turkey hunters	●	●	●	●	●	●	●	●	●	●
4.3 Assess/explore opportunities for continued development/promotion of the youth and adult mentored hunting programs	●	●	●	●	●	●	●	●	●	●
4.4 Consider implementation of expanded spring hunting opportunities in conjunction with the population objective and hunter satisfaction	●	●	●	●	●	●	●	●	●	●
4.5 Maintain/expand the PGC's Hunter Access Programs to promote and protect these privately-owned lands open to public hunting	●	●	●	●	●	●	●	●	●	●
4.6 Acquire turkey habitat to expand hunting opportunities and protect/enhance habitat	●	●	●	●	●	●	●	●	●	●
4.7 Monitor hunter success	●	●	●	●	●	●	●	●	●	●
4.8 Maintain average annual turkey hunting-related shooting incident rate below 2 per 100,000 hunters for spring and below 1.5 for fall, and promote wild turkey hunter safety/ethics	●	●	●	●	●	●	●	●	●	●
4.9 Annually provide program/s to expand and promote turkey hunter knowledge, safety and ethics, and update as needed	●	●	●	●	●	●	●	●	●	●
4.10 Assure that complete information on turkey hunting-related shooting incidents are included in all International Hunting Education Association reports	●	●	●	●	●	●	●	●	●	●

APPENDIX 1. Continued.

Objective and Strategies	By End of Fiscal Year (e.g., FY 2018 = July 2018-June 19)									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Wild Turkey Protection										
Strategy:										
5.1 Assess compliance with laws and regulations to protect the wild turkey resource, seek necessary changes	●	●	●	●	●	●	●	●	●	●
5.2 Use wild turkey decoys and other appropriate law enforcement tools to discourage road hunting and poaching, and utilize partnerships to assist with purchasing equipment	●	●	●	●	●	●	●	●	●	●
5.3 Seek legislation to increase penalties for violations	●	●	●	●	●	●	●	●	●	●
5.4 Monitor hunter compliance with fluorescent orange	●	●	●	●	●	●	●	●	●	●
5.5 Update/finalize Standard Operating Procedure 40.13, Guidelines for Handling Nuisance Wild Turkey Conflicts										
5.6 Individually address nuisance turkey complaints	●	●	●	●	●	●	●	●	●	●
Cooperative Partnerships Objective										
Strategy:										
6.1 Maintain/create partnerships with other public landowners, NGOs including, NWTF, and private landowners via the Hunter Access Programs	●	●	●	●	●	●	●	●	●	●
6.2 Maintain the MOU with the NWTF and financial support of NWTF's regional biologist position	●	●	●	●	●	●	●	●	●	●
6.3 Participate in regional and national initiatives for the benefit of the wild turkey resource	●	●	●	●	●	●	●	●	●	●
6.4 Continue the WMU 5A Wild Turkey Task Force and initiate other Task Forces where deemed necessary	●	●	●	●	●	●	●	●	●	●
6.5 Assist states and Canadian provinces with wild turkey restoration through trap and transfers where feasible	●	●	●	●	●	●	●	●	●	●
6.6 Create/maintain partnerships with non-traditional turkey management NGOs and other groups to address habitat improvement needs	●	●	●	●	●	●	●	●	●	●

APPENDIX 2. SUMMARY OF PUBLIC COMMENTS

Draft Wild Turkey Management Plan 2018-2027

The draft Pennsylvania Wild Turkey Management Plan 2018-2027 was made available for a 60-day public comment period, July 2 to Aug. 31, 2018. A news release and postings on the PGC's webpage and social media announced the comment period, and newspaper outlets carried additional coverage. The document was available electronically through the webpage or in print by request. Comments could be submitted via our Facebook page, the webpage, by e-mail, or in writing.

