# Legislative Budget and Finance Committee

A JOINT COMMITTEE OF THE PENNSYLVANIA GENERAL ASSEMBLY
Offices: Room 400 Finance Building, 613 North Street, Harrisburg
Mailing Address: P.O. Box 8737, Harrisburg, PA 17105-8737
Tel: (717) 783-1600 • Fax: (717) 787-5487 • Web: http://lbfc.legis.state.pa.us




# The Deer Management Program of the Pennsylvania Game Commission

Conducted Pursuant to House Resolution 2008-642

February 2010

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To the Members of the General Assembly:

House Resolution 642 of 2008 directs the Legislative Budget and Finance Committee to evaluate the Pennsylvania Game Commission's deer management program.

Due to the specialized nature of this study, the Committee issued a Request for Proposal for assistance in developing the report. In April 2009, the Committee contracted with the firm of Wildlife Management Institute to conduct this study.

The WMI report is contained herein. As with all LB&FC reports, the release of this report should not be construed as an indication that the Committee or its individual Committee members necessarily concur with its findings and recommendations.

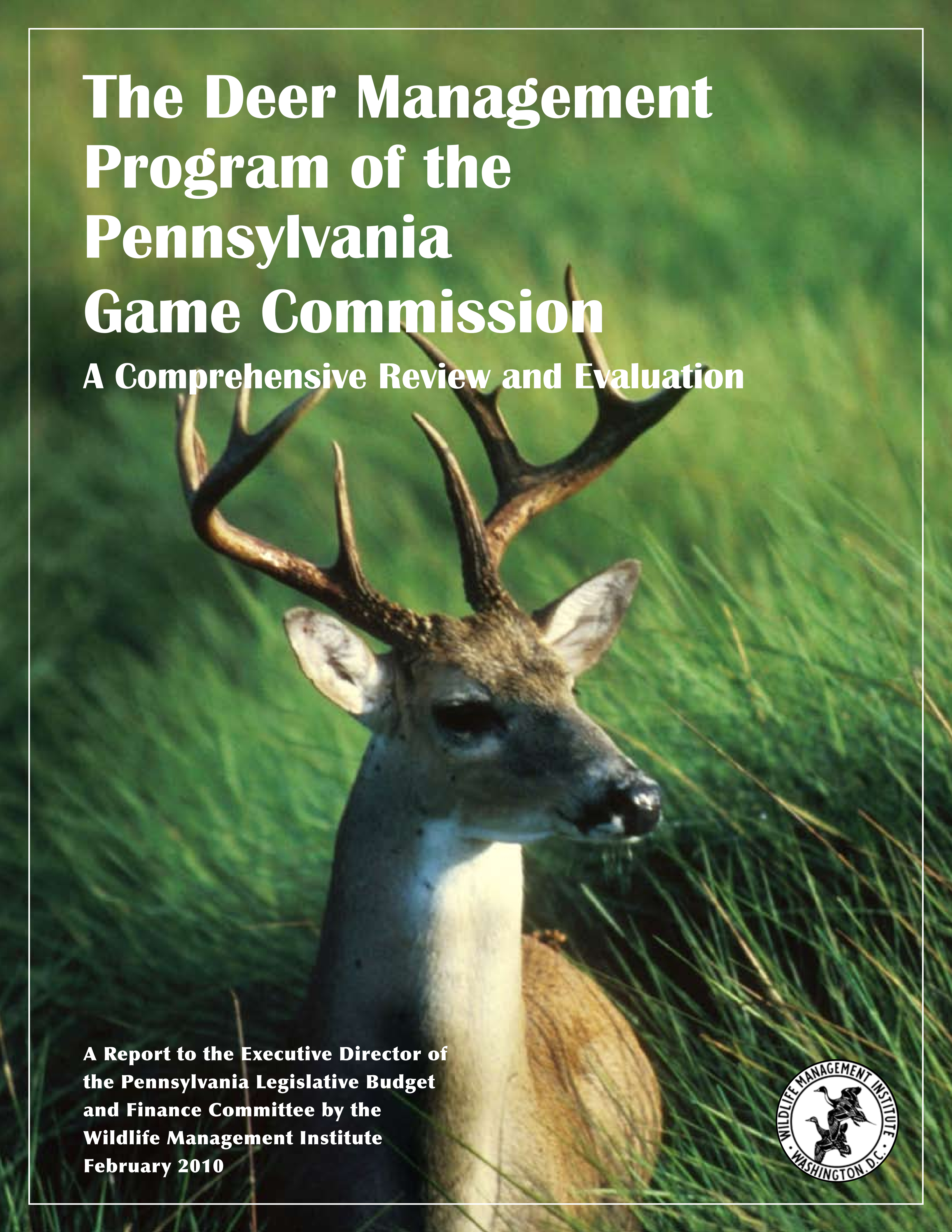
Sincerely,

Philip Durgin

Philip R. Durgin
Executive Director

# The Deer Management Program of the Pennsylvania Game Commission

## A Comprehensive Review and Evaluation



**A Report to the Executive Director of the Pennsylvania Legislative Budget and Finance Committee by the Wildlife Management Institute**
**February 2010**

WILDLIFE MANAGEMENT INSTITUTE
• WASHINGTON, D.C. •

# Contents

# Executive Summary

The Wildlife Management Institute (WMI) was asked by the Pennsylvania Legislative Budget and Finance Committee to conduct an evaluation and study of the Pennsylvania Game Commission's (PGC) current deer management program and practices. Between May and December, 2009, WMI analyzed the scientific basis of deer management in the Commonwealth, including the scientific foundation of deer management goals, deer population and habitat measurements and citizen input procedures. The analysis was designed to judge the adequacy of the methods employed by the PGC to provide the agency and the public with an independent evaluation of how the deer management goals were chosen and measured, and how they affected deer management.

WMI employed various methodologies to evaluate deer management. We requested and reviewed more than 90 documents provided by the PGC, the Department of Conservation and Natural Resources, Penn State University, the U. S. Forest Service and references from the scientific literature to define the logic framework behind deer management. WMI conducted interviews of natural resource management specialists both within and outside of the PGC. The WMI review team consulted and surveyed other state fish and wildlife agencies to determine how the PGC deer management program compared with other state deer management systems. Finally, WMI conducted statistical analyses of PGC data to test assumptions, make predictions, and evaluate decision making. The report is, by necessity, a highly technical document. WMI elevated the complexity of its analysis because deer management, as practiced by the PGC, is a complex undertaking that merges the fields of biology, statistics, ecology, and sociology.

WMI documented that in the history of deer management in Pennsylvania, the PGC has been frequently criticized for attempting to balance the size of the herd with forages available in deer habitat. It was learned that the PGC has taken that approach because of a constitutional mandate: "Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."

The current deer management goals reflect measures of forest health, deer health and citizen desires. The management action used by the PGC to achieve desired deer goals is primarily the number of antlerless permits allocated in various hunting seasons. The PGC has invited the public to participate in deer management decision making, but WMI believes that the current goals have long been recognized and applied by agency staff. WMI's finding is that the deer management goals chosen by the PGC are reflective of the mandate. WMI did not find that any economic interest or stakeholder group receives preferential treatment.

Since approximately 2000, the PGC has increased the harvest of antlerless deer. While there have been other deer management goals initiated during the time period (e.g.: antler restrictions, urban deer management, diversification of weapons and seasons), the underlying goal of reducing deer density has been the primary management policy. Beginning in 2005, permit allocations were reduced as the PGC moved to stabilize deer populations at lower population levels.

Tools used by the PGC to conduct management include estimation of harvest, sex ratio, and age distribution, and research to document mortality and movement patterns of deer. All of the tools are integrated into a management model – the Pennsylvania Sex-Age-Kill (PA SAK) model – that generates numerical estimates of population parameters. Based on estimates derived from PGC sponsored research of the PA SAK model, statewide deer populations have declined approximately 25 percent between 2002 and 2007, from 1,280,000 - 1,520,000 in 2002 to 850,000 - 1,280,000 in 2007. Changes in deer population size have differed by Wildlife Management Unit (WMU) but have been consistent with goals established by the PGC.

WMI tested the PA SAK model to determine limits of sensitivity, test assumptions, and measure outcomes. In general, WMI documented that the PGC has developed a credible population model that factors in necessary adjustments to reflect antler restrictions. WMI also documented that the PGC strives to improve continually the accuracy and precision of model inputs by conducting field research. All parties interested in deer management in Pennsylvania can be confident in the ability of the PGC to track deer population trends at statewide and WMU scales through use of the PA SAK as long as PGC data collection thresholds for data input are met or exceeded and model assumptions are not violated.

WMI documented that the utility of the PA SAK is significantly reliant on accurate annual deer harvest estimation. The recent trend of declining harvest reporting rates should be a concern to the PGC as low reporting rates increase the variability of harvest estimation. The strong correlation between annual deer harvest estimation and the PGC game take survey, however, as independent measures of deer harvest, provides a measure of confidence in the current results from the PGC methodology. WMI recommends that the PGC develop and prioritize policies and procedures to increase harvest reporting.

The PGC employs deer management practices in a system of 22 WMUs. WMU size and configuration were developed to provide homogenous landscape management units and statistically valid sample sizes of deer population parameters. The design of the current WMUs reflects a necessary compromise between the need for adequate sampling size of deer age, sex and reproductive data, hunter preferences and harvest, deer population information and deer habitat distributions. The DMAP, Red Tag and Urban Deer Management programs appear to provide substantial management flexibility within the current WMUs and provide a viable alternative to designating smaller management units. WMI notes, however, that the harvest from these programs needs to be incorporated fully into the PA SAK and permit allocation procedures.

The PGC uses a scientifically valid method to calculate deer population size for each WMU. Model inputs provide additional estimates of age structure and sex ratio. WMI believes that the PGC should publish its estimates of population size and age and sex structure, accompanied by associated levels of variance, and an explanation of their appropriate use.

WMI documented insufficient evidence that the PGC practice of using the number of embryos per adult doe is a reliable index of herd health. For a variety of reasons, including insufficient sampling and concerns about the sensitivity of the index, WMI recommends that the PGC seek an alternative to embryos per adult doe as an index of herd health or consider deleting the herd health goal and putting additional resources into evaluation of forest (or habitat) health. Fawn reproductive rate may be a viable replacement if sampling deficiencies are corrected. Another variable that may be useful is fawn-to-adult doe ratios derived from harvest statistics.

WMI received extensive testimony and reviewed an extensive body of scientific literature regarding the health and vitality of Pennsylvania forestlands. WMI evaluated the myriad influences that impact forest health. While Pennsylvania forests are challenged by a number of environmental and social factors, the clear majority of evidence provided to WMI indicated that abundance of deer was a major cause of forest regeneration failure. WMI expects that, as deer management goals are met, the percentage of Pennsylvania forests with adequate regeneration will improve. While WMI agrees that quantifying

the extent and success of forest regeneration is a practical and ecologically sound indicator of forest habitat health, WMI documented significant concerns that insufficient sampling currently jeopardizes the value of the measure. Several remedial actions are recommended. Because this is a prime decision making variable in the PGC deer management system, especially if the recommendation regarding herd health indices is instituted, WMI encourages improved collection of these data.

The PGC has instituted a Citizen Advisory Committee (CAC) process to allow stakeholders to participate in deer management. Some form of CAC, perhaps at the statewide level, should be continued by the PGC. The CAC process, while grounded in social science, may not be an efficient or fully objective method to assess all citizens' desires in each of the 22 WMUs. Cost-effective data relative to public desires, with less bias and variation, may be readily available through a statistically valid public information and survey method designed at the scale of the WMU.

Comparison of the deer management programs and processes in eight states, including Pennsylvania, indicated that while there are a few differences in procedures and techniques among the states, all eight states addressed management of white-tailed deer in a very similar manner. WMI found nothing in this comparison that would be considered problematic in the PGC's general approach to deer management by professional wildlife biologists. The PGC appears to be at the forefront of developing techniques to assess impacts of deer on forest habitat quality.

The PGC continues to be subjected to considerable criticism from some hunters about deer management programs. Although most states have had a period of time when deer management goals, practices or decisions were controversial, Pennsylvania is unique in that the period of controversy seems to have never waned. The strained nature of the relationship between the PGC and some hunters is problematic, and in the long-term, damaging to society's perception of how hunters and the PGC must work together to conserve and maintain deer and other wildlife resources consistent with the aforementioned constitutional mandate.

Finally, the scientific foundation of the PGC deer management system is sound, but there are important components identified that need modification or additional evaluation and assessment. Striving for continual improvement appears to be the approach identified by the PGC, and WMI supports the apparent recognition that an open, adaptive, transparent and inclusive process will increase the effectiveness of PGC management plans. Because some portions of the public continue to vocalize discontent with PGC goals, the trends towards conflict resolution, increased communication, and increased opportunities for collaboration are necessary and recommended.

# Introduction

On March 17, 2008, the General Assembly of Pennsylvania passed House Resolution 642. The Resolution directed the Legislative Budget and Finance Committee (LBFC) to conduct an evaluation and study of the Pennsylvania Game Commission's (PGC) current deer management program and practices. The Resolution recognized the value of white-tailed deer to the citizens of the Commonwealth, the statutory responsibility of the PGC to manage the white-tailed deer resource appropriately and the "serious and longstanding concerns about the status of the State's deer" among some publics. HR 642 requested that the study commissioned by the LBFC examine specific measurements, trends, assumptions, methods, and strategies employed by the PGC. Finally HR 642 required that the study be "science-based" and include comparisons between Pennsylvania and other states with similar deer management programs.

The LBFC issued RFP 2008-03: "An Examination of the Pennsylvania Game Commission's Deer Management Program" on April 11, 2008. The RFP translated HR 642 into a specific set of objectives and prescribed a definitive scope of work. Responses to the RFP were requested by May 14, 2008. The Wildlife Management Institute (WMI) submitted a proposal to conduct the review in early May 2008. WMI was awarded the contract from the LBFC to conduct the review in an agreement dated April 29, 2009.

The WMI proposal defined the issue in both the widest possible view and at the most narrow, focused view. In the widest sense, the PGC deer management program was representative of the time-tested system of wildlife conservation in this continent -- the North American Model of Wildlife Conservation. The model rests, in part, on the following three pillars:

1. Wildlife is a public trust resource, owned equally by all citizens.

2. Hunters as a user-group of the citizen's wildlife, pay for the majority of wildlife conservation programs through their license fees and associated excise taxes. As the primary funding source and user-group, hunters are therefore entitled to offer direction to hunting programs. State fish and wildlife agencies, including the PGC, are structured with a Commission form of governance to ensure representation of both public and hunter interests.

3. Notwithstanding the relationship between hunter's financial support and agency governance described above, the foundation of the continent's wildlife conservation programs rests on sound science. In modern times, when a super-majority of citizens do not hunt, continued support for deer management programs arises from citizen beliefs that such programs result in sustainable harvests that are designed to obtain specific population goals complementary to societal goals.

WMI's proposal stated that deer management in Pennsylvania lies within the interface of the three pillars mentioned above and the PGC must address each independently and comprehensively. Deer are a public resource and the public has the right to understand and influence deer management goals. Pennsylvania deer hunters are motivated by their hunting experiences to influence deer management goals and feel special dispensation because of their financial support to have their desires translated to agency policy. Finally, the PGC must interact with the public, deer hunters and the wild deer resource itself, only within a scientifically defensible program of work.

WMI outlined procedures by which it would conduct an independent analysis of the scientific basis of deer management in the Commonwealth, including the scientific foundation of deer management goals, deer population and habitat measurements. The analysis would judge the adequacy of science so that the agency and its publics could evaluate the likelihood that the fulfillment of their various and diverse interests would be obtainable within realms of scientific method.

In the most narrow sense, the RFP requested both evaluation and determination products. For both types of products, WMI stated that review findings would need to conform to the standards of sound science and scientific method. For the evaluation products, WMI expected the PGC to provide certain data to WMI, and WMI would compare and contrast the data to established scientific norms. For the determination products, WMI expected the PGC to provide certain data to WMI, and WMI would then analyze the data to create various deer population estimates. WMI cautioned that, if in the judgment of WMI, the data were not sufficiently scientifically rigorous to make reasonable population estimates, WMI would advise in the report the level of power needed to make such a statistical effort and recommend how to achieve that level of statistical power.

# Review Methods

WMI assembled a team of deer management experts to assist WMI staff in the conduct of the review. WMI review team members had lengthy experience in deer harvest management, planning, goal setting, deer research, forestry, human dimensions and deer population analysis (see Appendix A for team resumes). Methods employed by WMI included synthesis of issues facing the PGC and PGC publics, definition of areas of potential investigation for each issue, requests (3) for relevant documentation, surveys of other state wildlife agencies and personal interviews. When appropriate, data provided by the PGC and others were subjected to statistical analysis to detect trends, levels of variation and sources of potential bias.

## Review of Agency Documents

In recent years, deer management in Pennsylvania was guided by the PGC Commission approved "Population Management Plan for White-tailed Deer in Pennsylvania (2003-2007)." A fortunate coincidence of timing allowed the WMI review to occur during the development of the next edition of the plan. WMI reviewed the internal working draft of the update to the Pennsylvania deer management plan "Management and Biology of White-tailed Deer in Pennsylvania 2008-2017 (Draft April 2009)" for the most up-to-date reference documents supporting the science and policy of deer management. WMI made three document requests to the PGC via letter to the PGC's Executive Director. The Chief of the Wildlife Management Bureau coordinated the staff response. In each instance, the PGC provided documents, data or explanation within one week of receiving the request. The following documents (including reports, Web page resources, data queries and analysis working papers) were received from the PGC.

1. 1991 Deer Hunter Survey
2. 1995 Deer Hunter Survey 1.DOC
3. 2002-2005 Deer Hunter Surveys (survey instrument included in report in ii.)
4. 2005-06 Allocation Recommendation Handout v1.doc
5. 2006 – F-D Ratio Correction – 20090306.xls
6. 2006 – PA SAK Procedures v2(Sept2006) – FINAL – FINAL.xlsx
7. 2006 DMAP Hunter Survey (survey instrument included in report in ii.)
8. 2006 DMAP SURVEY REPORT – V2 – 20070109.doc
9. 2006 SAK Model Prelim version 1
10. 2006 SAK Model Prelim version 2
11. 2006-07 WMU Allocation Worksheets-BWM verion.xls
12. 2006-08 t-test for differences between mean and hypo mean.xls
13. 2007 – PA SAK Procedures v2(Sept2006) – PRELIM V2 – FINAL.xlsx
14. 2007 SAK Model Prelim version 1
15. 2007/08 Commissioner Allocation Recommendation sheet - v3.doc
16. 2007-08 WMU Allocation Worksheets-BWM verion.xls
17. 2008 – PA SAK Procedures v2(Sept2006) – PRELIM V1 – FINAL.xlsx
18. 2008 2A Deer Hunter Survey REPORT – v2 20080509.doc
19. 2008 4 WMU Deer Hunter Survey (2008 Deer Hunter Survey – 4 WMUs – v5.doc)
20. 2008 5C 5D Baiting Survey REPORT – v2 20080512.doc
21. 2008 Deer Hunter Diaries (Pennsylvania Deer Hunter Diary v6 20081112.doc; 2008 Deer Hunter Diary Cover Letter v5 20081030.doc)
22. 2008 Taxidermist Survey (survey instrument included in report in ii.)
23. 2008-09 WMU Allocation Worksheets-BWM verion.xls

24. 2009 5C and 5D Baiting Survey (2009 Hunter Baiting Survey-v1.docx)
25. 2009-10 WMU Allocation Worksheets-BWM verion.xls
26. 5A Member Interview Questions v2 20071016.doc
27. Antlered kill by day during the firearms season
28. Antlerless Allocations -- Summary Tables 2005-06 v4.xls
29. Antlerless Allocations, Sales, and Harvests 1990-2008 20090701.xlsx
30. BWM - WMUs 1A-1B, 2005-06 Allocation.xls
31 BWM - WMUs 2A-2D, 2005-06 Allocation.xls
32. BWM - WMUs 2E-2G, 2005-06 Allocation.xls
33. BWM - WMUs 3A-3D, 2005-06 Allocation.xls
34. BWM - WMUs 4A-4E, 2005-06 Allocation.xls
35. BWM - WMUs 5A-5B, 2005-06 Allocation.xls
36. CAC FAQs.pdf
37. CAC Overview.pdf
38. Commissioner Allocation Recommendation sheet - v3.doc
39. DCWG Summary – 20090619.doc
40. Decision Rules for Deer Management Recommendations.doc
41. Diefenbach, D. R. and W. L. Palmer. 1997. Deer management: marketing the science. Wildlife Society Bulletin, 25:378-381.
42. Diefenbach, D. R., W. L. Palmer, and W. K. Shope. 1997. Attitudes of Pennsylvania sportsmen towards managing white-tailed deer to protect the ecological integrity of forests. Wildlife Society Bulletin 25:244-251.
43. Example of WMU worksheet used to develop antlerless allocation
44. FIA Regeneration Data for 2001-2008 – 5 yr data sets – 20090326.xlsx
45. FINAL – EMBRYO DATA 2000 TO 2007 20080103.xls
46. FINAL – PA DEER HARVEST ESTIMATES FOR 2006-07.xls
47. Game Take deer harvest estimates compared to reporting rate deer harvest estimates – Statewide
48. Game Take deer harvest estimates compared to reporting rate deer harvest estimates by WMU
49. Harvest Estimates M-R v3 20050228.doc
50. http://www.pgc.state.pa.us/pgc/cwp/browse.asp?a=465&C=70129&BMDRN=2000&BCOB=0&PM=1
51. Management_Plan4_06.pdf
52. Mann-Kendall Test for Trends for WMUs – ANTLERED HARVESTS 2004-08.xlsx
53. Mann-Kendall Tests for Trends for WMUs – ANTLERLESS CPUES 2004-08.xlsx
54. Mann-Kendall Tests for Trends for WMUs – SAK ESTIMATES 2004-08.xlsx
55. Rosenberry et al 2004 JWM. pdf
56. Rosenberry et al. 2007 21001-06Z.pdf
57. Rosenberry et al. 2008 21001-07z.pdf
58. SAK Population Estimation – Review Version – WMI 20090608.pdf
59. Summary of antlerless allocation information provided to Commissioners and the public
60. Taxidermist Survey Report – v5 20081001.docx
61. Wallingford et al. 2006 21009-05.pdf
62. WMI – PA Deer Population Objectives 2003 to 2009 20090701.xlsx
63. WMI – Yearling ABD by county.xls
64. WMI-Annual Adult Embryo WMU Summary 2000-2008.xls
65. WMI-PA DEER HARVEST ESTIMATES FOR YYYY-YY.xls
66. WMI-Percentage of Total Antlered Harvest Comprised of 1.5 Males by WMU.xls
67. WMI-Percentage of Total Antlerless Harvest Comprised of 0.5 Females by WMU.xls
68. WMI-Percentage of Total Antlerless Harvest Comprised of 0.5 Males by WMU.xls
69. WMI-Percentage of Total Antlerless Harvest Comprised of 1.5 Females by WMU.xls
70. WMU FINAL Report – Entire Report.pdf

## Review of Pertinent Literature

WMI also consulted the following documents from sources outside of the PGC.

1. Bailey, et al. Influence of edaphic factors on sugar maple nutrition and health on the Allegheny Plateau.pdf
2. Bailey, Horsely and Long. Thirty years of change in forest soils of the Allegheny Plateau, Pennsylvania.pdf
3. DCNR DD Browse Impact Data sheet
4. GC PA Regen Interim Results 0 - 39 2009.xls
5. GC PA Regen Interim Results 40 to 75 2009.xls
6. GC PA Regen Interim Results 75 plus 2009.xls
7. GC PA Regen Interim Results All 2009.xls
8. Hallet, et al. Influence of nutrition and stress on sugar maple at a regional scale.
9. Horsely, et al. Factors associated with the decline disease of sugar maple on the Allegheny Plateau, pdf
10. Horsley, Stout, DeCalesta. 20034. White tailed deer impact on the vegetation of a northern hardwood forest.pdf
11. Long et a., Sugar maple growth in relation to nutrient stress in the Northeastern US.pdf
12. Long, Horsely and Lilja. Impact of forest liming on growth and crown vigor of sugar maples and associated hardwoods.pdf
13. McWilliams. FIA Analysis Overview 2009.ppt
14. McWilliams. Number of plots 2004-2008 40 to 75.htm
15. PA BOF CFI Manual 2009 Cycle3.pdf
16. PA BOF Deer Density Browsing Impact Protocol
17. PA BOF Deer Impact Data Sheet 2010.xls
18. PA BOF Deer Impact Survey Protocol 2010.doc
19. PA BOF DMAP Harvest Summary 2008-09
20. PA BOF Reports Instructions for Deer Impact Survey Database.doc
21. Sharpe et al. Impacts of acid deposition on PA forests (hard copy for each team member)
22. Wallingford. Unpublished Dissertation table draft v2 WMI audit.xls
23. Wallingford. Unpublished Response rates and methods PGC surveys WMI audit.doc

## On-Site Staff Interviews

WMI conducted interviews in State College, PA from July 27-30, 2009. Interviews ranged from 1 hour to 10 hours, and included both individual and group interview settings. Affiliations of interview participants included the PGC; School of Forest Resources – Penn State University; Bureau of Forestry – Pennsylvania Department of Conservation and Natural Resources; and the U. S. Department of Agriculture – Forest Service. Interviews served two functions: exploratory investigation and fact-finding. Interviews did not follow pre-determined methodology and discussions were free-flowing depending upon the topic.

## Surveys of Other States

WMI surveyed fish and wildlife agencies of all the states that border Pennsylvania plus Michigan and Wisconsin. All states that were contacted responded to a questionnaire that was designed to determine similarities and differences in deer management programs among the states. In addition, WMI obtained and analyzed a summary of deer hunting and harvest data for the 2007-08 hunting season from the 14 states (including Pennsylvania) that participate on the Northeast Deer Technical Committee of the Northeastern Association of Fish and Wildlife Agencies.

## Analysis

WMI performed various analyses on the data provided by the PGC and others. Specific methods used in the analysis are included in the Results and Discussion section.

# Results and Discussion

At the risk of oversimplification, WMI has found in the course of its many state agency reviews that agencies repeatedly structure their management systems based on three questions:

1. What is the current status of our program?
2. What are our goals for the future status of our program?
3. What strategies and/or methodologies do we employ to reach our goals?

The response to these questions normally involves the use of scientific methodology, management tools or processes, and public input. The current status and strategies questions are dependent on tools – processes that allow the agency to define the current situation and employ the appropriate methodologies to achieve a goal. Analysis of tools can be objectively analyzed, conclusions drawn, and recommendations offered to verify or improve upon the use of the tools.

The goal question is more subjective. Goals define the desired condition or state of some resource as compared with the current condition or state. Normally goals are constrained by resource condition measures, available resources for future sustainability, and public demand and opinion. Although WMI evaluated the PGC goals in the context of its analysis, WMI recognized that deer management goals must be decided by the PGC in consultation and collaboration with hunters and the rest of the Pennsylvanian citizenry.

The PGC deer program was similarly constructed around answers to the three questions. WMI documented that the deer population model used by the PGC was a tool to answer the "current status?" question. The model produced deer population estimates, including size, age distribution and sex ratio. Model outputs clearly defined the current condition and status of the Pennsylvania deer population.

WMI documented that the population model was not designed to answer the question regarding goals for the future. Instead, the PGC created three measures--forest health, deer population health and citizen desires-- to define the desired condition and status of the deer population.

Last, WMI learned that the primary management tool used by the PGC was antlerless permit allocations. WMI recognized that other special management programs are important to achieve specific goals. As with the deer population model outputs, antlerless allocations were not a goal, but were a tool to achieve a desired deer herd condition. Decisions to increase, decrease or stabilize a deer population were the strategy employed by PGC and, again, the tool used by the PGC to inform of those decisions was the deer population model.

## Deer Management in Pennsylvania

The constitution of Pennsylvania proclaims: "Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."

The PGC is the legal entity charged with upholding the Commonwealth's responsibility to conserve and maintain the public's wildlife resources. The PGC was created in response to lobbying efforts by far-thinking hunters in the late 1800s. Since then, the PGC has conserved and maintained the public's deer resource through regulation of legal harvest, protection from illegal harvest and improvement of habitat. As is true of most state wildlife agency deer programs, the goals of management evolved from protection in times of scarcity, to management to meet multiple objectives, and to control to prevent overpopulation.

One of the first jobs of the PGC was to restock deer. From 1906 to 1925, deer were trapped in Kentucky, Maine, Michigan, New Hampshire, New Jersey, North Carolina, Ohio, and released in Pennsylvania. At the same time, deer were protected from overharvest. Bag limit was dropped from two to one in 1905. The harvest of antlerless deer was banned beginning in 1907.

In the 1920s, as deer populations reached a point of surplus, the PGC initiated antlerless harvests , which were generally opposed by the hunting public. Although the PGC was given authority to establish antlerless deer seasons in 1923 and the ability to fix seasons and bag limits in 1925, it wasn't until 1957 that the PGC committed to an annual antlerless deer season.

Deer seasons were structured so that the majority of the season was buck-only, followed by a one- to three-day antlerless season following the end of buck season. Buck-only seasons opened on the Monday following Thanksgiving and continued for 12 days. Antlerless permits were allocated at the county level. In an effort to quantify antlerless allocations, the PGC established deer density goals based on forage availability in forested habitats in 1979. With goals in place, deer densities fluctuated but generally grew throughout the 1980s and 1990s even though deer numbers were 50 to 100 percent above goal throughout most of the Commonwealth (PGC 2003).

The PGC recognized the continued inability to move deer densities toward county goals, and sought additional remedies. The Deer Management Plan issued in 2003 highlighted the changes approved by the PGC to move populations towards goal (PGC 2003): *"The inability to remove enough antlerless deer annually was impacting the PGC's ongoing efforts to reach deer density goals and reduce deer impacts. In response, the agency implemented measures in the late 1980s and early 1990s to increase the antlerless harvest. Probably the most effective of these changes was allowing properly licensed hunters to shoot more than one deer annually – hunters previously were limited to taking either an antlered or antlerless deer – with an emphasis on antlerless deer. Other measures included issuance of bonus antlerless licenses; expanding archery deer season from four to six weeks; lengthening and extending antlerless deer seasons; allocating record numbers of antlerless licenses; providing additional antlerless harvest opportunities to junior and senior license holders; and providing expanded antlerless harvest opportunities on farm properties and in municipalities where deer overpopulation was impacting public safety or causing substantial property damage. "*

Even with the increased programs to reduce deer density toward the desired goal, the PGC continued to measure deer populations above goal. *"The PGC again modified the framework of Pennsylvania's deer hunting season in the late 1990s to reduce whitetail populations. Liberalized antlerless tags were issued and the separate buck and antlerless deer seasons were combined to maximize hunter opportunities for harvesting antlerless deer"* (PGC 2003). The combination of methods to increase antlerless harvest was successful. Since 1990, antlerless harvest averaged 232,000 (Figure 1, page 13) from an average antlerless permit allocation of 773,000 (Figure 2, page 13). Beginning in 2005, permit allocations were reduced as the PGC moved to stabilize deer populations.

The progression of deer population management by the PGC to meet deer density goals has occurred as deer hunter numbers have declined. From 1957 to present, Pennsylvania general license sales peaked at 1.3 million in the early 1980s and subsequently declined to 920,000 (Figure 3, page 14). From 1986 to present, the percentage of PA general license buyers who identify themselves as a deer hunters via the Game Take Survey declined from more than 85 percent to less than 80 percent (Figure 4, page 14).

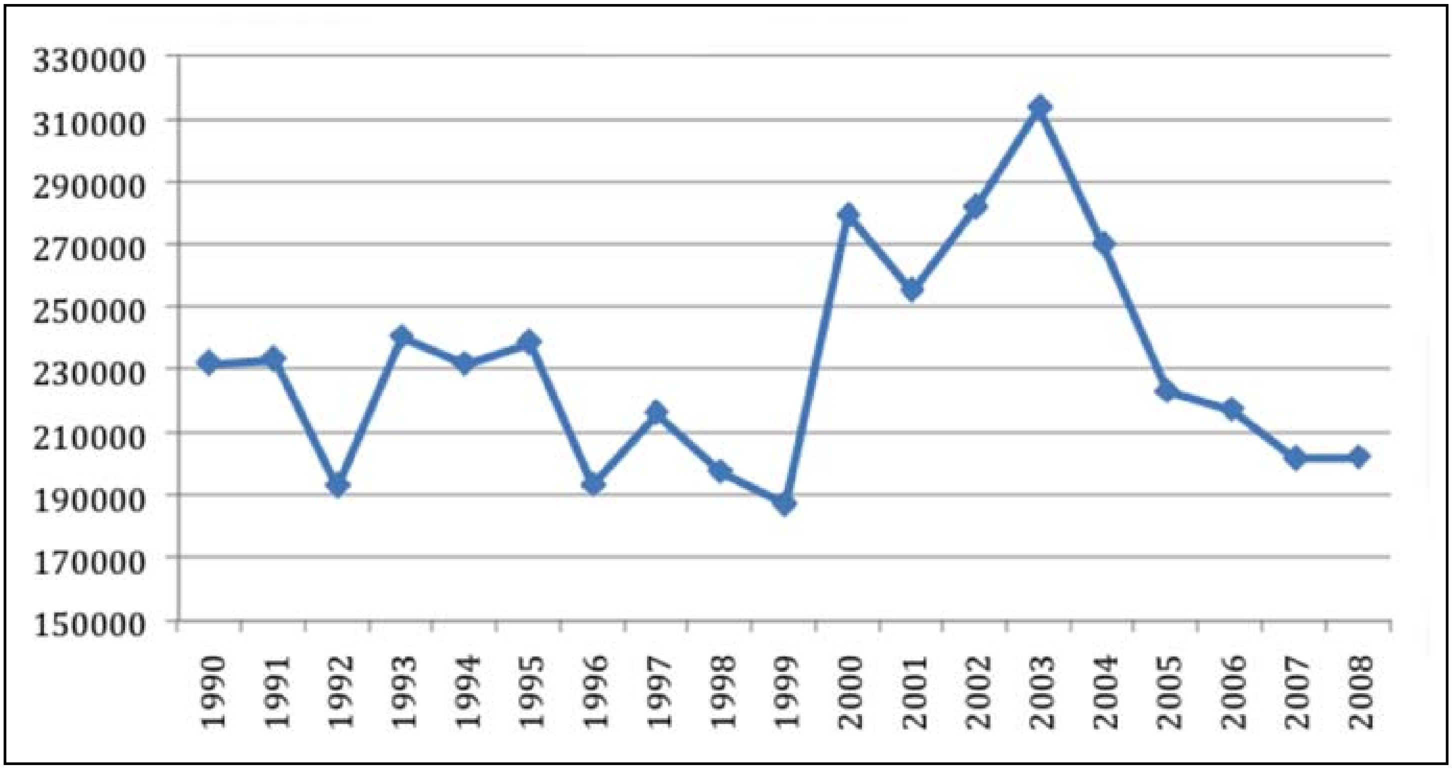



**Figure 1: Antlerless deer harvest from 1990-2008.**

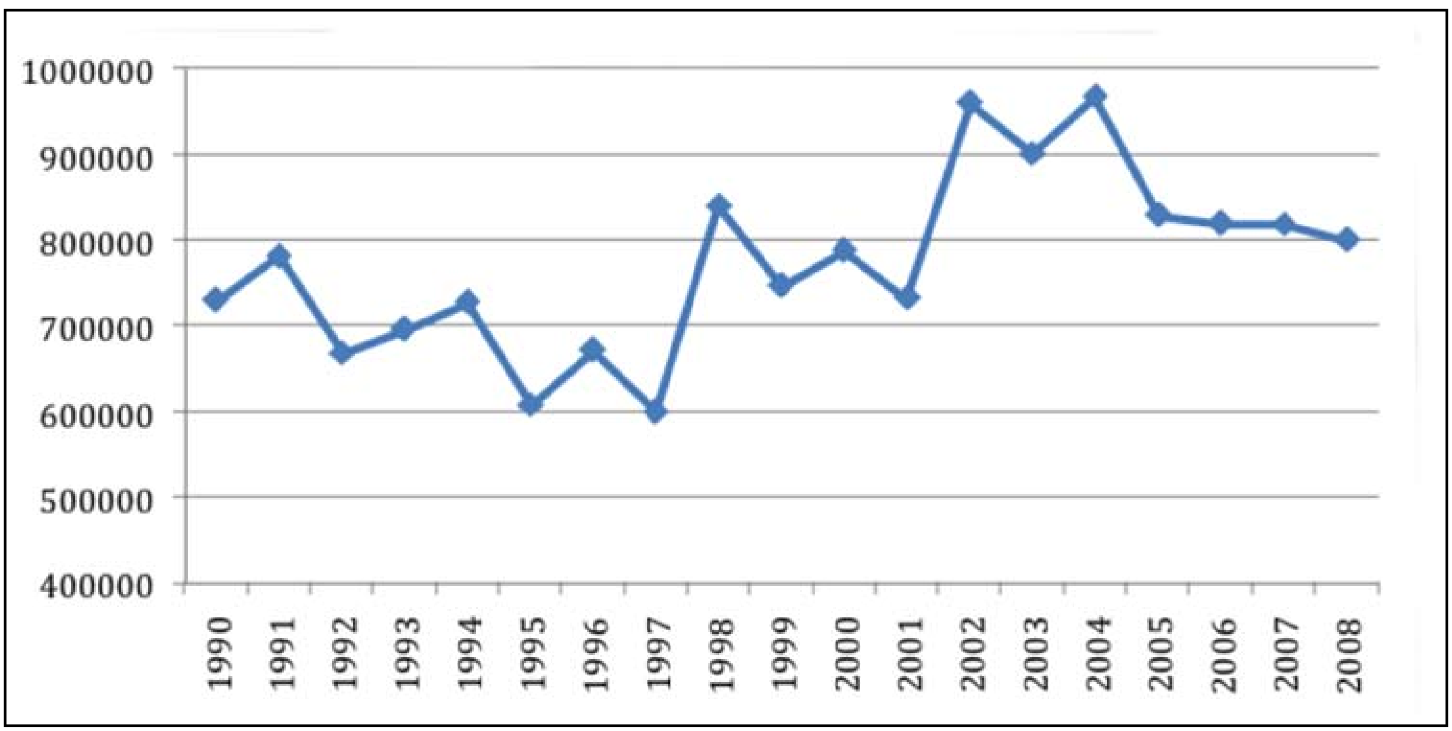



**Figure 2: Antlerless allocations from 1990-2008 (does not include DMAP permits).**

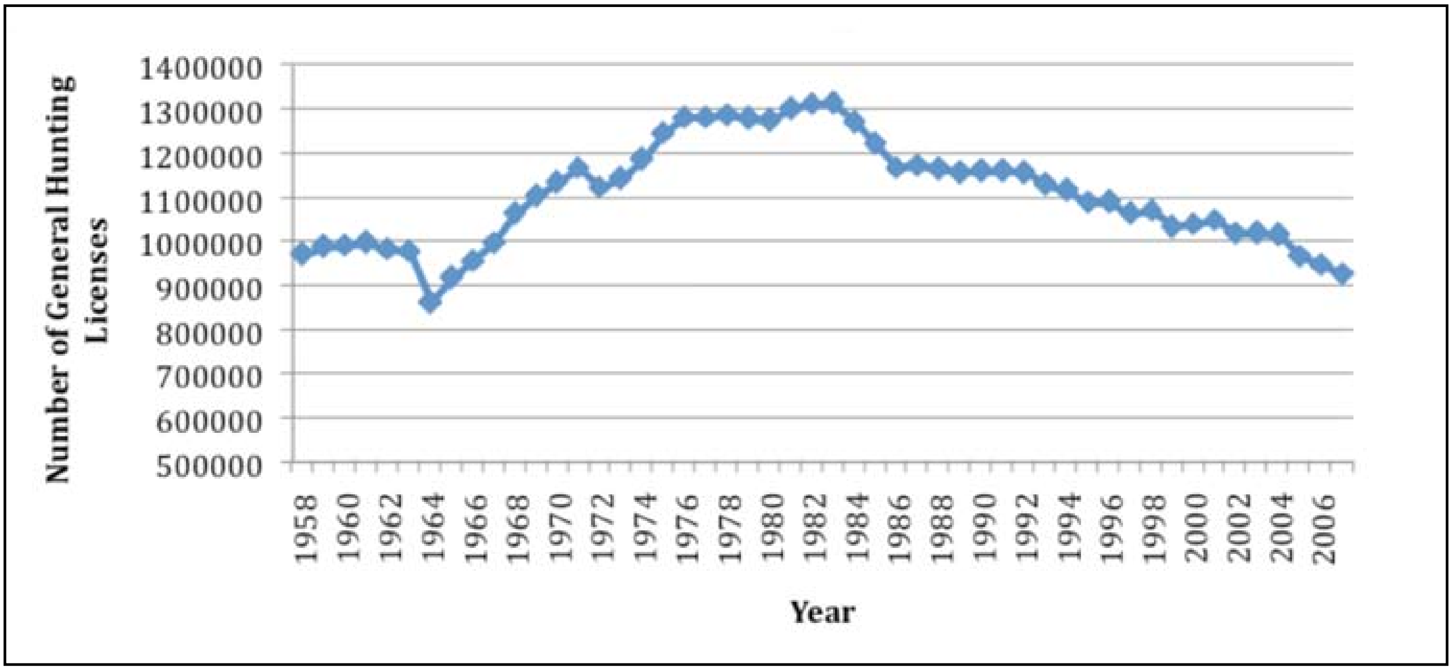



**Figure 3: Number of hunting licenses sold in Pennsylvania from 1958 to 2007.**

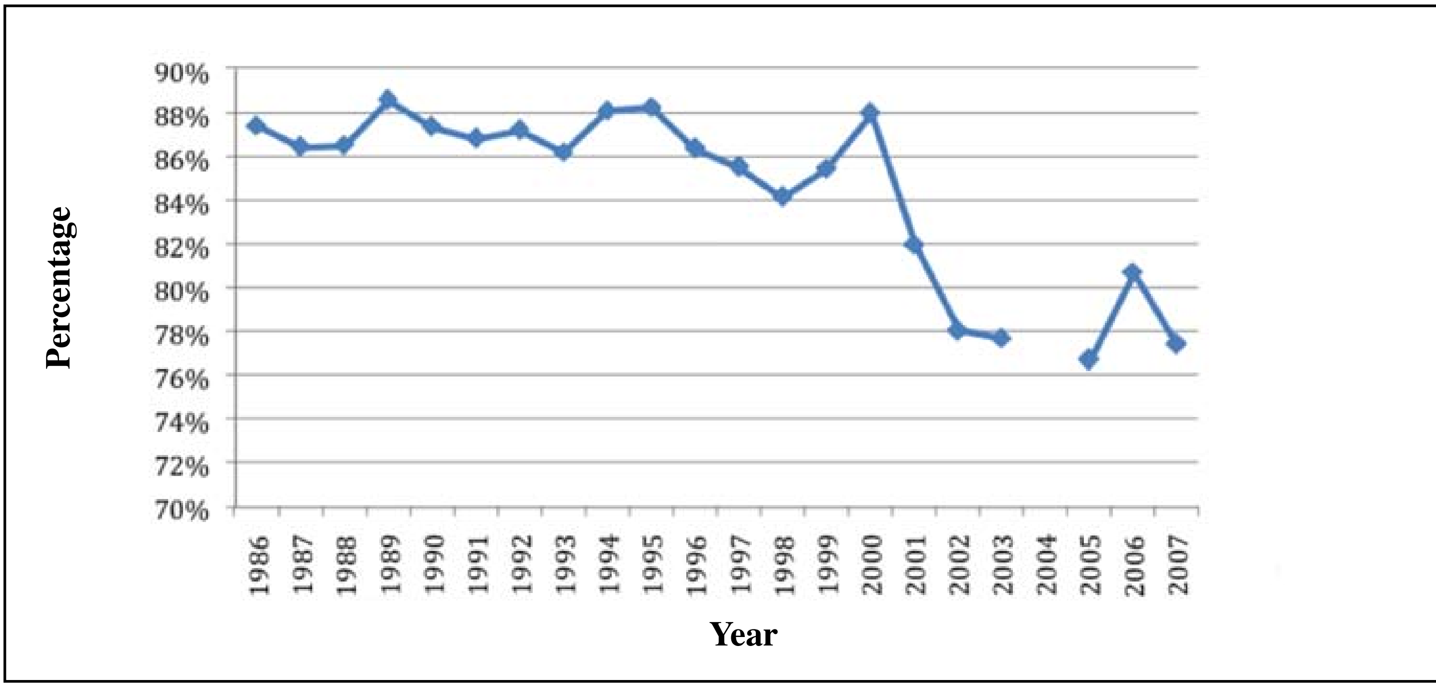



**Figure 4: The percentage of Pennsylvania general license buyers identified as deer hunters from 1986 to 2007 from the Game Take Survey (no survey in 2004).**

## Management Tools

The foundation of the PGC deer management system is an understanding of the number, sex and age structure of the annual deer harvest. Hunters who take a deer in Pennsylvania are required to return a harvest report card to the PGC. Report cards are attached to the hunting license and request basic information about the date and location of the deer harvest and information about the hunter. If 100 percent of successful hunters returned a report card, then the reported annual harvest would be a total count. But a varying percentage of successful deer hunters ignores the law and does not report their harvest, forcing the PGC to estimate the harvest by calculating an estimate of reporting rate. To do that, PGC staff examined more than 40,000 harvested deer taken to meat processors each year. An estimate of reporting rate is calculated by dividing the number of harvested deer examined at meat processors that were legally reported to the PGC by the total number of deer examined. The calculated reporting rate is then used to transform reported harvest at the WMU level to calculated harvest. For illustration, a hypothetical example of this process follows (Note this is a simplified example -- the PGC uses a Mark: Recapture estimator):

- deer examined at meat processing facilities = 40,000
- deer examined at meat processing facilities which were reported = 15,000
- reporting rate = 15,000/40,000 = 37.5%
- deer harvest reported = 75,000
- estimated deer harvest calculated = 75,000/37.5% = 240,000

Data collected at meat lockers from harvested deer include the animals' sex and age. Aging is accomplished by trained observers evaluating the eruption and wear patterns of teeth on the deer's lower jaw. As a check on the accuracy of aging, teeth may be pulled and provided to a lab for microscopic aging of annual growth rings. Because deer are born approximately six months prior to hunting season, ages of deer are expressed at the half year. Age categories include fawn (0.5-year), yearling (1.5-year) and adult (2.5-year and older).

