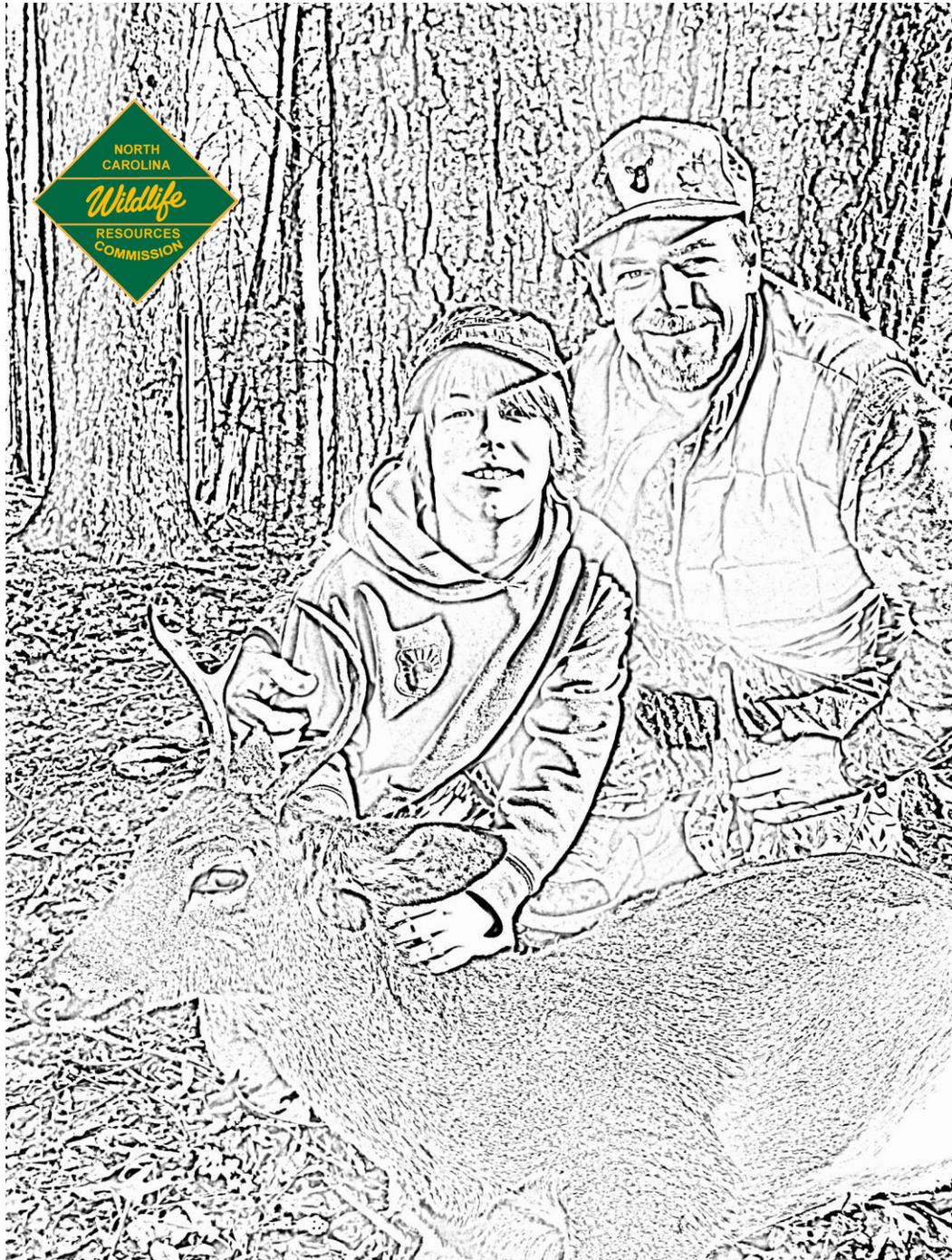


# Evaluation of Deer Hunting Season Structures and Deer Management Units in North Carolina



February, 2015



## **Evaluation of Deer Hunting Season Structures and Deer Management Units in North Carolina**

February 2015

### **Introduction and Background**

Currently N.C. has four deer season zones which were established many years ago when our deer and human populations and distributions were much different. While there was some biological justification for these zones, they were primarily based on then-existing administrative regions. As deer populations expanded and densities increased, regulations were developed and/or modified to address landowner and hunter desires but always within these four deer season zones. In the fall of 2009, Division of Wildlife Management (DWM) staff began evaluating these existing deer season structures based on a set of biological goals for deer hunting management in our state. Staff were further tasked with developing a set of deer season establishment criteria that are biologically based and independent of geo-political boundaries for use by DWM and Executive staff in considering potential management recommendations to Commissioners.