We received 180 comments from 82 individuals outside the agency plus an in-depth review by the PANWTF, NWTF and Board of Commissioners. Comments were summarized, reviewed and, where applicable, incorporated into the final plan. General replies were sent to all those who emailed and mailed comments, unless a specific reply was warranted. Comments unrelated to turkey management were not recorded. Comments were grouped into 58 distinct themes, with many of these repeated by multiple respondents demonstrating the high level of interest and passion that turkey hunters and other stakeholders have for this species. These comments were grouped into the following 10 categories: Perceptions of Turkey Populations, Perceptions of Turkey Hunter Numbers, Perceptions of Issues Negatively Affecting Turkey Populations, Spring Turkey Hunting Regulations, Fall Turkey Hunting Regulations, Hunter Safety & Ethics, Habitat Management, Predator Hunting and Trapping, General Comments About Turkey Management, and Miscellaneous Turkey or Turkey Hunting Experiences / Observations.

Most comments did not explicitly express support for or opposition to implementing the plan or dismiss the need for the plan. Rather, most contained specific comments. Five respondents stated general support of the PGC and the management plan or commented on the plan's thoroughness, and 3 commented on the need to manage based on science. One comment complimented the PGC for including information regarding climate change and the potential profound impacts it may have. One respondent supported a turkey hunting license while another was against it (Strategy 4.1).

Most comments centered around the respondent's perceptions of the turkey populations (44 comments), perceptions of issues negatively affecting turkey populations (35), and hunting regulations (33 regarding spring season, 13 regarding fall season). When comments regarding predators are grouped together 33 comments centered around predation of turkeys. Not surprisingly given PGC data showing turkey populations in most WMUs at lower densities than 10 years ago, 77% of the 44 comments regarding perceptions of turkey populations centered around declining turkey populations. The other 10 comments noted increased or 'good' populations. Respondents who referred to specific locations were from all areas of Pennsylvania such that there was no consensus as to higher populations in certain areas and lower in others.

Sixty percent of comments regarding perceptions of issues negatively affecting turkey populations stated that predators may be causing reduced populations. An additional 11 respondents recommended increasing harvests of predators, particularly fishers; although it seems reasonable to assume these suggestions reflect perceptions of negative affects to turkey populations, most did not explicitly state this. The management plan devotes a section to predation including study

conclusions regarding fisher diets which have not been shown to include wild turkeys. Public perception of fisher predation on wild turkeys is a public education challenge that the PGC will continue to address.

Four respondents noted poor reproduction due to weather as the factor negatively affecting populations, which is supported by scientific literature. However, 7 respondents stated the cause was due to some factor related to the spring season: overharvest of gobblers, especially from the second turkey license, and the all-day spring hunting. Clearly, more education is needed regarding biologically established spring turkey hunting (Strategies 3.4-3.6).

Of the 33 comments regarding spring hunting regulations most comments requested some form of more restrictions. Thirty-three percent requested removal of the second spring license, most claiming, as noted above, this was the cause of lower populations. Data, however, do not support this claim. Conversely, despite the PGC's efforts to inform the public that the spring season opening date of the Saturday closest to 1 May is based on biological data, 18% of the comments regarding spring season regulations requested opening spring season earlier. Comments made it apparent that hunters are concerned with equitability of all hunters having the opportunity and satisfaction of harvesting one gobbler before other, more successful, hunters harvest a second gobbler. This request could be implemented by restricting harvest of the second bird to the last 2 weeks of the season, as noted by one respondent (Strategy 4.4). Two comments regarding spring regulations were not biologically justifiable due to hen disturbance prior to nest incubation initiation; conducting a week-long youth season, and an archery only season before the regular spring season. Education is needed regarding biologically established spring turkey hunting (Strategies 3.4-3.6).

Of the 13 comments regarding fall turkey hunting regulations, they were equally divided between requesting more liberal and more restrictive regulations. Two additional suggestions may be implementable after completion of the structured decision protocol: begin the season later so a portion of it does not overlap archery deer to give turkey hunters a portion of the season to themselves; and conduct an archery only fall turkey season concurrent with archery deer. These two options might be able to be combined, such that the archery only turkey season would be concurrent with archery deer season, then the regular turkey season continue after the close of the archery deer season, prior to bear season (Strategy 4.4).