Antler characteristics are also recorded from males. Data on the number of points by age, spread and the percentage of spikes allowed the PGC to implement antler restrictions in 2002 to protect a segment of the yearling male population.

An annual Game Take Survey is used as an independent measure to validate harvest estimates calculated from harvest report cards and the estimated harvest-reporting rate.

The various indices used in deer management inform a decision to increase, decrease or stabilize a deer herd within a specific WMU. The tool used to implement the decision is the annual antlerless permit allocation. Recommended allocations are based on previous antlerless harvests, antlerless hunter success, deer population trends and population status relative to the WMU population goal. The number of antlerless deer that needs to be harvested to achieve progress toward the population goal is calculated. Then, the number of permits that needs to be allocated to achieve the desired harvest is determined. As long as season frameworks are consistent, allocations have proven to be very accurate with respect to the number of antlerless deer harvested. Antlerless allocations are reviewed and approved by the PGC Board of Commissioners. On occasion, the Board may alter the recommended antlerless allocations in response to constituent input.

## Deer Population Models

The PGC has used a variety of deer population models through time. PGC biologists were among the first to publish the description of a population model in the peer-reviewed scientific literature (Lang and Wood 1976). The population model was based on harvest statistics and reconstructed deer population estimates based on the representation of different aged cohorts sampled in the annual deer harvest. The main criticisms of the Lang and Wood model were related to an arbitrary "average annual reduction rate" and the lack of a measure of precision in model output. Since then, different accounting and predictive models have been used by the PGC but none has received peer review.

The majority of states that use a deer population model use a Sex-Age-Kill (SAK) model (Millsbaugh et al. 2006). SAK models track the appearance of year-class cohorts as sampled in annual deer harvest. By understanding the representation of deer born in year t in harvests of year t+1, t+2, t+3, etc., a population can be reconstructed for year t. Associated measures of precision of the estimate are available. Millsbaugh et al. (2006) extensively reviewed the SAK model methodology, assumptions and use, and readers are encouraged to review this publication and Skalski et al. (2005) for background on the SAK model.

The PGC discontinued the use of all previously used models in 2006 and developed the Pennsylvania Sex-Age-Kill (PA SAK) population model. Prior to this review, the PA SAK was reviewed and refined through a peer-review process (Norton and Diefenbach 2009). Since 2006, only PA SAK outputs have entered the deer management decision system. Because of different techniques, assumptions and data requirements between PA SAK and earlier models, PA SAK model outputs are not directly comparable to any other model output.

An assumption of SAK models was that all individuals within an age class had the same likelihood of being represented in the harvest. And because the most numerous antlered male deer in the harvest was the yearling, most states that used SAK models rely on various calculations centered on the representation of the yearling male cohort in the harvest.

Antler restrictions adopted by PGC in 2002 required a correction factor to be employed in estimating the age structure of antlered (adult) deer in the conventional SAK model. In Pennsylvania, antler restrictions violated the assumption of equal representation (because a percentage of the yearling male cohort was protected) and eliminated the feasibility of using the yearling cohort variables without transformation. In response, the PGC designed the PA SAK to transform statistics from older cohorts to become estimates of the yearling cohort. Specifically, PGC delayed final assessment of the yearling age class until it was proportionately represented in the harvest as 2.5-year old males. Calculations of size, survival and representation of the 2.5-year-old male cohort were therefore found to be the most critical calculations in the PA SAK model. All model outputs to some extent were derivatives of the calculations surrounding the 2.5-year-age class.

## Testing the Effect of Using Constant Values for Three Variables in the PA SAK Model

The modifications contained within the PA SAK centered on three inputs generated by the PGC:

1. Harvest rate of 2.5-year-old and older antlered bucks

2. Proportion of 2.5-year-old and older bucks that were 2.5-years old

3. Yearling buck (1.5-year-old) non-harvest survival

The PA SAK model relies on estimates of the three variables to calculate deer population parameters. The PGC chose to input constants to the model that, while based on PGC deer research, did not vary between WMU or over time. WMI questioned whether a deer population model that relied on constant inputs would adequately capture the inherent variation in deer populations over time and space. In addition, WMI questioned how sensitive the model outputs would be if variation were occurring in reality. To test its concerns, WMI took the 2008 PA SAK model and replaced the PGC constant inputs with randomly generated numbers designed to be +/- 10 percent of the PGC input. WMI averaged model outputs over 10 simulations.

The first step in the PA SAK model tested by WMI was the calculation that employed the proportion of the harvest composed of 2.5-year-old and older deer to calculate the population size of 2.5-year-old and older deer. For the calculation, the PGC used two independent estimates of 2.5-year-old and older harvest rate--0.59 in WMUs 1A thru 2B and 2D and 0.53 elsewhere. Harvest divided by harvest rate yielded population size.

The PGC based its estimate of 2.5-year and older harvest rate on results of its buck mortality research. The PGC believed the harvest rate estimate was based on sound science. PGC was also aware that the actual harvest rate could vary over time and space. PGC confidence in the validity of the harvest rate estimate increased as buck mortality research sample sizes and geographical spread of study areas increased.

WMI tested the extent that variation in the two harvest rate constants would affect PA SAK model outputs. WMI allowed each harvest rate to vary randomly +/- 10 percent for each WMU for each of 10 simulations. A coefficient of variation (CV) statistic was used to evaluate the PA SAK model outputs as the two harvest rates randomly varied. The CV statistic is an accepted tool to measure variability associated with an estimate, especially when the estimates (means) are drastically different from each other or are measured with different units. The more variability associated with an estimate, the higher the CV, and the higher the uncertainty around an estimate. The model output chosen by WMI as the dependent variable was the PA SAK estimates of antlered population size.

When WMI allowed the constant to vary by +/- 10 percent, it found that the PA SAK model was somewhat sensitive to variation in the harvest rate of 2.5-year old and older bucks (Table 1, page 18). CVs of PA SAK model outputs estimating the size of the antlered population averaged 3.3 percent. Generally, CVs less than 10 percent are indicative of low variation around the estimate. A CV of 3.3 percent indicates that the PA SAK model is somewhat sensitive to variation in harvest rates of 2.5-year and older bucks.

With the estimate of the population size of 2.5-year-old and older bucks established, the PA SAK model then calculated the proportion of 2.5-year-old and older bucks that were 2.5-years old. For the calculation, the PGC inputs a constant of 72.2 percent into the PA SAK to represent the proportion of 2.5-year-old and older bucks that were 2.5-years old. The same constant was input for all WMUs and for all years.

For the second test of the PA SAK model, WMI tested the extent that variation in the proportion of 2.5-year-old and older bucks that were 2.5-years old would affect PA SAK model outputs. WMI allowed the proportion to randomly vary +/- 10 percent for each WMU for each of 10 simulations. A coefficient of variation (CV) statistic was used to evaluate the PA SAK model outputs as the proportion randomly varied. The model output chosen by WMI as the dependent variable was the PA SAK estimates of antlered population size.

WMI found that the PA SAK model was not sensitive to variation in the proportion of 2.5-year-old and older bucks that were 2.5-years old (Table 2, page 19). CVs of PA SAK model outputs estimating the size of the antlered population averaged less than1 percent. CVs below 1 percent are indicative of a model with little variation and suggests the PA SAK is not sensitive to variation in the proportion of 2.5-year and older bucks that were 2.5-years old.

With the various age structures of males older than 1.5-years established, the PA SAK completes the calculation of the number of yearling males in the population. The PGC estimated the number of yearling bucks in the population by dividing the number of 2.5-year old deer in the population by a non-harvest survival rate estimate. The number of deer alive prior to the season in year t+1 divided by the non-harvest survival rate provided an estimate of the number of deer alive after the season in year t.

The PGC based its estimate of yearling buck non-harvest survival on the results of its buck harvest

**Table 1. Ten simulations of the 2008 PA SAK model where the two harvest rate inputs (0.59 and 0.53) of antlered males 2.5-year old and older were allowed to vary by +/- 10 percent. The model output chosen to measure variation was the PA SAK estimate of antlered population size.**

| Estimated Antlered Populations - Simulations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WMU | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | CV |
| 1A | 9457 | 9730 | 9879 | 9138 | 9730 | 9252 | 9373 | 9636 | 9214 | 9252 | 2.75% |
| 1B | 15612 | 14561 | 14696 | 14907 | 15285 | 15698 | 14765 | 14836 | 15054 | 15875 | 3.05% |
| 2A | 12243 | 13421 | 12683 | 12819 | 13340 | 12488 | 13108 | 12071 | 13184 | 12683 | 3.58% |
| 2B | 6530 | 6783 | 6530 | 6445 | 6560 | 6501 | 6621 | 6684 | 6501 | 6445 | 1.64% |
| 2C | 13243 | 13408 | 13036 | 13707 | 13137 | 12986 | 13190 | 12986 | 13645 | 13707 | 2.20% |
| 2D | 16019 | 16305 | 17396 | 16456 | 16612 | 16019 | 16456 | 16160 | 16019 | 16533 | 2.54% |
| 2E | 9904 | 9854 | 9616 | 9358 | 9571 | 9662 | 9616 | 9200 | 10008 | 9278 | 2.80% |
| 2F | 15121 | 15391 | 14179 | 14041 | 15581 | 13973 | 15121 | 15391 | 15034 | 14396 | 4.13% |
| 2G | 18360 | 17675 | 16509 | 16871 | 17159 | 17062 | 17159 | 17159 | 18123 | 17360 | 3.25% |
| 3A | 9025 | 8916 | 9138 | 9138 | 8473 | 9503 | 8566 | 9138 | 8812 | 8970 | 3.35% |
| 3B | 11486 | 11486 | 12466 | 12729 | 11486 | 12218 | 11692 | 12382 | 11984 | 11420 | 4.07% |
| 3C | 12789 | 12927 | 12998 | 13960 | 12527 | 13219 | 12591 | 13615 | 12927 | 12722 | 3.49% |
| 3D | 9126 | 8328 | 8375 | 8328 | 8471 | 8726 | 9006 | 8835 | 8471 | 8570 | 3.32% |
| 4A | 9650 | 9718 | 9209 | 9718 | 9787 | 9038 | 9209 | 8624 | 8673 | 9151 | 4.63% |
| 4B | 7592 | 7971 | 8188 | 7627 | 8188 | 7592 | 7699 | 7735 | 8281 | 7592 | 3.59% |
| 4C | 9988 | 10386 | 9833 | 9735 | 9548 | 9936 | 10386 | 9884 | 9735 | 9884 | 2.72% |
| 4D | 15337 | 13925 | 14788 | 15147 | 14297 | 14618 | 14788 | 14455 | 13925 | 14618 | 3.18% |
| 4E | 8026 | 7984 | 8069 | 7535 | 7501 | 7535 | 8203 | 7603 | 7569 | 8297 | 3.99% |
| 5A | 4538 | 4538 | 4419 | 4538 | 4309 | 4670 | 4642 | 4289 | 4697 | 4309 | 3.45% |
| 5B | 12192 | 11915 | 11812 | 11812 | 12694 | 12371 | 11761 | 12433 | 12079 | 11614 | 2.88% |
| 5C | 18938 | 18023 | 19280 | 18938 | 18118 | 18312 | 17749 | 18829 | 17749 | 18312 | 2.93% |
| 5D | 2860 | 3181 | 2895 | 2843 | 3008 | 3008 | 2950 | 3181 | 2931 | 3204 | 4.57% |

research. The constant used was a survival rate of 0.91 for all WMUs and for all years. PGC believed the survival rate estimate was based on sound science, but was aware that the actual rate of non-harvest mortality could vary over time and space. PGC confidence in the validity of the non-harvest mortality estimate increased as buck mortality research sample sizes and geographical spread of study areas increased.

For the third test of the PA SAK, WMI tested the extent that variation in the non-harvest mortality rate would affect PA SAK model outputs. WMI allowed the non-harvest mortality rate to vary randomly +/- 10 percent for each WMU for each of 10 simulations. A coefficient of variation (CV) statistic was used to evaluate the model outputs as the non-harvest mortality rate randomly varied. The model output chosen by WMI as the dependent variable was the PA SAK estimates of antlered population size.

WMI found that the PA SAK model was not sensitive to variation in the yearling buck non-harvest mortality rate (Table 3, page 20). CVs of PA SAK model outputs estimating the size of the antlered population varied by less than 1 percent.

As stated, WMI questioned whether a deer population model that relied on constant inputs would adequately capture the inherent variation in deer populations over time and space. In addition, WMI

**Table 2. Ten simulations of the 2008 PA SAK model where the proportion of 2.5-year old and older bucks that were 2.5-years old (0.722) was allowed to vary by +/- 10 percent. The model output chosen to measure variation was the PA SAK estimate of Antlered Population size.**

| Estimated Antlered Populations - Simulations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WMU | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | CV |
| 1A | 9483 | 9417 | 9492 | 9407 | 9473 | 9571 | 9554 | 9563 | 9545 | 9528 | 0.62% |
| 1B | 15173 | 15206 | 15256 | 15050 | 15320 | 15121 | 15366 | 15156 | 15272 | 15190 | 0.62% |
| 2A | 12581 | 12767 | 12554 | 12620 | 12633 | 12554 | 12791 | 12645 | 12658 | 12645 | 0.63% |
| 2B | 6705 | 6684 | 6705 | 6624 | 6596 | 6641 | 6700 | 6652 | 6668 | 6641 | 0.56% |
| 2C | 13184 | 13272 | 13222 | 13285 | 13369 | 13321 | 13197 | 13222 | 13309 | 13210 | 0.46% |
| 2D | 16490 | 16700 | 16714 | 16729 | 16536 | 16490 | 16714 | 16612 | 16536 | 16700 | 0.60% |
| 2E | 9521 | 9531 | 9665 | 9561 | 9655 | 9628 | 9480 | 9628 | 9490 | 9531 | 0.72% |
| 2F | 14787 | 14689 | 14675 | 14773 | 14553 | 14746 | 14600 | 14600 | 14827 | 14760 | 0.63% |
| 2G | 17038 | 17062 | 17419 | 17438 | 17195 | 17279 | 17129 | 17340 | 17238 | 17238 | 0.80% |
| 3A | 9026 | 9026 | 9033 | 8911 | 8911 | 8994 | 9041 | 8986 | 8994 | 9048 | 0.56% |
| 3B | 11861 | 11998 | 11932 | 11965 | 11813 | 11965 | 11954 | 11813 | 11861 | 11837 | 0.59% |
| 3C | 13194 | 13155 | 13256 | 13181 | 13155 | 13326 | 13155 | 13280 | 13088 | 13088 | 0.59% |
| 3D | 8752 | 8699 | 8769 | 8717 | 8786 | 8663 | 8761 | 8744 | 8699 | 8735 | 0.43% |
| 4A | 9056 | 9105 | 9178 | 9076 | 9187 | 9123 | 9095 | 9133 | 9114 | 9222 | 0.57% |
| 4B | 7822 | 7881 | 7856 | 7804 | 7864 | 7881 | 7906 | 7961 | 7938 | 7813 | 0.66% |
| 4C | 9856 | 9886 | 9964 | 10020 | 9906 | 9945 | 9974 | 9886 | 9983 | 9896 | 0.53% |
| 4D | 14535 | 14702 | 14604 | 14670 | 14765 | 14670 | 14825 | 14553 | 14553 | 14654 | 0.65% |
| 4E | 7922 | 7889 | 7869 | 7827 | 7862 | 7909 | 7869 | 7841 | 7915 | 7922 | 0.43% |
| 5A | 4525 | 4489 | 4446 | 4530 | 4446 | 4535 | 4520 | 4535 | 4462 | 4520 | 0.82% |
| 5B | 12167 | 12157 | 12113 | 12124 | 12199 | 12146 | 12241 | 12022 | 12022 | 12146 | 0.57% |
| 5C | 18549 | 18498 | 18429 | 18411 | 18447 | 18224 | 18301 | 18357 | 18375 | 18498 | 0.54% |
| 5D | 2979 | 3001 | 2970 | 2965 | 3003 | 2972 | 2984 | 2991 | 2979 | 3005 | 0.49% |

questioned how sensitive the model outputs would be if variation were occurring in reality. The three tests of the PA SAK model were designed to quantify how much the PA SAK model would be affected if inputs fluctuated +/- 10 percent from the constant input used by PGC. For all tests, WMI found that the PA SAK estimates of buck population size did not change dramatically when inputs fluctuated randomly. While WMI prefers that model inputs be based on real measurements to accommodate spatial and geographical variation, the model as presented likely meets deer manager's needs.

## Testing Two Methods to Calculate Yearling Buck Cohorts in the PA SAK Model

The transformations of data collected on 2.5-year old and older deer allowed an estimate of the yearling age class. The calculation described above produced an estimate of the number of yearling males alive at the end of the season. To calculate the number of yearling males alive prior to the season, the PGC input an estimate of yearling buck harvest rate. PGC used

**Table 3. Ten simulations of the 2008 PA SAK model where the non-harvest survival rate of antlered males from post-hunt 1.5-year olds to pre-hunt 2.5-year olds was allowed to vary by +/- 10 percent. The model output chosen to measure variation was the PA SAK estimate of Antlered Population size.**

| Estimated Antlered Populations - Model Runs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WMU | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | CV |
| 1A | 9557 | 9492 | 9510 | 9424 | 9416 | 9588 | 9510 | 9465 | 9528 | 9510 | 0.57% |
| 1B | 15190 | 15157 | 15125 | 15190 | 15328 | 15094 | 15275 | 15346 | 15292 | 15346 | 0.62% |
| 2A | 12683 | 12760 | 12683 | 12566 | 12683 | 12635 | 12611 | 12774 | 12801 | 12589 | 0.63% |
| 2B | 6626 | 6631 | 6669 | 6621 | 6601 | 6711 | 6636 | 6631 | 6686 | 6686 | 0.54% |
| 2C | 13334 | 13183 | 13183 | 13205 | 13360 | 13415 | 13347 | 13273 | 13401 | 13249 | 0.66% |
| 2D | 16472 | 16772 | 16772 | 16485 | 16627 | 16554 | 16627 | 16612 | 16597 | 16540 | 0.62% |
| 2E | 9653 | 9621 | 9590 | 9571 | 9514 | 9571 | 9552 | 9621 | 9621 | 9621 | 0.43% |
| 2F | 14777 | 14594 | 14647 | 14732 | 14580 | 14647 | 14567 | 14823 | 14732 | 14689 | 0.59% |
| 2G | 17217 | 17177 | 17137 | 17117 | 17157 | 17157 | 17454 | 17409 | 17238 | 17259 | 0.67% |
| 3A | 8938 | 9039 | 8995 | 9030 | 8930 | 8987 | 9004 | 9039 | 8954 | 8946 | 0.47% |
| 3B | 11863 | 11932 | 12032 | 11810 | 11932 | 11981 | 11852 | 11944 | 11909 | 11841 | 0.58% |
| 3C | 13146 | 13283 | 13257 | 13146 | 13182 | 13101 | 13112 | 13270 | 13123 | 13244 | 0.53% |
| 3D | 8771 | 8781 | 8700 | 8762 | 8771 | 8735 | 8643 | 8651 | 8771 | 8810 | 0.65% |
| 4A | 9248 | 9160 | 9082 | 9179 | 9160 | 9208 | 9179 | 9160 | 9169 | 9208 | 0.47% |
| 4B | 7898 | 7834 | 7950 | 7889 | 7849 | 7941 | 7857 | 7857 | 7906 | 7889 | 0.49% |
| 4C | 9986 | 9936 | 9853 | 9955 | 9845 | 9955 | 9996 | 9965 | 9945 | 9853 | 0.57% |
| 4D | 14686 | 14551 | 14580 | 14751 | 14784 | 14853 | 14801 | 14784 | 14566 | 14751 | 0.74% |
| 4E | 7797 | 7905 | 7810 | 7797 | 7835 | 7890 | 7829 | 7803 | 7869 | 7920 | 0.60% |
| 5A | 4468 | 4444 | 4511 | 4444 | 4444 | 4474 | 4479 | 4479 | 4522 | 4489 | 0.61% |
| 5B | 12033 | 12072 | 12092 | 12180 | 12033 | 12042 | 12191 | 12072 | 12215 | 12146 | 0.57% |
| 5C | 18393 | 18447 | 18324 | 18307 | 18393 | 18503 | 18358 | 18484 | 18580 | 18484 | 0.47% |
| 5D | 2997 | 2971 | 2982 | 3002 | 3012 | 3004 | 2995 | 2980 | 2973 | 2982 | 0.47% |

two iterations of the PA SAK in year t and year t+1 to estimate and refine the estimate of yearling harvest rate. In year t, the PGC used the three-year running average of the yearling buck harvest rate as input to the PA SAK. The three-year running average yearling buck harvest rate was believed to be a reasonable surrogate to the actual yearling buck harvest rate for year t. In year t+1, yearling buck pre-hunt populations for year t were reconstructed from the representation of 2.5-year-olds in the harvest in year t+1. The representation of 2.5-year-olds in the harvest was transformed with the calculations mentioned previously. Following the reconstruction, the PGC revisited the PA SAK for year t with the updated estimate of yearling buck harvest frequency and all model outputs were updated. Final computations for model variables that were dependent on yearling age males were therefore lagged one year.

The PA SAK produced two estimates of population parameters from two different years of data. WMI questioned whether two estimates were required and evaluated the degree to which the two calculations of yearling harvest rate affected model outputs. WMI assembled a step-wise comparison of the two methods of calculating yearling buck harvest rate for 2006 and 2007. For each year, WMI ran a simulation using the three-year average yearling buck harvest rate to calculate the size of the yearling buck population. Then, it ran a simulation for the same years using the reconstructed yearling buck harvest rate to calculate the size of the yearling buck population. All other variables were held constant. WMI calculated a statistic that represented the percentage change in the size of the yearling buck population between the two inputs.

As an example, in 2006, in WMU 1A, the three-year average harvest rate of yearling bucks was 0.57, producing an estimate of 6,804 yearling bucks alive in 2006. The reconstructed yearling harvest rate was 0.60, producing an estimate of 6,477 yearling bucks alive in 2006. The second yearling buck harvest rate input changed the estimate of the number of yearling bucks alive in 2006 by 4.8 percent (Table 4, right). Estimates of the number of yearling bucks alive in any one year changed very little when averaged across all years and all WMUs (1.9 percent, Table 4) but displayed noticeable variation within years and within certain WMUs. The estimate of the yearling buck population size for WMU 2F, for example, increased by 28 percent in 2006 and decreased by 27 percent in 2007. Estimates for WMUs in 2006 were nearly all increased with the reconstructed statistics, whereas the majority of estimates for WMUs in 2007 was lower with the reconstructed statistics. The level of unexplained variation was believed to be problematic.

The two statistics were not dissimilar. The three-year running average yearling buck harvest rate was actually a running average of the previous three years of reconstructed harvest rate estimates. So, variation in model outputs caused by the two statistics suggests high and unexplained variation in the reconstruction. Given that model outputs are protracted over two years to allow the incorporation of the reconstructed yearling buck harvest rate, the year t three-year average harvest rate may suffice.

**Table 4. Percentage change in estimates of yearling buck population size in WMUs between PA SAK simulations using three-year average yearling buck harvest rate and reconstructed yearling buck harvest rate.**

| WMU | 2006 | 2007 | AVG |
|---|---|---|---|
| 1A | 4.8% | -7.3% | -1.2% |
| 1B | 8.7% | -13.0% | -2.1% |
| 2A | 18.5% | 1.1% | 9.8% |
| 2B | 17.7% | 1.7% | 9.7% |
| 2C | 4.6% | 10.9% | 7.8% |
| 2D | 18.6% | 0.5% | 9.5% |
| 2E | 18.2% | -19.0% | -0.4% |
| 2F | 27.8% | -27.0% | 0.4% |
| 2G | 30.0% | -18.5% | 5.8% |
| 3A | 23.8% | -24.7% | -0.4% |
| 3B | 13.1% | -0.1% | 6.5% |
| 3C | 20.1% | -25.0% | -2.5% |
| 3D | 29.6% | -9.6% | 10.0% |
| 4A | 19.6% | 5.8% | 12.7% |
| 4B | 22.8% | -9.0% | 6.9% |
| 4C | 13.5% | -6.4% | 3.5% |
| 4D | 18.8% | -4.1% | 7.3% |
| 4E | 7.0% | -27.7% | -10.3% |
| 5A | -21.3% | 11.4% | -4.9% |
| 5B | 6.2% | -11.6% | -2.7% |
| 5C | 14.2% | -27.3% | -6.6% |
| 5D | 21.4% | -54.9% | -16.8% |
| **Grand Total** | **15.4%** | **-11.5%** | **1.9%** |

## Testing Methods to Calculate Adult Sex Ratio in the PA SAK Model

With the antlered population estimated, the PA SAK was then used to estimate the female and male fawn segment of the population. Age classes in the adult female segment were broken out conventionally by assessment of yearling and older age classes in the harvest observed in meat locker check stations. The proportion of yearling does in the harvest (and, by extension, the antlerless population) was the first statistic to reconstruct the antlerless population. The yearling doe frequency was calculated because it was the denominator in an equation developed by Severinghaus and Maguire (1955) to estimate adult sex ratio:

*Adult sex ratio = [Proportion of yearling bucks in harvest (or population) / Proportion of yearling does in harvest (or population)]/Birth sex ratio.*

The adult sex ratio equation was used to calculate the number of adult females in the population. Previous PA SAK calculations determined the size of the adult male population, which, when multiplied by the adult sex ratio, yielded the adult female population.
The calculation of adult sex ratio was the second component of the conventional SAK model requiring transformation in the PA SAK. Most states using SAK models employ un-transformed yearling male and yearling female harvest frequencies as the components of the adult sex ratio equation, i.e., harvest frequencies are believed to be coequal to population frequencies. In Pennsylvania, antler restrictions violate the assumption that the yearling buck harvest frequency was representative of the yearling buck population frequency.

The PGC did not utilize the aforementioned estimations of yearling buck harvest rate in the adult sex ratio equation. Instead, it used the PA SAK estimates for the number of yearling bucks in the population and the number of antlered deer in the population as the numerator and denominator in a statistic labeled by the PGC as the "Proportion of 1.5-year old bucks in the antlered population." This proportion--not the three-year average yearling harvest rate or the reconstructed yearling buck harvest rate--was the input to the adult sex ratio equation.

Differences between the two yearling buck statistics were apparent. WMI compared four iterations of yearling buck frequencies:

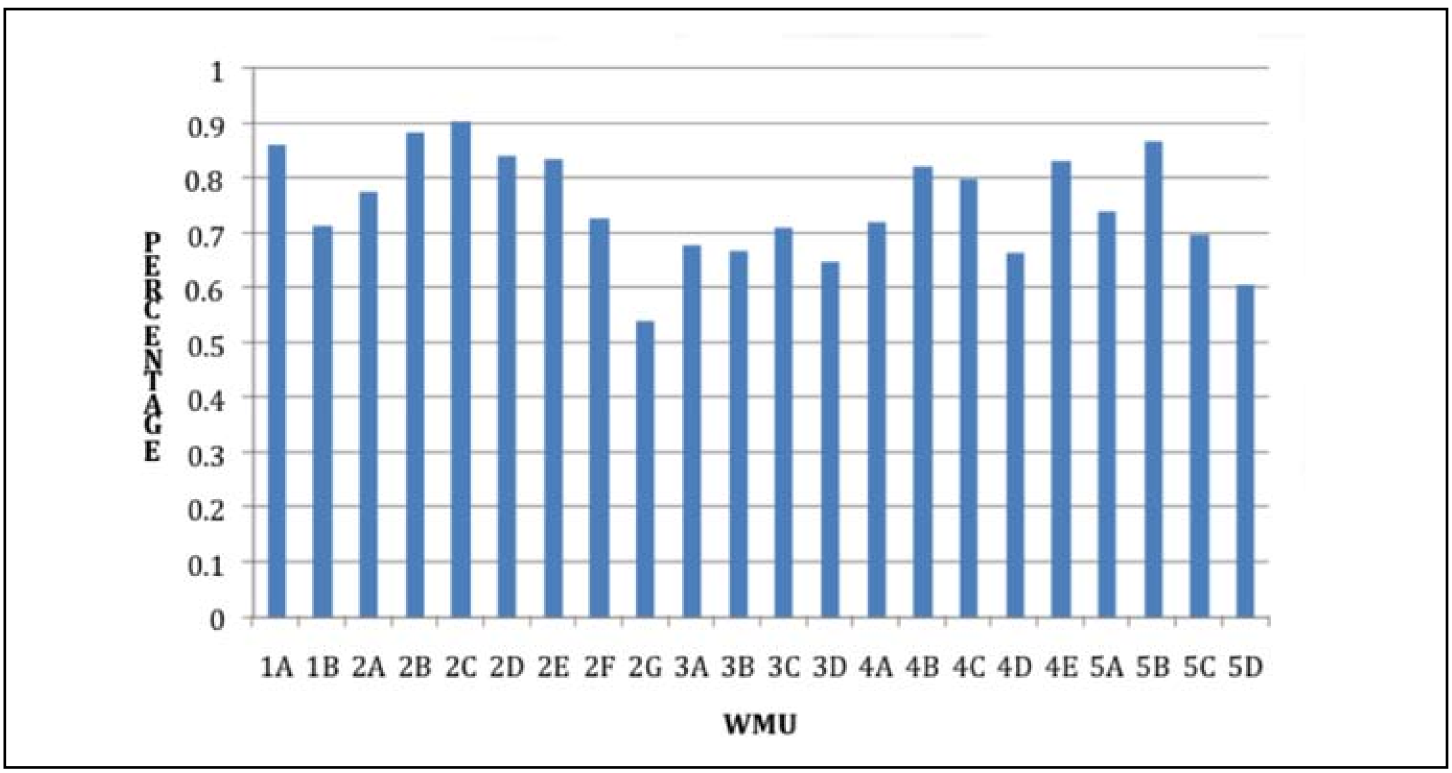



**Figure 5. Yearling buck harvest frequency divided by yearling buck population frequency as estimated by PA SAK. Yearling buck harvest frequency was consistently lower than yearling buck population frequency.**

1. Three-year average yearling buck harvest rate
2. Reconstructed yearling buck rate (from t+1)
3. PA SAK estimated yearling buck frequency in models using the 3three-year average yearling buck harvest rate
4. PA SAK estimated yearling buck frequency in models using the reconstructed yearling buck harvest rate (from t+1)

For each WMU for 2006 and 2007, WMI averaged the two harvest rates and the two population rates and then divided the harvest rate average by the population rate average. Differences were apparent between WMUs (Figure 5, page 22).

Yearling male harvest frequency was consistently lower than yearling male population frequency. The ratio of harvest to population frequency also varied by WMU, with WMU 2G showing the greatest difference between harvest frequency and population frequency. Because the adult sex ratio was a critical component of the PA SAK model, the difference warranted explanation. To illustrate why the difference was important and using WMU 2G in 2008 as the example, the yearling doe harvest frequency was calculated as 0.23, with an adult buck population of 16,337. When the yearling buck population frequency of 0.56 was used, the PA SAK model calculated an adult sex ratio of 2.39 adult female to adult male and a population estimate of 39,089 adult females. When the three-year average yearling male harvest rate of 0.28 was used, the PA SAK model calculated an adult sex ratio of 1.20 adult female to adult male and a population estimate of 19,624 adult females. The 50 percent difference in model outputs depending on the choice of yearling buck frequency input corresponds potentially to a significantly different population projection on which to base antlerless permits allocations.

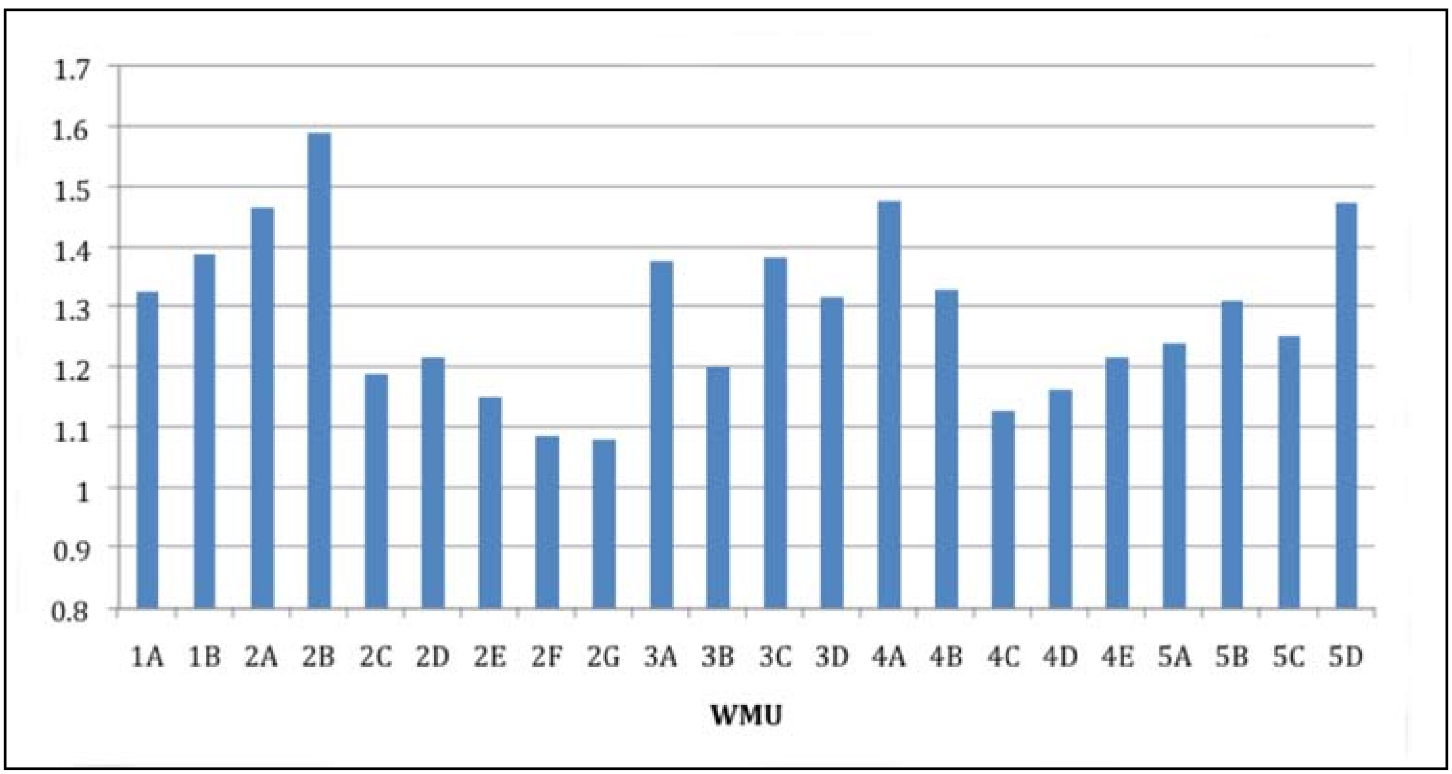



**Figure 6: Average fawn-to-adult doe correction factors for 2003-2006 for Pennsylvania WMUs.**

Antler restrictions clearly violate the assumption that yearling male harvest frequency is coequal to yearling male population frequency. Because a component of the yearling cohort is protected by sublegal antlers, only a yearling male population frequency reconstructed from age classes not receiving unequal protection was valid.

WMI found that the PA SAK model was modified in a manner appropriate to accurately estimates adult sex ratio.

## Testing the Impact of Hunter Selectivity on Fawn Population Estimates in the PA SAK Model

With the adult female population estimated, the PA SAK was used to estimate the fawn age class. A fawn to adult doe ratio (fawn to yearling and older females) was calculated from age class data collected at biological check stations. The PGC transformed the fawn to doe ratio in the PA SAK through a correction factor believed to represent hunter selectivity against fawns and towards adult females. The pre-hunt yearling buck population in year t+1 was multiplied by 2 to produce an estimate of the minimum number of fawns in the post-hunt population of year t+1. The number of fawns estimated in the harvest was then added to produce a pre-harvest fawn population for year t. A minimum fawn-to-doe ratio was calculated by dividing the pre-harvest fawn population by the PA SAK estimate of the number of adult females in the pre-harvest population. This ratio was divided by the harvest fawn-to- doe ratio to derive the correction factor.

WMI analyzed the correction factor for 2003-2006 by WMU. A correction factor of 1.0 indicates that hunters harvest fawns in proportion to their representation in the population. A correction factor of less than 1 indicates that hunters preferentially select fawns for harvest; a correction factor of more than 1 indicates selectivity against fawn harvest.

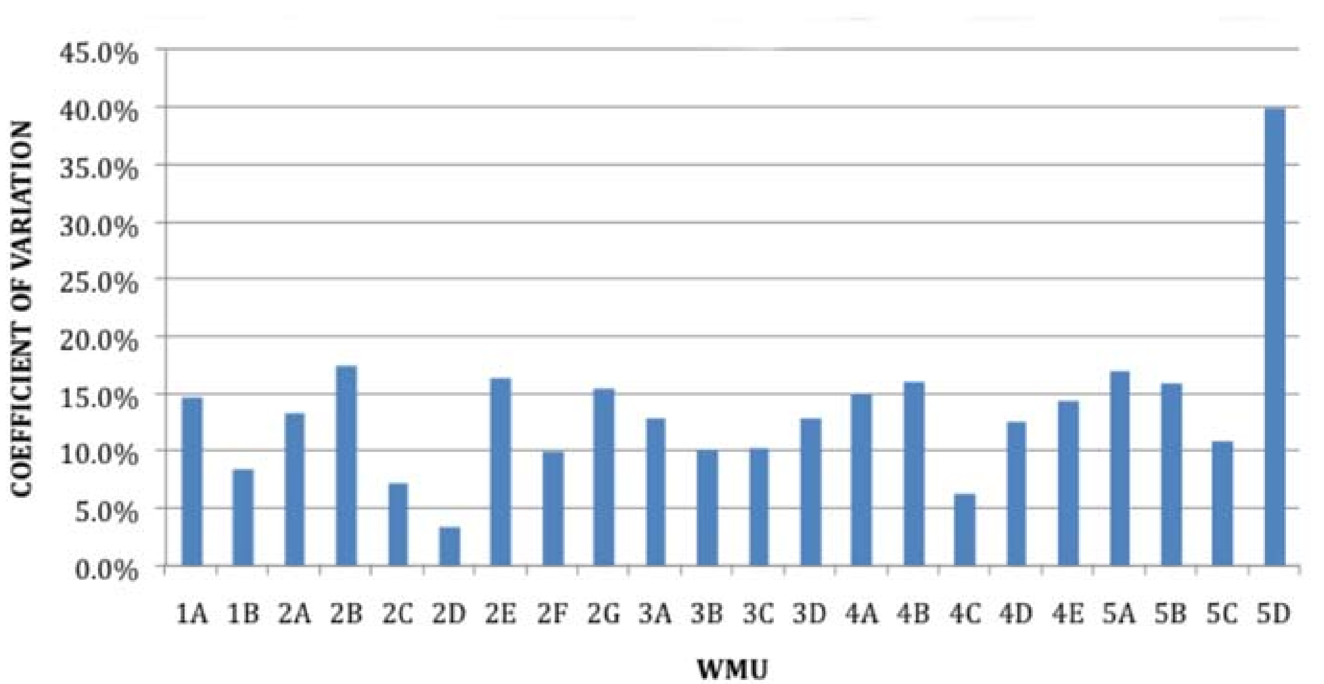



**Figure 7: The coefficient of variation of fawn-to-adult doe correction factor for 2003-2006 by WMUs.**

WMI calculated that the 2003-2006 average correction factor was 1.29, suggesting that hunters had significant bias against the harvest of fawn deer. When compared across WMUs, differences were apparent (Figure 6, page 23). Hunters in WMUs 2F and 2G were least likely to pass up an opportunity to harvest a fawn deer, whereas hunters in 2B were most likely to pass up an opportunity to harvest a fawn.

Geographical differences in the likelihood that deer hunters harvest fawns may be explainable due to differences in deer populations, habitat, hunting conditions, etc. But WMI documented that fawn-to-adult doe correction factors also had considerable variation between years. Using the CV in fawn-to-adult doe correction factor as the measurement statistic, WMI documented substantial variation in most WMUs (Figure 7, page 24). CVs of greater than 10 percent are indicative of excessive variation in an estimate.

Variation across time was more difficult to explain biologically or socially. WMI cannot construct a scenario that would indicate hunters would take fawns one year and pass up fawns the next.

Variation across time (and perhaps across WMU) may be an artifact of the method of calculation. As with the estimation of yearling buck harvest rate, PGC makes a preliminary estimate of fawn-to-adult doe correction factor for year t by averaging the prior three years of fawn-to-adult doe correction factor. When fawns "show up" as 2.5-year olds in year t+2, the PGC then returns to the year t PA SAK and updates the fawn-to-adult doe correction factor. The final estimate of the fawn population is therefore lagged two years.

For example, the fawn-to-adult doe correction factor for 2006 is dependent on the estimation of the number of yearling bucks in the 2007 pre-hunt population, which was itself dependent on the number of 2.5-year olds harvest in 2008.

**Table 5: PA SAK estimated fawn populations derived using the three-year average fawn-to-adult doe correction factor and the reconstructed (t+2) fawn-to-adult doe correction factor.**

| Number of Fawns in 2006 | | | |
|---|---|---|---|
| WMU | Three-yr Average Fawn-to-adult Doe Correction Factor | Reconstructed Fawn-to-adult Doe Correction Factor from t-1 | Percentage Change |
| 1A | 25,660 | 17,761 | -31% |
| 1B | 25,958 | 20,632 | -21% |
| 2A | 28,438 | 22,741 | -20% |
| 2B | 27,846 | 17,216 | -38% |
| 2C | 27,758 | 23,134 | -17% |
| 2D | 40,733 | 32,128 | -21% |
| 2E | 15,701 | 12,897 | -18% |
| 2F | 23,168 | 19,103 | -18% |
| 2G | 30,757 | 18,275 | -41% |
| 3A | 19,449 | 14,357 | -26% |
| 3B | 23,198 | 20,275 | -13% |
| 3C | 25,841 | 19,215 | -26% |
| 3D | 17,322 | 13,268 | -23% |
| 4A | 20,033 | 15,643 | -22% |
| 4B | 19,928 | 12,124 | -39% |
| 4C | 20,500 | 16,099 | -21% |
| 4D | 27,802 | 21,141 | -24% |
| 4E | 15,315 | 13,448 | -12% |
| 5A | 6,482 | 7,593 | 17% |
| 5B | 28,561 | 20,691 | -28% |
| 5C | 29,180 | 27,474 | -6% |
| 5D | 4,568 | 5,448 | 19% |
| TOTAL | 504,197 | 390,663 | -23% |

WMI evaluated the degree to which the two calculations of fawn-to-adult doe affected model outputs. For each WMU, WMI compared the 2006 PA SAK estimate of the size of the fawn population using the three-year average fawn-to-adult doe correction factor and the reconstructed fawn-to-adult doe correction factor. For 2006, the single year for which WMI had data, the reconstructed fawn-to-adult doe correction factor produced substantially lower estimates of fawn population size than did those estimates derived with the three-year average (Table 5, page 25).