In November 2010, the Commission's Big Game Committee received the staff report, "*Evaluating Proposed Changes in Deer Hunting Regulations*" (Appendix I). Designed for evaluating proposed changes in deer hunting regulations, this report also established biological variables to evaluate the form and function of deer season frameworks using available data. Further, in that report we recommended an agency goal statement for deer management and hunting. All recommendations in the report were approved by the full Commission on November 4, 2010 including the following goal for deer management and hunting:

"The NCWRC's goal for deer management and hunting is to use science-based decision making and biologically-sound management principles to assure long-term viability of deer populations at desirable levels of health, herd composition, and density with respect to land cover type and use, hunter satisfaction, and overall social acceptance."

All activities undertaken in the project described herein were premised on this agency goal statement.

The recommended implementation of a new deer hunting regulation change proposal process included a deer regulation evaluation tool (Appendix I). In the tool we define the biological variables indicative of a well-managed deer herd. Following approval by the Commission, these

biological and social variables became the standards upon which evaluating deer regulation proposals and deer season frameworks begins. The Commission also approved staff's recommendations to:

1. Delineate deer management units using biological variables.
2. Set specific biological objectives for these deer management units.
3. If applicable, develop regulations to achieve those objectives as soon as feasible.

Herein, we address the results and status of these Commission directives. This is the first time our agency has attempted to use biological data to delineate deer management areas based on specific biological variables, establish deer management objectives for delineated areas, and implement unique regulatory actions designed to accomplish those objectives.

### **1) Delineating deer management units using biological variables.**

A preliminary attempt to delineate deer management units (DMUs) based upon biological data was conducted in 2011. We were unable to appropriately delineate DMUs due to specific data limitations. However, working through the process provided valuable information significant to the completion of this task. Specifically, we identified weaknesses in peak conception date data, which is the most important biological variable in the delineation of DMUs. We also identified significant limitations in other biological deer data and developed specific deer sampling units (DSUs) to guide timing, location, and sample sizes for data collection required to complete the task.

Upon consensus by the Commission and Executive staff, DWM staff designed a project to improve and expand data collection for three years. Biologists were instructed to identify data limitations relative to deer management and implement strategies to improve the quantity and quality of deer data. Beginning with the 2011 deer hunting season, statewide data collection efforts were enhanced to ensure appropriate sample sizes, reduce bias in the harvest data, increase overall quality of collected data, and to determine peak conception dates across the state.

Biological data were collected from 22,560 deer during the three-year project. Of these, 16,928 (75%) met the sampling criteria of being known-age hunter-harvested adult deer (i.e.,  $\geq 1.5$  years of age). Including useable samples collected in 2009 and 2010, fetuses were collected from 1,468 does to estimate peak conception dates within DSUs. Datasets were reviewed and data therein evaluated for biases before final inclusion in delineation of DSUs.

The delineation of DMUs required multiple data analysis steps. DWM biologists worked with faculty from both North Carolina State University and East Carolina University to employ the most current and appropriate data analysis techniques to develop DMUs. Final biological clustering analyses and results were developed in conjunction with Dr. Paul Vos, Chair, Department of Biostatistics, East Carolina University. Biological DMU delineations evaluated

biological and landscape variables, but did not include social or political variables. Inclusion of social and political attributes and variables are proposed as subsequent steps to facilitate design of final DMU structures.

Final delineation of DSUs was based on a county-based cluster analysis using a step-wise comparison of ranked variables for each individual county. Variables used in the delineation included median conception date, antlered buck harvest per square mile, parcel size, and average weights of 1.5- and 2.5-year-old does. Median conception was the primary variable that contributed to the biological delineation of DMUs. Results of these analyses and mapping of DMUs developed from biological variables represent groups of counties within North Carolina that are the most similar with respect to the biological variables included in the cluster analysis (Figure 1). A full description of methods and results for all steps involved in completing this task is provided in Appendix II. These DMUs represent areas of the state where deer populations should be expected to have similar biological responses to regulatory changes or other management efforts.