Of the 11 comments regarding habitat management, 6 requested the PGC to do more habitat management on State Game Lands, including prescribed burns and improving habitat to help turkeys avoid predation. Two commenters thought the PGC's timber harvests have reduced turkey populations, showing that the importance of creating young forest habitat is another area where public education is needed (Strategies 3.4-3.6).

Two respondents requested elimination of high-powered rifles during the fall season with one comment also stating fluorescent orange requirements should also be removed to force hunters to positively identify their target. However, removing that requirement during a time of year when other hunters are afield is highly unlikely for general safety reasons (Strategies 4.2, 4.8, 4.9).

In addition, due to the strong partnership with PANWTF and NWTF they reviewed the

management plan prior to the public review period and provided detailed comments throughout the body of the plan. They had another opportunity to comment during the public review period, providing additional comments.

Changes to the Turkey Management Plan Resulting from Public Input

The public response to the PA Wild Turkey Management Plan clearly shows support for continued improvement in turkey populations across most areas of Pennsylvania and continued public education / outreach on turkey population / harvest management.

One reviewer noted that although the comprehensive nature of the document is valuable, the 100+ pages were daunting for the public to read. This reviewer suggested creating a 10-page summary that truly specifies the 'meat' of the plan and 'becomes the management plan' to be distributed. Although creation of such a summary was not formally incorporated as an additional strategy in the plan, we intend to implement this suggestion very soon after the full plan is approved.

Due to the thoroughness of the 60 strategies in the draft plan, no new strategies were necessary in the final plan, but many of the comments provided will be incorporated into the existing strategies as they are implemented. Other than these added considerations under existing strategies and some editorial revisions to supporting text, public comments did not change the plan. The overall direction, goals, and major objectives remain identical to those presented for public review.

The PGC appreciates the input from all who took time to evaluate the wild turkey management plan and provide commentary. The depth of thought in comments reflects the passion of Pennsylvanians for wild turkeys and the recreational benefits they provide. The input received will clearly improve the PGC's implementation of our stewardship efforts for this valuable North American resource.

APPENDIX 2 TABLE. Summary of public comments.

PUBLIC COMMENTS ON THE WILD TURKEY MANAGEMENT PLAN, 2018-2027					
#	Comments	FaceBook	Emailed	Mailed	Total
	Perceptions of Turkey Populations				
1	Populations poor / lower in WMU where I live / hunt	12	16	1	29
2	Populations good / higher in WMU where I live / hunt	6	2	1	9
3	Populations poor / lower (general comment, not geographically specific)	1	4		5
4	Populations good / higher (general comment, not geographically specific)	1			1
	Sum	**20**	**22**	**2**	**44**
	Perceptions of Turkey Hunter Numbers				
5	Fall / Spring hunter numbers low / declining in WMU where I live / hunt **Sum**	**1**	**1**		**2**
	Perceptions of Issues Negatively Affecting Turkey Populations				
6	Predation by native predators has / may have reduced populations	8	13		21
7	Poor reproduction due to weather has reduced populations	2	2		4
8	General overharvest of gobblers has reduced populations, especially from 2nd turkey license	1	3		4
9	All-day spring hunting in 2nd half of season has reduced populations	1	2		3
10	Predation by feral cats has / may have reduced populations	2			2
11	Poaching has reduced populations	1			1
	Sum	**15**	**20**		**35**
	Spring Turkey Hunting Regulations				
12	Do not allow harvest of a second gobbler in the spring	4	6		10
13	Open spring season earlier (suggestion: split season: 1st season-1st week April, 2nd season-May)	2	3		5
14	Eliminate all-day spring hunting		3		3
15	2-bird limit in the spring is not a problem	2	1		3
16	2-bird limit in the spring does not provide equitability to less successful hunters	1	1		2
17	Separate opening days for spring season in northern vs. southern PA	1	1		2
18	Do not allow pre-season calling in the spring	1	1		2
19	Limit use of second tag to last 2 weeks of spring season		1		1