WMI documented substantial variation in fawn-to-adult doe correction factors between WMUs. PGC acknowledged in interviews that fawn-to-adult doe correction factors may reflect differences in WMU characteristics, but did not quantify how they came to that understanding. The PGC did not offer any explanation why fawn-to-adult doe correction factors would vary over time.

Results of WMI analysis suggested the two methods of calculating fawn-to-adult doe correction factors would provide significantly different population estimates. WMI acknowledges that its analysis is based on only one year of data. But because antlerless deer permits allocation for year t+1 are based on the PA SAK model outputs from year t, WMI does not understand how refinement of fawn-to-adult doe correction factors from PA SAK model outputs from year t+2 were valuable to PGC managers.

**Table 6. Correlation coefficients for comparisons of WMU population indices from the years of 2004-2006. A correlation coefficient of 1 one indicate a perfect correlation, or a 1:1 relationship.**

| WMU | SAK v. Antlered Harvest | SAK v. CPUE | Antlered Harvest v. CPUE |
|---|---|---|---|
| 1A | 0.88 | -0.50 | -0.85 |
| 1B | 0.97 | 0.87 | 0.96 |
| 2A | 0.04 | 0.92 | 0.43 |
| 2B | 0.93 | 0.19 | 0.53 |
| 2C | 0.22 | 0.50 | -0.73 |
| 2D | 0.14 | 0.19 | -0.95 |
| 2E | -0.50 | 0.00 | 0.00 |
| 2F | -0.41 | 0.72 | 0.34 |
| 2G | 0.97 | 0.28 | 0.50 |
| 3A | -0.64 | 0.98 | -0.48 |
| 3B | -0.27 | 0.98 | -0.45 |
| 3C | 0.99 | 0.76 | 0.68 |
| 3D | -0.96 | -0.76 | 0.90 |
| 4A | -0.50 | -0.93 | 0.78 |
| 4B | -0.58 | -0.28 | 0.94 |
| 4C | -1.00 | 0.99 | -1.00 |
| 4D | -0.92 | -0.87 | 0.99 |
| 4E | 1.45 | 0.50 | -0.55 |
| 5A | 0.63 | 0.50 | -0.36 |
| 5B | 0.86 | 0.87 | 0.49 |
| 5C | -0.51 | 1.00 | -0.51 |
| 5D | -0.42 | 0.50 | 0.58 |
| STATEWIDE | -0.88 | 0.61 | -0.17 |

The PGC did not provide sufficient evidence to validate their method of calculating fawn to doe ratios based on hunter selectivity. WMI found the PA SAK model produces defensible estimates with unadjusted fawn to doe ratios

### *Correlation Analyses For Deer Population Indices*

WMI conducted simple correlation analyses between three of the major population indices that inform deer management. The indices included the PA SAK deer density estimates, the calculated antlered harvests and the antlerless catch per unit effort (CPUE or antlerless permit success rate) for each of the WMUs for both a three- and five-year time period. Each of these indices should reflect population size. PA SAK deer density estimates for each WMU was an obvious expression of population size. The calculated antlered harvest, given a reasonably stable hunter population and effort, also expressed population size (i.e., the more antlered deer available the more that will be harvested). Finally, the CPUE expressed the number of antlerless deer taken divided by the number of antlerless permits allocated. The higher the CPUE the higher the population level of antlerless deer, another accepted expression of population size.

The hypothesis WMI tested was that each of these population indices should correlate with one another. Because the PA SAK model involved parameter estimates developed over a three-year period (t, t+1, t+2), the correlation analyses for three years (2004-2006) was most appropriate for analysis. However, the relative lack of correlation among these indices over the five year period demonstrated a limitation to the use of the PA SAK model for annual antlerless allocations. That is, the lag time between parameter development and population estimation results in less precise information for deer managers for the year in which antlerless allocations are derived.

WMI found that for the three year analyses (Table 6, page 26), only one WMU (1B) exhibited a high degree of positive correlation (r>=0.85) among the three indices. Of the 22 WMUs, 14 exhibited high positive correlation between one or more of the indices comparisons. In some cases, the correlation coefficient was highly negative (e.g., WMUs 2D, 3D, 4A, 4C, 4D). The comparison of antlered harvest and CPUE was not expected to show strong correlation because the indices represent subpopulations of the total deer population. However, in four WMUs, there was a positive correlation. The sex structure of each WMU population would have an impact on all three comparisons. However, WMI expected that the correlation between total population size (SAK) and antlered harvest to be positive, and population size and the CPUE (i.e., antlerless permit success rate) to be positive throughout most if not all WMUs. That strong positive correlation was not found. A possible explanation is that harvest estimation, a common factor for all three indices, is inadequately calculated due to a bias and/or unaccounted variability from year to year. This is a critical issue that must be addressed by the PGC. Without a reliable population trend index or indices, it is difficult to define population goals and the antlerless permit allocations necessary to achieve those goals.

WMI understands that the PGC incorporated internet reporting of deer harvest on the PGC website in 2009. Other states have had success in increasing reporting rate by the use of internet reporting;  other options that states have used to increase the reporting rate of big game include reporting  by phone, reporting by email, phone surveys, mail surveys, email surveys, and mandatory registration.

## WMU Deer Population Characteristics and Trends

### *WMU Deer Population Estimates*

The RFP for this review requested deer population estimates and population trends for WMUs. When WMI submitted our proposal to conduct a review of deer management in Pennsylvania, it cautioned that the requested estimates would not be attainable if data of sufficient scientific rigor were not available.

WMI learned that the PGC had calculated estimates for deer populations for each WMU, including breakdowns by sex and age, via the PA SAK. In addition, WMI learned that estimates had been refined and their associated variances had been calculated in a PGC-sponsored research project at Penn State University (Norton and Diefenbach 2009), although the authors cautioned that the results made available to WMI were preliminary and subject to change. WMI documented no other source of population estimates that were based on scientific analysis. Population estimates for each WMU, including the mean, upper and lower confidence limit, are provided for each WMU for the years 2002-2007 (Norton and Diefenbach 2009) in Appendix B.

Based on estimates derived from PGC sponsored research of the PA SAK model, statewide deer populations have declined approximately 25 percent between 2002 and 2007, from 1,280,000 - 1,520,000 in 2002 to 850,000 - 1,280,000 in 2007. Changes in deer population size have differed by Wildlife Management Unit (WMU) but have been consistent with goals established by the PGC.

## *WMU Deer Population Characteristics*

WMI assembled data summaries (Appendix C) to provide trends in deer population characteristics and to serve as inputs for its analysis of the relationship between deer management variables. Descriptions of data collected follow. Antlered and anterless harvest for each WMU represented a transformation of harvest statistics collected at the county level and then aggregated to WMU based on the county or township of kill as reported on hunter harvest report cards. The PGC provided the analysis and the resulting data. The Population Objective was the PGC management goal to increase, decrease or stabilize deer populations. The Harvest Sex Ratio was the calculated ratio of adult does-to-adult bucks in the harvest. Yearling Buck and Yearling Doe Harvest Frequency was the proportion of adult deer of each sex represented by the yearling age class as estimated through age data collected at meat locker biological checks. Data representing years earlier than 2000 were from Williamson (2002); data from 2003-2008 were provided by the PGC; no data were provided for 2001-2002. The Fawn Harvest Frequency was the proportion of the antlerless harvest composed of fawn females and fawn males. Adult Doe Embryo and Fawn Doe Embryo Counts represented the average number of fawns per adult does and fawns checked, respectively, from collection of road-killed females. The Five-Year Average Percent Adequate Regeneration was the percentage of Forest Inventory and Analysis (FIA) plots that showed adequate stocking of regeneration as a measure of forest health. The Antlerless License Allocation, and the Antlerless License Sold represented the number of antlerless tags issued by the PGC and the resulting number of the tags actually sold to hunters. The Antlerless License Catch per Unit Effort (CPUE) was the proportion of Antlerless permits sold that resulted in an antlerless deer harvested.

Data assembled by the PGC allow a comprehensive tracking of statistics important to deer management. Trends in harvest, age structure, herd health, forest health and citizen desires can be tracked.

The RFP requested a compilation of 12 years of population data. Two measures were available: antlered buck harvest as a population index and PA SAK model population estimates. To comply with the RFP, WMI evaluated estimates of population size prior to the development of the PA SAK. Trends in buck harvest were the only reliable index to deer populations prior to 2002 and those trends are presented in Appendix C. The utility of buck kill as a population index ended with the incorporation of antler restrictions in 2002. For 2002-2008, population estimates from the PA SAK model were available and were included in Appendix C as well as shown graphically in Appendix B.

## *Deer Population Estimation Using Forward Looking Infrared (FLIR) Surveys*

DCNR Bureau of Forestry conducted surveys using FLIR in 2005-2007 to gain a more complete understanding of deer populations and use of forest habitat and to provide an additional feedback mechanism on the effectiveness of the Deer Management Assistance Program (DMAP). FLIR was chosen for comparison with several other methods of deer population census because of the perceived low cost and defensibility of resulting data.

The 2005 deer survey was used to test the "effectiveness and applicability of FLIR technology, to develop the mechanism for subsequent use of this technology, and to calibrate other field techniques for assessing deer populations" (http://www.dcnr.state.pa.us/forestry/deer/report.aspx). Twelve areas encompassing 311,134 acres were surveyed.

Following the 2005 pilot test, DCNR concluded (http://www.dcnr.state.pa.us/forestry/deer/report.aspx) that:

1. Observations of deer using FLIR imagery appeared to be a useful technique in determining a minimum count of deer on a site-specific basis in Pennsylvania's forests;

2. FLIR surveys provide useful information for deer and forest management decision making, but are not as useful without the contextual information of habitat condition and hunter harvest pressure;

3. FLIR potentially may be a cost-effective tool to provide estimates of deer populations across larger areas through sampling rather than complete census; and

4. deer densities estimated through FLIR vary greatly on a local, regional and statewide bases, and local monitoring of the deer, hunter success rates and the habitat were important to use management tools like the DMAP program most effectively .

In 2006, FLIR surveys were conducted on state forestland enrolled in DMAP, the PGC's Doe Study Area on Tuscarora State Forest, the Kinzua Quality Deer Cooperative in McKean County, the Ridley Creek State Park area, and State Game Lands requested by the PGC. Acres flown in 2006 totaled 464,100 acres. Most tracts were surveyed at 100 percent. At the request of the PGC, most of the state game lands were surveyed using a 50-percent flight coverage to gain a better appreciation for sampling variation over large areas (http://www.dcnr.state.pa.us/forestry/deer/newsurvey.aspx). Surveys were conducted in 2007, but concerns over sampling techniques, weather difficulties and data quality prevented DCNR from using the data.

WMI was not provided with actual FLIR data, but it did interview DNCR current and former employees familiar with the survey and PGC staff. The vendor did not return phone calls and was therefore not interviewed. In addition, WMI evaluated publicly available analyses of FLIR data. Based on interviews and assessment of publicly available data summaries, WMI documented that the FLIR technique might be useful in some situations, but was limited as a deer management tool for the following reasons:

1. Deer do not distribute themselves equally across the landscape. As a result, there is high variation in deer observed from place to place. In 2005, for example, deer were apparently concentrated in areas of red oak mast. Resulting deer density estimates were highly influenced by the representation of red oak mast areas in survey transects.

2. The sampling technique did not adjust for area surveyed as topography changed in a flight path. Measures of variation, therefore, were not available. Population estimates without a corresponding measure of variation may be misleading to managers and the public.

3. The sampling technique did not adjust for sightability differences. An analysis by Penn State concluded that three replicate surveys per year could detect a greater than 20 percent decline in deer abundance with greater than 80 percent probability.

4. The sampling technique did not test for bias. The Penn State analysis included concerns that the assumption that bias is constant among observers and years remains untested. Without direct measurement of bias, a greater number of replicate surveys would likely be needed to detect population change.

5. DCNR did find weak correlations between FLIR data and pellet group counts and browse impact surveys. Because browse impact surveys more directly illustrated the basis for issuance of DMAP permits, they were preferred over FLIR.

6. As an estimate of deer density, DCNR concluded that the cost was prohibitive when considering the variability of the results. FLIR may be valuable in some situations, but the cost and the uncertainty about variation and bias preclude its use as a technique for estimating deer populations over large areas.

## Reproductive Rate as an Index to Herd Health

For decades, the PGC has annually collected embryo data from road-killed deer during February through May. Counts of embryos per adult doe were interpreted as a measure of reproductive success and an index to herd health. This measure was relatively straightforward and easy for interested publics to understand. More importantly, PGC assumed that reproductive rate was an index to the quality of the population and, by extension, the quality of the habitat. PGC believed that reproductive rates should be viewed as a long-term index to herd health and were not necessarily useful as an annual index.

### *The Theory Linking Reproductive Rate and Herd Health*

The suspected correlation between reproductive rate and herd health demonstrated that the PGC suspected that density dependence was a primary

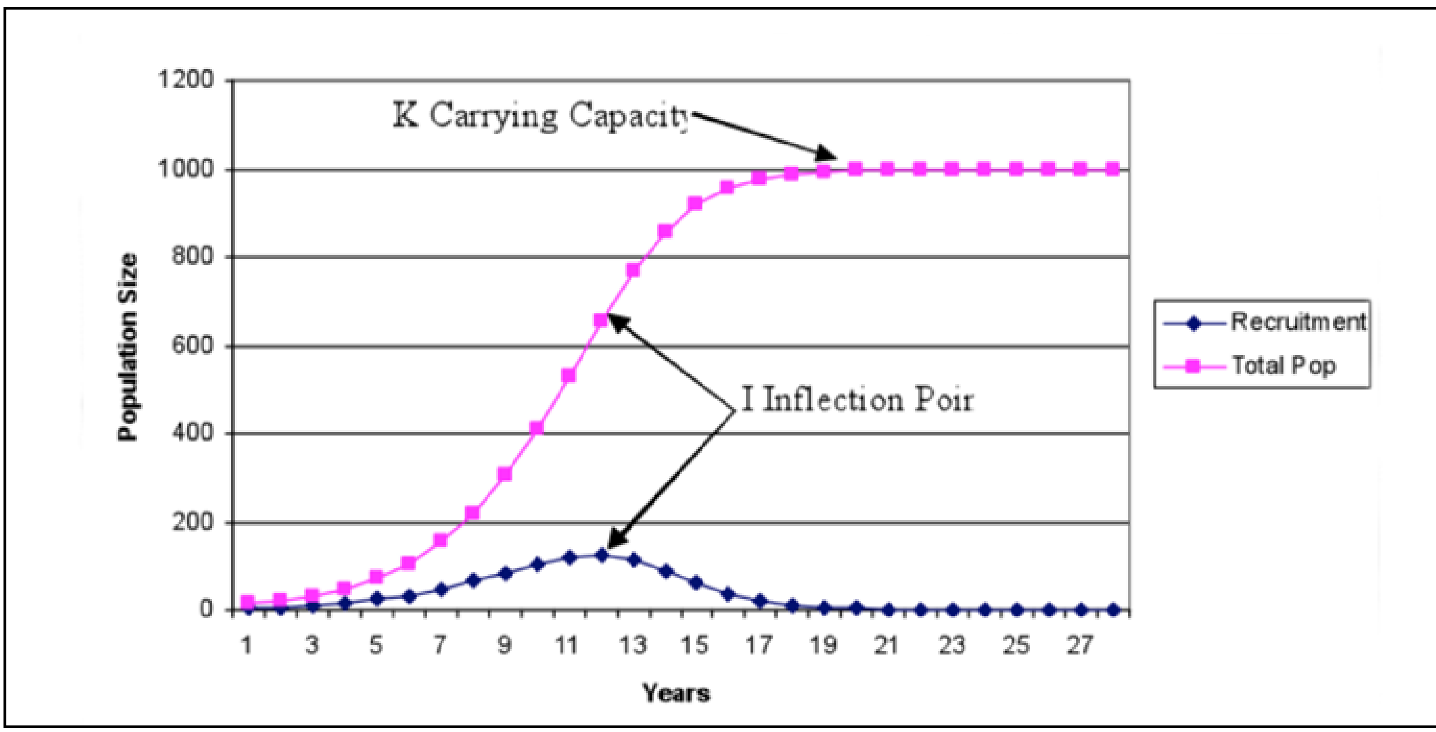



**Figure 8: Graphical representation of the logistic growth model showing recruitment and population size as a function of density. K is the population size at which recruitment stabilizes. I is the point above which recruitment begins to decrease with increasing population size.**

influence on deer population dynamics. Known in the wildlife profession as the Logistic Growth Model, density-dependent deer populations exhibit patterns of population growth that are increasingly affected by intra-specific competition for resources as density increases (Figure 8, page 30). A stable equilibrium occurs when density-regulating processes balance with resource availability. This model is defined by the logistic equation as first conceptualized by Nicholson (1933, cited in Drury 1998).

The logic behind logistic population growth is straightforward. Rates of population growth depend on availability of nutritious food. At low densities, competition for food is absent and population growth rate is consequently high. Population growth rates remain high as population density increases until a threshold density is exceeded. Then, due to competition for food between members of the population, growth rates become inversely correlated with density. At some level of population density, food availability limits further population growth, and the population stabilizes. Biologists track the level of recruitment (the number of fawns that survive to become adults) as the measure of population growth.

The logistic model is an appropriate management regime for deer managers when deer are in a food-limited system with feedback loops in place that correlate changes in deer density to changes in food availability. Logistic growth equations will not model deer populations for which:

- food is artificially unlimited
- availability of food is unaffected by density
- competition for resources is not affected by density
- herbivore density is affected by factors unrelated to vegetative density

McCullough's study (1979) and subsequent publications (1984, 1987, 1997a, 1999) concerning the George Reserve deer herd in Michigan has influenced deer managers to incorporate the logistic equation into their management plans. The majority of state deer managers in the Northeast incorporate some component of density dependence into their philosophies and/or models of deer population dynamics (Williamson 2002).

Despite what is known about density dependence in deer, much remains untested. For example, the extent to which deer populations shape vegetative abundance and composition when at I or K density through the effects of their selection for certain preferred species is unknown. White-tailed deer populations of 65-90 deer per square mile were found to cause local extinction of Trillium species in Minnesota (Augustine and Frelich 1998). Significantly lower effects were noted when deer population was at I or below 25 deer per square mile (Augustine and Frelich 1998).

Assume for the sake of illustration that the Minnesota deer population referenced above stabilized at 65-90 deer per square mile, i.e., from the perspective of the logistic equation, population growth stabilized at K – and managers found that the deer herd could maintain itself at such a density from consumption of foods other than Trillium. Clearly the population-based measure of K would be higher than the ecologically based measure of K. Conversely, if the long-term absence of Trillium from the diet of those deer caused diminishment of condition to the point where population growth eventually declined, then K would clearly be at some density lower than 65-90 per square mile. The confounding problem in determining such a plant/herbivore relationship is the expense in measuring K at that minute a scale and the time lag necessary for such an expression of K to articulate itself clearly. Such time lags may be much longer than managers envision, e.g., it may take several hundred years of total acorn consumption by deer to eliminate oak from a forest stand, effectively lowering K (Susan Stout, USFS, personal communication).

The third confounding problem in determining I and K is the effect that human-caused mosaics of agricultural and forested lands have on K. Deer populations may reach high densities in agricultural areas, resulting in overbrowsing of native plants (Augustine and Jordan 1998, Underwood and Porter 1997). Densities at the inflection point may occur simultaneously with extinction of preferred deer foods from overbrowsing, but the influence of crops and their artificially high sources of nutrition mask population effects on natural forages. In the past, deer managers in Pennsylvania have directly addressed the influence of agricultural lands by expressing K only in terms of forested browse availability (Diefenbach et al. 1997). That may be an appropriate political goal, but it suppressed the utility of managing Pennsylvania deer based on density-dependent logistic growth models.

### *Evidence Linking Reproductive Rate and Herd Health*

As mentioned, PGC officials believed that reproductive rate was the best expression of density-dependent herd heath. However, depending on the species, population and environment, density dependence can take many forms. Gaillard et al. (1998) reported that, in studies of 21 species of large herbivores for which density dependence was reported, juvenile survival was affected in 15, age at first breeding in 12 and adult survival in 9. Eberhardt (1977) was the first to hypothesize that juvenile survival would be the most sensitive parameter to density dependence.

There is considerable evidence, however, both from white-tailed deer and from other ungulate research, to support the PGC's use of reproductive rate as an index to herd health. In white-tailed deer, differences in reproductive rates (embryos per female) have been demonstrated between female deer in good physical condition and those in poor physical condition (Verme 1965, Verme 1967, Verme 1969, Hesselton and Jackson 1974). In as closely controlled test yet of deer population dynamics, McCullough (1979) documented decreases in reproductive rate of white-tailed deer when densities increased. Swihart et al. (1998) suggested that weak density dependence in fertility rate occurs among adult female white-tailed deer, although substantial reproduction still occurs when densities exceed 100 deer per square mile. Density effects become progressively stronger for first-year and yearling females, with reproduction in the first-year age group (six months-old) virtually ceasing when densities exceed 60 deer per square mile. White-tailed deer twinning rates more than tripled following a substantial population reduction in Connecticut (Kilpatrick et al. 2001).

Reproduction in mule deer *(Odocoileus hemionus)* fawns was triggered when populations were lowered from 65 to 25 deer per square mile (McCullough 1997b).

Taper and Gogan (2002) documented inverse density dependence in fertility in northern Yellowstone elk *(Cervus elaphus)*. Fertility ranged from 0.6 when density was 3,000 elk, versus 0.3 when density was 12,000 elk.

In roe deer *(Capreolus capreolus),* the proportion of young females that breed was inversely density dependent (Gaillard et al. 1992). Fawns born to lower-weight roe deer mothers also experienced higher mortality rates than did fawns born to higher-weight mothers (Anderson and Linnell 1998). The occurrence of stillbirths in a roe deer population increased with increasing density (Anderson and Linnell 1999). Focardi et al. (2002) found that female roe deer in high-density areas produced smaller litters.

Fecundity in red deer *(Cervus elaphus)* was found to be inversely density dependent (Albon et al. 1987) and was the primary explanation for variance in population growth in a growing population (Albon et al. 2000). As density increased, however, the relative importance of birth rate to population growth diminished Albon et al. (1983) found that high population density in a red deer herd limited conception by lower-weight females. They theorized that females minimized the risk of dying during pregnancy by conceiving only when higher weight would compensate for the increased energetic costs of lactation. Such a strategy also maximized the likelihood of producing viable offspring (Albon et al. 1983). Clutton-Brock et al. (1983) found that the fecundity of female red deer that produced a calf decreased in subsequent years when the population density was high. Fecundity of female red deer that did not produce a calf did not decrease in subsequent years when population density was high. No pregnant yearlings or lactating two-year-olds were found in a high-density red deer population (Mitchell et al. 1986). In the same population, 34 percent of adult females did not breed each year (Mitchell et al. 1986).

**Table 7. Embryo counts for three ages of does across 22 WMUs in Pennsylvania for years 2000-2007.**

| | | YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| WMU | Age | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Avg. |
| 1A | 1 | 0.6 | 0.2 | 0.6 | 0.8 | 0.5 | 0.4 | 0.5 | 0.6 | 0.5 |
| | 2 | 1.1 | 1.9 | 1.9 | 1.7 | 1.6 | 1.6 | 1.8 | 1.2 | 1.5 |
| | 3 | 1.6 | 1.9 | 1.8 | 1.8 | 1.3 | 1.5 | 1.3 | 1.7 | 1.6 |
| 1A Total | | 0.9 | 1.2 | 1.2 | 1.3 | 1 | 1 | 0.9 | 1.1 | 1.1 |
| 1B | 1 | 0.3 | 0.3 | 0.3 | 0.4 | 0.2 | 0.1 | 0.5 | 0.4 | 0.3 |
| | 2 | 1.4 | 1.7 | 1.6 | 1.2 | 1.3 | 1.4 | 1.8 | 2 | 1.5 |
| | 3 | 1.8 | 1.5 | 1.8 | 1.7 | 2.1 | 1.8 | 1.5 | 1.7 | 1.7 |
| 1B Total | | 0.9 | 0.9 | 1 | 0.8 | 1.3 | 0.9 | 1.1 | 1 | 1 |
| 2A | 1 | 0.2 | 0.4 | 0.1 | 0 | 0.1 | 0.2 | 0.3 | 0.1 | 0.2 |
| | 2 | 1.7 | 1 | 1.3 | | 1.6 | 1.5 | 0.5 | 1.5 | 1.5 |
| | 3 | 1.8 | 1.4 | 1.7 | | 1.8 | 1.3 | 1.2 | 1.5 | 1.5 |
| 2A Total | | 0.8 | 0.8 | 1 | 0 | 1 | 0.9 | 0.8 | 1 | 0.9 |
| 2B | 1 | 0.5 | 0.5 | 0.5 | 0.7 | 0.3 | 0.4 | 0.3 | 0.5 | 0.4 |
| | 2 | 1.9 | 1.7 | 1.5 | 1 | 1.4 | 1.4 | 1 | 1.6 | 1.5 |
| | 3 | 1.5 | 1.5 | 2 | 1.7 | 1.3 | 1.7 | 1.6 | 1.7 | 1.7 |
| 2B Total | | 1 | 1.1 | 1.3 | 1.1 | 0.8 | 1 | 1.1 | 1.3 | 1.1 |
| 2C | 1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.4 | 0.3 | 0.2 | 0.2 |
| | 2 | 1.7 | 1.7 | 1.5 | 1.4 | 1.2 | 1.2 | 1.2 | 1.4 | 1.4 |
| | 3 | 1.7 | 1.6 | 1.6 | 1.5 | 1.6 | 1.5 | 1.2 | 1.8 | 1.6 |
| 2C Total | | 0.9 | 0.9 | 1.1 | 1.1 | 0.8 | 1 | 0.7 | 0.9 | 0.9 |
| 2D | 1 | 0.5 | 0.3 | 0.2 | 1 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 |
| | 2 | 1.4 | 1.1 | 1.8 | 0.5 | 0.7 | 1.8 | 1.4 | 1.4 | 1.4 |
| | 3 | 1.9 | 1.6 | 1.2 | 2 | 1.4 | 1.8 | 2.1 | 1.5 | 1.7 |
| 2D Total | | 1.1 | 0.8 | 1 | 1.3 | 0.5 | 1 | 1 | 1 | 1 |
| 2E | 1 | 0.4 | 0 | 0 | | 0 | 0.5 | 0.5 | 0.2 | 0.3 |
| | 2 | 1 | 1.5 | 0 | | 1.5 | 1 | 2 | 1.8 | 1.4 |
| | 3 | 2 | 1.8 | | | 2 | 1.5 | 1 | 1.8 | 1.7 |
| 2E Total | | 0.8 | 1.2 | 0 | | 1.4 | 1 | 1 | 0.9 | 0.9 |
| 2F | 1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.2 | 0 | 0.2 | 0.1 |
| | 2 | 1.4 | 1.2 | 1.8 | 1.4 | 0.5 | 1.3 | 1 | 1.2 | 1.3 |
| | 3 | 1.4 | 1.5 | 1.6 | 1.6 | 1.6 | 1.5 | 1.6 | 1.4 | 1.5 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2F Total | | 0.8 | 0.8 | 1 | 0.9 | 0.9 | 1 | 0.9 | 0.8 | 0.9 |
| 2G | 1 | 0 | 0.3 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.1 |
| | 2 | 1.5 | 1 | 1 | 1.3 | 1.3 | 0.7 | 1.7 | 1.5 | 1.3 |
| | 3 | 1.6 | 1.4 | 1.4 | 1.5 | 1.6 | 1.5 | 2.1 | 1.8 | 1.6 |
| 2G Total | | 0.9 | 0.9 | 1.1 | 1 | 1.2 | 1 | 1.5 | 1.3 | 1.1 |
| 3A | 1 | 0 | 0 | | 0 | 0 | 0 | 0.5 | 0 | 0 |
| | 2 | 1.3 | 1 | | 1.3 | 0 | | 1.7 | 2 | 1.2 |
| | 3 | 1.3 | 1.3 | | 1.7 | 1.6 | 1.2 | 1.8 | 1.8 | 1.5 |
| 3A Total | | 0.6 | 0.8 | | 1.3 | 1 | 0.8 | 1.5 | 1 | 1 |
| 3B | 1 | 0.2 | 0 | 0.1 | 0 | 0 | 0.1 | 0 | 0.1 | 0.1 |
| | 2 | 1.4 | 1.4 | 1.4 | 1.4 | 1.2 | 1.5 | 1.3 | 1 | 1.4 |
| | 3 | 1.6 | 1 | 1.2 | 1.9 | 1.7 | 1.7 | 1.5 | 1.2 | 1.5 |
| 3B Total | | 1 | 0.7 | 0.8 | 1.3 | 0.9 | 1 | 0.9 | 0.9 | 1 |
| 3C | 1 | 0.4 | 0.1 | 0 | 0 | 0 | 0.1 | 0.1 | 0.2 | 0.1 |
| | 2 | 1.1 | 1.2 | 1 | 1.4 | 1 | 2 | 1.3 | 0.8 | 1.2 |
| | 3 | 1.5 | 1.7 | 1.5 | 1.4 | 1.4 | 1.5 | 1.7 | 1.8 | 1.5 |
| 3C Total | | 0.8 | 1 | 1 | 0.9 | 0.6 | 0.9 | 0.7 | 0.9 | 0.9 |
| 3D | 1 | 0.1 | 0.2 | 0.7 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 |
| | 2 | 1.4 | 1.7 | 2.3 | 1 | 1 | 1 | 1.3 | 1.1 | 1.4 |
| | 3 | 1.6 | 1.7 | 1.8 | 1.6 | 1.4 | 1.3 | 1.3 | 1.3 | 1.5 |
| 3D Total | | 0.9 | 1.3 | 1.7 | 0.9 | 1 | 0.9 | 0.8 | 1 | 1 |
| 4A | 1 | 0.1 | 0.2 | 0 | 0.1 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 |
| | 2 | 1.6 | 1.4 | 1.8 | 1.4 | 1.3 | 1.7 | 1.2 | 1.1 | 1.4 |
| | 3 | 1.9 | 1.5 | 1.6 | 1.5 | 1.6 | 1.9 | 1.5 | 1.5 | 1.6 |
| 4A Total | | 1.1 | 0.9 | 1.1 | 1 | 0.8 | 1.3 | 0.8 | 0.8 | 1 |
| 4B | 1 | 0.2 | 0.6 | 0.5 | 0.1 | 0.3 | 0.3 | 0.5 | 0.2 | 0.3 |
| | 2 | 1.8 | 2 | 1.5 | 2 | | 1.3 | 1.5 | 1.7 | 1.7 |
| | 3 | 1.6 | 1.8 | 1.2 | 2.2 | 2 | 1.9 | 2 | 1.2 | 1.6 |
| 4B Total | | 1.2 | 1.1 | 1 | 1.1 | 0.8 | 1.2 | 1.1 | 1.1 | 1.1 |
| 4C | 1 | 0.4 | 0.2 | | 0.3 | 0.1 | 0 | 0.3 | 0.4 | 0.3 |
| | 2 | 1.4 | 1.4 | 2.3 | 1.5 | 1 | | 2 | 1.5 | 1.6 |
| | 3 | 1.5 | 1.8 | 2 | 2 | 1.8 | 1.3 | 1.2 | 1.2 | 1.5 |
| 4C Total | | 0.9 | 0.7 | 2.2 | 1 | 0.8 | 0.7 | 0.9 | 1 | 0.9 |
| 4D | 1 | 0.2 | 0.2 | 0.3 | 0.3 | 0 | 0.3 | 0.4 | 0.3 | 0.2 |
| | 2 | 1.6 | 1.5 | 1 | 1.5 | 1 | 1.3 | 2.1 | 1.2 | 1.5 |
| | 3 | 1.6 | 1.8 | 1.3 | 1.6 | 1.6 | 1.3 | 1.7 | 1.6 | 1.6 |
| 4D Total | | 1.1 | 1.3 | 0.9 | 1.1 | 1.2 | 0.9 | 1.3 | 1 | 1.1 |
| 4E | 1 | 0.4 | 0.4 | 0.3 | 0.2 | 0 | 0.3 | 0.1 | 0.2 | 0.2 |
| | 2 | 1.4 | 1.8 | 1.2 | 1.8 | 1.3 | 1.4 | 1.9 | 1.6 | 1.6 |
| | 3 | 2.1 | 2 | 1.4 | 1.9 | 1.8 | 1 | 2.2 | 1.7 | 1.8 |
| 4E Total | | 1.1 | 1.1 | 0.8 | 1.3 | 0.7 | 0.6 | 1 | 1.1 | 1 |
| 5A | 1 | 0.2 | 0.6 | 0 | 0.4 | 0 | 1 | 0.5 | 0.5 | 0.4 |
| | 2 | 1.8 | 2 | 1 | 2 | 1 | 2 | 1.8 | 1.8 | 1.8 |

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|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 1.6 | 1.5 | 1.3 | 1.4 | 1 | 1 | 2 | 1.8 | 1.4 |
| 5A Total | | 1.1 | 1.3 | 0.5 | 0.8 | 0.7 | 1.1 | 1.2 | 1.1 | 1 |
| 5B | 1 | 0.6 | 0.3 | 0.4 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | 2 | 2.1 | 1.8 | 1.8 | 1.8 | 1.2 | 1.5 | 1 | 1.6 | 1.7 |
| | 3 | 2.2 | 1.8 | 1.9 | 2.1 | 2 | 1.3 | 1.5 | 1.7 | 1.8 |
| 5B Total | | 1.5 | 1 | 1.2 | 1.3 | 1.1 | 0.8 | 0.7 | 1 | 1.1 |
| 5C | 1 | 0.6 | 0.6 | 0.4 | 0.6 | 0.1 | 0.6 | 0.3 | 0.4 | 0.5 |
| | 2 | 1.7 | 1.5 | 1.7 | 1.8 | 2.4 | 1.6 | 1.5 | 1.2 | 1.7 |
| | 3 | 1.6 | 1.9 | 1.9 | 1.7 | 1.7 | 1.6 | 1.9 | 1.6 | 1.7 |
| 5C Total | | 1.1 | 1.2 | 1.3 | 1.4 | 1.3 | 1.2 | 1.1 | 1 | 1.2 |
| 5D | 1 | 0.8 | 0.3 | 0.5 | 1 | 0.2 | 0 | 0 | 1.3 | 0.5 |
| | 2 | 2 | 2 | 2 | 1.7 | 1.7 | 1.5 | 1 | 2 | 1.8 |
| | 3 | 1.5 | 2 | 2.5 | 1.3 | 1.9 | 1.9 | 1.6 | 1.7 | 1.8 |
| 5D Total | | 1.4 | 1.2 | 1.6 | 1.3 | 1.4 | 1.3 | 1.2 | 1.7 | 1.4 |
| Grand Total | | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

## *PGC Assessment of Reproductive Rate*

To increase the sample size, reduce variability and improve precision in order to interpret reproductive rates better, PGC pools embryo counts into a three-year running average by WMU. Pooled rates minimized the impact of an outlier year (high or low) that could unduly affect the characterization of herd health and provide larger sample sizes than would be available on an annual basis. PGC determined that a target of 1.50 embryos per adult female represented a healthy deer population. The target value of 1.50 was chosen because it corresponds to a population at maximum, sustained yield based on work of Downing and Guynn (1985).

To obtain adequate sample sizes, the PGC groups data from does at ages two, three and older. Embryo data from does one-year-old were not used in the calculation. The measure

**Table 8. Embryo counts by WMU for adult does for years 2000-20008.**

| Annual Adult Doe (2 years old and older) Embryo counts by WMU | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WMU | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| 1A | 1.31 | 1.91 | 1.86 | 1.78 | 1.43 | 1.57 | 1.44 | 1.47 | 1.41 |
| 1B | 1.62 | 1.52 | 1.74 | 1.35 | 1.87 | 1.64 | 1.63 | 1.8 | 1.33 |
| 2A | 1.75 | 1.38 | 1.59 | | 1.76 | 1.39 | 1.12 | 1.46 | 1.23 |
| 2B | 1.76 | 1.59 | 1.8 | 1.44 | 1.33 | 1.58 | 1.55 | 1.65 | 1.82 |
| 2C | 1.72 | 1.61 | 1.57 | 1.44 | 1.36 | 1.32 | 1.19 | 1.61 | 1.71 |
| 2D | 1.61 | 1.43 | 1.55 | 1.57 | 1.13 | 1.75 | 1.83 | 1.45 | 1.85 |
| 2E | 1.67 | 1.7 | 0 | | 1.75 | 1.4 | 1.25 | 1.8 | 1.81 |
| 2F | 1.38 | 1.41 | 1.72 | 1.46 | 1.25 | 1.48 | 1.47 | 1.29 | 1.61 |
| 2G | 1.55 | 1.3 | 1.25 | 1.43 | 1.56 | 1.38 | 2 | 1.79 | 1.35 |
| 3A | 1.29 | 1.18 | | 1.56 | 1.47 | 1.2 | 1.75 | 1.86 | 1.75 |
| 3B | 1.5 | 1.26 | 1.3 | 1.71 | 1.55 | 1.6 | 1.45 | 1.14 | 1.44 |
| 3C | 1.23 | 1.43 | 1.4 | 1.4 | 1.31 | 1.57 | 1.5 | 1.5 | 1.5 |
| 3D | 1.52 | 1.71 | 2 | 1.42 | 1.27 | 1.28 | 1.25 | 1.3 | 1.44 |
| 4A | 1.8 | 1.47 | 1.68 | 1.5 | 1.53 | 1.83 | 1.37 | 1.38 | 1.55 |
| 4B | 1.67 | 1.86 | 1.29 | 2.08 | 2 | 1.56 | 1.71 | 1.41 | 1.59 |
| 4C | 1.44 | 1.5 | 2.17 | 1.86 | 1.5 | 1.33 | 1.44 | 1.34 | 1.54 |
| 4D | 1.58 | 1.68 | 1.24 | 1.55 | 1.36 | 1.29 | 1.86 | 1.53 | 1.68 |
| 4E | 1.71 | 1.81 | 1.3 | 1.83 | 1.63 | 1.22 | 2 | 1.58 | 1.76 |
| 5A | 1.73 | 1.67 | 1.2 | 1.56 | 1 | 1.2 | 1.8 | 1.75 | 1.5 |
| 5B | 2.18 | 1.82 | 1.85 | 1.94 | 1.53 | 1.36 | 1.38 | 1.69 | 1.75 |
| 5C | 1.66 | 1.75 | 1.8 | 1.75 | 1.84 | 1.61 | 1.81 | 1.47 | 1.67 |
| 5D | 1.78 | 2 | 2.33 | 1.5 | 1.79 | 1.82 | 1.6 | 1.75 | 2 |
| Means | 1.61 | 1.59 | 1.55 | 1.61 | 1.51 | 1.56 | 1.56 | 1.55 | 1.6 |

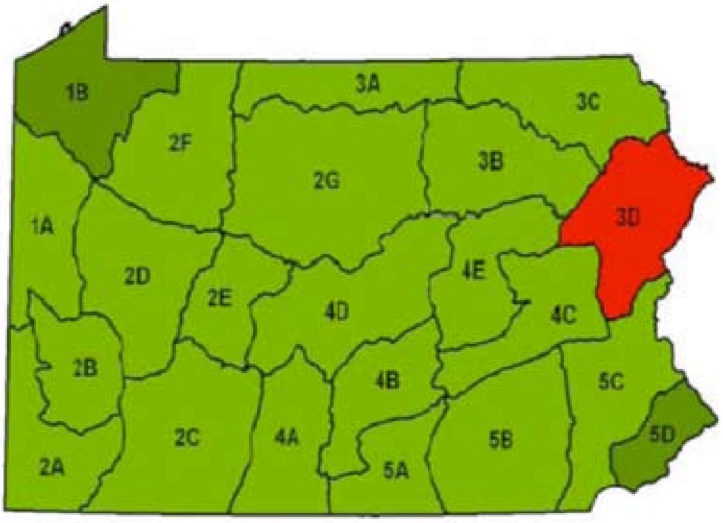


**Figure 9: Pennsylvania Game Commission deer health map for WMUs for 2008 data. Red = Below Target; Light Green = At Target and Dark Green = Above Target.**

of reproduction was based on a sample of deer from across a WMU and a point estimate (mean) with associated measures of variability was calculated for each WMU. A two-tailed t-test was used to determine if the calculated point estimate differed significantly from the target of 1.50 embryos per doe. The PGC determined that the three-year estimate of embryos per adult female must have a coefficient of variation (CV) of less than 13 percent to achieve precision goals.

Density dependence was assumed to be the primary influence on reproductive rate. If reproductive rates were lower than target, reductions in deer density were recommended. The PGC believed reproductive rates to be a function of an aggregation of both forest and non-forest habitat quality. Historically, road-killed

**Table 9. T-tests for differences between population mean and hypothesized population mean for embryo count data for years 2006-2008.**

| WMU | n | mean | vari-ance | SE | CV | Hypo mean | t * | v | t | Significant? |
|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 84 | 1.44 | 0.88 | 0.1 | 7% | 1.5 | -0.583 | 83 | | NO |
| 1B | 57 | 1.58 | 0.61 | 0.1 | 7% | 1.5 | 0.766 | 56 | | NO |
| 2A | 80 | 1.33 | 0.75 | 0.1 | 7% | 1.5 | -1.803 | 79 | | NO |
| 2B | 137 | 1.67 | 0.56 | 0.06 | 4% | 1.5 | 2.682 | 136 | | YES |
| 2C | 132 | 1.55 | 0.6 | 0.07 | 4% | 1.5 | 0.786 | 131 | | NO |
| 2D | 100 | 1.65 | 0.45 | 0.07 | 4% | 1.5 | 2.231 | 99 | | YES |
| 2E | 30 | 1.73 | 0.55 | 0.14 | 8% | 1.5 | 1.728 | 29 | | NO |
| 2F | 87 | 1.47 | 0.67 | 0.09 | 6% | 1.5 | -0.327 | 86 | | NO |
| 2G | 41 | 1.66 | 0.58 | 0.12 | 7% | 1.5 | 1.332 | 40 | | NO |
| 3A | 23 | 1.78 | 0.18 | 0.09 | 5% | 1.5 | 3.214 | 22 | | YES |
| 3B | 66 | 1.32 | 0.74 | 0.11 | 8% | 1.5 | -1.713 | 65 | | NO |
| 3C | 32 | 1.5 | 0.45 | 0.12 | 8% | 1.5 | 0 | 31 | | NO |
| 3D | 77 | 1.34 | 0.7 | 0.1 | 7% | 1.5 | -1.702 | 76 | | NO |
| 4A | 100 | 1.43 | 0.61 | 0.08 | 5% | 1.5 | -0.895 | 99 | | NO |
| 4B | 51 | 1.51 | 0.49 | 0.1 | 7% | 1.5 | 0.1 | 50 | | NO |
| 4C | 54 | 1.41 | 0.66 | 0.11 | 8% | 1.5 | -0.837 | 53 | | NO |
| 4D | 72 | 1.69 | 0.38 | 0.07 | 4% | 1.5 | 2.662 | 71 | | YES |
| 4E | 51 | 1.78 | 0.41 | 0.09 | 5% | 1.5 | 3.161 | 50 | | YES |
| 5A | 37 | 1.62 | 0.35 | 0.1 | 6% | 1.5 | 1.245 | 36 | | NO |
| 5B | 61 | 1.64 | 0.6 | 0.1 | 6% | 1.5 | 1.404 | 60 | | NO |
| 5C | 74 | 1.61 | 0.52 | 0.08 | 5% | 1.5 | 1.295 | 73 | | NO |
| 5D | 32 | 1.69 | 0.29 | 0.09 | 6% | 1.5 | 1.982 | 31 | | NO |

deer collections have been plagued by sampling logistics and inconsistencies. Wildlife Conservation Officers (WCO) conduct the collections as part of their routine activities. Effort among WCOs was

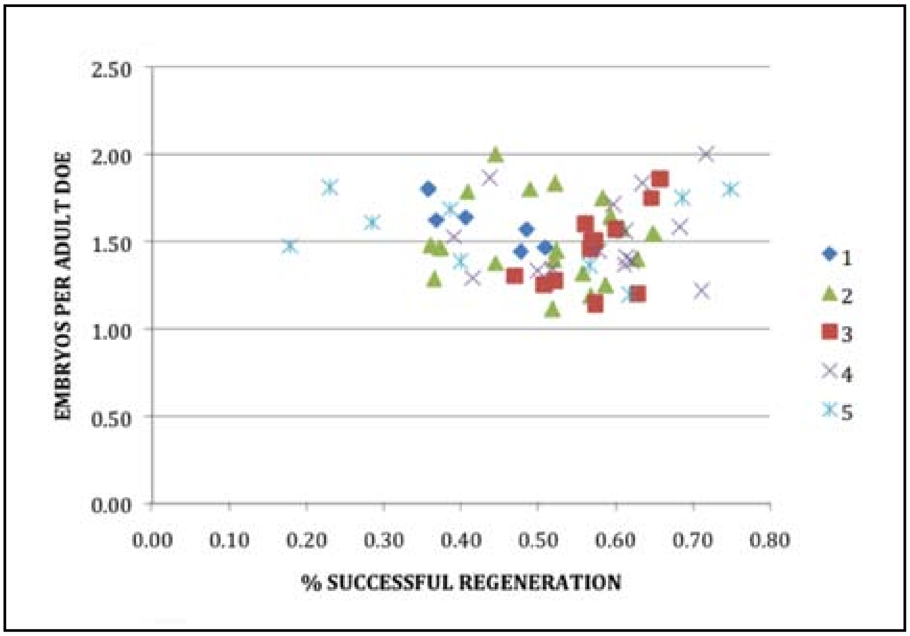


**Figure 10. Relationship between the number of embryos per adult doe and the percentage of plots showing adequate forest regeneration. Data aggregated by WMU Region for the years 2005-2007.**

highly variable. The PGC indicated to WMI that it was negotiating an Memorandum of Understanding with Pennsylvania Department of Transportation to achieve a uniform embryo collection system for all state roads. The PGC believed that bias in embryo collections was not a concern as roads were well distributed throughout the WMUs.