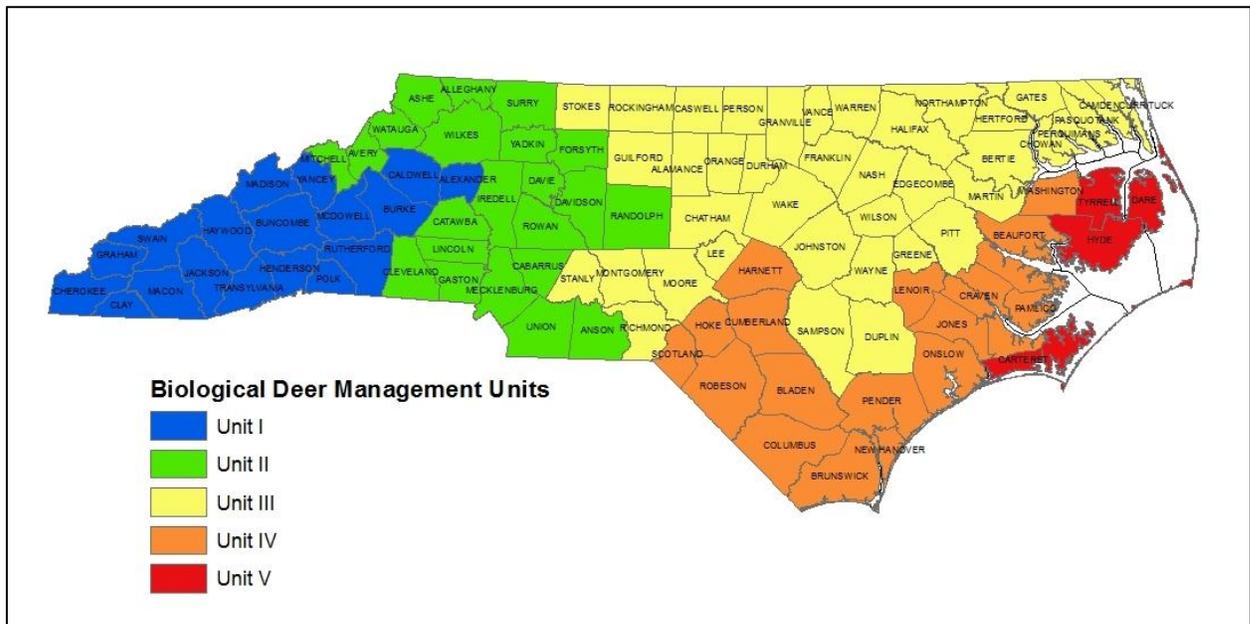


Figure 1. Final biological DMUs based on a variable prioritization approach, 2014.

## 2) Setting specific biological objectives for deer management units.

The agency's deer regulation proposal evaluation tool, which provides biological variables that define a well-managed deer herd, was previously used to evaluate current deer season areas (Appendix D). Based on that evaluation, the current deer season frameworks are not meeting the majority of variables that define a well-managed herd. Following the development of the biological DMUs, a statistical evaluation was conducted to determine how well the current deer season areas and newly developed DMUs fit biological data we collected (Appendix III). Based on this evaluation and from a biological perspective, our current deer season frameworks are not

the best geographic fit with the biological attributes of our state's deer herd; the biologically delineated DMUs are a much better fit.

As was previously conducted for the current deer season zones, these DMUs were evaluated using the agency's deer regulation proposal evaluation tool. The goal was to provide insight into which variable values need to be improved within each DMU. Results of this evaluation (Appendix III) indicate that some DMUs had variable values that fell outside of the desired ranges. However, specific biological objectives that move DMUs toward the variables of a well-managed deer herd should only be developed with further input and review from the Commission and our constituents.