20	2 bird annual limit, no 2nd tag, Hunter choice of 2 spring males or 1 spring male, 1 fall either sex		1		1
21	All-day spring during the 2nd week for one week, then close the season		1		1
22	Shorten spring season, but open earlier		1		1
23	Archery only season before the start of the regular spring gobbler season		1		1
24	Week-long spring youth season		1		1
	Sum	**11**	**22**		**33**
	Fall Turkey Hunting Regulations				
25	Consider reducing or closing fall season for a few years in certain WMUs	2	2		4
26	Fall season too short in WMU where I hunt	1	3		4
27	Fall season is just right in WMU where I hunt		1		1
28	Same fall season lengths, but begin season later so part does not overlap with archery deer		1		1
29	Conduct an archery only fall turkey season concurrent with archery deer		1		1
30	Increase to a 2-bird limit in the fall		1		1
31	I assist with management by willingly only harvesting long-beards during fall		1		1
	Sum	**3**	**10**		**13**
	Hunter Safety & Ethics				
32	Improve safety: Prohibit high-powered rifles during fall, eliminate fluorescent orange-force hunters to identify target		2		2
33	Turkey license obtainable only after mandatory training and competency certification		1		1
	Sum	**0**	**3**		**3**
	Habitat Management				
34	PGC should plant more food plots and/ or do more prescribed burns	2	2		4
35	Harvests of big timber (oaks), turkeys main winter food source, has reduced populations	1	1		2
36	Improve habitat to allow turkeys to avoid predation, e.g., create better roosting habitat, cover		1	1	2
37	PGC should not do prescribed burns during turkey nesting season	1			1
38	PGC should use less herbicide on SGLs		1		1
39	Increase in no-till agriculture may have reduced populations	1			1
	Sum	**5**	**5**	**1**	**11**
	Predator Hunting and Trapping				
40	Education/incentives/bounties to encourage furbearer trapping/hunting; e.g., credit towards pheasant stamp, fisher permit, etc.		4		4

41	Need to harvest more foxes, raccoons, fishers, and / or coyotes	2			2
42	Allow raccoon/fisher hunting 365 days a year	1	1		2
43	Open fox hunting on first day of small game season	1			1
44	Open a hunting season on fisher & bobcat where I hunt (not enough trappers)		1		1
45	Conduct a predator-only season		1		1
	Sum	**4**	**7**		**11**
	General Comments About Turkey Management				
46	Manage based on science. Do not overly rely on sightings by individuals to set seasons	1	2		3
47	Conduct a study of impacts of the increased/additional predators on turkey populations		2		2
48	Conduct a study of impacts of diseases on turkey populations		2		2
49	General support of the Game Commission		3	2	5
50	Hunters need to do a better job reporting turkey harvests	1			1
51	Manage turkeys similar to deer and bear with WMU-level management	1			1
52	Effects from climate change may become profound		1		1
53	No turkey hunter license or other barriers, especially for seniors & youth		1		1
54	Support a turkey hunter license to acquire accurate data on number of turkey hunters		1		1
55	Possible Sunday hunting - positive for hunters, but suggest conservative approach-unknown effects to populations			1	1
56	Due to length of document, create a 10-page executive summary as the 'working' plan to distribute			1	
57	Streamline and prioritize the strategies and differentiate the re-occurring vs. new and finite strategies			1	
	Sum	**3**	**12**	**5**	**20**
58	**Miscellaneous Turkey or Turkey Hunting Experiences / Observations** **Sum**	**5**	**1**	**2**	**8**
	Total	**67**	**103**	**10**	**180**

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