WMI evaluated deer embryo data for 22 individual WMUs for the years 2000-2007 (Table 7, page 33). There was little variation in embryo counts either over years or between WMUs. Embryo counts for fawns were lower than adult does and never averaged higher than 0.5 embryo per female. Data were generally complete over these years and locations.

Embryo counts per adult doe (two years and older) for all WMUs and for years 2000-2008 were summarized (Table 8, page 35). Mean values varied from a high of 2.18 in WMU 5B in 2000 to a low of 1.12 in WMU 2A in 2006. However, as with the fawn data, there was little variability year-to-year or across the WMUs for adults as well. Overall, means were near 1.60 most years. A PGC map with 2008 data illustrated the health status of WMU's (Figure 9, page 36). The graphic illustrated that most WMUs were at target.

Deer health relative to the target of 1.50 embryos per adult doe was assessed by PGC for each WMU. Data were grouped into three-year running averages and tested annually for significant changes over time. Data for years 2006-2008 illustrated sample sizes, statistics, variances, test results and conclusions for this process (Table 9, page 36). Results show that, for these three years, 17 WMUs were at target with five above target. None was below target. These data were used by the PGC as one of its decision points when making recommendations on annual harvest levels.

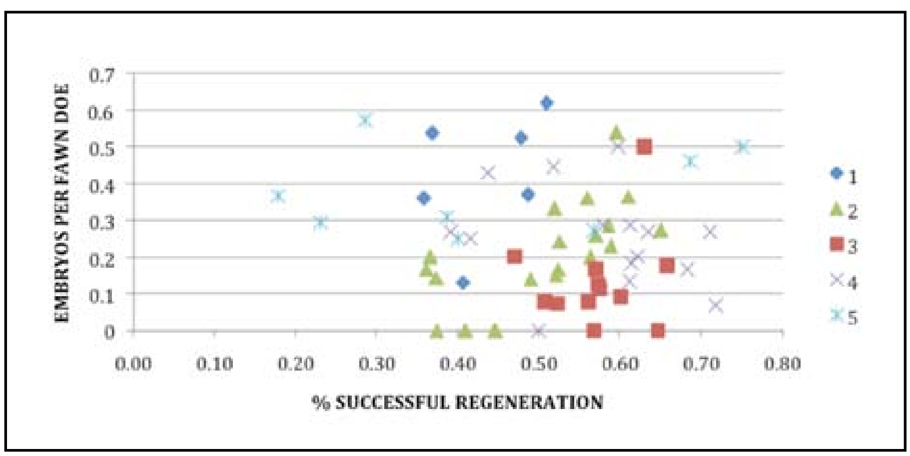


**Figure 11. Relationship between the number of embryos per fawn doe and the percentage of plots showing adequate forest regeneration. Data aggregated by WMU Region for the years 2005-2007.**

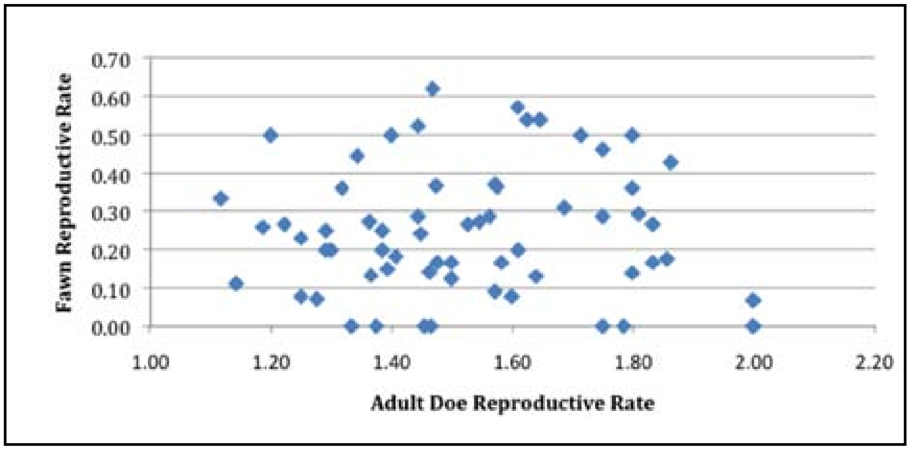


**Figure 12. Relationship between the number of embryos per fawn doe and the number of embryos per adult doe. Data aggregated by WMU Region for the years 2005-2007.**

To be effective in the decision-making process, embryo data should correlate with the forest-regeneration data. If deer densities were lowered over a period of years, the forest-regeneration data should improve or, if deer densities increase, forest health should decrease. To evaluate if this relationship existed in the data, embryo data from 2005-2007 and forest adequate stocking data from 2003-2007 were plotted (Figure 10, page 37). The correlation between reproductive rates and forest health was poor (r =-0.04), indicating little relationship. It is suspected that the small change in the mean embryo counts from year to year and from one WMU to another was the reason for this lack of relationship. It appears embryo data were not sufficiently sensitive (at least in three-year periods) to reflect changes in forest health.

WMI evaluated other independent measures of herd health. Like adult doe reproductive rates, fawn reproduction was not correlated with forest regeneration levels (Figure 11, page 37). The small variance in embryos per pregnant fawn suggests that this statistic would not be useful. Of concern was the lack of correlation between adult doe and fawn doe reproductive rate (Figure 12, left). If reproductive rates are indicative of herd health, fawn and adult rates should correlate.

Research conducted to date on ungulate population dynamics suggests that the percentage of fawns pregnant might be a more sensitive indicator of deer health. It would be necessary to increase significantly

**Table 10. A comparison of reproductive rates (2007/08) from Northeastern states that collect deer reproduction data.**

| | Reproduction | | | | | |
|---|---|---|---|---|---|---|
| State | % Fawn bred | % Yrlg Bred | % Adult Bred | Fawns/ Fawn | Fawns/ Yrlg | Fawns/ Adult |
| CT | | | | | | |
| DE | 7.9 | 94 | 97.3 | 0.11 | 1.7 | 1.97 |
| ME | | | | 0.23 | 1.334 | 1.688 |
| MD | | | | | | |
| MA | | | | 0.18 | 1.2 | 1.7 |
| NH | | 17 | 66 | | | |
| NJ | | | | 0.6 | 2 | 2 |
| NY | | | | | | |
| PA | 25 | 85 | 87 | 0.29 | 1.38 | 1.53 |
| RI | | | | | | |
| VT | 1 | 91 | | | 1.45 | |
| VA | | 16 | | | | |
| WV | | | | | | |

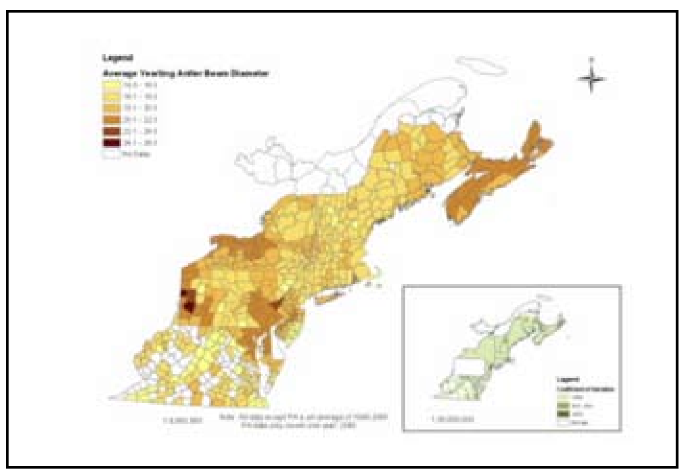

**Figure 13: Mean yearling buck antler beam diameter from Pennsylvania counties (2000-2001) and WMUs from Northeastern states (1990-2000) (from Williamson 2002).**

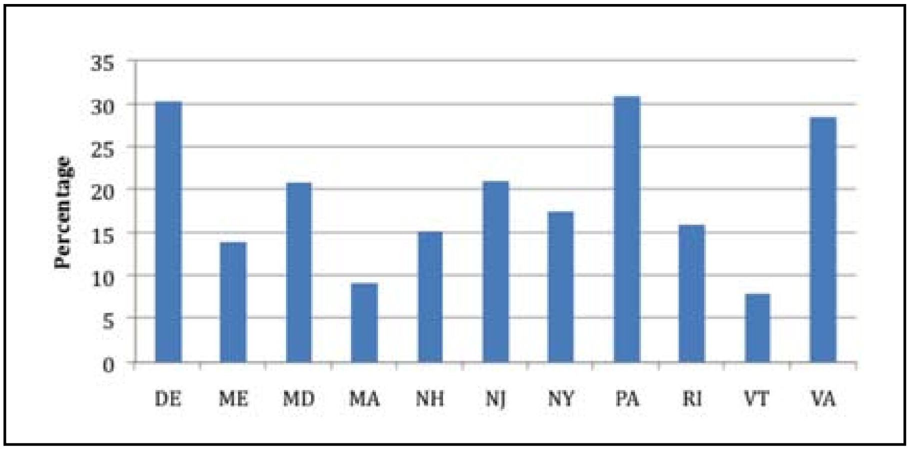


**Figure 14. Harvest fawn-to-doe ratios from Northeastern states that collect age data from harvested deer. The ratio of fawns: adult does in the harvest is used by some states to index fawn recruitment, carrying capacity or both.**

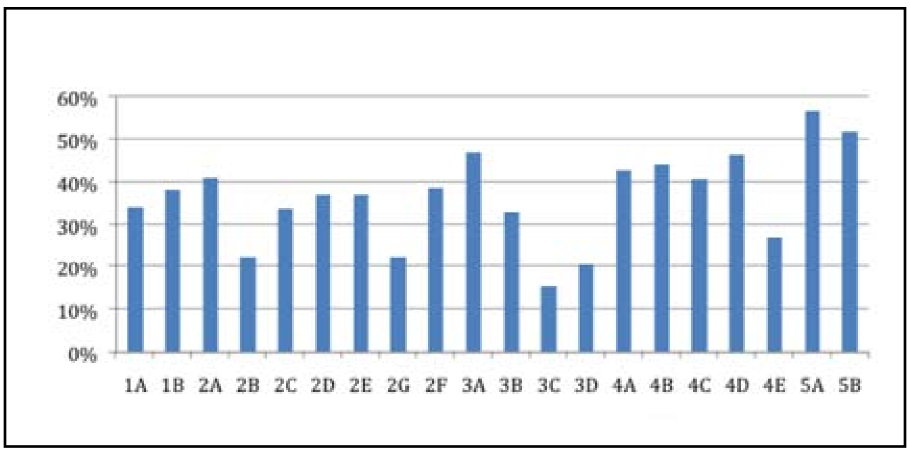


**Figure 15. Average (1990-2008) harvest fawn-to-doe ratios for WMUs in Pennsylvania.**

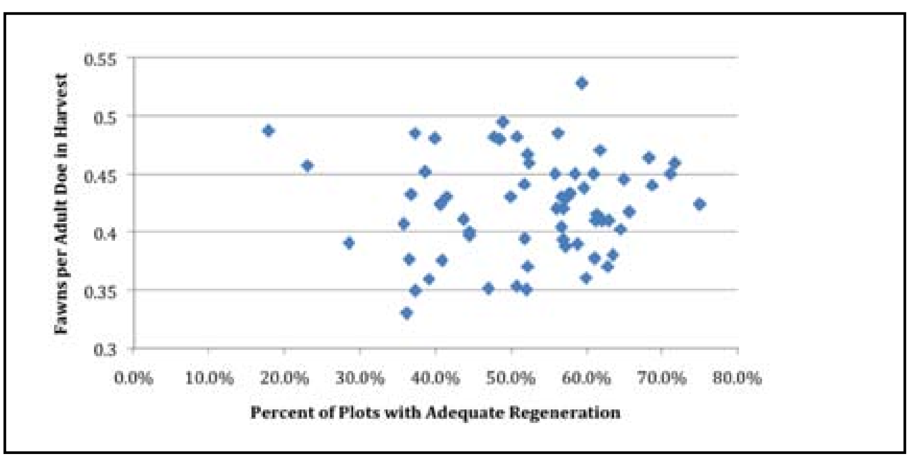


**Figure 16. Relationship between regeneration success and fawn-to-adult doe harvest ratio.**

the sample size of fawns in the embryo data to address adequately the potential of this measure. When compared to other states, there appears to be large variation in fawn reproductive rates (Table 10, page 38).

Antler beam diameters of yearling bucks are used by many jurisdictions in the Northeast to characterize deer herd health. The PGC collected two years of antler beam diameter data prior to antler restrictions. Differences between regions of Pennsylvania and between Pennsylvania and other states are apparent (Figure 13, page 38). Current antler point restrictions in Pennsylvania eliminate the utility of this index to herd health.

A measure of fawn survival has been demonstrated to be one of the most sensitive and effective parameters in assessing deer population performance (Unsworth et al. 1999, Bishop et al 2009, Lukacs et al 2009). Some states in the Northeast utilize fawn-to-adult doe harvest ratios as an index to fawn survival. PGC managers believed that hunter selectivity against fawns invalidated the measure (refer to the SAK model discussion for the correction factor employed by the PGC to correct for selectivity). Pennsylvania historically has relatively high fawn-to-adult doe harvest rates when compared with other Northeastern states (Figure 14, left).

Fawn-to-adult doe harvest ratios varied between WMUs (Figure 15, left), with WMUs 2B, 2G, 3C and 3D having the lowest ratios, generally around 20 fawns per 100 does in the harvest. WMUs 3A, the rest of the 4 region WMUs and WMUs 5A and 5B had highest rates, generally above 40 fawns per 100 adult does in the harvest.

Like adult doe and fawn doe reproductive rates, fawn-to-adult doe harvest ratio did not exhibit any correlation with forest regeneration (Figure 16, page 39). If fawn-to-adult doe harvest ratio was an indicator of carrying capacity, a negative relationship would be apparent between the ratio and forest regeneration success.

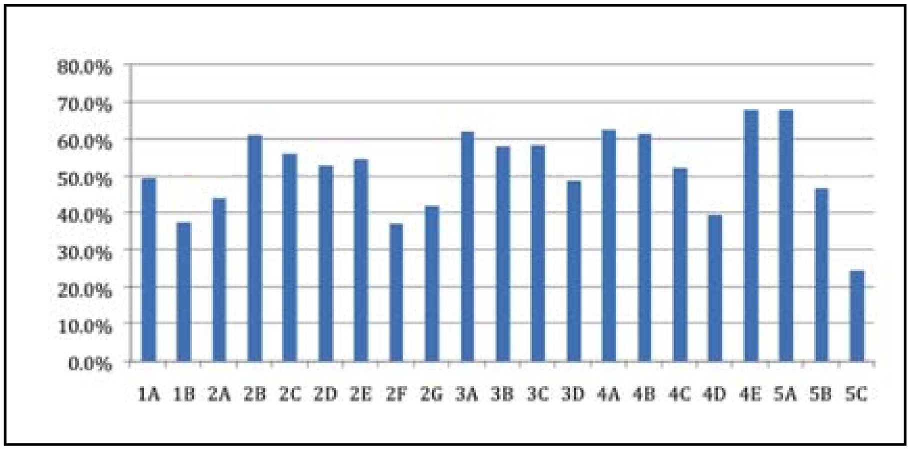


**Figure 18: Regeneration success as measured by Forest Inventory and Analysis data averages on Pennsylvania WMUs.**

## Forest Regeneration as an Index to Habitat Health

The abundance and condition of forest regeneration was selected by the PGC as an indicator of forest habitat health. Tree seedlings and saplings growing beneath the forest canopy are referred to as advance regeneration, and the development of advance regeneration is essential for the maintenance of both managed forests and natural areas. Pennsylvania's native hardwood forests depend almost exclusively on advance regeneration for the development of new stands after timber harvest or natural disturbance. Measurements of advance regeneration are used to prepare silvicultural prescriptions and to predict the types and numbers of trees that will grow on a site if the overstory is removed.

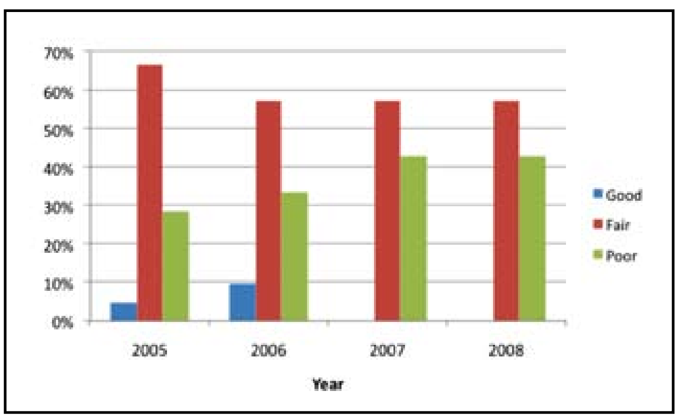


**Figure 17: Plots assessed as having good, fair or poor regeneration present during Forest Inventory and Analysis surveys for 2005-2008.**

The PGC standards for forest habitat health were derived from the "SILVAH" guidelines, which are based on extensive research and testing throughout Pennsylvania (Marquis 1994). These guidelines were universally accepted and used by foresters in Pennsylvania. The definitions for good, fair, and poor habitat were based on the percentage of sample plots with adequate advance regeneration. Forest habitat health was considered "good" if the observed percentage of plots with adequate regeneration was greater than, equal to or not significantly different from 70 percent. Habitat was considered "poor" if the observed percentage of plots with adequate regeneration was significantly less than 50 percent. Habitat health was considered "fair" if the percentage of plots with adequate regeneration was equal to 50 percent, or between 50 and 70 percent and significantly less than 70 percent, or not significantly different from 50 percent.

The criterion for good habitat (70 percent or more plots with adequate regeneration) was a critical threshold at which trees can be harvested with standard forestry practices and forest canopy replacement will occur without further actions to mitigate deer impacts. When regeneration stocking was below the 70-percent threshold, remedial actions, such as deer fencing or control of competing vegetation, were required before trees could be harvested.

Advance regeneration was inadequate across all regions, ownerships and forest types in Pennsylvania (McWilliams et al. 2004). In 2008, the PGC judged forest habitat health to be good in 2 WMUs, fair in 15 WMUs and poor in 4 WMUs. The number of WMUs rated as good habitat has declined since 2005, while the number rated as poor has increased (Figure 17, page 40). Currently, about 50,000 acres of PGC and Bureau of Forestry land are fenced to exclude deer to meet habitat management goals. Levels of adequate stocking vary by WMU. WMUs 1B, 2F, 2G and 4D show the lowest levels of adequate regeneration (Figure 18, page 40), generally less than 40 percent of plots showing adequate regeneration. WMUs with the highest regeneration success, generally near 70 percent, are WMUs 4E and 5A. The PGC used the best available data to assess forest habitat health. Forest habitat data were collected by the USDA Forest Service's Forest Inventory and Analysis (FIA) program. The methods used to quantify the composition, abundance and quality of tree seedlings and other understory vegetation were developed in collaboration with the Pennsylvania Bureau of Forestry, Northeastern Research Station silvicultural research labs, and the Penn State School of Forest Resources. Samples were collected during a 10-week period during summer, and plots were screened to include only those where light was adequate for regeneration.

The FIA followed a standard, national protocol for sampling. Each year 20 percent of the plots were sampled; it takes five years to complete the inventory. Each year's sample, called a "Sample Panel," provides an unbiased representation of conditions across the state, but sample sizes were too small to make inferences about individual WMUs. The FIA provides data for individual WMUs, and the PGC used five-year running averages to assess forest habitat health. The PGC assessment of adequate advance regeneration included any tree species capable of growing into the canopy.

## *Factors Affecting Regeneration*

Pennsylvania's forests face two broad, interconnected problems--a lack of tree regeneration and the replacement of oaks and hickories with tree species of less value to wildlife (Abrams and Nowacki 2008, Healy et al. 1997, McShea and Healy 2002, Nowacki and Abrams 2008). The lack of regeneration and loss of nut producing trees have different underlying causes, and both were influenced by multiple, interacting factors. Factors that limit tree regeneration generally accelerated the shift in tree species composition towards more shade-tolerant species. Unless conditions change, most of Pennsylvania's forestland faces two equally undesirable outcomes--either no regeneration at all or the replacement of oak forests with red maple and black birch. Either outcome results in a decrease in the amount of food available for wildlife, and a decrease in the value and quantity of resources available for people.

WMI was presented with substantial testimony and reviewed an extensive body of scientific literature documenting that deer browsing can prevent the regeneration of forest stands and alter forest structure and plant species composition (Behrend et al. 1970, Tilghman 1989, Trumball et al. 1989, Healy 1997, Augustine and Frelich 1998, Horsley et al. 2003, Pederson and Wallis 2004; see Latham et al. 2005 for a comprehensive review of the scientific literature). The most recent survey of forest regeneration indicates that only about half of Pennsylvania's forests would regenerate to high-canopy status following a significant overstory disturbance, and only 34 percent of plots contain regeneration of desirable commercial timber species (McWilliams et al. 2004). Advanced  regeneration is inadequate in all forest types and regions of the state (McWilliams et al.

2004). There was a consensus among scientists and forest managers that excessive deer browsing was the primary factor limiting forest regeneration, and that forest regeneration could be achieved where deer numbers were regulated. Both the PGC and DCNR routinely exclude deer with fencing to meet habitat management goals. PA DCNR has documented that nearly 100% of fenced overstory stands have adequate regeneration when the fence is removed (Brad Ellison, DCNR, personal communication January 2010). Similar regeneration success following fence removal from research areas is reported by the U. S. Forest Service (S. Stout, USFS, personal communication, January 2010). The net effect of excessive deer browsing was an overall decrease in the number of plant species and an increase in the abundance of plants avoided by deer or resilient to browsing. The increased abundance of ferns and other unpalatable plants in itself becomes a barrier to tree regeneration. Thus, the effects of over-browsing are progressive and, the longer they persist, the more difficult they are to reverse (Horsley et al. 2003).

The effective suppression of fire since the 1920s was the underlying cause for the replacement of oaks with more shade-tolerant species (Nowacki and Abrams 2008). When frequent burning stopped, fire-sensitive tree species thrived and the forest canopy became denser. The forest floor became more shaded, cooler, wetter and less flammable. The longer fire was excluded from the forest, the more favorable conditions become for shade-tolerant species and the less favorable they become for oaks and other sun-loving, fire-tolerant species.

Burning by Native Americans maintained the eastern oak forests and prairies for the last 5,000 to 7,000 years (Abrams and Nowacki 2008). Frequent burning promoted fire-tolerant trees and shrubs that supplied nuts and fruits for people and the game they hunted. Oak forests continued to thrive after European settlement and during the era of clearcutting, burning and forest grazing. Replacement of oaks by more shade-tolerant tree species became evident in the 1960s and, since then, much research has been directed toward the problem (Healy et al. 1997). The PGC and DCNR land managers have been leaders in using controlled burning and the best available management practices to maintain oak forests and other high-quality wildlife habitat.

Acidic deposition, invasive species, pathogens, insect pests and poor land management also influence forest health at regional and statewide levels. These stress factors interact with each other and with deer, and generally the interactions intensify the negative effects on forest health. Acid rain is a statewide problem that has changed forest soils over the past century, lowering ph, depleting soil reserves of calcium and magnesium and increasing the availability of aluminum, which is toxic to aquatic organisms and some plants (Bailey et al. 2005). The effects of acid depositions have been most pronounced on nutrient poor soils on the unglaciated Allegheny plateau in northwestern and northcentral Pennsylvania (Horsley et al. 2000). On these soils, nutrient stress caused by acid rain, coupled with insect defoliations and drought, has caused extensive decline and mortality of sugar maple (Horsley et al. 2000). Other species, such as American beech and black cherry have shown positive growth responses under these conditions. The nutrient requirements of most forest tree species remain unknown, but consideration of soil quality will become increasingly important for forest management.

Acid deposition will be an increasing challenge to the maintenance of forest productivity. Pennsylvania receives some of the highest acid deposition rates measured in the United States (Bailey et al. 2005). If these deposition trends continue, there will be additional loss of soil nutrients, increased soil acidity and greater availability of toxic elements. These changes will create additional nutrient imbalances that can negatively affect plant growth. To date, nutrient deficiencies caused by acid rain have been noted primarily in mature sugar maple trees. The soil changes apparently have not affected seedling germination or growth, and tree regeneration has not shown a positive response to the application of lime.

Poor forest management contributes to both the lack of regeneration and the loss of oaks and other species important to wildlife. Private owners hold the majority of Pennsylvania's forestland, with families and individuals owning 54 percent of the forest acreage (McWilliams et al. 2004). Timber harvest on "noncorporate" forestland is generally conducted without the guidance of a professional forester. Sales are usually diameter-limit cuttings,--a process that takes the largest and best trees and leaves the rest. Such cuts are usually made without regard for advance regeneration and result in poor regeneration, loss of valuable timber species and reduced future potential returns to the landowner. In addition, if done during unfavorable weather, or skid roads and stream crossings are poorly designed, such cuts result in increased erosion and loss of soil nutrients. Both the PGC and DCNR have programs to assist landowners and educate them about the benefits of good forest management.

Introduced pathogens have had profound negative impacts on Pennsylvania's forests, and new threats will undoubtedly arise in the future. Pathogens that eliminate "foundation" species (those that define forest structure and control ecosystem dynamics) have had the most damaging and persistent effects (Ellison et al. 2005). Chestnut blight provides the best example. Within 50 years of its introduction in 1904, the blight had eliminated American chestnut as a fruiting tree across 3.6 million hectares. Chestnut was the most reliable seed producer in the eastern forest, and loss of chestnuts as a food source affected all wildlife, not just animals that eat seeds. Because of its abundance and rapid growth, loss of chestnut also changed nutrient cycling and growing conditions for other forest plants. Two other foundation species, American beech and eastern hemlock are currently threatened by introduced pathogens and insect pests.

Insect defoliators, both native and introduced, have caused extensive tree mortality, but have not caused the loss of species. Forests can generally recover from defoliations, provided deer numbers are in balance with the habitat. Where mortality from defoliation is coupled with excessive deer browsing, the results are poor regeneration and change in species composition. The numerous factors affecting forest health emphasize the importance of maintaining healthy forests with abundant advance regeneration.

### *Pooling Data For Deer/Habitat Interactions*

Forest habitat health data must be pooled over five-year periods to achieve desired levels of precision for statistical testing. Forest habitat data were collected by the USDA Forest Service Forest Inventory and Analysis unit (FIA). The FIA used a standardized, national sampling design with a sampling intensity of about one plot per 6,000 acres. The FIA methods were designed to produce reliable estimates of forest characteristics for the state. FIA analyzed data for smaller areas, but the smaller the area of interest, the smaller the sample size, and the larger the confidence limits on estimates. The PGC system of WMUs was developed independently of the FIA sampling frame, and the relatively small size of WMUs requires pooling data to make reliable estimates.

The FIA habitat data was one of the strongest data sets available to the PGC, but both parties recognize the benefits of increasing sample size, especially in the smaller WMUs and those with little forest area. The PGC and FIA staffs are discussing ways to increase sample size, but the options are limited by budget constraints and the sampling method itself. Regeneration must be sampled during summer (10 weeks) when seedlings can be identified, and the regeneration analysis is limited to plots with 40-75 percent overstory stocking.

## Citizen Advisory Committees

Citizen Advisory Committees (CACs) were a tool used by the PGC to gain insight into public opinions on deer management. In a CAC, representatives of predetermined stakeholder groups volunteer to serve with one another to arrive at a consensus for management action. Such committees have been employed in other states (e.g., New York) and in local municipalities (e.g., Rochester Hills, Michigan) to address a wide range of natural resource issues, including white-tailed deer, water quality and fisheries management. CACs were initiated in Pennsylvania during April 2006 in WMU 4B. Each WMU was slated to hold a CAC, and a total of 15 CACs have met and provided recommendations to the PGC to date, with three scheduled to meet during 2010 and four more thereafter.

The process of convening the CACs and structure of the committees were the same across all WMUs. A public announcement was distributed through various media (newspapers, on the PGC website, etc.), potential members either nominated themselves or were nominated by another member of their stakeholder group, or suggested by PGC staff and other "outside organizations" (according to Office of Strategic Services) and were then interviewed by a member of the team from the Bureau of Management Consulting contracted to facilitate the CAC meetings. The standard interview consisted of a series of questions to determine willingness to serve on the CAC, ability to commit to the meeting dates and willingness to complete the tasks required of the committee members. Once CAC members were identified, an introductory meeting was held in winter/early spring to review procedures and purpose of the CAC. PGC management goals (maintain healthy deer herd and healthy forest habitat), history of Pennsylvania's deer management program and deer management data specific to the WMU were presented to CAC members at that time. Each member also received a copy of "Pennsylvania Game Commissions Citizen Advisory Committee (CAC) Pilot Study, Objectives, and Overview" prior to the first meeting. A second meeting was held approximately one month after the first meeting. CAC members were asked to solicit responses to three questions related to perceptions of deer herd growth ("increasing," "decreasing," "stable"); perspectives on population ("too high," "too low," "about right"); and preferences for herd growth ("increasing," "decreasing," "stay the same") from at least 10 members of their stakeholder group and report the responses at the second meeting.

The goal of the CAC process was to build consensus regarding deer management in the particular WMU, specifically whether the deer population should increase, remain the same or decrease. Consensus was reached when all participants, or all but one, were in agreement with the population recommendation. CAC recommendations were used by the PGC deer team to aid in its decisions regarding changes in deer populations.

### *Results of CAC Process*

Of the 15 CAC meetings held as of July 2009, 10 recommended populations increase, 1 increase or stay the same, 2 stay the same, 1 decrease, and 1 CAC was not able to reach consensus in WMU 5B. The PGC deer team accepted recommendations from 7 of the 14 CACs that provided them (discounting WMU 5b). The reason recommendations were not accepted by the remaining four WMUs was that the deer team determined forest health could not accommodate an increased deer population.

### *Interpretation of Data*

Given that the CAC process was incomplete (seven WMUs have yet to hold their CACs and WMU 5B did not reach consensus), it was too early to interpret the overall contribution of the CACs to deer management in Pennsylvania. However, analysis of key components of the process can be conducted at this time.

### *Reliability of Measure*

The CAC process relies on representatives from stakeholder groups to volunteer to serve on the committees. Stakeholder groups were suggested by PGC staff, but this process does not take the place of stakeholder scoping through accepted scientific procedures. Having volunteers serve on these committees was necessary (people cannot be forced to serve) and useful in gaining cooperation from committed members of the public. However, no assurance can be given that such volunteers represent the values and express attitudes held by the majority of the stakeholder groups they represent.

Moreover, these volunteers were then asked to collect perceptions and preferences regarding deer populations from members of their stakeholder group. It was reasonable to assume that, in some instances ,representatives will work within their known social networks and gather responses that may represent a biased stakeholder perspective. In other words, people naturally associate with individuals who share their values and will naturally turn to these individuals when seeking input, thereby calling into question the extent to which their responses represent the group as a whole.

Another limitation of the CAC process is the use of facilitators from the Office of Strategic Services (OSS). Use of such facilitators provided the PGC with a ready framework for the CAC meetings, but lack of understanding of the issue and the stakeholder groups may pose a problem. There also appears to be inconsistencies in the manner in which the CAC process was conducted. For example, CAC meetings conducted during 2008 included a question to be asked of members of the stakeholder group: "Of those wanting an increase…" and responses to each of the following: "Number willing to tolerate an increase in negative interactions" and "Number not willing to tolerate an increase in negative interactions." This item was not included in prior CAC meetings or in subsequent CAC meetings held during 2009. Such differences make comparisons more difficult. Furthermore, examining the proportions of stakeholder responses to these items suggests stakeholder discrepancies with the consensus decisions arrived at through the CAC. For example, it was common to find a majority (or even a unanimous response) for one or the other response category.

Conflict can ensue in WMUs where representatives from a particular stakeholder group express a strong majority or unanimity in not willing to tolerate an increase in negative interactions and the CAC otherwise reaches consensus to increase the deer population.

The apparent discrepancy in the degree to which stakeholder groups were willing to tolerate negative interactions highlights another aspect of the CAC that warrants further attention. This is the disparity between CAC recommendations and human conflicts. Several CACs expressed comments that appeared to downplay negative interactions, such as deer/vehicle collisions, agriculture crop damage and homeowner complaints. Although data were lacking to quantify the extent of these negative interactions, if CACs determine to accept them as necessary and are even willing to accept more such negative interactions, such may reflect negatively on the process in the future, particularly if deer/human conflict increases with an increased deer population that the CAC promoted. This potential for conflict is especially troublesome in urban areas, where forest health has not been an issue and hunting is most limited, and also in agricultural areas.

Opinion leader bias was often noted in focus groups and may be a potential source for concern with the CAC process as well. Opinion leader bias occurs when a vocal member of a focus group, public meeting or other body is highly persuasive and able to convince others to his or her point of view. Considering the initial perceptions of the levels of present deer populations of the WMUs presented in some second meetings of the CAC (e.g. WMU 2A), a clear consensus was not apparent. However, agreement was reached, although it was not clear what persuaded the change in stakeholder determination. When desired direction for deer population growth expressed by stakeholder members at large was considered, the change in direction for desired population growth was more apparent and it became obvious that some CAC members went against the preferences expressed by their fellow stakeholders in meeting consensus. This action illustrated not only the potential for members to be influenced by the process (socially desirable to not be the "holdout," which is akin to a dynamic observed in jury deliberations), but also the subjective nature of the CAC process. What was not clear in the results of the CAC process was how the CAC representative was received when reporting the consensus decision to the stakeholder group at large.

The issue of dissent was not given much consideration in the written record of the CACs. Few of the CAC reports detailed the stakeholder group in dissent. An examination of the responses to questions posed to stakeholder members showed a different picture than that reported in the final decision. In approximately one-third of the WMUs, the private forestry industry members responded counter to the consensus decision, namely, to decrease the size of the deer herd. A similar sentiment was observed among the Agriculture Livestock/Cash Crop group. Given that members of those two groups expressed preferences for herd size counter to consensus decisions for respective WMUs suggests the potential for conflict over the final decision.

Representation as a particular stakeholder was difficult, as stakeholder groups were not mutually exclusive. In a state such as Pennsylvania, where participation in deer hunting was high (especially in rural areas), it was difficult to find representatives of stakeholder groups who were not also deer hunters. This overlap made it difficult to assign the values and attitudes expressed to one stakeholder group when they are influenced by another role on the part of the representative. In one CAC, the highway safety representative expressed this clearly when he reported that older members were deer hunters and expressed one preference, whereas younger members had few deer hunters and therefore expressed different viewpoints. It is difficult for individuals to compartmentalize their values based on association with one group, when association with another group (i.e., deer hunters) may be more important to them and a source of their attitudes when discussing deer management.

### Refinement

Use of the CAC process provided direct, qualitative stakeholder input into deer management decision making; however, it was not a substitute for quantitative data collected via scientific surveys that would allow drawing inferences for stakeholder populations. Moreover, such surveys would provide information from groups not represented in the CAC process. Appropriately conducted scientific surveys provide a better vehicle to collect quantitative information than the current CAC process. Responses collected through the stakeholder-input process cannot be confused with data collected through scientific surveys using random samples of populations. Scientific surveys work to reduce bias, yet no such efforts are made with the CAC process. As such, results of the CAC process should be viewed in the context of larger scientific studies. Attitudes expressed during the CAC meetings can be tested in the surveys, public stakeholder attitudes determined and compared with attitudes expressed during the CAC process.

### CAC Recommendations and Deer Management Plan

The PGC conducted numerous open houses, gathered stakeholder comments and concerns through a series of public meetings, and organized CACs for each WMU. CACs strived to reach consensus on decisions regarding managing size of deer populations in the respective WMU (Table 11, page 49). CAC recommendations were made for 14 of the 15 WMUs for which CACs had been conducted (the CAC for WMU 5B was not able to reach consensus). Of the 15 recommendations, 11 were to increase, 1 to either increase or remain the same, 2 to remain the same, and 1 to decrease deer populations. PGC deer team accepted 7 of the CAC recommendations, but rejected 4 as they provided recommendations (increase deer population) in opposition to deer team determinations based on habitat quality and deer herd health. Decision are currently pending on the remaining 4 WMUs.

The PGC was committed to employing stakeholder input into its decision-making process, as evidenced in the change to use impacts over deer numbers for population goals based on input provided during stakeholder meetings in 2003. One aspect of impacts that needs to be refined is the metric used and data provided to determine impacts. It appears from the allocation worksheets that, thus far, "impacts" were defined by "deer/human conflicts." However, the metrics used to assess these conflicts as reported in the antlerless allocation worksheets were restricted to Agricultural Control Deer Permits ("Red Tag" permits) and Deer Management Assistance Program (DMAP). Such assessment was skewed toward agricultural interests and excluded impacts experienced by other stakeholders, including homeowners (e.g., landscaping damage), motorists (deer/vehicle collisions), and persons especially concerned with biodiversity issues.

Interpretation of CAC recommendations with respect to PGC decisions provided common factors leading to the decision to accept or reject CAC recommendations. Each of the four CAC recommendations rejected suggested an increase in the deer population for the respective WMUs (1A, 2C, 4C, 4D). Recommended increases ranged from 15 percent for WMU 4D, 20 percent for 4C, 30-40 percent for 1A, and to 25-50 percent for WMU 2C. Habitat health was rated as "fair" (2008-09) for all four WMUs, although 2C and 4D had been rated as "poor" during 2006-07. CAC recommendations were accepted for ten WMUs: 1B, 2A, 2E, 3A, 3B, 4A, 4B, 4E, 5A, and 5C. The CAC for WMU 4C recommended a 40 percent increase in the deer population and, as habitat health was rated "good" for both 2006-07 and 2008-09 assessments, this recommendation was accepted. Two CAC recommendations (WMUs 4B and 5C) were also for increased deer populations, but the recommended percentage increases were more modest than those rejected (10-20 and 12 percent, respectively) even though habitat health was also rated as "fair." Two CAC recommendations were to hold the population stable (2A and 3B) and one was for a decrease in the population (4E). Four CAC recommendations (1B, 2E, 3A and 4A) recommended population increases conditioned on improvement in the habitat measure.

Another difference noted between CAC recommendations accepted and those rejected was that, in each of the four accepted CAC recommendations for a population increase, associated comments contained language explicitly stating that such population increases were contingent upon the habitat supporting such an increase. Such comments relating population increase to habitat health did not appear in the CAC reports for any of the WMUs for which recommendations were rejected. Although it was assumed from instructions to CAC members provided by OSS facilitators that deer population increases were possible only where the habitat quality supported the increase, the question remains why the difference in the comments existed between the two groups.

CACs provide a valuable means for the PGC to gather stakeholder input and, from comments received by PGC deer management staff, such input was highly valued.

The PGC has employed other sources of stakeholder input into deer management in the state, including open houses, public meetings and surveys. Use of scientific surveys is a vital source of data regarding wildlife management in many states. Whereas 10 surveys have been conducted either by the PGC or through a private consulting firm from 1995 through 2005, all have focused on hunters (six on deer hunters exclusively). Given the need to understand attitudes by a major stakeholder group in deer management, no attention has been given to understanding experiences, attitudes and management preferences of other stakeholders. Furthermore, two surveys exhibited lower response rates compared with surveys of hunters conducted in other states. This may in part be due to the particular methods used (telephone surveys). Surveys conducted by PGC staff received responses comparable to those of other states.

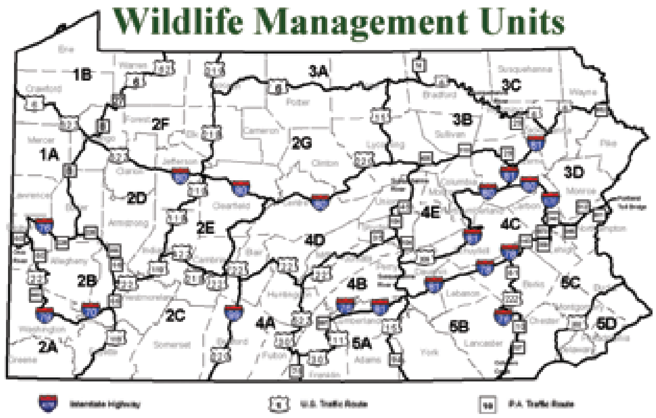


**Figure 19. Pennsylvania Wildlife Management Units.**

Generally speaking, hunters are avid respondents to surveys about hunting and wildlife management, and produce response rates (along with that of anglers) among the highest of survey research. Response rates aside, sample sizes were lower than hunter studies in many other states. Lower sample sizes and response rates may render inferential statistics more difficult, especially in terms of confidence intervals for reported findings. One study conducted in 2004 did not report the initial sample size. Questionnaire items in these surveys focused on attitudes and experiences, with few items addressing management preferences. Reported findings have been limited to frequencies of response, with little attention given to more detailed analyses, such as multivariate statistics or modeling.

Issues surrounding deer management in Pennsylvania are complex, not only biologically and ecologically, but socially as well.

## Wildlife Management Unit Effectiveness

Prior to the 2003-04 deer hunting season, Pennsylvania counties were used as deer management units. The PGC pooled data among counties to increase sample size and to achieve desired levels of precision in estimation of deer population measures. Prior to the 2003-04 season, the PGC grouped data from Pennsylvania's 67 counties into 31 management units for statistical analysis.

The PGC also managed bear, beaver, bobcat, pheasant, quail and turkey on a management unit basis. Management units for these species were also based on county boundaries although each species had different unit boundaries. The PGC concluded that inconsistent boundaries between units could be a source of confusion for hunters and trappers. WMI recognizes that county boundaries can also be difficult to recognize in the field (as opposed to highways and large waterways used in conjunction with current WMUs). Management unit boundaries containing consistent, similar habitats were also believed to allow more consistent management techniques to achieve desired wildlife densities.

For these reasons, the PGC implemented the current system of WMUs for the seven species mentioned above, including deer, beginning with the 2003-04 hunting and trapping seasons (Rosenberry and Lovallo 2002) (Figure 19, left). The PGC considered the following factors during development of the current system of WMUs: amount of forested land, amount of public land, human populations density, and physiographic provinces and sections within the state.