Management of a deer herd relies significantly on the socio/political desires of deer stakeholders and their willingness to manage for certain biological outcomes. Ultimately, the ability to influence biological variables using regulatory management is directly linked to acceptance and support of regulations by our hunters, and the behavior they exhibit after regulations are implemented. Therefore, before development of biological objectives for DMUs can be completed, we must incorporate input from our constituents relative to their desired hunting experience. This includes both the biological characteristics of the deer herd (i.e., older buck age structure, more deer, balanced population, etc.) and the recreational value of the hunt (i.e., buck behavior they observe, number of deer they see, etc.). Meeting both biological deer management objectives and the objectives of our stakeholders (i.e., hunters, landholders, and other citizens) will require balancing biological and social objectives to develop regulations to produce the most acceptable outcome. Adjusting certain deer season components such as time of opening date, number of either-sex days, antlered buck bag limit and length of season will lead to different outcomes. Additional desires, such as minimizing effects of coyotes on deer recruitment, may also be addressed through this process. For example, if it is determined that coyotes are impacting deer recruitment then predation is likely best mitigated by modifying season structure to reduce the antlerless deer harvest and/or move toward more succinct fawning dates.

Additional input from both the Commission and our stakeholders is paramount to moving forward with setting biological objectives for deer management in these proposed DMUs. Before moving ahead with setting biological objectives we must first determine if new deer management areas are desired by North Carolinians. We propose the following series of steps to finalize this second recommendation, which will then determine the need and outcome of developing regulations to achieve biological objectives endorsed by our hunters and other citizens.

## **Proposed Steps to Move Forward**

- Determine if the current Commission desires to continue with DMU development.
- DWM Deer Committee meets to review and discuss biological findings of the 3-year study (This working meeting may include a contingent of commissioners or other stakeholders.)
- Spring 2015 public input meetings
  - Present results of this study
  - Obtain initial input from public on deer management goals and objectives
- Develop draft biological objectives for DMUs.
- Conduct scientific mail survey of North Carolina deer hunters.
  - Determine overall support for moving toward DMU objectives.
  - Identify acceptable DMU strategies to meet objectives.
- Collaboratively develop strategies for achieving mutually-agreed to goals and objectives.
- Test strategies with focus groups.
- Conduct a second series of public information and input meetings.
  - Present mail survey results and all other available information.
  - Present draft biological objectives and strategies.
  - Obtain input on draft objectives and strategies
- If warranted develop regulation options for moving toward public-supported objectives for deer management in North Carolina.

## **List of Appendices**

Appendix I: Evaluating Proposed Changes in Deer Hunting Regulations, November 2010

Appendix II: Development of North Carolina Biological Deer Management Units, February 2015

Appendix III: Evaluation of Biological Deer Management Units, February 2015

*Compiled, written, and edited by: Brad Howard, David Sawyer, and David Cobb*



## Evaluating Proposed Changes in Deer Hunting Regulations

November 2010

Herein, we present the North Carolina Wildlife Resource Commission's (NCWRC) goal for deer hunting and management, and provide a process using biological and non-biological variables for evaluating proposed changes in deer hunting regulations. This process was developed during 2010 by an Ad-hoc committee (see page 15) in the Division of Wildlife Management (DWM). Development of this protocol specifically addresses two elements of the NCWRC's Strategic Plan:

*Goal 3 - Strategic Objective 2-- Emphasize best available science in the application of fish and wildlife management programs, and*

*Goal 7- Strategic Objective 2-- Identify and review core processes to ensure efficiency and effectiveness and evaluate how rules and processes are supporting the needs of the resources.*

In addition, this effort directly addresses Objectives 2.1.1, 3.3.9, 3.3.11, 3.6.6, 4.1.16, and 5.2.2 in the DWM Strategic Plan.

The deer management goal provided herein is intended to encompass all aspects related to management of the deer herd and deer hunting throughout the state. However, achieving this goal via hunting will be challenging in urban areas or other places where hunting pressure is limited (Figure 1).

Biological and non-biological evaluations of proposed regulation changes should be completed using evaluation sheets on Pages 4 and 5. Although subjective interpretation may be required to overcome some shortcomings and possible biases in the data, the evaluations are designed to be as objective as possible by relying heavily on data. The biological evaluation of a proposal generates a numerical "score" that indicates the expected impacts on meeting the stated biological objectives. Information related to hunter attitudes, fiscal impacts, administration, and other non-biological issues are presented in such a way as to summarize the overall support, impact, and desirability of a given regulation change proposal.