## *An Evaluation of Management Unit Objectives*

The PGC provided data that allowed an evaluation of the effectiveness of the current WMUs in achieving management goals for five hunting seasons, beginning with the 2003-04 season through the 2007-08 season. WMI used the following criteria to evaluate the degree to which the PGC was meeting management objectives: if the management objective for year t was to increase or decrease the population, the year t+1 pre-hunt density estimate had to move at least 10 percent in the correct direction (up or down to correspond with increase or decrease) as compared with the pre-hunt density for year t. For example, for the 2003-04 season, the management objective for WMU 2C was to decrease the population. The pre-hunt deer density estimate in 2C for the 2003-04 season was 27 deer per square mile. Harvest during the 2003-04 season resulted in a pre-hunt density estimate of 23 deer per square mile in 2C going into the 2004-05 season--a decrease of 4 deer per square mile or 14.8 percent. Because the change in population size exceeded 10 percent, WMI judged that the management objective (decrease) for 2C was achieved during the 2003-04 season. Similarly, the harvest in 2C during the 2004-05 season resulted in a pre-hunt density estimate of 22 deer per square mile going into the 2005-06 season. Even though there was an estimated reduction of one deer per square mile from the previous year and the management objective for 2C during the 2004-05 season was to decrease the

**Table 11. Success in meeting management objectives in by Wildlife Management Unit for 2003-2008. Cells shown as UPPERCASE designate management objectives met. *Italicized* cells designate management objectives for which population changes were more than 10 percent in the direction opposite of the management objective or population changes more than 20 percent for which the objective was to stabilize.**

| WMU | 2003-04 | 2004-05 | 2005-06 | 2006-07 | 2007-08 |
|---|---|---|---|---|---|
| 1A | Decrease | Decrease | STABLE | ***Stable*** | STABLE |
| 1B | Decrease | Decrease | STABLE | Stable | STABLE |
| 2A | Decrease | Decrease | STABLE | STABLE | STABLE |
| 2B | Decrease | Decrease | Decrease | DECREASE | DECREASE |
| 2C | DECREASE | Decrease | STABLE | STABLE | STABLE |
| 2D | Decrease | Decrease | STABLE | Stable | STABLE |
| 2E | DECREASE | ***Decrease*** | STABLE | STABLE | Stable |
| 2F | DECREASE | DECREASE | STABLE | STABLE | STABLE |
| 2G | DECREASE | Decrease | STABLE | Stable | ***Stable*** |
| 3A | Decrease | Decrease | STABLE | ***Stable*** | ***Stable*** |
| 3B | Decrease | Decrease | STABLE | STABLE | ***Stable*** |
| 3C | DECREASE | Decrease | STABLE | STABLE | Stable |
| 3D | DECREASE | Decrease | STABLE | STABLE | STABLE |
| 4A | DECREASE | Decrease | ***Stable*** | ***Stable*** | ***Stable*** |
| 4B | DECREASE | DECREASE | STABLE | Increase | Increase |
| 4C | Decrease | Decrease | STABLE | STABLE | STABLE |
| 4D | DECREASE | Decrease | STABLE | Stable | Stable |
| 4E | DECREASE | Decrease | Stable | Stable | Stable |
| 5A | Decrease | DECREASE | STABLE | STABLE | STABLE |
| 5B | Decrease | Decrease | STABLE | STABLE | STABLE |
| 5C | Decrease | Decrease | Decrease | Decrease | DECREASE |
| 5D | Decrease | DECREASE | Decrease | Decrease | Decrease |

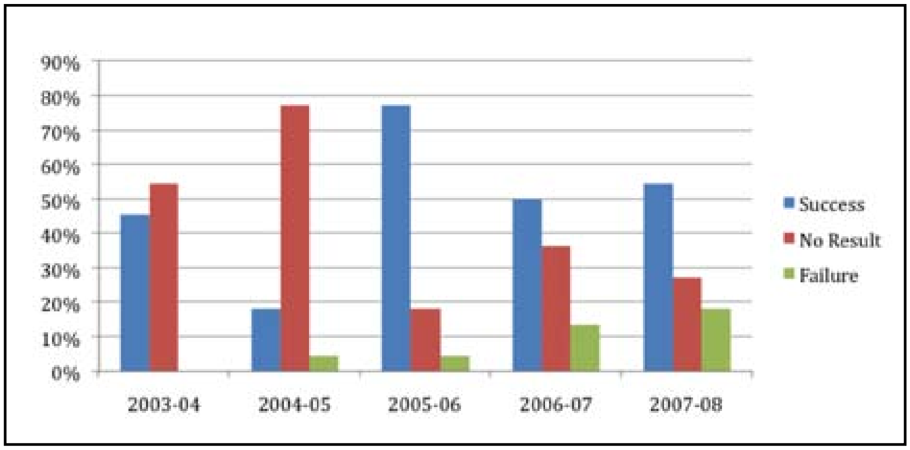


**Figure 20: Percentage of years in which PGC management unit objectives were attained or missed.**

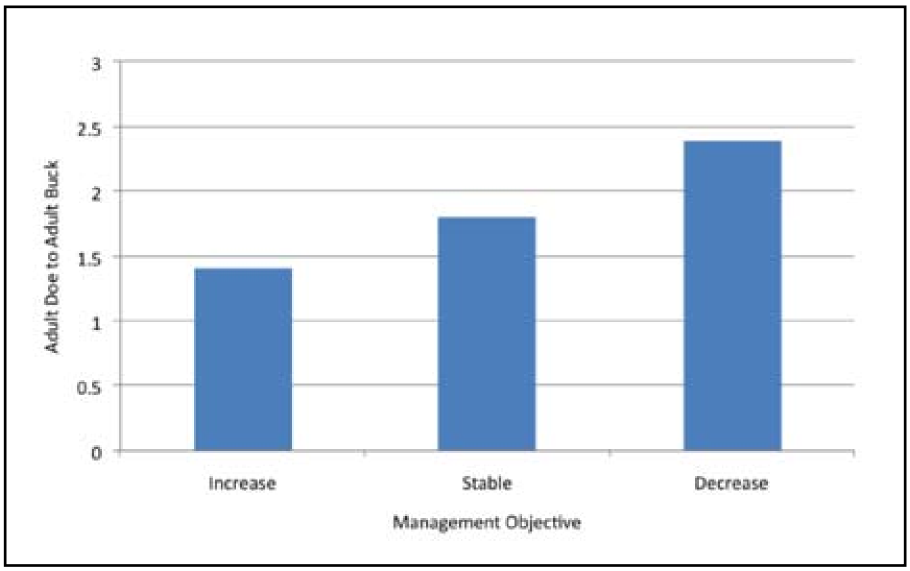


**Figure 21: Observed adult doe-to-adult buck ratios in the harvest in seasons with different management objectives.**

Using these criteria, WMI determined that the PGC met its management objective 49 percent of the time (54 of 110 opportunities) for the new, larger WMUs during the five hunting seasons beginning with 2003-04 (shown in UPPERCASE in Table 11, page 49).

WMI also analyzed the degree to which management objectives were missed. WMI evaluated those WMUs and years in which changes in density were more than 10 percent in the direction opposite of an increase/ decrease management objective or greater than 20 percent change in a population with a management objective of stabilize. For both sets of criteria combined, WMI documented nine occurrences (8 percent) with a significant deviation from the management objective These are highlighted in italics in Table 11, page 49.

In summary, management objectives for the new, larger WMUs were not met 42 percent of the time but not to the extent deemed problematic. They substantially missed the objective 8 percent of the time (Figure 20, left)).

population, the magnitude of the change in density estimates (4.3 percent) was not adequate to exceed the 10 percent criteria limit. So, it was judged that the management objective to decrease the population in WMU 2C during the 2004-05 season was not met. For WMUs and seasons for which the management objective was to keep the population stable, a change in pre-hunt density estimates less than +/- 10 percent were judged as meeting the objective. The 2008-09 season was not included in this evaluation because pre-hunt density estimates for the 2009 season were not available at the time this report was prepared.

The relatively high percentage that PGC management objectives were met indicates that WMUs are of sufficient size to provide adequate sample sizes to estimate deer harvest, age structure and sex ratios. WMI evaluated this indicator directly, by calculating differences in estimated adult sex ratio of harvested deer. Harvest sex ratios should be higher when the management objective is to decrease, and lowest when the objective is to increase. PGC results fit the expected relationship well (Figure 21, left).

**Table 12. Numbers of antlerless deer harvested through Pennsylvania's DMAP by WMU for the years 2003-2008.**

| WMU | 2003-2004 | 2004-2005 | 2005-2006 | 2006-2007 | 2007-2008 |
|---|---|---|---|---|---|
| 1A | 9 | 35 | 61 | 132 | 75 |
| 1B | 68 | 168 | 169 | 164 | 196 |
| 2A | 12 | 12 | 25 | 29 | 12 |
| 2B | 1 | 8 | 2 | 2 | 2 |
| 2C | -- | -- | 248 | 287 | 186 |
| 2D | -- | -- | 116 | 87 | 113 |
| 2E | -- | -- | 134 | 54 | 129 |
| 2F | 3075 | 3048 | 2698 | 2703 | 480 |
| 2G | 1158 | 1306 | 1308 | 1417 | 1629 |
| 3A | -- | -- | 383 | 387 | 270 |
| 3B | -- | -- | 383 | 319 | 256 |
| 3C | -- | -- | 242 | 245 | 231 |
| 3D | -- | -- | 386 | 408 | 278 |
| 4A | -- | -- | 323 | 328 | 338 |
| 4B | -- | -- | 44 | 9 | 9 |
| 4C | -- | -- | 188 | 121 | 133 |
| 4D | -- | -- | 721 | 540 | 517 |
| 4E | -- | -- | 28 | 33 | 39 |
| 5A | -- | -- | 40 | 54 | 60 |
| 5B | -- | -- | 52 | 26 | 28 |
| 5C | -- | -- | 14 | 41 | 33 |
| 5D | -- | -- | 1 | 10 | 0 |
| Total | 4323 | 4577 | 7566 | 7396 | 5014 |

**Table 13. Percentage of antlerless harvest comprised of deer taken via the DMAP by WMU for the years 2003-2008.**

| WMU | 2003-2004 | 2004-2005 | 2005-2006 | 2006-2007 | 2007-2008 |
|---|---|---|---|---|---|
| 1A | >1.0 | >1.0 | >1.0 | 1.0 | 5.6 |
| 1B | >1.0 | 1.4 | 1.6 | 1.4 | 1.7 |
| 2A | >1.0 | >1.0 | >1.0 | >1.0 | >1.0 |
| 2B | >1.0 | >1.0 | >1.0 | >1.0 | >1.0 |
| 2C | * | * | 1.8 | 2.3 | 1.6 |
| 2D | * | * | >1.0 | >1.0 | >1.0 |
| 2E | * | * | 1.8 | >1.0 | 2.0 |
| 2F | 15.3 | 18.8 | 24.5 | 25.2 | 6.3 |
| 2G | 7.0 | 10.9 | 17.4 | 23.7 | 16.1 |
| 3A | * | * | 4.2 | 4.2 | 3.3 |
| 3B | * | * | 3.4 | 2.9 | 2.5 |
| 3C | * | * | 2.1 | 2.6 | 2.4 |
| 3D | * | * | 5.1 | 5.2 | 3.8 |
| 4A | * | * | 4.1 | 4.0 | 4.8 |
| 4B | * | * | >1.0 | >1.0 | >1.0 |
| 4C | * | * | 1.9 | 1.3 | 1.4 |
| 4D | * | * | 7.9 | 5.2 | 6.0 |
| 4E | * | * | >1.0 | >1.0 | >1.0 |
| 5A | * | * | >1.0 | 1.0 | 1.5 |
| 5B | * | * | >1.0 | >1.0 | >1.0 |
| 5C | * | * | >1.0 | >1.0 | >1.0 |
| 5D | * | * | >1.0 | >1.0 | >1.0 |
| Statewide | 1.3 | 1.6 | 3.1 | 3.1 | 2.3 |

**DMAP not offered.*

## *Deer Management Assistance Program*

When the PGC concluded that "political subdivisions (counties) may or may not be associated with factors influencing wildlife populations" (Rosenberry and Lovallo 2002) and designed a set of 22 large WMUs, a parallel need was identified to allow landowners the opportunity to fine tune deer management to conditions present on their properties. In 2003, the PGC created the Deer Management Assistance Program (DMAP) to offer a viable alternative to smaller management units for deer. The DMAP program allows landowners to customize deer management within the WMU. Participants in DMAP include private forest landowners and state forests managed by DCNR Bureau of Forestry. Use of the DMAP has increased antlerless deer harvest by more than 3,000 in some years in some WMUs on lands where the landowners desired lower deer numbers (Table 12, above).

As noted in Table 12, above, the DMAP has potential to increase antlerless harvests substantially. Extensive use of the DMAP accounted for approximately 25 percent of the antlerless harvest in WMU 2F during the 2005-06 and 2006-07 seasons and nearly 24 percent of the antlerless harvest in WMU 2G during the 2006-07 season (Table 13, above).

## Table 14. Hunter numbers and effort (2007) from Pennsylvania and other northeastern states.

| State | Man Days of Effort | | | | | | Number of Hunters | Hunters per sq. mile |
|---|---|---|---|---|---|---|---|---|
| | Archery | Mzldr | Gun | Youth | Other | Total | | |
| CT | 160,257 | 56,153 | 126,298 | 346 | 43,616 | 386,670 | 60,454 | 16.0 |
| DE | 837,380 | 127,008 | 418,325 | | | 1,382,713 | 15,000 | 7.7 |
| ME | 401,841 | 234,612 | 4,163,616 | 15,274 | | 4,815,343 | 223,192 | 7.7 |
| MD | 2,225,000 | 836,000 | 920,000 | 5,000 | 189,000 | 4,175,000 | 132,500 | 13.5 |
| MA | 445,430 | 210,277 | 223,301 | | | 879,008 | 45,000 | 9.7 |
| NH | 1,795,656 | 304,326 | 1,544,114 | | | 3,644,096 | 106,573 | 13.1 |
| NJ | | | | | | - | 81,381 | 15.5 |
| NY | | | | | | - | 553,792 | 11.7 |
| PA | 2,422,940 | 527,399 | 3,153,296 | | | 6,450,948 | 715,553 | 15.8 |
| RI | 376,011 | 106,789 | 63,824 | | | 546,624 | 11,689 | 16.5 |
| VT | 640,000 | 216,000 | 2,000,000 | 19,200 | | 2,875,200 | 178,600 | 22.7 |
| VA | 717,587 | 745,245 | 1,730,954 | | | 3,193,786 | 434,500 | 11.7 |
| WV* | NA | NA | NA | NA | NA | 1,977,000 | 184,608 | 7.7 |

* 2006 data

## Table 15. Deer harvest statistics (2007) from Pennsylvania and other northeastern states.

| State | Kill | | | | | | Kill/Effort | Kill per sq. mile |
|---|---|---|---|---|---|---|---|---|
| | Archery | Mzldr | Gun | Youth | Other | Total | | |
| CT | 2,714 | 725 | 6,437 | 51 | 1,186 | 11,113 | 0.029 | 2.9 |
| DE | 1,467 | 2,088 | 9,283 | 78 | 773 | 13,689 | 0.010 | 7.0 |
| ME | 2,236 | 1,964 | 23,537 | 1,065 | | 28,802 | 0.006 | 1.0 |
| MD | 21,015 | 17,348 | 50,585 | 2,211 | 1,049 | 92,208 | 0.022 | 9.4 |
| MA | 3,303 | 2,246 | 6,020 | | 7 | 11,576 | 0.013 | 2.5 |
| NH | 3,808 | 2,787 | 6,322 | 642 | | 13,559 | 0.004 | 1.7 |
| NJ | 17,312 | 8,338 | 20,642 | 725 | | 47,017 | | 9.0 |
| NY | 31,060 | 17,207 | 77,114 | | 93,760 | 219,141 | | 4.6 |
| PA | 60,890 | 23,920 | 238,260 | | | 323,070 | 0.050 | 7.1** |
| RI | 515 | 1,378 | 693 | | | 2,586 | 0.005 | 3.7 |
| VT | 2,832 | 3,011 | 6,839 | 1,834 | | 14,516 | 0.005 | 1.8 |
| VA | 26,027 | 52,386 | 163,163 | | | 241,576 | 0.076 | 6.5 |
| WV* | 39,402 | 10,913 | 103,870 | | NA | 154,185 | 0.1 | 6.4 |

* 2006 data
** WMI calculated kill per square mile for PA based on 44,816 square miles of area in the state.

**Table 16: Responses of state deer project leaders to questions about deer management programs in Pennsylvania and states with comparable programs to Pennsylvania.**

| | |
|---|---|
| **Do you make annual estimates of your deer population size?** | |
| PA | Yes. Use SAK model |
| OH | Yes. Use Downing method for buck pop. & Lang and Wood SAK for rest |
| MI | Yes. Use SAK model |
| WI | Yes. Use SAK model and accounting style models |
| WV | Yes. Use rough estimate from antlered harvest & modified SAK |
| MD | Yes. Use Downing method for buck pop. & Lang and Wood SAK for rest |
| NJ | Yes. Use a modified SAK model |
| NY | Yes. Use SAK model |
| **Do you require hunters to register deer that they harvest** | |
| PA | Yes but not rigidly enforced. Follow up with hunter survey as a check |
| OH | Yes and it's rigidly enforced |
| MI | No. |
| WI | Yes and it's rigidly enforced |
| WV | Yes and it's rigidly enforced |
| MD | Yes and it's strongly enforced, but follow up with hunter survey as a check |
| NJ | Yes and it's rigidly enforced |
| NY | Yes but not rigidly enforced. Follow up with checks at meat proc. & a few check stations |
| **Do you regulate harvest of either the antlered or antlerless segments of your population, or both** | |
| PA | One antlered buck per season per hunter and use antler point restrictions. For antlerless use license quotas. |
| OH | One antlered buck per hunter per season and no antler point restrictions. Control antlerless harvest with bag limits, seasons and restrictions on special permits |
| MI | Two antlered bucks per season per hunter and use antler point restrictions. For antlerless use license quotas. |
| WI | Two antlered bucks per season per hunter and no antler point restrictions. Use antlerless permit quotas in some units and don't restrict it in others (CWD zone & herd reduction units) |
| WV | Three antlered bucks per season per hunter and use antler spread, season length and hunting implement restrictions on bucks. Use season length hunting implement restrictions, bag limits & license quotas on antlerless. |
| MD | Two antlered bucks per season per hunter in most areas use season length and bag limits to influence antlerless harvests |
| NJ | Two antlered bucks per season per hunter and some antler point restrictions. Use season length and bag limits to influence antlerless harvests |
| NY | Buck harvest not regulated except in 4 WMUs where there a pilot antler point restriction program. Use permits and adjust some season lengths to influence antlerless harvests |
| **Do you use management units or apply similar deer harvest regulations across the entire state** | |
| PA | Management Units |
| OH | Management Units |
| MI | Management Units |
| WI | Management Units |
| WV | Management Units |
| MD | Management Units (but currently only have 2) |
| NJ | Management Units |
| NY | Management Units |

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| | |
|---|---|
| **If you use management units, are they based on political boundaries or physiographic regions** | |
| PA | Yes, for the most part based on ecological features |
| OH | Political-Counties |
| MI | Both- mostly counties in lower peninsula & more ecologically based in upper peninsula |
| WI | Yes, for the most part based on ecological features |
| WV | Political-Counties, but further breakdown some counties into habitat management units |
| MD | Political-Counties, but further breakdown Counties into habitat management units |
| NJ | Yes, for the most part based on ecological features |
| NY | Based for the most part on physiographic differences |
| **Do you have annual management objectives for each unit** | |
| PA | Yes, use increase, decrease or stabilize |
| OH | Yes, except for heavily urbanized counties. Goals are expressed in term of buck harvest |
| MI | Yes, use deer density goals |
| WI | Yes, use increase, decrease or stabilize |
| WV | Yes. Goals are expressed in term of buck harvest per square mile. |
| MD | No, but considering using increase, decrease or stabilize |
| NJ | Yes, use increase, decrease or stabilize |
| NY | Yes, except for heavily urbanized counties and a few low density WMUs. Goals are expressed in terms of buck harvest |
| **How were management objectives determined and how are they measured** | |
| PA | Use a public stakeholder process |
| OH | Farmer attitude surveys |
| MI | Set by DNR biologists who consider hunter success & satisfaction crop damage/complaints, deer/vehicle accidents, etc. |
| WI | Use a public stakeholder process |
| WV | Set by DNR biologists who consider sociological and biological factors. |
| MD | Don't currently have them |
| NJ | Set by agency biologists who consider hunter success & satisfaction crop damage/complaints, deer/vehicle accidents, etc. |
| NY | Use a public stakeholder process |
| **Does the size of your management units impact your ability to generate population and harvest estimates at a desirable level of precision** | |
| PA | No. Units are large enough to produce population and harvest estimates sufficient for management purposes |
| OH | No. To date population estimates have been sufficient for management purposes |
| MI | Yes-in units where harvest is relatively low |
| WI | Suspect that management unit size is too small. Currently evaluating this. |
| WV | No. Mandatory registered harvest provides a census not an estimate. |
| MD | Data pool too small to make decisions at habitat unit level. Adequate at management unit level |
| NJ | Yes-in units where harvest is relatively low |
| NY | Data are sufficient to generate acceptable harvest estimates at the WMU level. Low sample size is a problem in some WMUs for biological data |
| **Do you group data from multiple management units or pool data from multiple years for individual units to boost the size of data sets to improve precision** | |
| PA | Yes, pool habitat data across years to boost sample size, however, this is driven more by the amount of data collected in units as opposed to the size of the units |

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| | |
|---|---|
| OH | No |
| MI | Yes-group low harvest units to increase data pool |
| WI | Yes-pool data to increase sample size and reduce variance |
| WV | No |
| MD | No |
| NJ | Yes-both as deemed necessary |
| NY | Yes-for some analyses |
| **Do you gather data to assess deer physical condition** | |
| PA | Yes. Productivity via road-killed does |
| OH | Yes. Yearling antler beam diameter and periodically productivity via road-killed does |
| MI | Collect data on antler beam diameters and antler points |
| WI | Yes, test for several diseases. Occasionally check bone marrow and collect data on percentage of forked yearling bucks and sublegal (<3″)yearling bucks in harvest |
| WV | Yes. Body weights fetus counts, antler beam diameter, antler spread and antler points are collected. Some annually; some irregularly. |
| MD | Assess general herd condition by examining 4000+ animals annually at butcher shops |
| NJ | Collect data on antler beam diameters and antler points |
| NY | Yes. Yearling antler beam diameter. Recently completed a project to assess conception rates |
| **Do you have a process to assess deer carrying capacity or deer impacts to habitat** | |
| PA | Yes, a system to assess deer impacts on forest regeneration is in place throughout the state. |
| OH | No |
| MI | No, but considering it |
| WI | No, some small scale evaluations, but nothing on a landscape scale |
| WV | Long term (30-year) deer exclosure project. |
| MD | No |
| NJ | No, but currently developing rapid assessment methodology for this |
| NY | Incorporate info from foresters in stakeholder process. Discussing development of a forest condition index |

## Management of Hunting Pressure

WMUs are not currently designed to distribute hunting pressure and the PGC has received comments that some areas within WMUs receive higher hunter pressure resulting in overharvest. WMI notes that some states require a permit to hunt public land or subdivide WMUs designed for sampling purposes into sub-units to distribute hunting pressure.

## Comparisons of Pennsylvania to Other State Deer Management Programs

To compare deer hunting and harvest in Pennsylvania to similar states, WMI obtained data from the 2007-08 hunting season from 14 states. Data were provided by members of the Northeast Deer Technical Committee of the Northeastern Association of Fish and Wildlife Agencies.

Although Pennsylvania ranked high in virtually every category (Tables 14 and 15, page 52) (first in hunter-days of archery effort, hunter-days of total hunting, number of hunters, archery kill, and gun kill; second in hunter-days of gun-hunting and muzzleloader kill; and, third in hunter-days of muzzleloader hunting), this is not surprising because Pennsylvania ranks third in size (117,363 square kilometers, behind Ontario and New York) and second in human population (12,432,792, behind New York) of the 14 states and provinces in the comparisons. Because of the wide range of geographic size and human population of the jurisdictions in Tables 14 and 15, page 52, the most instructive comparisons are the numbers of hunters per square mile, in which Pennsylvania ranks fourth of the 14, second in kill per unit effort, and third in kill per square mile.

Previous work by WMI (Williamson 2003) calculated antlered (Figure 22, page 57) and antlerless (Figure 23, page 58) harvest data from the Northeast states for the years 1990-2000. Data were calculated at the WMU or county level, depending upon the jurisdiction.

In addition to the hunting/harvest information from the Northeast states and provinces, WMI conducted a survey of deer biologists from all the states that border Pennsylvania, plus Michigan and Wisconsin. The survey was designed to determine similarities among and differences between the states in terms of the various deer management programs. All seven states that were contacted (Ohio, West Virginia, Maryland, New Jersey, New York, Michigan and Wisconsin) provided information. Their responses, along with information for Pennsylvania, is summarized (Table 16, page 53).

All eight of the states use the SAK model to generate deer population estimates. Most, including Pennsylvania, adjust the model to fit circumstances in their respective states. Some of the states (Ohio, Wisconsin and Maryland) also employ additional techniques. Seven of the eight require hunters to register harvested deer. Four of those seven rigidly enforce this and the remaining three, including Pennsylvania, do not. Four of the eight allow hunters to take two antlered bucks per season; West Virginia allows hunters to take three; Pennsylvania, Ohio and Wisconsin restrict hunters to one. Four states use some form of minimum antler restrictions. All eight states use management units (Maryland only has two). Four of the eight, including Pennsylvania, use ecologically based boundaries for their management units, three use a combination of ecologically and politically based (county) boundaries and one, Ohio, uses all politically based (county) boundaries. All eight states have management objectives for their units. Four, including Pennsylvania, use population increase/decrease/stabilize as their objectives. Three establish objectives that are measured in terms of buck harvest and one, Michigan, sets objectives based on deer densities. Four, including Pennsylvania, use some type of public stakeholder process to establish management goals. The other four use agency staff to set objectives based on consideration of biological and sociological factors.

Five of the eight states believed that having relatively small management units compromises the precision of their statistical techniques due to lower sample sizes. The three states that felt comfortable with the precision of their estimates were Pennsylvania, which has relatively large management units, and Ohio and Wisconsin which both rigidly enforce mandatory registration of harvested deer so they get actual counts and don't need to generate harvest estimates. Five of the eight states, including Pennsylvania, have to pool data across multiple years or among management units to achieve adequate sample sizes for some evaluations, to deliver a desirable level of statistical precision. All eight states collect deer physical condition data, such as productivity and antler beam diameter information. Pennsylvania is the only state that has a process in place to make annual assessments of deer impacts to habitat. West Virginia reported a long-term exclosure project underway and that it periodically assesses deer condition and parasite loads as indicators of habitat quality. Of the remaining six states, three indicated that they were considering development of a process to evaluate deer impacts to habitat.

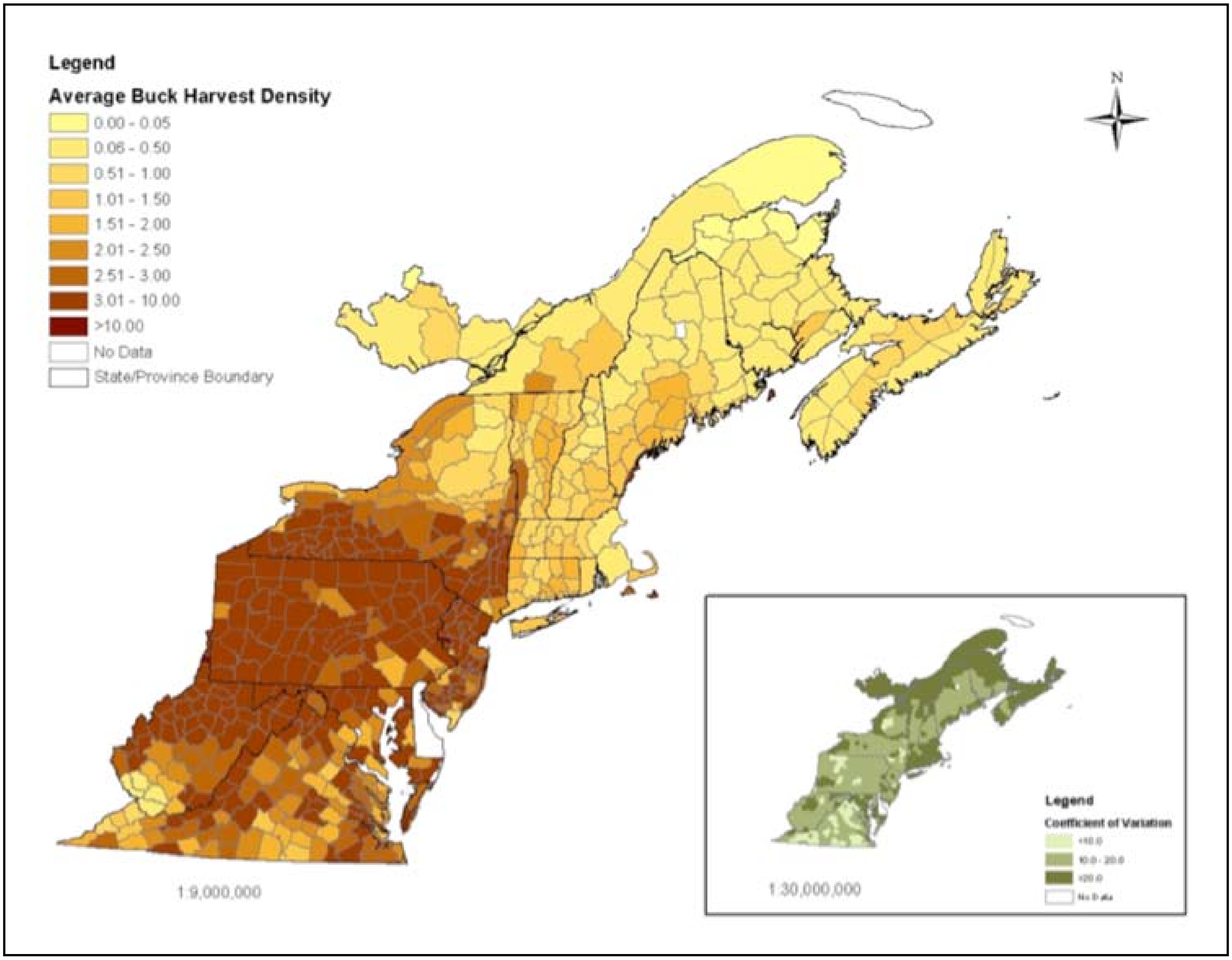


**Figure 22: Antlered deer harvest per square mile from eastern states and provinces. Data graphed are the average kill per square mile for the years 1990-2000.**

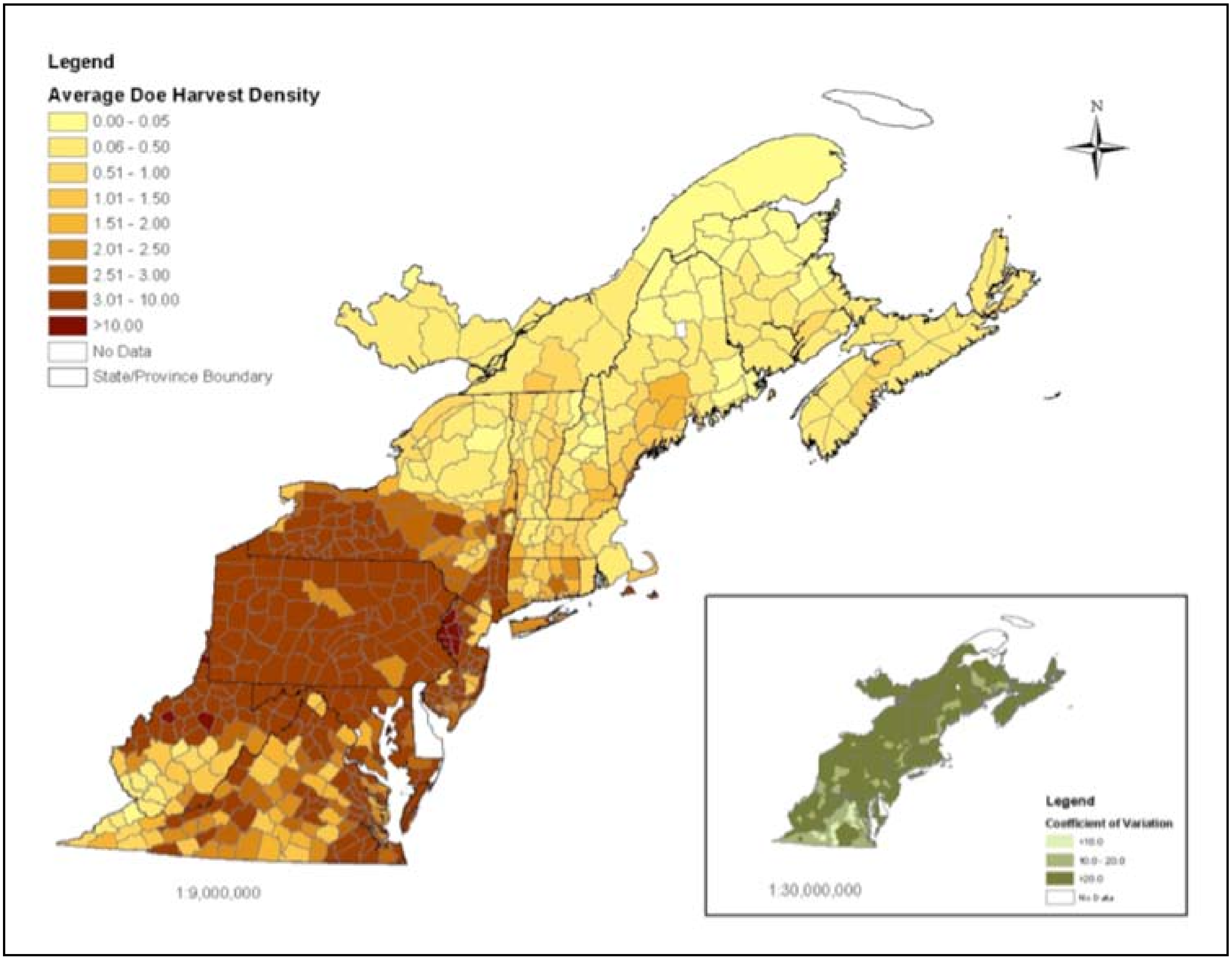


**Figure 23: Antlerless harvest per square mile from eastern states and provinces. Data graphed are the average kill per square mile for the years 1990-2000.**

# Findings, Conclusions and Recommendations

## Deer Management in Pennsylvania

***1. The PGC has created a framework for deer management decision making that allows the public to participate in defining the consequences of deer management through an open and science-based process.***

Since the 1920s, the PGC has sought to stabilize deer populations at levels that would avoid negative impacts to deer health, forest health and meet citizen desires. Until recently, population goals tied to deer health, forest health and citizen desires may not have been openly described or quantified to the public, to Commission members or even to PGC managers. Nonetheless, those three goals were operating under the surface throughout the period to guide antlerless permit allocations.

Through much of this time, the PGC used the empirically-derived carrying capacities of forest age classes to define deer density goals for management units. This early version of a forest health goal focused the public on expressions of deer density per square mile of young and old forest. The ensuing public debates about deer density overshadowed any discussions of the consequences of deer density to forest health, deer health and citizen desires.

Currently, the PGC has encouraged the public debate to focus on goals that openly and transparently allow the consequences of deer abundance to be understood. They have tried to shift the argument from "How many deer are there?" to "How many deer can Pennsylvania sustain without negative impacts"?

In too many circumstances, public debates about deer density or the size of an antlerless permit allocation (in Pennsylvania and in many other jurisdictions) camouflages the fact that deer can quickly become overabundant, cause harm to their habitat and impact both the hunting and non-hunting public. The PGC has invited the public to help the agency responsibly manage deer to minimize those consequences. For those who want more deer and those who want fewer deer, the language of debate is now centered on what is an adequate level of forest regeneration, how much will deer reproduction be affected by more deer, and how many instances of crop damage, Lyme disease, and deer/vehicle collisions and cost can the public tolerate before it demands fewer deer.

## Deer Management Goals and the Agency Mission

***2. The PGC has tried to develop deer management goals consistent with the agency's interpretation of its constitutional mandate. WMI found that the current goals chosen by the PGC are reflective of the mandate. WMI did not find that any economic interest or stakeholder group receives preferential treatment.***

The PGC is constitutionally mandated to conserve and maintain white-tailed deer and all other wildlife for the benefit of all people. Hence, the PGC should not legally take actions that benefit white-tailed deer at the expense of another native species of wildlife. Similarly, the PGC should not take actions that favor one citizen group over another. White-tailed deer management must balance all stakeholder interests in a manner that conserves and maintains the native flora and fauna of Pennsylvania.

The PGC cannot and does not manage white-tailed deer to achieve an economic goal. Although deer hunters and the economic impact of their spending are of considerable importance to many communities in Pennsylvania, the PGC should not adjust management goals to reflect economic sustainability. The goals of herd health and forest health allow the PGC to ascertain if its management of the white-tailed deer resource is affecting other wildlife resources. The CAC process allows the PGC to balance stakeholder interests for all of the people of the state, not just hunters (or environmentalists, foresters, farmers or motorists).

## Deer Population Models

***3. The PGC has developed a credible population model that factors in necessary adjustments to reflect antler restrictions. WMI also documented that the PGC strives continually to improve the precision of model inputs by conducting field research. All parties interested in deer management in Pennsylvania can be confident in the ability of the PGC to track deer population trends at the statewide and WMU scale through use of the PA SAK as long as PGC collection thresholds for data input are met or exceeded.***

WMI evaluated the PA SAK model by evaluating assumptions, data inputs, data interpretation and use of model outputs. It documented that the SAK model was used by the majority of states that employ a deer population model. More importantly, WMI learned how the PGC made necessary adaptations to the conventional SAK model to adapt to antler restrictions. While the sensitivity to model inputs varies, PGC will need to continue long-term research programs that continually test model inputs and refine model characteristics. Additional research funds will be necessary to continue to improve the model. The accuracy or bias of the PA SAK model was unknown and there were opportunities identified to use the PA SAK in experimental tests of adaptive harvest management. Numerous inputs to PA SAK rely on radio-collar- and research-derived estimates from a few, relatively small study areas over a relatively small time span. Finally, just as the PA SAK model was adapted to the imposition of antler restrictions, another iteration of the PA SAK would be required if regulatory changes are instituted that result in different vulnerabilities of adult bucks.

***WMI recommends that:***

1. The PGC continually test and evaluate the PA SAK outputs and inputs.

2. The PGC discontinue the practice of updating model outputs for year t with the reconstructed yearling buck harvest rate. Instead, WMI recommends that PGC rely solely upon the three-year average, yearling buck harvest rate as the PA SAK input.

3. The PGC prioritize research to understand better the significant variation present in yearling buck harvest rate.

4. The PGC discontinue the practice of calculating a fawn-to-adult doe correction factor until variation between WMUs and over time is better understood.

5. The PGC incorporate DMAP antlerless harvest into the PA SAK model and better highlight to the public the fact that DMAP is an important contributor to antlerless harvest in some WMUs.

***4. The PGC develop and prioritize policies and procedures to increase harvest reporting.***

The management system designed by the PGC is reliant upon accurate harvest data. While in general the system used by PGC to estimate deer harvest based on reporting rate is scientifically sound, WMI cautions that the declining trend in reporting rate may jeopardize the viability of harvest estimates in the future. With the point-of-sale license system now in place, the PGC has new capabilities to collect deer harvest information. WMI recommends consideration of different sampling methods, enhanced outreach efforts stressing the importance of hunters reporting their harvest, increased enforcement of mandatory reporting requirements and better understanding of biases associated with successful hunters who do not report harvest.

## WMU Deer Population Characteristics and Trends

***5. The PGC uses a scientifically valid method to calculate population size for each WMU. Model inputs provide additional estimates of age structure and sex ratio. The PGC should publish the estimates of population size and age and sex structure, accompanied by associated levels of variance, and an explanation of their appropriate use.***

The PGC's struggle to shift the public's emphasis away from "how many deer are there" has influenced PGC managers to withhold their estimates of deer population size to the public. The concern is that, if the public knows the estimate of population size, it will focus on that number instead of the consequences of that number. "You don't need to know the number of deer to manage deer" is the refrain often heard by the public.

WMI is aware that there are successful management systems for white-tailed deer that do not rely on population estimates *per se*. Indices to population size, such as the PA SAK model, are commonly used and sufficient for management.

WMI does not agree, however, that population estimates need to be shielded from the public. Doing so, in WMI's view, has weakened the trust placed in the PGC by the public and has affected the agency's credibility. The PA SAK model produces population estimates and associated measures of variation.  The population estimates are integrated into the process by which antlerless permit allocations are determined. WMI recommends that the estimates be made available to the public.

## Reproductive Rate as an Index to Herd Health

***6. The PGC should seek an alternative to embryos per adult doe as an index of herd health or consider deleting the herd health goal and putting additional resources into evaluation of forest (or habitat) health.***

Based on the analysis of embryo and forest regeneration data, there appears to be no correlation between reproductive rates and forest health at the WMU level. The lack of correlation is likely due to one or some combination of the following factors: either the regeneration estimate, the reproduction estimate, or both are too variable or biased; non-forest forages are the primary influence on reproductive rate, and forest regeneration will never reflect a true population carrying capacity; or reproductive rate is not sensitive to change in response to carrying capacity.

WMI believes the deer health index used by the PGC--embryos/adult doe--should be replaced. As noted, the index may not be sensitive to habitat conditions. The natural variability in embryo data (range=0-3) and its precision make this metric a poor parameter for analysis of variance. Data collection is difficult and collection of adequate samples to afford statistical precision is inadequate in many WMUs. Embryo data are pooled in a three-year running average, in part, to increase sample precision and because pooling impacts the usefulness of an annual estimate. Finally, there is continued uncertainty about the way that reproductive rate varies with population size and the extent of density-dependent population regulation. WMI notes that dead deer surveys are a historic form of data collection used by agencies to drive deer management decision making – winter mortality is likely density independent.

As much as WMI would like to recommend a viable alternative to embryos per adult doe as an index to herd health, it has not identified one apparent in historic PA deer data. Fawn reproductive rate has a better biological basis than adult reproductive rate, but likely inadequacies in sampling eliminate the variable. Sampling of yearling antler beam diameter would be biased with antler restriction regulations.

Fawn-to-doe harvest ratio is the most preferred alternative. While fawn-to-doe harvest rates do not correlate with forest health data, there does appear to be intuitive differences in harvest sex ratios between WMUs. WMI does not agree with the PGC transformation of fawn-to-doe ratios based on models of deer hunter selectivity.

## Forest Regeneration as an Index to Habitat Health

***7. Pennsylvania forests are challenged by a number of environmental and social factors, but abundance of deer is a major cause of forest regeneration failure.***

***8. Quantifying the extent and success of forest regeneration is a practical and ecologically sound indicator of forest habitat health, but insufficient sampling currently jeopardizes the value of the measure.***

Maintaining healthy forests has become a primary goal of the PGC deer management program. Deer and deer managers cannot be held accountable for the numerous challenges facing Pennsylvania's forests today, but it is clear that deer management is an essential part of forest ecosystem management. Progress cannot be made towards the goals of sustainable forestry and better wildlife habitat unless deer numbers are in balance with their food supply. Forest managers have consistently been able to practice sustainable forestry, improve wildlife habitat, and restore degraded ecosystems where deer numbers have been regulated by hunting or fencing.

Forest health data as currently collected suffers from inadequate sampling. The practice of pooling five years of FIA data into an estimate used to adjust annual antlerless permit allocations is difficult to interpret and defend. Furthermore, the current strategy for regulating deer harvest to reach habitat goals may not be responsive enough to prevent further declines in forest habitat health. If habitat conditions dictate a change in the deer population goal, deer harvest management is adjusted to deliver incremental change of about two deer per square mile in the population. This consistent regulatory approach has been effective, but it may take 15 to 20 years to balance deer numbers with habitat and achieve the goal of good forest health in all WMUs. Much of Pennsylvania's private forestland is likely to be cut within the next decade because the forest is even-aged, 90 to 115 years old, and ready to harvest. The potential negative consequences of that action have already been described.

To increase the precision of forest habitat health estimates, the PGC should analyze data from all FIA forest regeneration plots. The practice of screening the FIA data set to exclude plots with less than 40 percent and more than 75 percent overstory stocking should be discontinued. Limiting the analysis to stands with 40 -75 percent overstory stocking was intended to control for the effect of light, but it eliminates two ecologically important habitat types: mature, fully stocked stands and stands from which timber has been harvested. Advance tree regeneration should be abundant in mature stands regardless of the overstory stocking level because of the natural process of understory re-initiation. Tree seedling/sapling regeneration should be plentiful in stands with less than 40 percent overstory stocking because of favorable light conditions.

Preliminary analysis of the 2004-09 FIA regeneration data indicated no difference between stands with 40-75 percent and more than 75 percent overstory stocking in the percentage of plots with adequate advance tree regeneration. Stands with less than 40 percent overstory stocking had the lowest percentage of plots with adequate tree regeneration, presumably because of past regeneration failures. Analyzing data from all FIA plots represents no additional cost to PGC or FIA. Analyzing all available data increased the sample size by 71 percent (from 495 to 850) and should improve the precision of habitat health estimates.

At least two other methods of increasing sample size should be considered: (1) combining WMUs into five large regions for analysis and (2) using the PGC and DCNR forest inventory to supplement the FIA data set. The 21 WMUs are grouped into five large physiographic regions. Regional analysis would increase sample size and might detect habitat trends more quickly than the analysis of individual WMUs. A regional analysis would also help interpret trends when the results for individual WMUs are ambiguous. The PGC, DCNR and FIA should explore the possibility of using the PGC and DCNR forest inventory plots to supplement the FIA regeneration sample. The PGC and DCNR data are not suitable for statewide analysis because they apply to specific subsets of forestland. However, both the PGC and DCNR conduct continuous forest inventories to guide the management of their lands, and they use the same field techniques as the FIA. If a statistically acceptable method could be found for incorporating appropriate plots from the PGC and DCNR inventories into the FIA sample, it would benefit all three agencies.

## Citizen Advisory Committees

***9. The CAC process allows stakeholders to participate in deer management and some form of CAC, perhaps at the statewide level, should be continued by the PGC. The CAC process, while grounded in social science, may not be an efficient or fully objective method to assess citizen desires in each of the 22 WMUs, and the PGC does not commit to the results of the CAC process when establishing goals for each WMU. Cost-effective data relative to public desires, with less bias and variation, may be readily available through a statistically valid public information and survey method designed at the scale of the WMU.***

Public stakeholder input is essential in developing and executing a sound deer management program, and success of the program will only occur with stakeholder support. Differing levels of deer populations affect various stakeholders in differing ways and it is incumbent upon the PGC to consider impact assessments in determining target populations and other aspects of deer management. Perceived impacts of deer herds across individual WMUs must be incorporated into deer management. The gains the PGC receives in public relation from the CAC process aids in developing positive attitudes toward the agency, as stakeholders see a willingness to have their opinions regarded in the management process. It is a reasonable and rational approach to include direct stakeholder input in the decision-making process.

However, problems exist with the CAC process. The stakeholder-screening process should be modified to ensure non-hunting individuals are represented to a greater degree. In some WMUs, it will be difficult to find representatives from stakeholder groups (e.g., business, highway safety) that do not hunt or do not have members of their household who hunt. However, greater effort (including screening questions during the application process) should be included to ensure greater diversity of stakeholder interests. Another issue with stakeholder representation is greater participation by the agriculture industry, specifically the Pennsylvania Farm Bureau.

The CAC process should be made a permanent part of deer management in Pennsylvania. It will be extremely difficult to convene CACs on an annual basis, but instituting a standing CAC that meets on a periodic basis (e.g., every three years) will provide the PGC with one form of stakeholder feedback and potential partnership. This CAC may function best on a statewide scale instead of individual CACs for each WMU. This need for a regular CAC process is recognized by the deer management team and needs to be encouraged.

WMI notes that citizen preferences may be more apparent to the agency when measured through a statistically viable public survey. Greater attention needs to be given to scientific human dimensions studies, not only of deer hunters, but of other stakeholders statewide. This need cannot be overstated. Many deer management problems have a social origin, and future success of deer management in Pennsylvania will depend on greater understanding of the complexities inherent in stakeholder values and attitudes. The PGC has recognized this need and plans to create a human dimensions staff position as soon as fiscally feasible. Such efforts must be encouraged to reduce stakeholder conflict in deer management.

## Wildlife Management Unit Effectiveness

***10. The design of the current WMUs reflects a necessary compromise between the need for adequate sampling size of: deer age, sex and reproductive data; hunter preferences and harvest; deer population information and deer habitat distributions. The DMAP, Red Tag and Urban Deer Management programs appear to provide substantial management flexibility within the current WMUs and a viable alternative to designating smaller management units.***

The assumptions driving the decision to base deer harvest management on larger WMUs include:

1. County data have historically been pooled into multi-county units

2. Inconsistent management unit boundaries could be a source of confusion for hunters

3. County boundaries can be difficult to recognize in the field

4. Establishing management unit boundaries that result in fairly consistent, similar habitats within each of the units would also result in more consistent wildlife densities throughout each of the units

Given the large percentage of times that WMU management objectives were not met but were also not substantially missed (43 percent of the time), a success rate of 49 percent in meeting management objectives is adequate, but needs improvement. Information gleaned from WMUs falling in the "missed the objective but not to the extent that it is problematic" category should help improve future management actions and increase the proportion of WMUs that meet their objectives in the future.

## Comparisons with Other State Deer Management Programs

***11. The scientific foundation of the PGC deer management system is sound, but there are important components identified that need modification or additional evaluation and assessment. Striving for continual improvement appears to be the approach identified by the PGC, and WMI supports the apparent recognition that an open, adaptive, transparent and inclusive process will increase the effectiveness of PGC management plans. Because some publics continue to vocalize discontent with PGC goals, the trend towards conflict resolution, increased communication and enhanced opportunities for collaboration is necessary and recommended.***

Based on comparisons of hunter effort and harvest among 14 northeastern states and provinces, it appears that deer hunters in Pennsylvania have relatively good hunting opportunity, with the state

ranking fourth in hunter density and harvest success, and ranking second in kill per unit effort and third in kill per square mile (2007).

Comparison of the deer management programs and processes in eight states, including Pennsylvania, indicated that, while there were a few differences in procedures and techniques among the states, all eight addressed management of white-tailed deer in a very similar manner. WMI found nothing in this comparison that would be considered problematic in the PGC's general approach to deer management by professional wildlife biologists. The PGC appears to be at the forefront of developing techniques to assess impacts of deer on forest habitat quality.

The PGC however, continues to be subjected to considerable criticism from hunters about deer management programs. Most states have had a period of time when deer management goals, practices or decisions were controversial, but Pennsylvania is unique in that the period of controversy seems to have never waned. The strained nature of the relationship between the PGC and some hunters is problematic and, in the long-term, damaging to society's perception of how hunters and the PGC must work together to conserve and maintain the deer resource for the benefit of all the people.

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# Appendix A: Review Team Member Resumes

## Scot Williamson

Scot Williamson is Vice President of the Wildlife Management Institute, an organization of professional wildlife biologists chartered in 1911 to advance sound, science-based wildlife conservation. Scot has been with WMI since 1994 and has assisted Northeastern states and conservation groups on a number of wildlife and land management initiatives. The WMI publication, "Feeding Wildlife, Just Say No!" was authored by Scot and received the Wildlife Society Conservation Education Award in 2003. Prior to WMI, Scot was Big Game Director for Texas Parks and Wildlife Department and White-tailed Deer Project Leader for NH Fish and Game. Scot received a MS in Wildlife Science from the University of Vermont and a Bachelor of Science in Forestry from the Pennsylvania State University.

## Pat Ruble

Pat Ruble is the Midwest Field Representative for the Wildlife Management Institute. Pat received his B.S. (1973) and M.S. (1976) in Wildlife Management from Ohio State University. He started his career with the Ohio Division of Wildlife in 1974 as a college intern and worked as a district biologist and program administrator for research, federal aid and public lands management prior to assuming the position of Executive Administrator responsible for statewide wildlife management and research programs in 1981. He remained in that job until he retired from the Division of Wildlife in December, 2002. He then became the Program Coordinator for the Terrestrial Wildlife Ecology Laboratory at Ohio State for nearly a year and subsequently served as the Director of Government Relations for the Archery Trade Association from 2004 through June 2006, when he joined the staff of the Wildlife Management Institute. He has served as President of the Ohio Chapter of the Wildlife Society and the Ohio Fish and Wildlife Management Association. He has been active on a number of Association of Fish and Wildlife committees over the years, including: Fur Resources, Habitat Protection, Migratory Shore and Upland Game Bird, Resident Game Bird, Animal Damage Control, Waterfowl, Fish and Wildlife Health, Human/Wildlife Conflict and Wildlife Resource Policy.

## Len Carpenter

Len Carpenter retired from the Wildlife Management Institute in 2007 from the position of Southwest Field Representative. During his tenure with WMI, Len worked throughout the southwest on natural resource issues from his home base in Fort Collins, CO. Len coordinated closely with Federal and State management agencies and served on 3 WMI agency review teams. Len received a Bachelor of Science Degree in Wildlife Biology at Colorado State University in 1968 and worked as a research technician with the Colorado Division of Wildlife briefly as he initiated a PhD program in Range Science at Colorado State, which he completed in 1976. Len then began a 25-year career with the Division as a Wildlife Researcher, Wildlife Research Leader, and State Terrestrial Wildlife Manager. His research work focused on mule deer and their habitats. Len retired from the Division in 1995 and joined WMI in 1996. He is a long-term member of the Range Society and the Wildlife Society and served as President of the Wildlife Society (TWS) from 2000-2001. He has received several TWS Awards and was elected a TWS Fellow in 2005.

## William Healy

William Healy retired from the U.S. Forest Service in 2000 after a 33-year career as a research wildlife biologist. He received degrees in Forestry and Wildlife Management from Penn State University, and his Ph.D. from West Virginia University where he studied relationships among turkey poult feeding activity, insect abundance, and vegetation structure. After being transferred to Massachusetts, he continued studies of forest wildlife habitat relationships, including effects of deer browsing on forest vegetation, and the relationship between acorn crops and small mammal abundance. Bill now applies his research experience and knowledge on his 200-acre farm in West Virginia. He remains active in professional societies as well as in local chapters of various conservation organizations.

## Craig A. Miller

Craig A. Miller, Ph.D. is an Assistant Professor, Human Dimensions at the Warnell School of Forestry & Natural Resources at the University of Georgia. Craig's research emphasis includes studies of satisfaction, policy implementation, and conflict over resource allocations among hunters and anglers. Craig's past research includes extensive study of deer/human interactions and deer hunter participation and satisfaction. Craig received the Ph.D. in Parks and Recreation Management from The Pennsylvania State University, with minors in statistics, forest resources, and conservation biology. Craig has taught human dimensions courses at Penn State, University of Idaho, University of Illinois, Louisiana State University, and University of Georgia. Craig is the former Leader of the Human Dimensions Research Program at the Illinois Natural History Survey, Champaign, IL.

## Robert Turner

Robert Turner is the principal owner of the R. J. Turner Company: Established in 1989, the R. J. Turner Company is a small consulting firm dedicated to the collection, management and analysis of spatial and natural resource data. The firm's services strive to assist resource managers to make better decisions by using a range of sophisticated tools to add value to information. Clients include individual landowners, forest industrial landowners, municipalities, other consultants, state and federal agencies, and nonprofits. Areas of specialty include economic and fiscal analysis, statistical analysis, growth and yield modeling, GIS mapping and spatial analysis, and GPS data collection. As principal of R. J. Turner Company, Robert Turner brings a background in finance, real estate, economics and forestry together with substantial experience in GPS, GIS, database management, and modeling. Virtually all of this experience has been gained in northern New England and New York. He balances a broad social and environmental perspective with a strong analytical foundation and field experience.

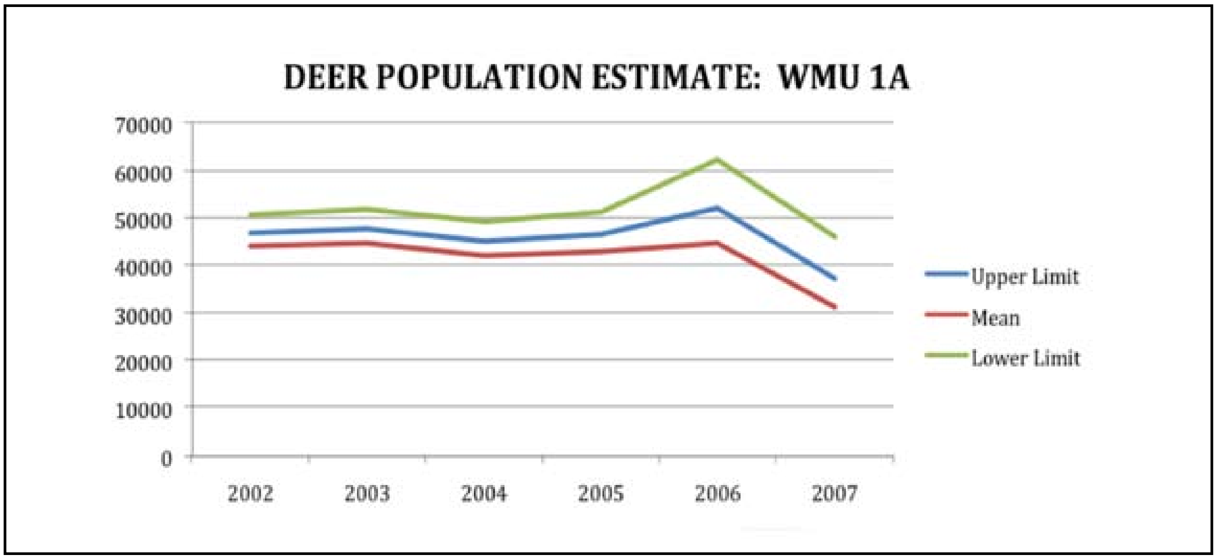
## Steven Williams

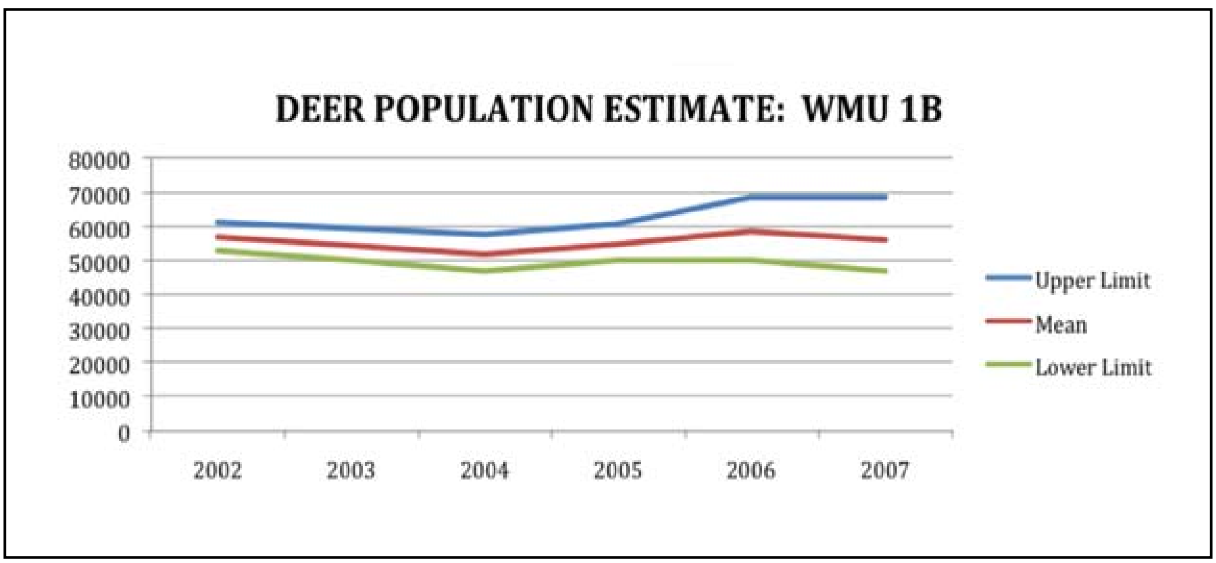
Steven Williams is the President of the Wildlife Management Institute, a non-profit scientific and educational organization dedicated to providing leadership to conserve, restore, and enhance North American wildlife and their habitat. Prior to serving in this role, Steve was the Director of the United States Fish and Wildlife Service within the Department of the Interior. He has also held the positions of Secretary of the Kansas Department of Wildlife and Parks, Deputy Executive Director of the Pennsylvania Game Commission, and Assistant Director for Wildlife and Deer Project Leader for the Massachusetts Division of Fisheries and Wildlife. Steve received a Ph.D. in Forest Resources from The Pennsylvania State University, a M.S. in Biology from the University of North Dakota and a B.S. in Environmental Resource Management from The Pennsylvania State University.

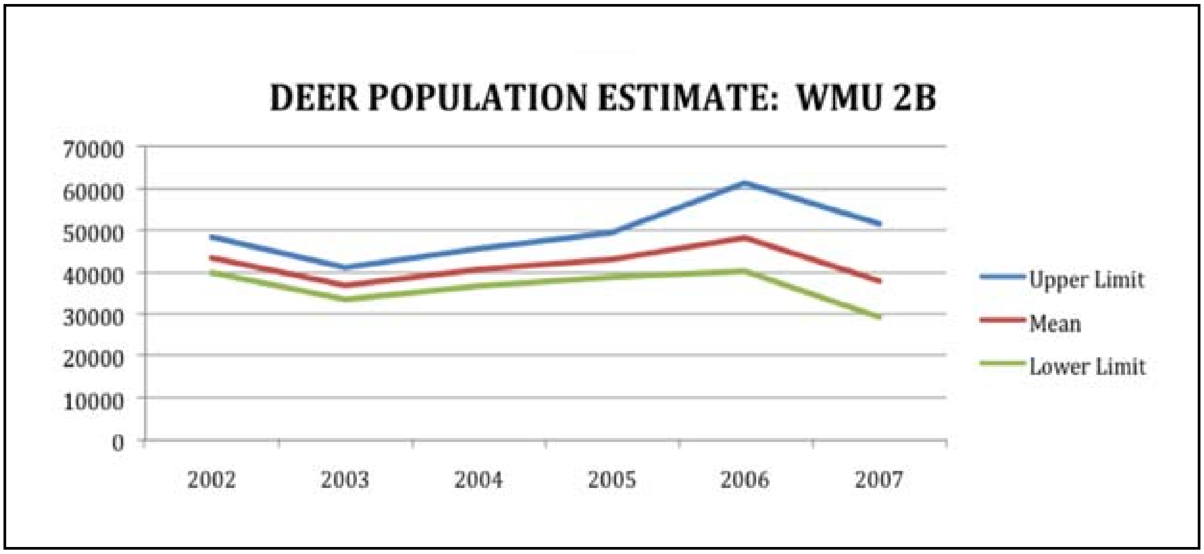
## Richard McCabe

Richard McCabe is Vice President of the Wildlife Management Institute. A native of Madison, Wisconsin, he received a B.A. degree from Wartburg College, Waverly, Iowa, in 1969, and an M.S. degree in Environmental Communications from the University of Wisconsin-Madison, in 1971. He worked for the Wisconsin Department of Natural Resources as a Conservation Aide in 1969-70. From 1972-76, he served on the faculty of the Institute for Environmental Studies and as a Project Coordinator for the Graduate School at the U.W.-Madison. He joined WMI in April 1977 as its publications director. He became the Institute's secretary in 1987, vice president in 1999, and has served in his present capacity since 2001.

# Appendix B: Deer Population Estimate Generated by the PA SAK for WMUs for 2002-2007

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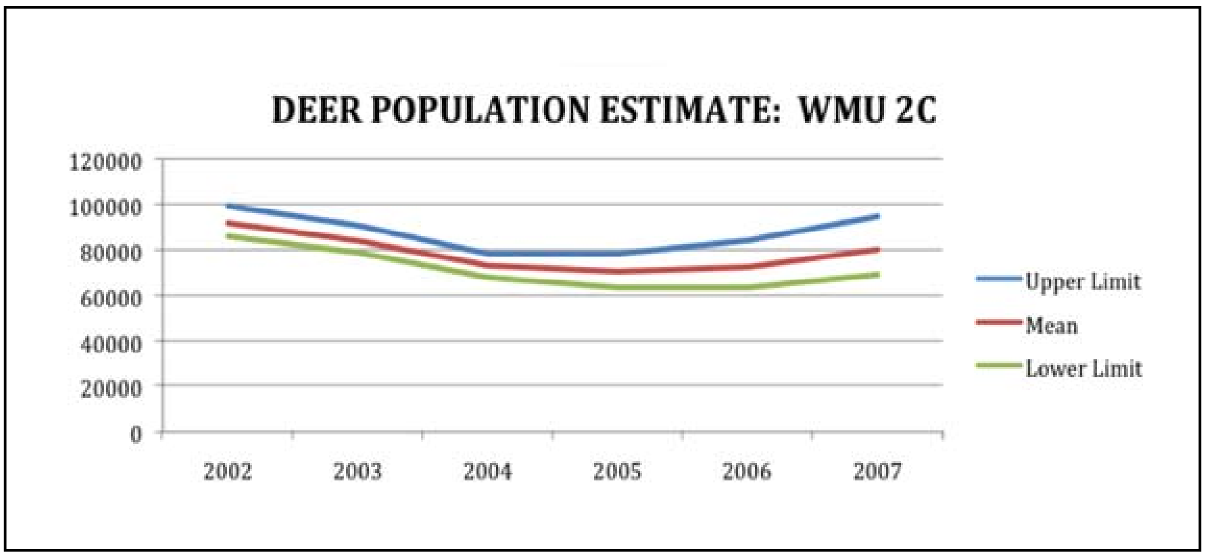
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 2C
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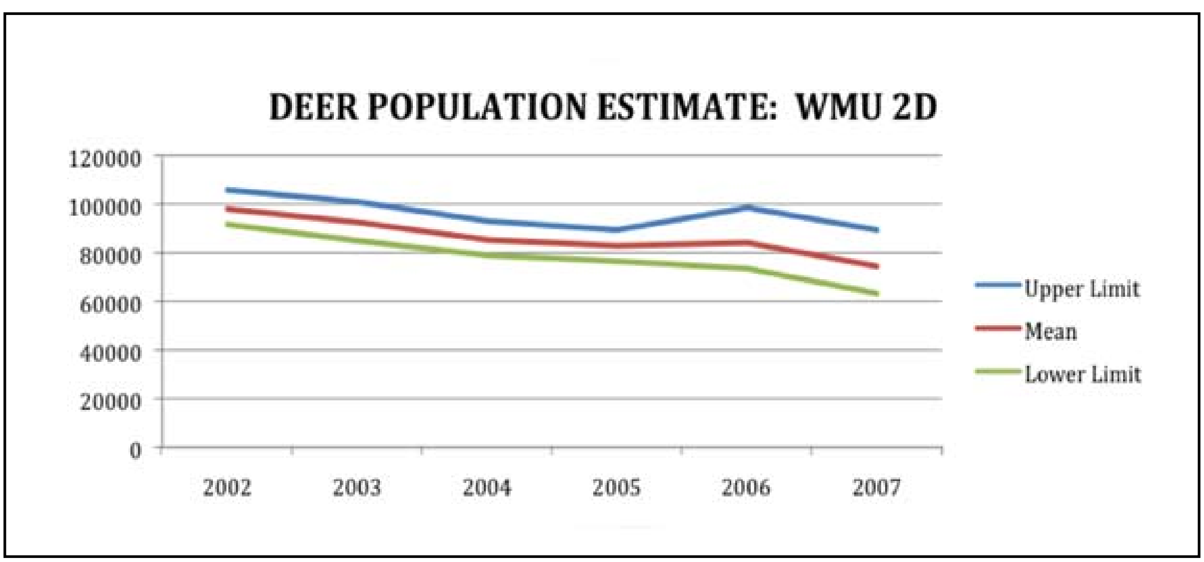
80000
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 2D
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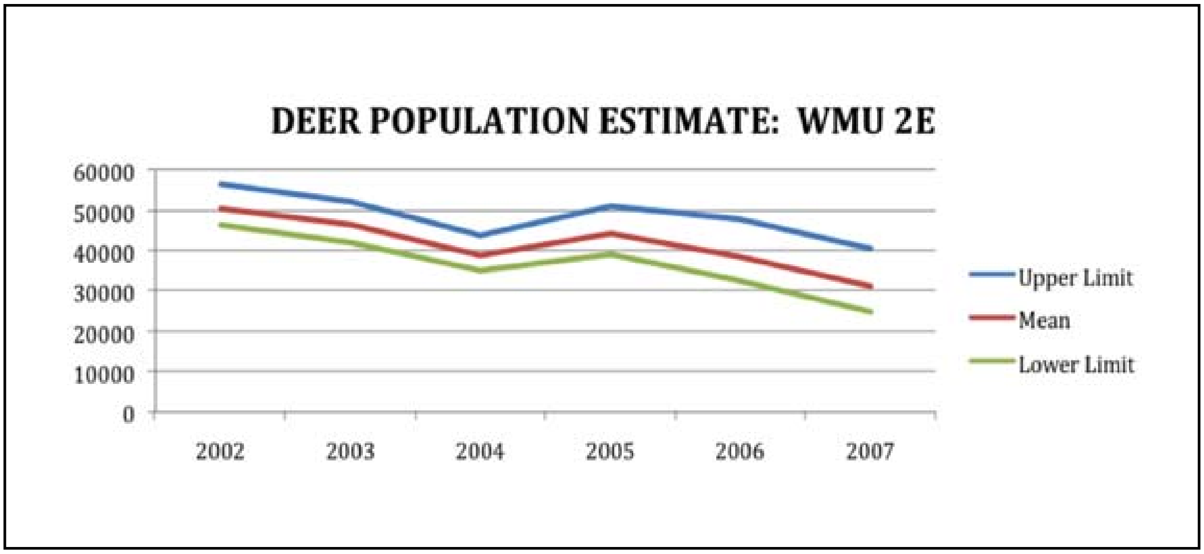
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 2E
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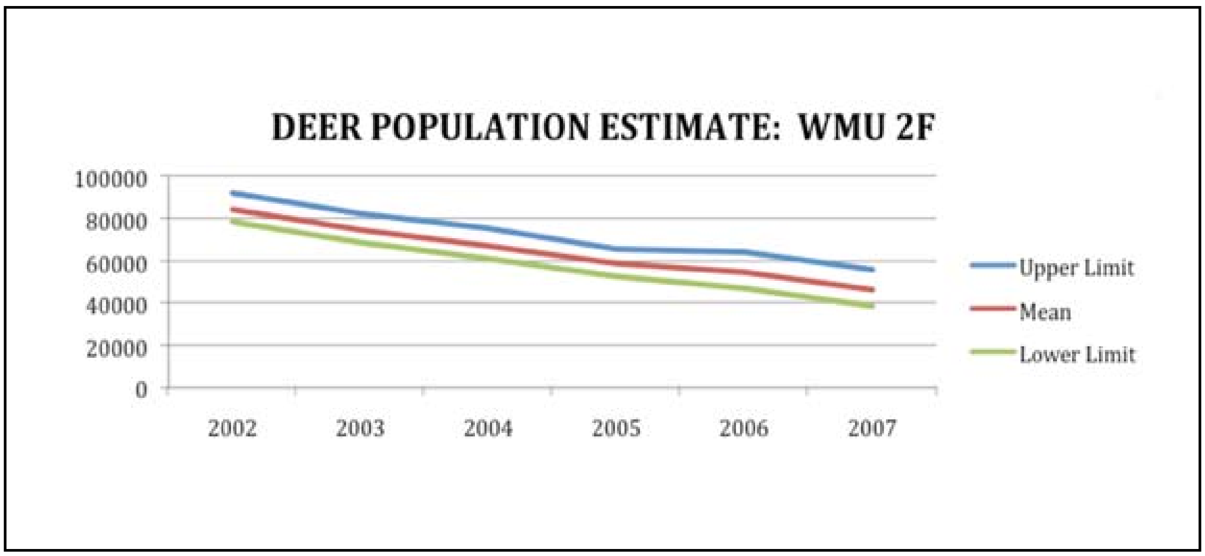
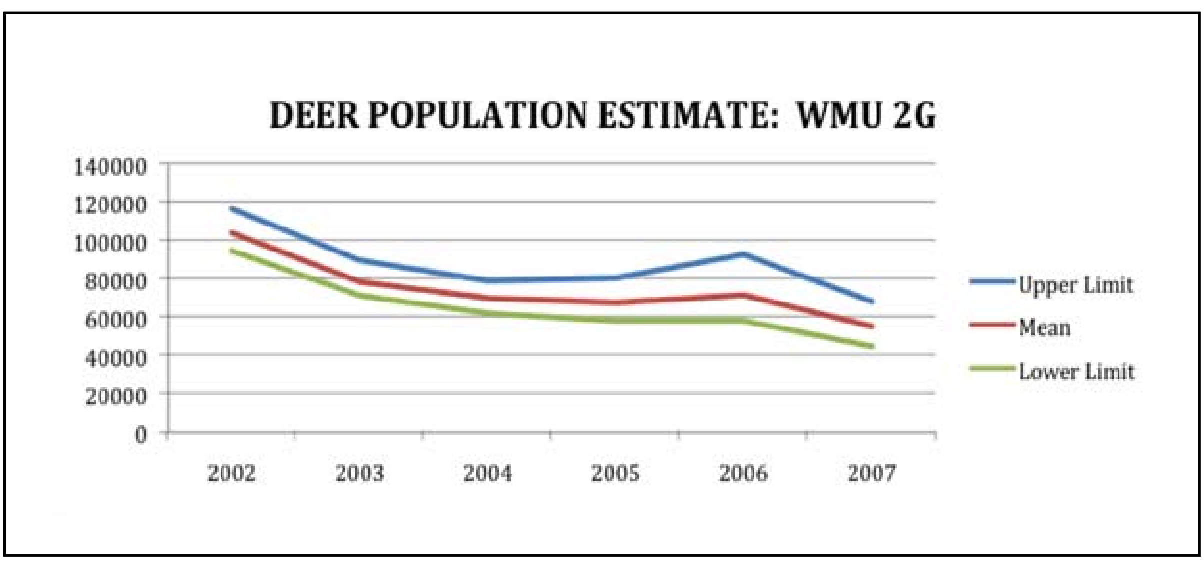
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 2F
100000
80000
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 2G
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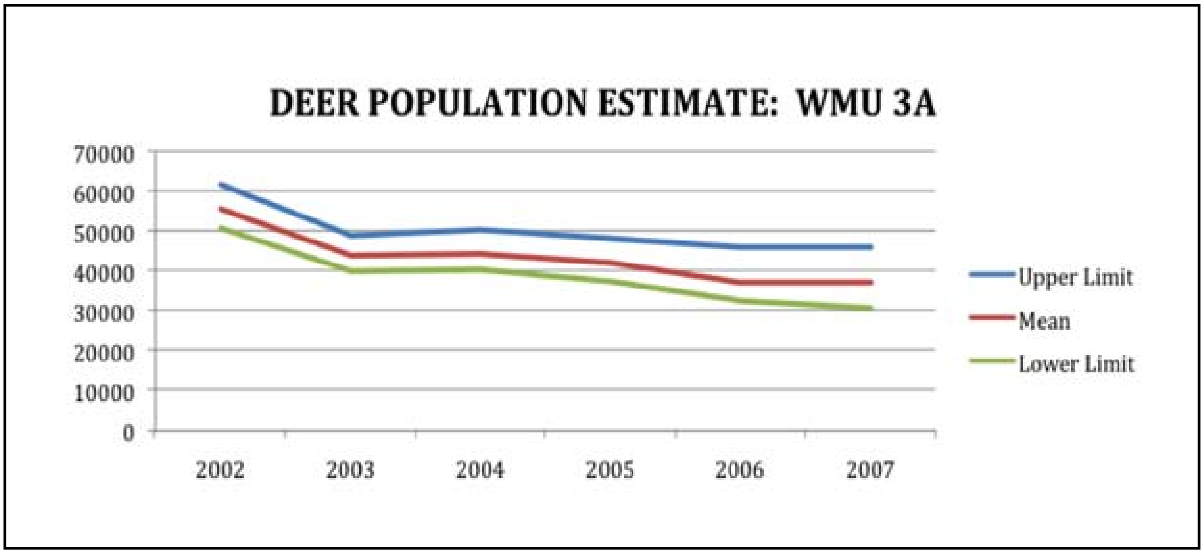
100000
80000
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 3A
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40000
30000
20000
10000
0
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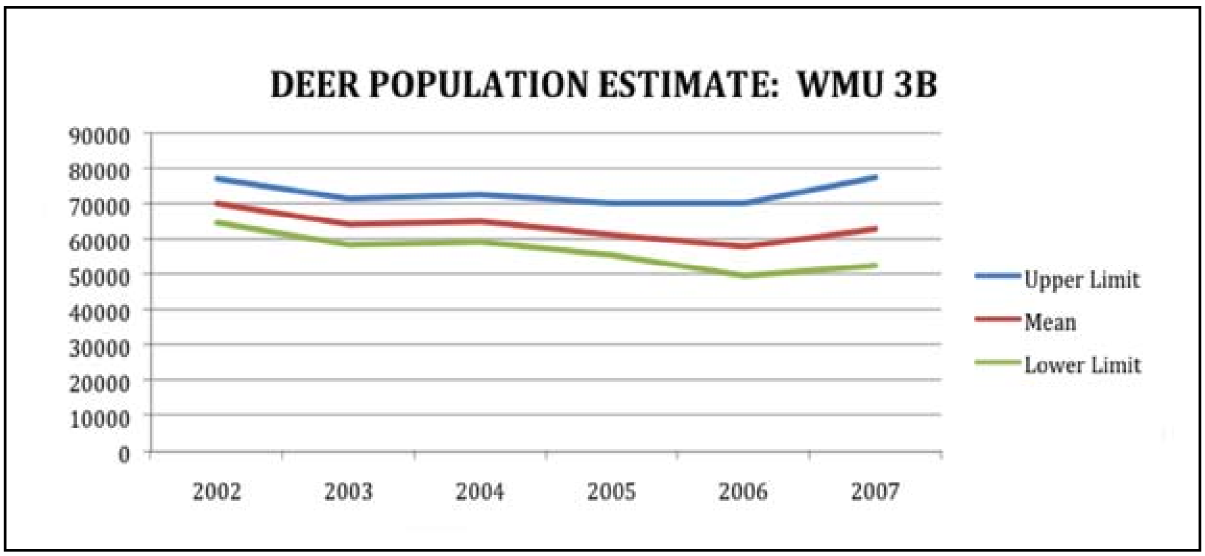
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 3B
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30000
20000
10000
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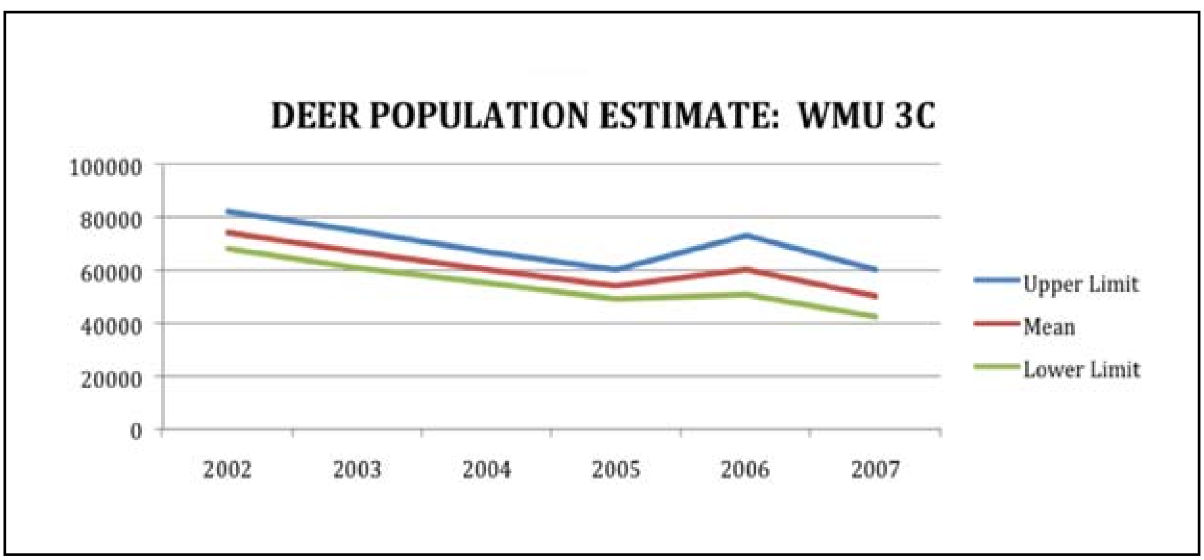
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 3C
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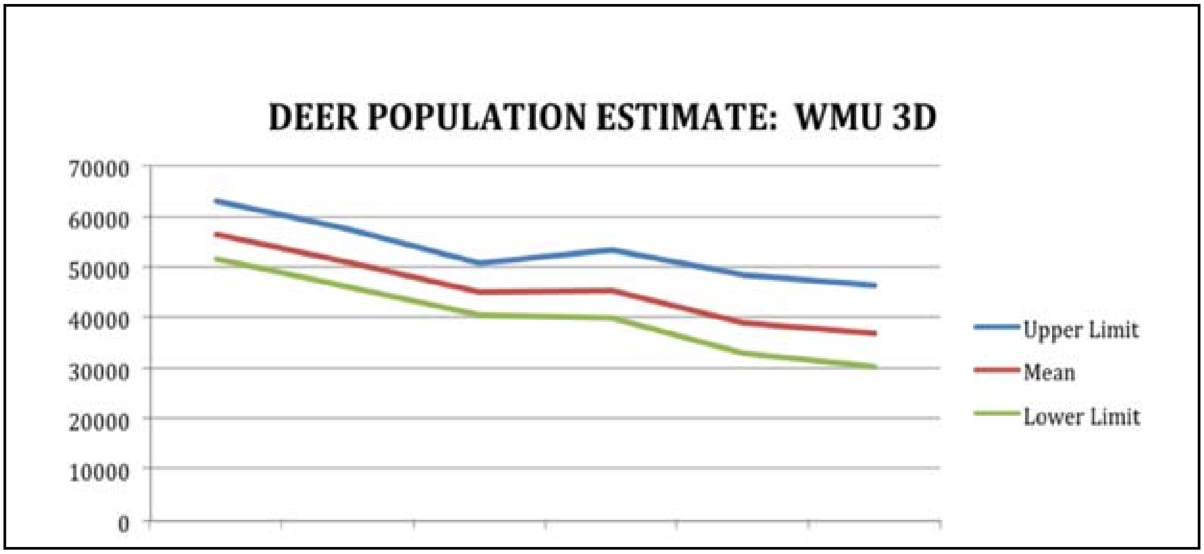
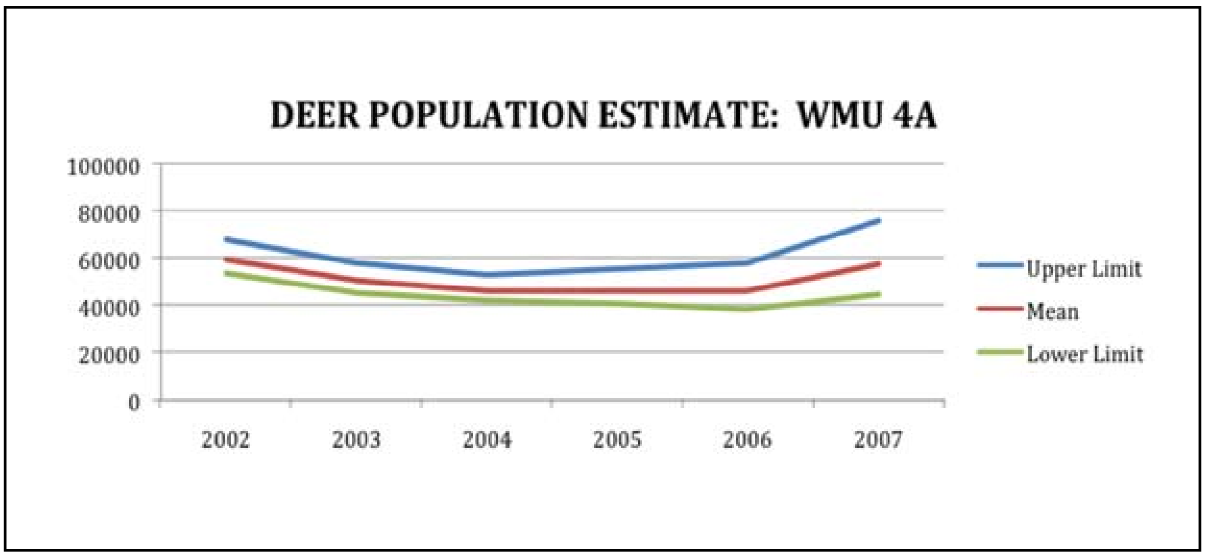
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE:  WMU 3D
70000
60000
50000
40000
30000
20000
10000
0
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE:  WMU 4A
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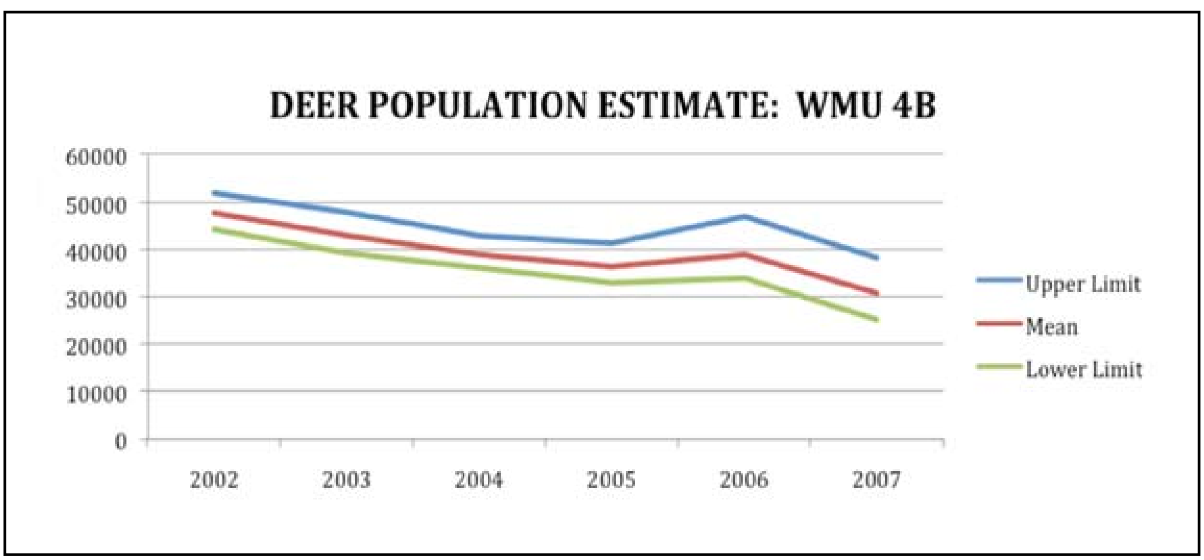
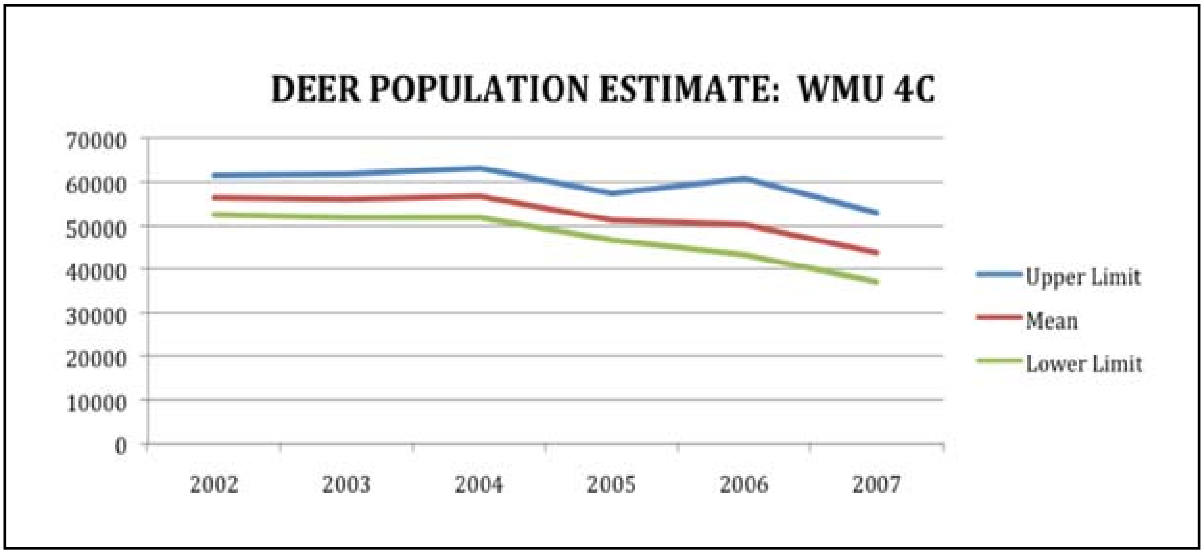
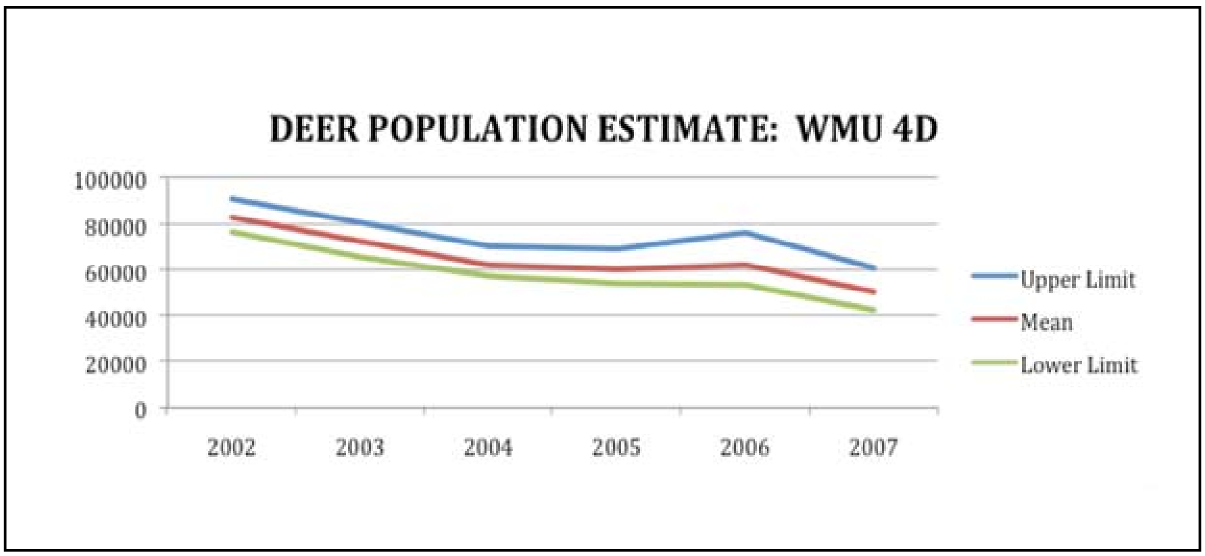
80000
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE:  WMU 4B
60000
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 4C
70000
60000
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 4D
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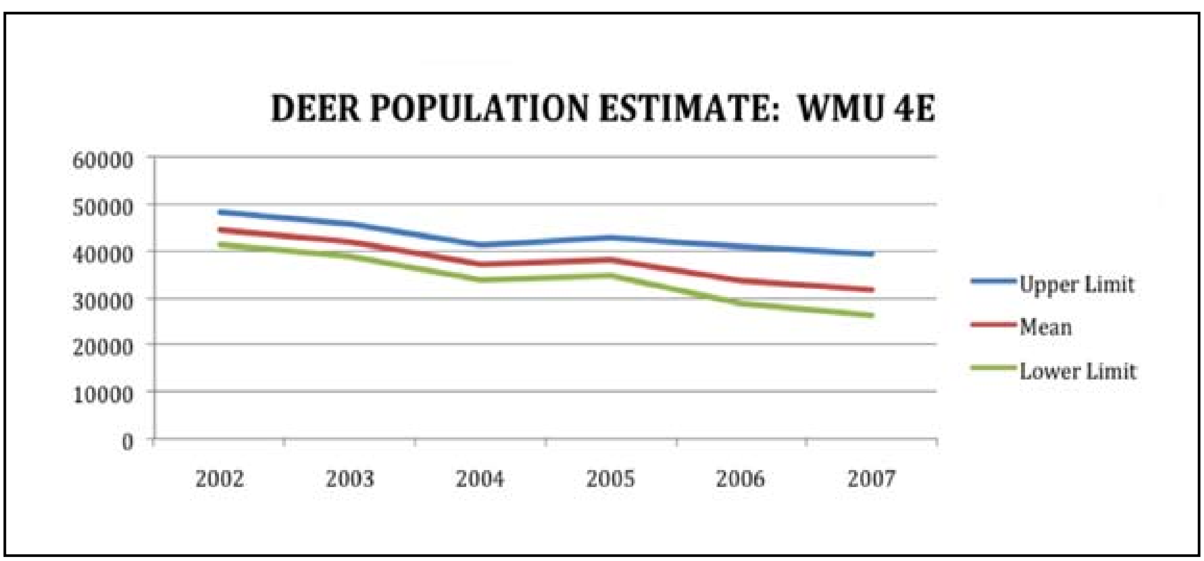
80000
60000
40000
20000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 4E
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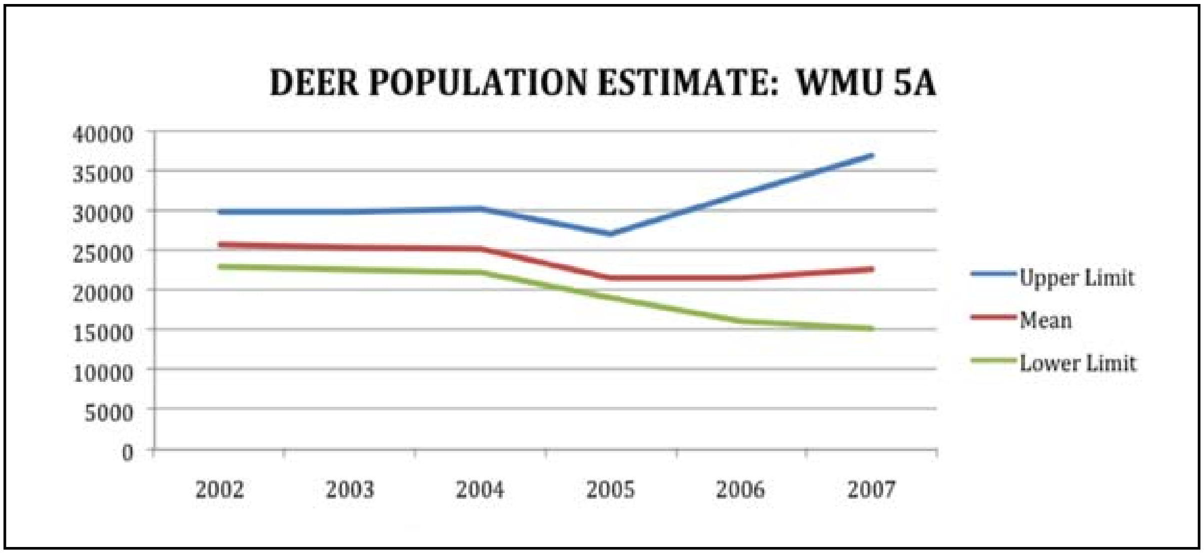
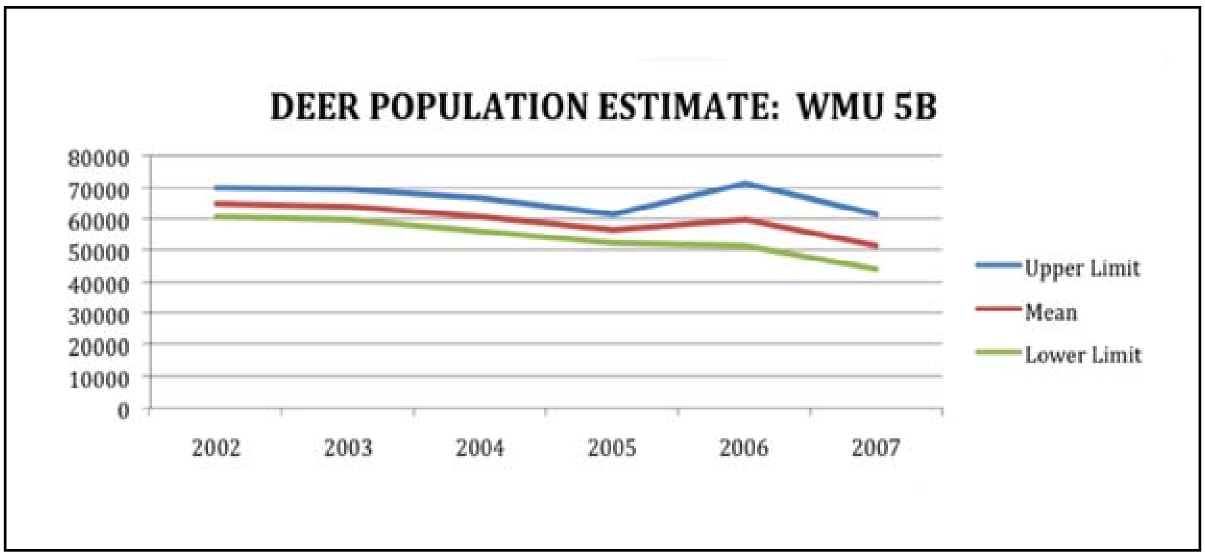
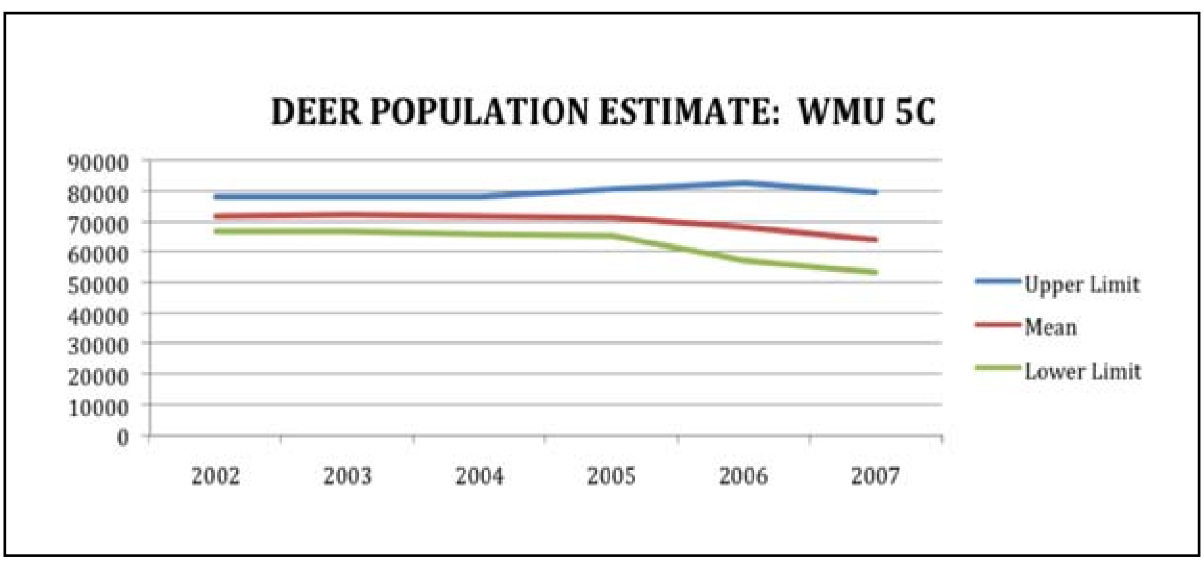
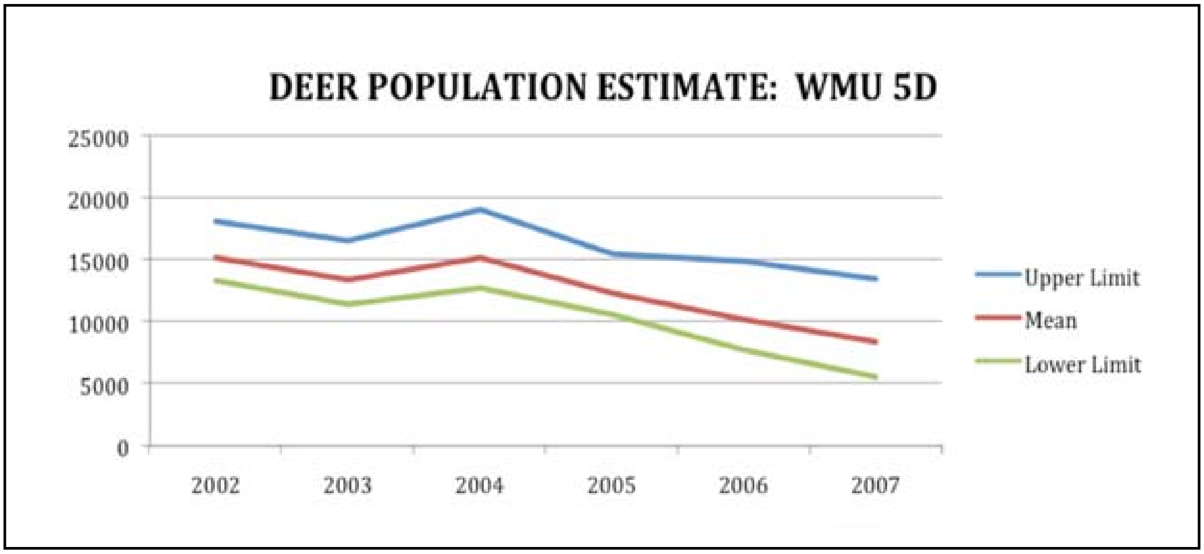
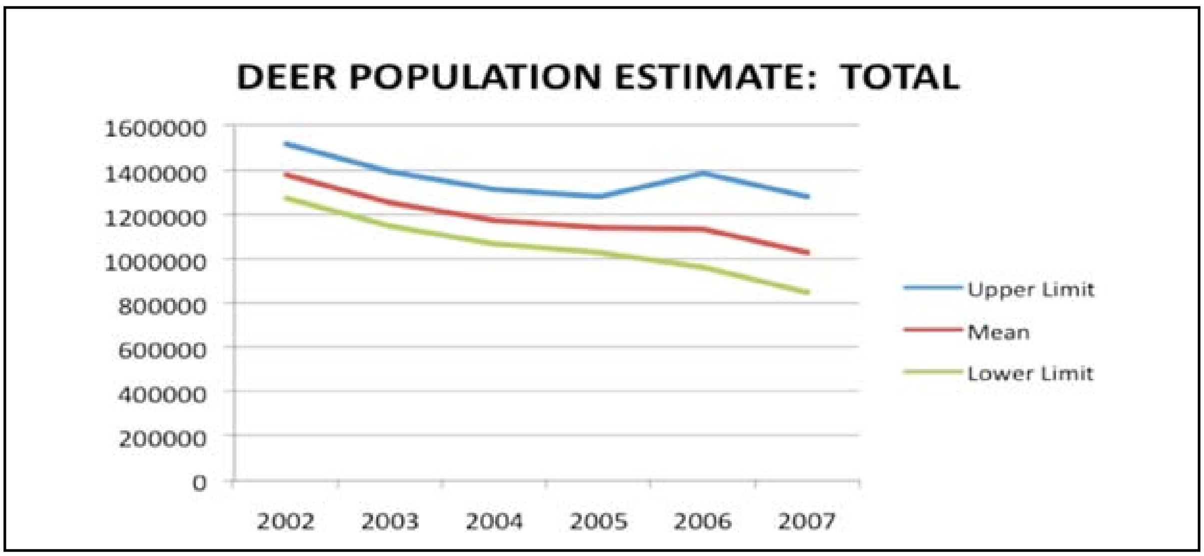
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 5A
40000
35000
30000
25000
20000
15000
10000
5000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 5B
80000
70000
60000
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 5C
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: WMU 5D
25000
20000
15000
10000
5000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit


DEER POPULATION ESTIMATE: TOTAL
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
2002
2003
2004
2005
2006
2007
Upper Limit
Mean
Lower Limit

Appendix B: Data used to construct graphs of mean and 95% confidence intervals (lower and upper limits) of deer population estimates from PA SAK model.

| WMU | STATISTIC | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| 1A | MEAN | 47048 | 47969 | 45203 | 46800 | 52275 | 37395 |
| | LOWER LIMIT | 44240 | 44872 | 42156 | 43235 | 44775 | 31410 |
| | UPPER LIMIT | 50902 | 51897 | 49345 | 51375 | 62460 | 46219 |
| 1B | MEAN | 56894 | 54343 | 51958 | 54999 | 58740 | 56167 |
| | LOWER LIMIT | 52997 | 50349 | 47514 | 50204 | 50359 | 47004 |
| | UPPER LIMIT | 61511 | 59513 | 57829 | 61085 | 68730 | 68578 |
| 2A | MEAN | 75554 | 70353 | 68335 | 68998 | 64282 | 58691 |
| | LOWER LIMIT | 69573 | 64743 | 62778 | 62324 | 54673 | 47856 |
| | UPPER LIMIT | 83083 | 78197 | 76150 | 77382 | 77726 | 74582 |
| 2B | MEAN | 43337 | 37042 | 40583 | 43333 | 48449 | 38028 |
| | LOWER LIMIT | 39949 | 33889 | 36879 | 39022 | 40431 | 29444 |
| | UPPER LIMIT | 48399 | 41304 | 45721 | 49660 | 61536 | 51624 |
| 2C | MEAN | 92131 | 84529 | 73490 | 70799 | 72693 | 80668 |
| | LOWER LIMIT | 86308 | 78932 | 68053 | 65166 | 63649 | 69435 |
| | UPPER LIMIT | 99687 | 91440 | 80005 | 78579 | 84722 | 94844 |
| 2D | MEAN | 98482 | 93003 | 85569 | 83226 | 84623 | 74811 |
| | LOWER LIMIT | 92102 | 85682 | 79044 | 76987 | 73954 | 63563 |
| | UPPER LIMIT | 106347 | 101640 | 93333 | 91244 | 98849 | 89797 |
| 2E | MEAN | 50656 | 46509 | 38922 | 44263 | 38722 | 31320 |
| | LOWER LIMIT | 46577 | 42211 | 35245 | 39071 | 32547 | 24985 |
| | UPPER LIMIT | 56715 | 52165 | 43838 | 51246 | 47744 | 40696 |
| 2F | MEAN | 84670 | 74664 | 67368 | 58846 | 54393 | 46516 |
| | LOWER LIMIT | 78833 | 68747 | 61359 | 53214 | 47498 | 38783 |
| | UPPER LIMIT | 92476 | 82478 | 75779 | 65962 | 64178 | 56059 |
| 2G | MEAN | 104417 | 79387 | 70371 | 67974 | 72358 | 55589 |
| | LOWER LIMIT | 95033 | 71648 | 62793 | 58598 | 58462 | 45236 |
| | UPPER LIMIT | 116979 | 89940 | 79196 | 80987 | 93178 | 68563 |
| 3A | MEAN | 55796 | 44240 | 44739 | 42300 | 38404 | 37318 |
| | LOWER LIMIT | 50991 | 40095 | 40430 | 37658 | 32658 | 30849 |
| | UPPER LIMIT | 61935 | 49119 | 50442 | 48286 | 46382 | 46180 |
| 3B | MEAN | 70358 | 64410 | 65175 | 61608 | 58166 | 63197 |
| | LOWER LIMIT | 64951 | 58554 | 59473 | 55774 | 49876 | 52879 |
| | UPPER LIMIT | 77358 | 71391 | 72823 | 70462 | 71157 | 77829 |
| 3C | MEAN | 74569 | 67172 | 60710 | 54458 | 60539 | 50421 |
| | LOWER LIMIT | 68421 | 61063 | 55568 | 49342 | 51034 | 42634 |
| | UPPER LIMIT | 82562 | 75197 | 67664 | 61377 | 73505 | 60463 |

continued on next page

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3D | MEAN | 56681 | 51090 | 45380 | 45683 | 39160 | 37101 |
| | LOWER LIMIT | 51813 | 46414 | 40832 | 40089 | 33229 | 30523 |
| | UPPER LIMIT | 63248 | 57666 | 51074 | 53705 | 48562 | 46597 |
| 4A | MEAN | 59732 | 50942 | 46873 | 47024 | 46418 | 58120 |
| | LOWER LIMIT | 53895 | 45960 | 42328 | 41337 | 38592 | 45367 |
| | UPPER LIMIT | 68463 | 58000 | 53253 | 55332 | 58260 | 76312 |
| 4B | MEAN | 47769 | 43020 | 39106 | 36653 | 39183 | 30867 |
| | LOWER LIMIT | 44336 | 39413 | 36251 | 33253 | 33953 | 25277 |
| | UPPER LIMIT | 51975 | 47784 | 43100 | 41537 | 46935 | 38336 |
| 4C | MEAN | 56543 | 56021 | 56841 | 51528 | 50460 | 43892 |
| | LOWER LIMIT | 52678 | 51969 | 52022 | 46863 | 43399 | 37220 |
| | UPPER LIMIT | 61680 | 62085 | 63346 | 57478 | 60885 | 53065 |
| 4D | MEAN | 83093 | 72531 | 62736 | 60572 | 62288 | 50608 |
| | LOWER LIMIT | 76753 | 66065 | 57169 | 54299 | 53600 | 42718 |
| | UPPER LIMIT | 91091 | 80899 | 70601 | 69481 | 75972 | 61029 |
| 4E | MEAN | 44675 | 42193 | 37322 | 38372 | 33902 | 31864 |
| | LOWER LIMIT | 41502 | 38956 | 33985 | 34850 | 28929 | 26392 |
| | UPPER LIMIT | 48502 | 45954 | 41450 | 43093 | 41354 | 39499 |
| 5A | MEAN | 25869 | 25496 | 25384 | 22003 | 21636 | 22733 |
| | LOWER LIMIT | 23071 | 22706 | 22349 | 19163 | 16228 | 15260 |
| | UPPER LIMIT | 30022 | 30004 | 30374 | 27188 | 32190 | 37085 |
| 5B | MEAN | 65076 | 64118 | 60875 | 56763 | 59755 | 51700 |
| | LOWER LIMIT | 60930 | 60062 | 56370 | 52543 | 51711 | 44247 |
| | UPPER LIMIT | 70181 | 69725 | 67014 | 62132 | 71536 | 61675 |
| 5C | MEAN | 71897 | 72509 | 72092 | 71708 | 68149 | 64265 |
| | LOWER LIMIT | 66953 | 67061 | 65941 | 65490 | 57505 | 53591 |
| | UPPER LIMIT | 78453 | 79670 | 79679 | 80797 | 82894 | 79778 |
| 5D | MEAN | 15232 | 13456 | 15198 | 12411 | 10165 | 8430 |
| | LOWER LIMIT | 13387 | 11494 | 12823 | 10635 | 7765 | 5598 |
| | UPPER LIMIT | 18206 | 16569 | 19128 | 15575 | 14941 | 13509 |
| Total | MEAN | 1380479 | 1254997 | 1174230 | 1140321 | 1134760 | 1029701 |
| | LOWER LIMIT | 1275293 | 1150885 | 1071362 | 1029117 | 964827 | 850271 |
| | UPPER LIMIT | 1519775 | 1392637 | 1311144 | 1293963 | 1383696 | 1282319 |

# Appendix C: Deer Population Characteristics for WMUs for 1998-2008

## Deer Population Characteristics for WMU 1A for 1996-2008.

| WMU 1A | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 44240 | 44872 | 42156 | 43235 | 44775 | 31410 | |
| Population (Low Limit) per Square Mile | | | | | | | 33.9 | 34.4 | 32.3 | 33.1 | 34.3 | 24.1 | |
| Population (High Limit) | | | | | | | 50902 | 51897 | 49345 | 51375 | 62460 | 46219 | |
| Population (High Limit) per Square Mile | | | | | | | 39.0 | 39.7 | 37.8 | 39.3 | 47.8 | 35.4 | |
| Antlered Harvest | 6430 | 7249 | 7500 | 7500 | 10700 | 9400 | 5700 | 5900 | 5100 | 5500 | 5800 | 4900 | 5400 |
| Antlered Harvest per Square Mile | 4.9 | 5.6 | 5.7 | 5.7 | 8.2 | 7.2 | 4.4 | 4.5 | 3.9 | 4.2 | 4.4 | 3.8 | 4.1 |
| Antlerless Harvest | 7541 | 9390 | 8700 | 9100 | 14100 | 11000 | 13100 | 17000 | 15600 | 13400 | 13200 | 12500 | 12600 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.3 | 1.2 | 1.2 | 1.3 | 1.2 | 2.3 | 2.9 | 3.1 | 2.4 | 2.3 | 2.6 | 2.3 |
| Yearling Buck Harvest Frequency | 91% | 89% | 90% | 88% | 90% | | | 69% | 65% | 58% | 67% | 60% | 62% |
| Yearling Doe Harvest Frequency | 39% | 39% | 38% | 37% | 36% | | | 21% | 22% | 18% | 19% | 22% | 24% |
| Fawn Harvest Frequency | 37% | 28% | 24% | 22% | 28% | | | 45% | 44% | 48% | 48% | 48% | 44% |
| Adult Doe Embryo Counts | | | | | 1.31 | 1.91 | 1.86 | 1.78 | 1.43 | 1.57 | 1.44 | 1.47 | 1.41 |
| Fawn Doe Embryo Counts | | | | | 0.56 | 0.21 | 0.64 | 0.82 | 0.55 | 0.37 | 0.52 | 0.62 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 49% | 48% | 51% | 51% |
| Antlerless License Allocation | 17777 | 16472 | 18932 | 18932 | 19603 | 16714 | 26643 | 44000 | 48000 | 40000 | 42000 | 42000 | 42000 |
| Antlerless License Sold | 17774 | 16361 | 18454 | 17682 | 19603 | 16667 | 26525 | 42409 | 46554 | 39594 | 41456 | 41353 | 41603 |
| Antlerless License CPUE | 42% | 57% | 47% | 51% | 72% | 66% | 49% | 40% | 34% | 34% | 32% | 30% | 30% |

*Decrease

## Deer Population Characteristics for WMU 1B for 1996-2008.

| WMU 1B | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 52997 | 50349 | 47514 | 50204 | 50359 | 47004 | |
| Population (Low Limit) per Square Mile | | | | | | | 24.8 | 23.5 | 22.2 | 23.4 | 23.5 | 22.0 | |
| Population (High Limit) | | | | | | | 61511 | 59513 | 57829 | 61085 | 68730 | 68578 | |
| Population (High Limit) per Square Mile | | | | | | | 28.7 | 27.8 | 27.0 | 28.5 | 32.1 | 32.0 | |
| Antlered Harvest | 8466 | 9113 | 9800 | 10200 | 11900 | 10300 | 6000 | 6300 | 5400 | 6400 | 6800 | 6000 | 7500 |
| Antlered Harvest per Square Mile | 4.0 | 4.3 | 4.6 | 4.8 | 5.6 | 4.8 | 2.8 | 2.9 | 2.5 | 3.0 | 3.2 | 2.8 | 3.5 |
| Antlerless Harvest | 11388 | 13027 | 12500 | 11400 | 17700 | 14800 | 15700 | 17600 | 12000 | 10700 | 12000 | 11400 | 13400 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.3 | 1.4 | 1.3 | 1.1 | 1.5 | 1.4 | 2.6 | 2.8 | 2.2 | 1.7 | 1.8 | 1.9 | 1.8 |
| Yearling Buck Harvest Frequency | 88% | 88% | 85% | 86% | 86% | | 57% | 49% | 49% | 55% | 49% | 52% | 0% |
| Yearling Doe Harvest Frequency | 33% | 36% | 33% | 36% | 40% | | 21% | 22% | 20% | 21% | 19% | 22% | 0% |
| Fawn Harvest Frequency | 51% | 46% | 51% | 55% | 35% | | 42% | 40% | 44% | 42% | 43% | 41% | 0% |
| Adult Doe Embryo Counts | | | | | 1.62 | 1.52 | 1.74 | 1.35 | 1.87 | 1.64 | 1.63 | 1.80 | 1.33 |
| Fawn Doe Embryo Counts | | | | | 0.28 | 0.26 | 0.35 | 0.36 | 0.15 | 0.13 | 0.54 | 0.36 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 41% | 37% | 36% | 37% |
| Antlerless License Allocation | 38151 | 32172 | 36814 | 36814 | 38527 | 31330 | 43921 | 37000 | 33000 | 27000 | 30000 | 30000 | 30000 |
| Antlerless License Sold | 37770 | 31131 | 33764 | 32773 | 38527 | 30986 | 43286 | 36188 | 32570 | 26812 | 29737 | 29741 | 29816 |
| Antlerless License CPUE | 30% | 42% | 37% | 35% | 46% | 48% | 36% | 49% | 37% | 40% | 40% | 38% | 45% |

*Decrease

## Deer Population Characteristics for WMU 2A for 1996-2008.

| WMU 2A | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 69573 | 64743 | 62778 | 62324 | 54673 | 47856 | |
| Population (Low Limit) per Square Mile | | | | | | | 58.1 | 54.1 | 52.4 | 52.1 | 45.7 | 40.0 | |
| Population (High Limit) | | | | | | | 83083 | 78197 | 76150 | 77382 | 77726 | 74582 | |
| Population (High Limit) per Square Mile | | | | | | | 69.4 | 65.3 | 63.6 | 64.6 | 64.9 | 62.3 | |
| Antlered Harvest | 9537 | 10730 | 10900 | 11300 | 13700 | 11600 | 9900 | 7500 | 7800 | 8500 | 8100 | 6600 | 6700 |
| Antlered Harvest per Square Mile | 8.0 | 9.0 | 9.1 | 9.4 | 11.4 | 9.7 | 8.3 | 6.3 | 6.5 | 7.1 | 6.8 | 5.5 | 5.6 |
| Antlerless Harvest | 14237 | 13163 | 12500 | 12400 | 18100 | 18400 | 16900 | 16600 | 18500 | 19600 | 17000 | 14300 | 15300 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.5 | 1.2 | 1.1 | 1.1 | 1.3 | 1.6 | 1.7 | 2.2 | 2.4 | 2.3 | 2.1 | 2.2 | 2.3 |
| Yearling Buck Harvest Frequency | 88% | 89% | 86% | 82% | 82% | 0% | 0% | 64% | 42% | 53% | 52% | 56% | 52% |
| Yearling Doe Harvest Frequency | 38% | 35% | 32% | 36% | 41% | 0% | 0% | 22% | 22% | 23% | 20% | 21% | 21% |
| Fawn Harvest Frequency | 41% | 51% | 62% | 58% | 59% | 0% | 0% | 40% | 41% | 35% | 39% | 49% | 40% |
| Adult Doe Embryo Counts | | | | | 1.75 | 1.38 | 1.59 | 0.00 | 1.76 | 1.39 | 1.12 | 1.46 | 1.23 |
| Fawn Doe Embryo Counts | | | | | 0.16 | 0.42 | 0.10 | 0.00 | 0.12 | 0.15 | 0.33 | 0.14 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 52% | 52% | 37% | 36% |
| Antlerless License Allocation | 31175 | 30658 | 35081 | 35081 | 32310 | 34345 | 38670 | 45000 | 55000 | 55000 | 55000 | 60000 | 55000 |
| Antlerless License Sold | 30367 | 20458 | 29758 | 31340 | 32310 | 33464 | 37659 | 43582 | 53354 | 53584 | 53582 | 56550 | 53711 |
| Antlerless License CPUE | 47% | 64% | 42% | 40% | 56% | 55% | 45% | 38% | 35% | 37% | 32% | 25% | 28% |

*Decrease

## Deer Population Characteristics for WMU 2B for 1996-2008.

| WMU 2B | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 39949 | 33889 | 36879 | 39022 | 40431 | 29444 | |
| Population (Low Limit) per Square Mile | | | | | | | 11.6 | 9.8 | 10.7 | 11.3 | 11.7 | 8.6 | |
| Population (High Limit) | | | | | | | 48399 | 41304 | 45721 | 49660 | 61536 | 51624 | |
| Population (High Limit) per Square Mile | | | | | | | 14.1 | 12.0 | 13.3 | 14.4 | 17.9 | 15.0 | |
| Antlered Harvest | 5239 | 5762 | 6300 | 5700 | 8100 | 6900 | 6000 | 4200 | 4200 | 5200 | 5800 | 4400 | 4000 |
| Antlered Harvest per Square Mile | 1.5 | 1.7 | 1.8 | 1.7 | 2.4 | 2.0 | 1.7 | 1.2 | 1.2 | 1.5 | 1.7 | 1.3 | 1.2 |
| Antlerless Harvest | 8457 | 8991 | 8900 | 9900 | 12600 | 11100 | 13600 | 13900 | 16000 | 14500 | 16500 | 15300 | 15300 |
| Population Objective | | | | | | | | Dec* | Dec* | Dec* | Dec* | Dec* | Dec* |
| Harvest Sex Ratio (D:B) | 1.6 | 1.6 | 1.4 | 1.7 | 1.6 | 1.6 | 2.3 | 3.3 | 3.8 | 2.8 | 2.8 | 3.5 | 3.8 |
| Yearling Buck Harvest Frequency | 91% | 89% | 88% | 86% | 89% | | | 73% | 57% | 65% | 67% | 66% | 61% |
| Yearling Doe Harvest Frequency | 43% | 39% | 36% | 40% | 37% | | | 24% | 22% | 22% | 20% | 22% | 21% |
| Fawn Harvest Frequency | 15% | 12% | 11% | 12% | 13% | | | 44% | 42% | 45% | 45% | 53% | 43% |
| Adult Doe Embryo Counts | | | | | 1.76 | 1.59 | 1.80 | 1.44 | 1.33 | 1.58 | 1.55 | 1.65 | 1.82 |
| Fawn Doe Embryo Counts | | | | | 0.53 | 0.47 | 0.50 | 0.71 | 0.33 | 0.36 | 0.27 | 0.54 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 61% | 65% | 59% | 59% |
| Antlerless License Allocation | 55962 | 54102 | 112127 | 74127 | 92242 | 93903 | 110129 | 45000 | 68000 | 68000 | 68000 | 68000 | 68000 |
| Antlerless License Sold | 93195 | 79418 | 92115 | 61688 | 91792 | 92669 | 105705 | 44453 | 65854 | 63651 | 63753 | 60226 | 62812 |
| Antlerless License CPUE | 9% | 11% | 10% | 16% | 14% | 12% | 13% | 31% | 24% | 23% | 26% | 25% | 24% |

*Decrease

## Deer Population Characteristics for WMU 2C for 1996-2008.

| WMU 2C | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 86308 | 78932 | 68053 | 65166 | 63649 | 69435 | |
| Population (Low Limit) per Square Mile | | | | | | | 29.4 | 26.9 | 23.2 | 22.2 | 21.7 | 23.6 | |
| Population (High Limit) | | | | | | | 99687 | 91440 | 80005 | 78579 | 84722 | 94844 | |
| Population (High Limit) per Square Mile | | | | | | | 33.9 | 31.1 | 27.2 | 26.7 | 28.8 | 32.3 | |
| Antlered Harvest | 11946 | 13719 | 13700 | 13800 | 17200 | 14000 | 12000 | 11200 | 8600 | 7400 | 9000 | 8400 | 7500 |
| Antlered Harvest per Square Mile | 4.1 | 4.7 | 4.7 | 4.7 | 5.9 | 4.8 | 4.1 | 3.8 | 2.9 | 2.5 | 3.1 | 2.9 | 2.6 |
| Antlerless Harvest | 14753 | 16777 | 16400 | 13900 | 20900 | 17800 | 18300 | 24600 | 19500 | 13700 | 12100 | 11600 | 12800 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.2 | 1.2 | 1.0 | 1.2 | 1.3 | 1.5 | 2.2 | 2.3 | 1.9 | 1.3 | 1.4 | 1.7 |
| Yearling Buck Harvest Frequency | 89% | 85% | 85% | 83% | 87% | | | 68% | 62% | 64% | 67% | 67% | 70% |
| Yearling Doe Harvest Frequency | 38% | 40% | 36% | 39% | 41% | | | 22% | 19% | 18% | 20% | 18% | 19% |
| Fawn Harvest Frequency | 35% | 34% | 35% | 35% | 44% | | | 40% | 40% | 45% | 42% | 49% | 43% |
| Adult Doe Embryo Counts | | | | | 1.72 | 1.61 | 1.57 | 1.44 | 1.36 | 1.32 | 1.19 | 1.61 | 1.71 |
| Fawn Doe Embryo Counts | | | | | 0.20 | 0.15 | 0.20 | 0.33 | 0.18 | 0.36 | 0.26 | 0.20 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 56% | 57% | 56% | 56% |
| Antlerless License Allocation | 44845 | 40519 | 49395 | 49395 | 47622 | 43846 | 57565 | 65000 | 75000 | 53000 | 49000 | 49000 | 49000 |
| Antlerless License Sold | 44599 | 39380 | 46781 | 46230 | 47622 | 43345 | 56961 | 64101 | 73945 | 52290 | 48622 | 48201 | 48699 |
| Antlerless License CPUE | 33% | 43% | 35% | 30% | 44% | 41% | 32% | 38% | 26% | 26% | 25% | 24% | 26% |

*Decrease

## Deer Population Characteristics for WMU 2D for 1996-2008.

| WMU 2D | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 92102 | 85682 | 79044 | 76987 | 73954 | 63563 | |
| Population (Low Limit) per Square Mile | | | | | | | 49.8 | 46.3 | 42.7 | 41.6 | 40.0 | 34.4 | |
| Population (High Limit) | | | | | | | 106347 | 101640 | 93333 | 91244 | 98849 | 89797 | |
| Population (High Limit) per Square Mile | | | | | | | 57.5 | 54.9 | 50.5 | 49.3 | 53.4 | 48.5 | |
| Antlered Harvest | 12642 | 14980 | 14700 | 14900 | 18600 | 15800 | 13400 | 10600 | 10500 | 10000 | 10900 | 9100 | 9500 |
| Antlered Harvest per Square Mile | 6.8 | 8.1 | 7.9 | 8.1 | 10.1 | 8.5 | 7.2 | 5.7 | 5.7 | 5.4 | 5.9 | 4.9 | 5.1 |
| Antlerless Harvest | 16068 | 19058 | 18700 | 17800 | 22900 | 18900 | 21900 | 25300 | 22100 | 22100 | 20400 | 18100 | 15600 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.3 | 1.3 | 1.3 | 1.2 | 1.2 | 1.2 | 1.6 | 2.4 | 2.1 | 2.2 | 1.9 | 2.0 | 1.6 |
| Yearling Buck Harvest Frequency | 89% | 90% | 88% | 90% | 89% | | | 75% | 53% | 56% | 63% | 67% | 60% |
| Yearling Doe Harvest Frequency | 37% | 37% | 37% | 40% | 37% | | | 22% | 20% | 20% | 19% | 22% | 19% |
| Fawn Harvest Frequency | 38% | 36% | 35% | 38% | 40% | | | 43% | 45% | 45% | 47% | 46% | 44% |
| Adult Doe Embryo Counts | | | | | 1.61 | 1.43 | 1.55 | 1.57 | 1.13 | 1.75 | 1.83 | 1.45 | 1.85 |
| Fawn Doe Embryo Counts | | | | | 0.53 | 0.30 | 0.20 | 1.00 | 0.17 | 0.29 | 0.17 | 0.24 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 59% | 52% | 52% | 49% |
| Antlerless License Allocation | 35892 | 34180 | 41610 | 41610 | 37588 | 34355 | 50268 | 58000 | 58000 | 56000 | 56000 | 56000 | 56000 |
| Antlerless License Sold | 35533 | 33105 | 38470 | 37196 | 37588 | 33866 | 49324 | 56421 | 56985 | 55257 | 55168 | 55365 | 55294 |
| Antlerless License CPUE | 45% | 58% | 49% | 48% | 61% | 56% | 44% | 45% | 39% | 40% | 37% | 33% | 28% |

*Decrease

## Deer Population Characteristics for WMU 2E for 1996-2008.

| WMU 2E | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 46577 | 42211 | 35245 | 39071 | 32547 | 24985 | |
| Population (Low Limit) per Square Mile | | | | | | | 36.4 | 33.0 | 27.6 | 30.5 | 25.4 | 19.5 | |
| Population (High Limit) | | | | | | | 56715 | 52165 | 43838 | 51246 | 47744 | 40696 | |
| Population (High Limit) per Square Mile | | | | | | | 44.3 | 40.8 | 34.3 | 40.1 | 37.3 | 31.8 | |
| Antlered Harvest | 5434 | 6951 | 6400 | 6100 | 9200 | 6400 | 6200 | 5500 | 4400 | 4100 | 5400 | 3600 | 5000 |
| Antlered Harvest per Square Mile | 4.2 | 5.4 | 5.0 | 4.8 | 7.2 | 5.0 | 4.8 | 4.3 | 3.4 | 3.2 | 4.2 | 2.8 | 3.9 |
| Antlerless Harvest | 6721 | 8384 | 7400 | 7300 | 8000 | 9300 | 12600 | 12500 | 8100 | 7500 | 7400 | 6400 | 6200 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.2 | 1.2 | 1.2 | 0.9 | 1.5 | 2.0 | 2.3 | 1.8 | 1.8 | 1.4 | 1.8 | 1.2 |
| Yearling Buck Harvest Frequency | 87% | 86% | 87% | 82% | 87% | | | 66% | 57% | 60% | 65% | 62% | 63% |
| Yearling Doe Harvest Frequency | 33% | 33% | 33% | 34% | 31% | | | 19% | 19% | 15% | 20% | 20% | 22% |
| Fawn Harvest Frequency | 45% | 44% | 39% | 27% | 51% | | | 42% | 39% | 41% | 39% | 50% | 40% |
| Adult Doe Embryo Counts | | | | | 1.67 | 1.70 | 0.00 | 0.00 | 1.75 | 1.40 | 1.25 | 1.80 | 1.81 |
| Fawn Doe Embryo Counts | | | | | 0.36 | 0.00 | 0.00 | 0.00 | 0.50 | 0.50 | 0.23 | 0.14 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 63% | 59% | 49% | 47% |
| Antlerless License Allocation | 22855 | 20974 | 22895 | 22895 | 18246 | 21170 | 27548 | 29000 | 23000 | 21000 | 21000 | 21000 | 21000 |
| Antlerless License Sold | 22505 | 20225 | 21955 | 21733 | 18246 | 20844 | 26963 | 27908 | 22308 | 20600 | 20678 | 20747 | 20692 |
| Antlerless License CPUE | 30% | 41% | 34% | 34% | 44% | 45% | 47% | 45% | 36% | 36% | 36% | 31% | 30% |

*Decrease

## Deer Population Characteristics for WMU 2F for 1996-2008.

| WMU 2F | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 78833 | 68747 | 61359 | 53214 | 47498 | 38783 | |
| Population (Low Limit) per Square Mile | | | | | | | 32.2 | 28.1 | 25.1 | 21.7 | 19.4 | 15.8 | |
| Population (High Limit) | | | | | | | 92476 | 82478 | 75779 | 65962 | 64178 | 56059 | |
| Population (High Limit) per Square Mile | | | | | | | 37.8 | 33.7 | 31.0 | 26.9 | 26.2 | 22.9 | |
| Antlered Harvest | 10391 | 12044 | 12600 | 11900 | 13800 | 12200 | 9800 | 8000 | 6400 | 6000 | 7200 | 4800 | 7000 |
| Antlered Harvest per Square Mile | 4.2 | 4.9 | 5.1 | 4.9 | 5.6 | 5.0 | 4.0 | 3.3 | 2.6 | 2.5 | 2.9 | 2.0 | 2.9 |
| Antlerless Harvest | 14654 | 16913 | 14600 | 12700 | 21800 | 18500 | 18200 | 17200 | 13100 | 8300 | 8000 | 7100 | 9100 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.4 | 1.4 | 1.2 | 1.1 | 1.6 | 1.5 | 1.9 | 2.2 | 2.0 | 1.4 | 1.1 | 1.5 | 1.3 |
| Yearling Buck Harvest Frequency | 78% | 81% | 79% | 80% | 78% | | | 59% | 44% | 49% | 55% | 58% | 50% |
| Yearling Doe Harvest Frequency | 31% | 34% | 31% | 32% | 33% | | | 18% | 15% | 18% | 18% | 18% | 18% |
| Fawn Harvest Frequency | 48% | 43% | 51% | 54% | 48% | | | 37% | 36% | 40% | 40% | 38% | 35% |
| Adult Doe Embryo Counts | | | | | 1.38 | 1.41 | 1.72 | 1.46 | 1.25 | 1.48 | 1.47 | 1.29 | 1.61 |
| Fawn Doe Embryo Counts | | | | | 0.14 | 0.06 | 0.24 | 0.12 | 0.17 | 0.17 | 0.00 | 0.20 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 36% | 37% | 37% | 39% |
| Antlerless License Allocation | 50299 | 41761 | 51717 | 51717 | 47529 | 41598 | 58436 | 44000 | 44000 | 30000 | 28000 | 28000 | 28000 |
| Antlerless License Sold | 49887 | 40294 | 43553 | 41479 | 47529 | 41108 | 57821 | 42996 | 43213 | 29526 | 27746 | 27716 | 27753 |
| Antlerless License CPUE | 29% | 42% | 34% | 31% | 46% | 45% | 31% | 40% | 30% | 28% | 29% | 26% | 33% |

*Decrease

## Deer Population Characteristics for WMU 2G for 1996-2008.

| WMU 2G | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 95033 | 71648 | 62793 | 58598 | 58462 | 45236 | |
| Population (Low Limit) per Square Mile | | | | | | | 22.9 | 17.2 | 15.1 | 14.1 | 14.1 | 10.9 | |
| Population (High Limit) | | | | | | | 116979 | 89940 | 79196 | 80987 | 93178 | 68563 | |
| Population (High Limit) per Square Mile | | | | | | | 28.1 | 21.6 | 19.1 | 19.5 | 22.4 | 16.5 | |
| Antlered Harvest | 10565 | 12930 | 12100 | 13800 | 14600 | 12700 | 11200 | 8800 | 6600 | 5000 | 7200 | 5100 | 6800 |
| Antlered Harvest per Square Mile | 2.5 | 3.1 | 2.9 | 3.3 | 3.5 | 3.1 | 2.7 | 2.1 | 1.6 | 1.2 | 1.7 | 1.2 | 1.6 |
| Antlerless Harvest | 9752 | 11294 | 9100 | 9500 | 13600 | 13600 | 18200 | 15500 | 10600 | 6200 | 4600 | 6600 | 6500 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 0.9 | 0.9 | 0.8 | 0.7 | 0.9 | 1.1 | 1.6 | 1.8 | 1.6 | 1.2 | 0.6 | 1.3 | 1.0 |
| Yearling Buck Harvest Frequency | 74% | 74% | 74% | 72% | 74% | | | 33% | 30% | 34% | 39% | 39% | 38% |
| Yearling Doe Harvest Frequency | 28% | 27% | 30% | 29% | 31% | | | 17% | 14% | 16% | 14% | 18% | 15% |
| Fawn Harvest Frequency | 27% | 23% | 27% | 30% | 18% | | | 33% | 31% | 33% | 35% | 38% | 35% |
| Adult Doe Embryo Counts | | | | | 1.55 | 1.30 | 1.25 | 1.43 | 1.56 | 1.38 | 2.00 | 1.79 | 1.35 |
| Fawn Doe Embryo Counts | | | | | 0.00 | 0.28 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 45% | 45% | 41% | 38% |
| Antlerless License Allocation | 52324 | 39475 | 50275 | 50275 | 47860 | 47091 | 68992 | 52000 | 52000 | 29000 | 19000 | 26000 | 26000 |
| Antlerless License Sold | 51895 | 38886 | 44790 | 44061 | 47860 | 46694 | 68305 | 50803 | 51006 | 28664 | 18808 | 25779 | 25775 |
| Antlerless License CPUE | 19% | 29% | 20% | 22% | 28% | 29% | 27% | 31% | 21% | 22% | 24% | 26% | 25% |

*Decrease

## Deer Population Characteristics for WMU 3A for 1996-2008.

| WMU 3A | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 50991 | 40095 | 40430 | 37658 | 32658 | 30849 | |
| Population (Low Limit) per Square Mile | | | | | | | 33.5 | 26.4 | 26.6 | 24.8 | 21.5 | 20.3 | |
| Population (High Limit) | | | | | | | 61935 | 49119 | 50442 | 48286 | 46382 | 46180 | |
| Population (High Limit) per Square Mile | | | | | | | 40.7 | 32.3 | 33.2 | 31.8 | 30.5 | 30.4 | |
| Antlered Harvest | 6501 | 7488 | 7700 | 7800 | 8900 | 7700 | 5800 | 4900 | 4200 | 4000 | 4500 | 3400 | 4100 |
| Antlered Harvest per Square Mile | 4.3 | 4.9 | 5.1 | 5.1 | 5.9 | 5.1 | 3.8 | 3.2 | 2.8 | 2.6 | 3.0 | 2.2 | 2.7 |
| Antlerless Harvest | 7365 | 8954 | 8500 | 7100 | 11500 | 9500 | 15000 | 12400 | 11600 | 8700 | 8800 | 7800 | 7500 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.1 | 1.2 | 1.1 | 0.9 | 1.3 | 1.2 | 2.6 | 2.5 | 2.8 | 2.2 | 2.0 | 2.3 | 1.8 |
| Yearling Buck Harvest Frequency | 79% | 76% | 75% | 75% | 77% | | | 44% | 46% | 46% | 51% | 52% | 41% |
| Yearling Doe Harvest Frequency | 31% | 31% | 30% | 31% | 31% | | | 20% | 17% | 16% | 19% | 17% | 20% |
| Fawn Harvest Frequency | 65% | 67% | 83% | 77% | 72% | | | 35% | 33% | 37% | 40% | 42% | 33% |
| Adult Doe Embryo Counts | | | | | 1.29 | 1.18 | 0.00 | 1.56 | 1.47 | 1.20 | 1.75 | 1.86 | 1.75 |
| Fawn Doe Embryo Counts | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.18 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 63% | 65% | 66% | 55% |
| Antlerless License Allocation | 22442 | 18072 | 26916 | 26916 | 24228 | 20017 | 29574 | 28000 | 32000 | 27000 | 29000 | 29000 | 26000 |
| Antlerless License Sold | 22268 | 17718 | 20163 | 19450 | 24228 | 19800 | 29148 | 27166 | 31290 | 26452 | 28499 | 28392 | 25540 |
| Antlerless License CPUE | 33% | 51% | 42% | 37% | 47% | 48% | 51% | 46% | 37% | 33% | 31% | 27% | 29% |

*Decrease

## Deer Population Characteristics for WMU 3B for 1996-2008.

| WMU 3B | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 64951 | 58554 | 59473 | 55774 | 49876 | 52879 | |
| Population (Low Limit) per Square Mile | | | | | | | 28.4 | 25.6 | 26.0 | 24.4 | 21.8 | 23.1 | |
| Population (High Limit) | | | | | | | 77358 | 71391 | 72823 | 70462 | 71157 | 77829 | |
| Population (High Limit) per Square Mile | | | | | | | 33.9 | 31.2 | 31.9 | 30.8 | 31.1 | 34.1 | |
| Antlered Harvest | 7255 | 8717 | 8700 | 9900 | 11100 | 9500 | 7500 | 6300 | 6400 | 6000 | 6500 | 5900 | 5500 |
| Antlered Harvest per Square Mile | 3.2 | 3.8 | 3.8 | 4.3 | 4.9 | 4.2 | 3.3 | 2.8 | 2.8 | 2.6 | 2.8 | 2.6 | 2.4 |
| Antlerless Harvest | 9152 | 9252 | 8600 | 8400 | 11100 | 11600 | 13600 | 14500 | 13400 | 10900 | 10600 | 10200 | 9900 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.3 | 1.1 | 1.0 | 0.8 | 1.0 | 1.2 | 1.8 | 2.3 | 2.1 | 1.8 | 1.6 | 1.7 | 1.8 |
| Yearling Buck Harvest Frequency | 83% | 78% | 76% | 76% | 78% | | | 48% | 44% | 47% | 47% | 51% | 39% |
| Yearling Doe Harvest Frequency | 31% | 31% | 32% | 36% | 33% | | | 19% | 17% | 17% | 19% | 18% | 19% |
| Fawn Harvest Frequency | 35% | 43% | 38% | 35% | 32% | | | 40% | 35% | 42% | 40% | 43% | 37% |
| Adult Doe Embryo Counts | | | | | 1.50 | 1.26 | 1.30 | 1.71 | 1.55 | 1.60 | 1.45 | 1.14 | 1.44 |
| Fawn Doe Embryo Counts | | | | | 0.18 | 0.00 | 0.13 | 0.00 | 0.00 | 0.08 | 0.00 | 0.11 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 56% | 57% | 57% | 63% |
| Antlerless License Allocation | 36541 | 27052 | 35558 | 35558 | 31609 | 31364 | 45415 | 45000 | 48000 | 41000 | 43000 | 43000 | 43000 |
| Antlerless License Sold | 36628 | 27055 | 30309 | 29439 | 31609 | 31362 | 45335 | 44285 | 47298 | 40616 | 42457 | 42792 | 42548 |
| Antlerless License CPUE | 25% | 34% | 28% | 29% | 35% | 37% | 30% | 33% | 28% | 27% | 25% | 24% | 23% |

*Decrease

## Deer Population Characteristics for WMU 3C for 1996-2008.

| WMU 3C | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 68421 | 61063 | 55568 | 49342 | 51034 | 42634 | |
| Population (Low Limit) per Square Mile | | | | | | | 31.6 | 28.2 | 25.7 | 22.8 | 23.6 | 19.7 | |
| Population (High Limit) | | | | | | | 82562 | 75197 | 67664 | 61377 | 73505 | 60463 | |
| Population (High Limit) per Square Mile | | | | | | | 38.2 | 34.7 | 31.3 | 28.4 | 34.0 | 27.9 | |
| Antlered Harvest | 9784 | 10798 | 10700 | 11400 | 13200 | 11000 | 7700 | 6800 | 6900 | 5800 | 6700 | 5300 | 6300 |
| Antlered Harvest per Square Mile | 4.5 | 5.0 | 4.9 | 5.3 | 6.1 | 5.1 | 3.6 | 3.1 | 3.2 | 2.7 | 3.1 | 2.4 | 2.9 |
| Antlerless Harvest | 12471 | 14146 | 10900 | 10700 | 14100 | 15800 | 15800 | 16700 | 13500 | 11200 | 9200 | 9600 | 7300 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.3 | 1.3 | 1.0 | 0.9 | 1.1 | 1.4 | 2.1 | 2.5 | 2.0 | 1.9 | 1.4 | 1.8 | 1.2 |
| Yearling Buck Harvest Frequency | 87% | 83% | 81% | 79% | 82% | | | 50% | 47% | 51% | 57% | 53% | 47% |
| Yearling Doe Harvest Frequency | 34% | 34% | 32% | 35% | 36% | | | 19% | 19% | 22% | 19% | 20% | 21% |
| Fawn Harvest Frequency | 6% | 5% | 4% | 5% | 4% | | | 36% | 35% | 36% | 39% | 39% | 31% |
| Adult Doe Embryo Counts | | | | | 1.23 | 1.43 | 1.40 | 1.40 | 1.31 | 1.57 | 1.50 | 1.50 | 1.50 |
| Fawn Doe Embryo Counts | | | | | 0.43 | 0.13 | 0.00 | 0.00 | 0.00 | 0.09 | 0.13 | 0.17 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 60% | 57% | 57% | 60% |
| Antlerless License Allocation | 29375 | 29979 | 31863 | 31863 | 29366 | 35142 | 41505 | 40000 | 37000 | 32000 | 27000 | 27000 | 27000 |
| Antlerless License Sold | 29472 | 29165 | 27969 | 27414 | 29366 | 35140 | 41493 | 39566 | 36683 | 31751 | 26728 | 26804 | 26884 |
| Antlerless License CPUE | 42% | 49% | 39% | 39% | 48% | 45% | 38% | 42% | 37% | 35% | 34% | 36% | 27% |

*Decrease

## Deer Population Characteristics for WMU 3D for 1996-2008.

| WMU 3D | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 51813 | 46414 | 40832 | 40089 | 33229 | 30523 | |
| Population (Low Limit) per Square Mile | | | | | | | 23.0 | 20.6 | 18.1 | 17.8 | 14.8 | 13.6 | |
| Population (High Limit) | | | | | | | 63248 | 57666 | 51074 | 53705 | 48562 | 46597 | |
| Population (High Limit) per Square Mile | | | | | | | 28.1 | 25.6 | 22.7 | 23.8 | 21.6 | 20.7 | |
| Antlered Harvest | 6385 | 7280 | 7300 | 8200 | 9100 | 8200 | 6200 | 4600 | 4500 | 3900 | 5000 | 3600 | 3900 |
| Antlered Harvest per Square Mile | 2.8 | 3.2 | 3.2 | 3.6 | 4.0 | 3.6 | 2.8 | 2.0 | 2.0 | 1.7 | 2.2 | 1.6 | 1.7 |
| Antlerless Harvest | 7947 | 8089 | 5400 | 5400 | 8800 | 9500 | 11000 | 13500 | 9800 | 7300 | 7400 | 7000 | 6900 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.1 | 0.7 | 0.7 | 1.0 | 1.2 | 1.8 | 2.9 | 2.2 | 1.9 | 1.5 | 1.9 | 1.8 |
| Yearling Buck Harvest Frequency | 75% | 73% | 73% | 72% | 72% | | | 39% | 42% | 42% | 47% | 49% | 39% |
| Yearling Doe Harvest Frequency | 32% | 29% | 35% | 33% | 36% | | | 15% | 18% | 16% | 20% | 19% | 17% |
| Fawn Harvest Frequency | 22% | 18% | 16% | 19% | 18% | | | 36% | 33% | 37% | 35% | 35% | 33% |
| Adult Doe Embryo Counts | | | | | 1.52 | 1.71 | 2.00 | 1.42 | 1.27 | 1.28 | 1.25 | 1.30 | 1.44 |
| Fawn Doe Embryo Counts | | | | | 0.09 | 0.22 | 0.67 | 0.19 | 0.20 | 0.07 | 0.08 | 0.20 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 52% | 51% | 47% | 45% |
| Antlerless License Allocation | 35177 | 25722 | 24061 | 24061 | 28066 | 32868 | 45513 | 50000 | 50000 | 38000 | 38000 | 38000 | 37000 |
| Antlerless License Sold | 35273 | 25492 | 22338 | 22210 | 27887 | 32852 | 45481 | 49096 | 49312 | 37352 | 37508 | 37435 | 36527 |
| Antlerless License CPUE | 23% | 32% | 24% | 24% | 32% | 29% | 24% | 27% | 20% | 20% | 20% | 19% | 19% |

*Decrease

## Deer Population Characteristics for WMU 4A for 1996-2008.

| WMU 4A | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 53895 | 45960 | 42328 | 41337 | 38592 | 45367 | |
| Population (Low Limit) per Square Mile | | | | | | | 30.7 | 26.2 | 24.1 | 23.6 | 22.0 | 25.9 | |
| Population (High Limit) | | | | | | | 68463 | 58000 | 53253 | 55332 | 58260 | 76312 | |
| Population (High Limit) per Square Mile | | | | | | | 39.1 | 33.1 | 30.4 | 31.6 | 33.2 | 43.5 | |
| Antlered Harvest | 7115 | 8345 | 7000 | 8500 | 9400 | 7300 | 6300 | 6600 | 4100 | 3700 | 5900 | 4500 | 4200 |
| Antlered Harvest per Square Mile | 4.1 | 4.8 | 4.0 | 4.8 | 5.4 | 4.2 | 3.6 | 3.8 | 2.3 | 2.1 | 3.4 | 2.6 | 2.4 |
| Antlerless Harvest | 8398 | 9189 | 9600 | 7600 | 13000 | 10700 | 13000 | 12200 | 11000 | 7600 | 7800 | 6700 | 6900 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.1 | 1.4 | 0.9 | 1.4 | 1.5 | 2.1 | 1.8 | 2.7 | 2.1 | 1.3 | 1.5 | 1.6 |
| Yearling Buck Harvest Frequency | 81% | 77% | 77% | 77% | 83% | | | 50% | 42% | 49% | 44% | 56% | 39% |
| Yearling Doe Harvest Frequency | 31% | 32% | 32% | 29% | 37% | | | 20% | 15% | 19% | 18% | 17% | 20% |
| Fawn Harvest Frequency | 46% | 43% | 48% | 49% | 45% | | | 31% | 36% | 38% | 38% | 41% | 34% |
| Adult Doe Embryo Counts | | | | | 1.80 | 1.47 | 1.68 | 1.50 | 1.53 | 1.83 | 1.37 | 1.38 | 1.55 |
| Fawn Doe Embryo Counts | | | | | 0.06 | 0.20 | 0.00 | 0.08 | 0.06 | 0.27 | 0.13 | 0.20 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 64% | 61% | 62% | 64% |
| Antlerless License Allocation | 31253 | 29902 | 43257 | 43257 | 40298 | 30737 | 41002 | 37000 | 43000 | 35000 | 29000 | 29000 | 29000 |
| Antlerless License Sold | 31232 | 27972 | 31833 | 30445 | 40298 | 30629 | 40746 | 35996 | 42192 | 34477 | 28520 | 28402 | 28731 |
| Antlerless License CPUE | 27% | 33% | 30% | 25% | 32% | 35% | 32% | 34% | 26% | 22% | 27% | 24% | 24% |

*Decrease

## Deer Population Characteristics for WMU 4B for 1996-2008.

| WMU 4B | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 44336 | 39413 | 36251 | 33253 | 33953 | 25277 | |
| Population (Low Limit) per Square Mile | | | | | | | 27.7 | 24.6 | 22.7 | 20.8 | 21.2 | 15.8 | |
| Population (High Limit) | | | | | | | 51975 | 47784 | 43100 | 41537 | 46935 | 38336 | |
| Population (High Limit) per Square Mile | | | | | | | 32.5 | 29.9 | 26.9 | 26.0 | 29.3 | 24.0 | |
| Antlered Harvest | 6433 | 7100 | 6800 | 7600 | 8400 | 6500 | 5900 | 4600 | 4900 | 3600 | 5000 | 3500 | 3900 |
| Antlered Harvest per Square Mile | 4.0 | 4.4 | 4.3 | 4.8 | 5.3 | 4.1 | 3.7 | 2.9 | 3.1 | 2.3 | 3.1 | 2.2 | 2.4 |
| Antlerless Harvest | 6377 | 8341 | 6900 | 6700 | 11000 | 9100 | 9400 | 11200 | 11000 | 6600 | 6600 | 4500 | 3800 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Increase | Increase | Increase |
| Harvest Sex Ratio (D:B) | 1.0 | 1.2 | 1.0 | 0.9 | 1.3 | 1.4 | 1.6 | 2.4 | 2.2 | 1.8 | 1.3 | 1.3 | 1.0 |
| Yearling Buck Harvest Frequency | 84% | 83% | 82% | 82% | 83% | | | 61% | 52% | 56% | 57% | 60% | 57% |
| Yearling Doe Harvest Frequency | 31% | 31% | 34% | 38% | 34% | | | 21% | 21% | 21% | 19% | 21% | 19% |
| Fawn Harvest Frequency | 86% | 61% | 58% | 78% | 45% | | | 39% | 42% | 41% | 44% | 42% | 38% |
| Adult Doe Embryo Counts | | | | | 1.67 | 1.86 | 1.29 | 2.08 | 2.00 | 1.56 | 1.71 | 1.41 | 1.59 |
| Fawn Doe Embryo Counts | | | | | 0.17 | 0.64 | 0.50 | 0.14 | 0.25 | 0.29 | 0.50 | 0.18 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 61% | 60% | 61% | 63% |
| Antlerless License Allocation | 30571 | 29280 | 33608 | 33608 | 33394 | 25790 | 34320 | 38000 | 49000 | 35000 | 31000 | 23000 | 23000 |
| Antlerless License Sold | 30500 | 27361 | 27932 | 27185 | 33394 | 25665 | 34151 | 35736 | 48155 | 34578 | 30593 | 22687 | 22696 |
| Antlerless License CPUE | 21% | 30% | 25% | 25% | 33% | 35% | 28% | 31% | 23% | 19% | 22% | 20% | 17% |

*Decrease

## Deer Population Characteristics for WMU 4C for 1996-2008.

| WMU 4C | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 52678 | 51969 | 52022 | 46863 | 43399 | 37220 | |
| Population (Low Limit) per Square Mile | | | | | | | 28.8 | 28.4 | 28.4 | 25.6 | 23.7 | 20.3 | |
| Population (High Limit) | | | | | | | 61680 | 62085 | 63346 | 57478 | 60885 | 53065 | |
| Population (High Limit) per Square Mile | | | | | | | 33.7 | 33.9 | 34.6 | 31.4 | 33.3 | 29.0 | |
| Antlered Harvest | 6070 | 7256 | 7100 | 8100 | 9400 | 7800 | 6100 | 6200 | 5400 | 5900 | 6100 | 4800 | 5000 |
| Antlered Harvest per Square Mile | 3.3 | 4.0 | 3.9 | 4.4 | 5.1 | 4.3 | 3.3 | 3.4 | 3.0 | 3.2 | 3.3 | 2.6 | 2.7 |
| Antlerless Harvest | 6818 | 8101 | 7500 | 7500 | 12000 | 10800 | 12100 | 13700 | 12100 | 9800 | 8900 | 9400 | 8000 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.1 | 1.1 | 1.1 | 0.9 | 1.3 | 1.4 | 2.0 | 2.2 | 2.2 | 1.7 | 1.5 | 2.0 | 1.6 |
| Yearling Buck Harvest Frequency | 81% | 77% | 77% | 80% | 83% | | | 60% | 54% | 56% | 59% | 57% | 55% |
| Yearling Doe Harvest Frequency | 33% | 35% | 35% | 36% | 38% | | | 19% | 16% | 19% | 19% | 18% | 19% |
| Fawn Harvest Frequency | 53% | 56% | 50% | 44% | 54% | | | 40% | 41% | 43% | 43% | 44% | 42% |
| Adult Doe Embryo Counts | | | | | 1.44 | 1.50 | 2.17 | 1.86 | 1.50 | 1.33 | 1.44 | 1.34 | 1.54 |
| Fawn Doe Embryo Counts | | | | | 0.41 | 0.23 | 0.00 | 0.25 | 0.14 | 0.00 | 0.29 | 0.44 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 50% | 58% | 52% | 50% |
| Antlerless License Allocation | 31449 | 25456 | 34858 | 34858 | 36245 | 31012 | 40454 | 46000 | 44000 | 39000 | 39000 | 39000 | 35000 |
| Antlerless License Sold | 31492 | 24531 | 29109 | 28754 | 36245 | 30870 | 40292 | 44906 | 43403 | 38531 | 37580 | 38373 | 34596 |
| Antlerless License CPUE | 22% | 33% | 26% | 26% | 33% | 35% | 30% | 31% | 28% | 25% | 24% | 24% | 23% |

*Decrease

## Deer Population Characteristics for WMU 4D for 1996-2008.

| WMU 4D | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 76753 | 66065 | 57169 | 54299 | 53600 | 42718 | |
| Population (Low Limit) per Square Mile | | | | | | | 27.6 | 23.8 | 20.6 | 19.5 | 19.3 | 15.4 | |
| Population (High Limit) | | | | | | | 91091 | 80899 | 70601 | 69481 | 75972 | 61029 | |
| Population (High Limit) per Square Mile | | | | | | | 32.8 | 29.1 | 25.4 | 25.0 | 27.3 | 22.0 | |
| Antlered Harvest | 10867 | 13398 | 11900 | 13500 | 15600 | 12000 | 9100 | 7700 | 6300 | 5600 | 6800 | 5800 | 6600 |
| Antlered Harvest per Square Mile | 3.9 | 4.8 | 4.3 | 4.9 | 5.6 | 4.3 | 3.3 | 2.8 | 2.3 | 2.0 | 2.4 | 2.1 | 2.4 |
| Antlerless Harvest | 11079 | 12499 | 12100 | 10100 | 18400 | 14800 | 14600 | 18500 | 12700 | 8400 | 9900 | 8100 | 9300 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.0 | 0.9 | 1.0 | 0.7 | 1.2 | 1.2 | 1.6 | 2.4 | 2.0 | 1.5 | 1.5 | 1.4 | 1.4 |
| Yearling Buck Harvest Frequency | 79% | 77% | 78% | 77% | 80% | | | 49% | 40% | 46% | 47% | 53% | 45% |
| Yearling Doe Harvest Frequency | 31% | 30% | 35% | 29% | 32% | | | 18% | 16% | 17% | 16% | 24% | 18% |
| Fawn Harvest Frequency | 61% | 70% | 54% | 65% | 45% | | | 36% | 37% | 43% | 41% | 36% | 34% |
| Adult Doe Embryo Counts | | | | | 1.58 | 1.68 | 1.24 | 1.55 | 1.36 | 1.29 | 1.86 | 1.53 | 1.68 |
| Fawn Doe Embryo Counts | | | | | 0.15 | 0.16 | 0.33 | 0.25 | 0.00 | 0.25 | 0.43 | 0.27 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 42% | 44% | 39% | 34% |
| Antlerless License Allocation | 41877 | 34127 | 49512 | 49512 | 48811 | 39474 | 53056 | 58000 | 55000 | 40000 | 40000 | 40000 | 40000 |
| Antlerless License Sold | 41675 | 32411 | 40931 | 40354 | 48811 | 39265 | 52700 | 56746 | 54152 | 39544 | 39418 | 39426 | 39559 |
| Antlerless License CPUE | 27% | 39% | 30% | 25% | 38% | 38% | 28% | 33% | 23% | 21% | 25% | 21% | 24% |

*Decrease

## Deer Population Characteristics for WMU 4E for 1996-2008.

| WMU 4E | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 41502 | 38956 | 33985 | 34850 | 28929 | 26392 | |
| Population (Low Limit) per Square Mile | | | | | | | 23.6 | 22.2 | 19.4 | 19.9 | 16.5 | 15.0 | |
| Population (High Limit) | | | | | | | 48502 | 45954 | 41450 | 43093 | 41354 | 39499 | |
| Population (High Limit) per Square Mile | | | | | | | 27.6 | 26.2 | 23.6 | 24.6 | 23.6 | 22.5 | |
| Antlered Harvest | 5157 | 6075 | 6100 | 6300 | 9500 | 6600 | 6000 | 5100 | 4100 | 4500 | 4100 | 3300 | 4300 |
| Antlered Harvest per Square Mile | 2.9 | 3.5 | 3.5 | 3.6 | 5.4 | 3.8 | 3.4 | 2.9 | 2.3 | 2.6 | 2.3 | 1.9 | 2.5 |
| Antlerless Harvest | 6581 | 7378 | 7000 | 6800 | 10500 | 10100 | 10600 | 12300 | 11000 | 9100 | 9000 | 8100 | 7200 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Increase |
| Harvest Sex Ratio (D:B) | 1.3 | 1.2 | 1.1 | 1.1 | 1.1 | 1.5 | 1.8 | 2.4 | 2.7 | 2.0 | 2.2 | 2.5 | 1.7 |
| Yearling Buck Harvest Frequency | 86% | 79% | 78% | 76% | 82% | | | 67% | 64% | 61% | 70% | 63% | 60% |
| Yearling Doe Harvest Frequency | 30% | 34% | 36% | 33% | 34% | | | 20% | 21% | 16% | 20% | 16% | 20% |
| Fawn Harvest Frequency | 21% | 18% | 20% | 24% | 21% | | | 40% | 43% | 45% | 46% | 46% | 44% |
| Adult Doe Embryo Counts | | | | | 1.71 | 1.81 | 1.30 | 1.83 | 1.63 | 1.22 | 2.00 | 1.58 | 1.76 |
| Fawn Doe Embryo Counts | | | | | 0.43 | 0.35 | 0.25 | 0.22 | 0.00 | 0.27 | 0.07 | 0.17 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 71% | 72% | 68% | 61% |
| Antlerless License Allocation | 27098 | 21279 | 31124 | 31124 | 31422 | 29225 | 35797 | 38000 | 38000 | 38000 | 38000 | 38000 | 30000 |
| Antlerless License Sold | 27184 | 21297 | 25603 | 24989 | 31422 | 29189 | 35754 | 37460 | 37724 | 37755 | 37723 | 37710 | 29829 |
| Antlerless License CPUE | 24% | 35% | 27% | 27% | 33% | 35% | 30% | 33% | 29% | 24% | 24% | 21% | 24% |

*Decrease

## Deer Population Characteristics for WMU 5A for 1996-2008.

| WMU 5A | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 23071 | 22706 | 22349 | 19163 | 16228 | 15260 | |
| Population (Low Limit) per Square Mile | | | | | | | 6.8 | 6.7 | 6.6 | 5.7 | 4.8 | 4.5 | |
| Population (High Limit) | | | | | | | 30022 | 30004 | 30374 | 27188 | 32190 | 37085 | |
| Population (High Limit) per Square Mile | | | | | | | 8.9 | 8.9 | 9.0 | 8.0 | 9.5 | 11.0 | |
| Antlered Harvest | 3219 | 3691 | 3200 | 3900 | 5000 | 3800 | 2700 | 2900 | 2400 | 2400 | 2200 | 2400 | 2100 |
| Antlered Harvest per Square Mile | 1.0 | 1.1 | 0.9 | 1.2 | 1.5 | 1.1 | 0.8 | 0.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 |
| Antlerless Harvest | 3744 | 4071 | 3200 | 3300 | 5300 | 6700 | 7300 | 7700 | 7300 | 4700 | 5200 | 3900 | 3800 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Increase |
| Harvest Sex Ratio (D:B) | 1.2 | 1.1 | 1.0 | 0.8 | 1.1 | 1.8 | 2.7 | 2.7 | 3.0 | 2.0 | 2.4 | 1.6 | 1.8 |
| Yearling Buck Harvest Frequency | 83% | 77% | 79% | 79% | 80% | | | 56% | 57% | 47% | 49% | 49% | 52% |
| Yearling Doe Harvest Frequency | 32% | 26% | 29% | 32% | 32% | | | 20% | 17% | 17% | 20% | 18% | 17% |
| Fawn Harvest Frequency | 69% | 66% | 66% | 65% | 72% | | | 39% | 44% | 47% | 42% | 44% | 40% |
| Adult Doe Embryo Counts | | | | | 1.73 | 1.67 | 1.20 | 1.56 | 1.00 | 1.20 | 1.80 | 1.75 | 1.50 |
| Fawn Doe Embryo Counts | | | | | 0.22 | 0.60 | 0.00 | 0.40 | 0.00 | 1.00 | 0.50 | 0.46 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 62% | 75% | 69% | 67% |
| Antlerless License Allocation | 26423 | 26359 | 31406 | 31406 | 25071 | 23603 | 28097 | 28000 | 32000 | 28000 | 25000 | 22000 | 19000 |
| Antlerless License Sold | 26302 | 16971 | 16812 | 16086 | 24295 | 23257 | 27494 | 27206 | 31313 | 27378 | 24328 | 21517 | 18460 |
| Antlerless License CPUE | 14% | 24% | 19% | 21% | 22% | 29% | 27% | 28% | 23% | 17% | 21% | 18% | 21% |

*Decrease

## Deer Population Characteristics for WMU 5B for 1996-2008.

| WMU 5B | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 60930 | 60062 | 56370 | 52543 | 51711 | 44247 | |
| Population (Low Limit) per Square Mile | | | | | | | 21.7 | 21.4 | 20.1 | 18.7 | 18.4 | 15.8 | |
| Population (High Limit) | | | | | | | 70181 | 69725 | 67014 | 62132 | 71536 | 61675 | |
| Population (High Limit) per Square Mile | | | | | | | 25.0 | 24.8 | 23.9 | 22.1 | 25.5 | 22.0 | |
| Antlered Harvest | 6813 | 7167 | 7100 | 8100 | 10900 | 8800 | 8100 | 8000 | 7400 | 7400 | 7000 | 6000 | 6800 |
| Antlered Harvest per Square Mile | 2.4 | 2.6 | 2.5 | 2.9 | 3.9 | 3.1 | 2.9 | 2.8 | 2.6 | 2.6 | 2.5 | 2.1 | 2.4 |
| Antlerless Harvest | 7851 | 8696 | 7700 | 7800 | 13000 | 13500 | 14500 | 17200 | 14800 | 11700 | 11400 | 11100 | 11200 |
| Population Objective | | | | | | | | Dec* | Dec* | Stable | Stable | Stable | Stable |
| Harvest Sex Ratio (D:B) | 1.2 | 1.2 | 1.1 | 1.0 | 1.2 | 1.5 | 1.8 | 2.2 | 2.0 | 1.6 | 1.6 | 1.9 | 1.6 |
| Yearling Buck Harvest Frequency | 86% | 82% | 81% | 80% | 85% | | | 68% | 69% | 61% | 69% | 66% | 64% |
| Yearling Doe Harvest Frequency | 38% | 40% | 37% | 40% | 41% | | | 23% | 23% | 21% | 20% | 19% | 20% |
| Fawn Harvest Frequency | 61% | 72% | 71% | 63% | 67% | | | 41% | 41% | 43% | 48% | 45% | 44% |
| Adult Doe Embryo Counts | | | | | 2.18 | 1.82 | 1.85 | 1.94 | 1.53 | 1.36 | 1.38 | 1.69 | 1.75 |
| Fawn Doe Embryo Counts | | | | | 0.58 | 0.29 | 0.36 | 0.71 | 0.33 | 0.27 | 0.25 | 0.31 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 57% | 40% | 39% | 52% |
| Antlerless License Allocation | 46830 | 45867 | 52977 | 50777 | 51270 | 45544 | 58787 | 60000 | 64000 | 56000 | 53000 | 53000 | 51000 |
| Antlerless License Sold | 49308 | 36352 | 36399 | 32630 | 51184 | 45230 | 58160 | 57753 | 61762 | 54195 | 51192 | 51376 | 48980 |
| Antlerless License CPUE | 16% | 24% | 21% | 24% | 25% | 30% | 25% | 30% | 24% | 22% | 22% | 22% | 23% |

*Decrease

## Deer Population Characteristics for WMU 5C for 1996-2008.

| WMU 5C | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population (Low Limit) | | | | | | | 66953 | 67061 | 65941 | 65490 | 57505 | 53591 | |
| Population (Low Limit) per Square Mile | | | | | | | 22.1 | 22.1 | 21.7 | 21.6 | 18.9 | 17.7 | |
| Population (High Limit) | | | | | | | 78453 | 79670 | 79679 | 80797 | 82894 | 79778 | |
| Population (High Limit) per Square Mile | | | | | | | 25.8 | 26.2 | 26.2 | 26.6 | 27.3 | 26.3 | |
| Antlered Harvest | 6398 | 6935 | 6800 | 7600 | 10100 | 7500 | 8700 | 7800 | 7100 | 7700 | 7700 | 6500 | 8700 |
| Antlered Harvest per Square Mile | 2.1 | 2.3 | 2.2 | 2.5 | 3.3 | 2.5 | 2.9 | 2.6 | 2.3 | 2.5 | 2.5 | 2.1 | 2.9 |
| Antlerless Harvest | 11934 | 12014 | 10500 | 11500 | 14800 | 13600 | 15100 | 19100 | 16900 | 17600 | 16100 | 18900 | 20200 |
| Population Objective | | | | | | | | Dec* | Dec* | Dec* | Dec* | Dec* | Dec* |
| Harvest Sex Ratio (D:B) | 1.9 | 1.7 | 1.5 | 1.5 | 1.5 | 1.8 | 1.7 | 2.4 | 2.4 | 2.3 | 2.1 | 2.9 | 2.3 |
| Yearling Buck Harvest Frequency | 75% | 75% | 77% | 73% | 76% | | | 55% | 52% | 49% | 59% | 53% | 50% |
| Yearling Doe Harvest Frequency | 41% | 40% | 42% | 42% | 42% | | | 20% | 18% | 18% | 20% | 18% | 20% |
| Fawn Harvest Frequency | 10% | 11% | 10% | 11% | 17% | | | 44% | 44% | 39% | 46% | 49% | 44% |
| Adult Doe Embryo Counts | | | | | 1.66 | 1.75 | 1.80 | 1.75 | 1.84 | 1.61 | 1.81 | 1.47 | 1.67 |
| Fawn Doe Embryo Counts | | | | | 0.59 | 0.61 | 0.35 | 0.59 | 0.14 | 0.57 | 0.29 | 0.37 | 0.00 |
| 5-Yr Avg. % Adequate Regeneration | | | | | | | | | | 29% | 23% | 18% | 29% |
| Antlerless License Allocation | 16035 | 16490 | 76719 | 23419 | 75261 | 71124 | 93660 | 66000 | 71000 | 71000 | 79000 | 84000 | 92000 |
| Antlerless License Sold | 82718 | 74004 | 67774 | 14768 | 74058 | 69916 | 87395 | 64812 | 66862 | 69423 | 77086 | 82051 | 89972 |
| Antlerless License CPUE | 14% | 16% | 15% | 78% | 20% | 19% | 17% | 29% | 25% | 25% | 21% | 23% | 22% |

*Decrease

# Appendix D – Response to This Report

OFFICE OF
EXECUTIVE DIRECTOR
717-787-3633

COMMONWEALTH OF PENNSYLVANIA

**Pennsylvania Game Commission**

2001 ELMERTON AVENUE
HARRISBURG, PA 17110-9797

*"To manage all wild birds, mammals and their habitats for current and future generations."*

ADMINISTRATIVE BUREAUS:
ADMINISTRATION ..................... 717-787-5670
PERSONNEL ..................... 717-787-7836
AUTOMOTIVE AND PROCUREMENT DIVISION .. 717-787-6594
LICENSE DIVISION ............... 717-787-2084
WILDLIFE MANAGEMENT .......... 717-787-5529
INFORMATION & EDUCATION .. 717-787-6286
WILDLIFE PROTECTION ........... 717-783-6526
WILDLIFE HABITAT MANAGEMENT ........................ 717-787-6818
REAL ESTATE DIVISION ...... 717-787-6568
AUTOMATED TECHNOLOGY SERVICES ............................ 717-787-4076

www.pgc.state.pa.us

February 9, 2010

Philip R. Durgin
Executive Director
Legislative Budget and Finance Committee
Finance Building, Room 400A
Harrisburg, PA 17105

Dear Mr. Durgin,

We appreciate the opportunity to comment on "The Deer Management Program of the Pennsylvania Game Commission, A Comprehensive Review and Evaluation." We believe it was a thorough and detailed review of our program.

We welcome the conclusion that the overall scientific foundation of the PGC deer management system is sound, and that the design of the current Wildlife Management Units reflect a necessary compromise between the various needs.

The report also provides some opportunities to improve our deer management program. Some of the recommendations we can address easily, but some will require additional resources to be able to implement.

We look forward to discussing those issues further with members of the Committee and WMI team members in an effort to continue improvement of the program.

Sincerely,

Carl G. Roe

The following comments on "The deer management program of the Pennsylvania Game Commission: a comprehensive review and evaluation" by the Wildlife Management Institute focus on the technical aspects of the 'Findings, Conclusions, and Recommendations' section of the report. We concur with the findings of the audit that indicate the PGC has implemented a deer management program that is consistent with its mandates through structured public involvement and scientific data collection methods.

As with any complex undertaking, such as a statewide deer program, room for improvement exists. In the past, the PGC has actively sought peer-reviews of various components of our deer program, conducted research and analyses to evaluate strengths and weaknesses, and implemented changes when warranted. The recommendations from this audit will be treated in a similar manner.

**PA SAK deer population model**

WMI recommended the PGC continue to test and evaluate the PA SAK model, discontinue use of reconstructions in yearling buck harvest rate and fawn-to-adult doe ratio calculations, incorporate DMAP antlerless harvests into the PA SAK model, and publish results of the PA SAK model. The PGC agrees that continual testing and evaluation of the PA SAK model is needed; that DMAP be included in the PA SAK model; and that relevant information from the PA SAK model be made available to the public.

As with any model of a natural system, the PA SAK model does not provide exact numbers of deer living in Pennsylvania at any given time. Rather, the PA SAK model is a representation, or index, of the deer population in Pennsylvania. The PGC's goal in using the PA SAK model is to create a useful tool to monitor and adjust deer population trends by WMU. Because of the uncertainty associated with all models, continual testing and evaluating of the inputs and outputs are required. Consequently, we agree with the recommendation to continually test and evaluate the PA SAK inputs and outputs.

As noted in the report, the PGC and PCFWRU at Penn State University have been testing and evaluating the PA SAK model as part of a graduate project since 2007. Results of an interim report (Norton and Diefenbach 2009, reference on page 68 of report) are included in the audit report. The recommendations to discontinue use of updated yearling buck harvest rates and fawn-to-doe correction factors will be incorporated into the ongoing evaluation of the PA SAK model. We strongly agree with the recommendation to prioritize research to better understand variation associated with yearling buck harvest rates. Findings of the audit correspond with findings from the graduate project to date and field studies of yearling buck harvest rates are ongoing.

It was recommended that DMAP antlerless harvests be incorporated into the PA SAK model. Because of the operation of the PA SAK model, antlerless harvests, such as DMAP harvest, affect adult sex and fawn-to-doe ratio inputs. These data come from field checks conducted by trained deer agers each hunting season. Beginning with the 2009-10 hunting seasons, these ratios from DMAP antlerless harvests will be included into the PA SAK model.

Finally, WMI recommended the PGC publish estimates of population size and age and sex structure, accompanied by levels of variance and an explanation of their appropriate use. Results of the PA SAK model are an index of the deer population in Pennsylvania and are used by the PGC, not to set management objectives, but to track deer population trends. As such, the PGC annual reports have provided results of the PA SAK model in the form of annual changes in the index values since the PA SAK model was developed in 2006.

The PGC will consider altering methods of presenting PA SAK model results based on this recommendation. However, PA SAK model results will continue to play a supporting role by tracking deer population trends and not absolute deer abundance. Deer management goals and objectives will continue to be based on measures of deer impacts, and not deer numbers.

**Deer harvest estimates and reporting rates**

WMI recommended additional efforts to increase deer harvest reporting rates by successful deer hunters. The PGC agrees that increased reporting rates would reduce variance in estimates.

The PGC uses a standard wildlife management estimating procedure (i.e., mark-recapture) and peer-reviewed data collection protocols to estimate annual deer harvests. PGC deer harvest estimates appear to have minimal bias based on strong correlation with results from an independent, annual hunter survey. Variation in reporting rates is accounted for by estimating deer harvests using year, WMU, and deer-specific data. In other words, the 2008 antlered harvest in WMU 1A was estimated using data collected from antlered deer in WMU 1A in 2008. There is no pooling of data across years, locations, or type of deer. Current levels of data collection by PGC personnel produce precise deer harvest estimates with low variance. Deer harvest estimates represent the strongest data set in the PGC's deer program.

As always, more data would improve deer harvest estimates. The PGC agrees that improving outreach efforts to encourage greater reporting by successful deer hunters is a viable option to increase reporting rates. Beginning in 2009, the PGC began accepting deer harvest reports over the Internet in addition to the report cards. Other options for reporting may be available in the future. As a result, the PGC provides multiple ways for hunters to comply with existing mandatory registration requirements.

However, the PGC recognizes that until all successful hunters comply with existing mandatory registration requirements, deer harvest estimates will be needed. As such, our primary focus will remain on obtaining adequate and unbiased data to generate reliable harvest estimates.

**Deer herd health**

WMI recommended the PGC seek an alternative to embryos per adult doe as an index of herd health or delete the herd health goal and focus more resources into measuring the habitat health goal. An alternative measure, as noted by WMI, is not readily apparent.

The PGC's use of reproductive rate as an index of herd health is supported by the scientific literature (see page 32 of report). In addition, the PGC's method of pooling 3 years of reproductive data for management purposes produces adequate sample sizes and precise estimates (see Table 9 on page 36 of report).

Despite biological and statistical support for this measure, the value of the measure to the deer management decision-making process warrants further consideration, as recommended. The PGC will investigate the utility of this measure and alternatives based on responsiveness to change in deer population condition and fiscal efficiency.

**Forest habitat health**

WMI recommended the PGC analyze data from all FIA regeneration plots. The PGC agrees that this recommendation will efficiently increase sample sizes and improve precision of WMU regeneration estimates.

However, just like the deer health measure, a forest habitat health measure should be evaluated based upon it effectiveness in the decision-making process. In the case of the forest regeneration measure, the PGC adopted the USFS criteria for limiting regeneration estimates to plots that were 40-75 percent stocked. This screening was done to ensure regeneration plots represented areas with sufficient light conditions for regeneration to occur. The PGC considers this a valuable method to minimize the effects of non-deer factors on regeneration. The PGC's deer management program has strived to implement a measure that most accurately represents the impact of deer – not other factors, such as light – on regeneration.

Other alternatives were recommended for consideration including grouping WMUs and incorporating State Game Land and State Forest data into WMU measures. Compared to efforts to bolster sample sizes in individual WMUs, we consider these alternatives least preferred. Grouping WMUs would easily increase sample sizes, but would reduce specificity of data to a particular WMU. The benefit of incorporating State Game Land and State Forest data into a WMU measure is uncertain from a statistical perspective. However, it certainly would complicate the analysis and interpretation of the data.

As noted in the report, the PGC and USFS have recognized the issue with sample sizes of FIA regeneration plots for WMU applications. The PGC will include WMI's recommendation as part of the considerations with the USFS to address this deer management need.

**Citizen Advisory Committees (CACs)**

WMI recommended CACs remain a part of the deer management program at the state level, but that public surveys may provide more defensible measures of public preferences. The PGC recognizes the value of engaging stakeholders on both the state and WMU level.

The goals of the current deer management plan are based on a CAC-like stakeholder meeting. In addition, the PGC plans to establish and maintain a statewide stakeholder group during its next deer management planning cycle (i.e., fiscal years 2009-2018).

The recommendation to replace WMU CACs with surveys has merit. The PGC will evaluate the potential value of surveys as replacements for CACs. Given current funding levels, obstacles to implementing this recommendation include the lack of a professional human dimensions staff position and the expense of conducting surveys with sufficient sample sizes in each WMU.

**Outreach and communications**

WMI recommended the PGC continue its efforts towards conflict resolution, increased communications, and enhanced opportunities for collaboration. The PGC agrees with these recommendations and will continue to strive to implement them.

The PGC plans to continue the work of its Deer Communications Working Group that was established in 2007. This group of PGC employees has increased outreach and communications via methods such as brochures, booklets, videos, and open houses. In addition, biologists within the deer program will continue publishing "The Deer Chronicle" twice a year, publishing Game News articles on important topics, and posting publications on the PGC's website.

**Conclusion**

The PGC appreciates the thoroughness of WMI's review and evaluation of our deer program. This audit identified current strengths and areas for improvement within the deer management program. As with previous peer-reviews, the PGC will use these findings and recommendations to improve its deer management program where possible.