The timeline presented on Page 6 outlines how the biological and non-biological evaluations can be incorporated into the regulatory process. Following the proposed process will enable the NCWRC to proactively promote sound deer management. Doing so will focus efforts toward developing regulations that address hunter satisfaction and other non-biological issues, but only after ensuring that proposed changes will not have negative biological impacts. The biological variables (e.g., reported deer harvest, sex and age data, estimated breeding dates) used in the evaluation process draw from scientific knowledge, empirical data, and working experience of NCWRC biologists. Although not perfect, this is currently the best information available and is appropriate for this type of evaluation. Future adjustments may be desirable as data collection and reliability improves.

## Goal

The NCWRC goal for deer hunting and management is to:

Use science-based decision making and biologically-sound management principles to assure long-term viability of deer populations at desirable levels of health, herd composition, and density with respect to land cover type and use, hunter satisfaction, and overall social acceptance.

Achievement of this goal would be reflected by a well-managed herd that:

- may be managed with hunting as the primary tool,
- carries with it a primarily positive resource value, with acceptable levels of long-term negative impacts to people, property, and other natural resources,
- is capable of supporting a broad range of traditional and new hunting opportunities,
- is capable of accommodating diverse landholder deer management goals,
- does not exceed the land's ability to sustain it, and
- can be evaluated using the following biological variables:
  1. a viable population is maintained within nutritional carrying capacity,
  2. all age classes of bucks and does are adequately represented,
  3. adult sex-ratios are balanced during breeding season to increase the likelihood of synchronized breeding and parturition,
  4. yearling buck dispersal is adequate,
  5. standing genetic diversity is maintained,
  6. the herd is free-ranging, and
  7. the risk of disease introduction and transmission is minimal.

## Biological Evaluation of Proposed Deer Regulation Change

**Proposal Number:**

**Area and regulation(s):**

In regard to achieving and/or maintaining biological objectives, are current trends expected to be **improved, worsened, or not affected** by this proposed rule change?

Biological Objective	For the area considered, what is the 3-year average and trend?	Points to be awarded in answer to the question above			Points
		Improved	Worsened	Not Affected or No Data	
Harvest of at least 1.0 antlered buck/mi <sup>2</sup> , or if less than 1.0 buck/mi <sup>2</sup> the area has a stable or increasing trend.		30	-30	0	
Total adult doe harvest (i.e., excluding fawns) is comprised of 30-35% yearling does (1.5 years old).		10	-10	0	
Total antlered buck harvest (i.e., excluding button bucks) is comprised of no more than 30% yearling bucks (1.5 years old).		10	-10	0	
Total harvest is comprised of at least 50% does.		10	-10	0	
Sex composition of harvest that occurs prior to peak breeding is comprised of at least 50% does.		10	-10	0	
No more than 20% of total antlered buck harvest (i.e., excluding button bucks) occurs before the time of peak breeding.		10	-10	0	
Deer are a naturally occurring product of the landscape. There is no genetic manipulation and movements are not restricted.		20	-20	0	
The risk of disease transmission is reduced.		20	-20	0	
<b>Explanation of Score:</b> A positive (+) score indicates an overall expected improvement over current regulations. A negative score (-) indicates an expectation that the proposed change will hinder meeting biological objectives. The highest possible score is +100% and the lowest possible score is -100%.	Total Points _____ Maximum Points Possible <u>120</u>			<b>Biological Score</b> _____ % <i>(% of total points possible)</i>	
	Comments:				

## Evaluation of Non-Biological Issues Related to Proposed Deer Regulation Change

<b>Proposal Number:</b>
<b>Area and regulation(s):</b>

In considering whether to support this proposed regulation, what is the current level of support or expected impact for the following parameters?

		Direction and Magnitude of Support or Impacts						Source of Information	Comments
		Positive		Neutral Support or Little to No Impact	Negative				
		Strong	Moderate		Moderate	Strong			
Parameter		Strong	Moderate	Impact	Moderate	Strong	Unknown		
<b>Constituent Considerations</b>	1. <b>Deer hunters:</b> Expected level of support				X			Example- Professional Knowledge	Example- Some hunters oppose additional either-sex opportunitites
	2. <b>Deer hunters:</b> Expected impacts on hunting opportunity/long term satisfaction	X						Example- Professional Knowledge	Example - Additional either-sex opportunities not expect to negatively impact herd
	3. <b>Other hunters:</b> Expected level of support								
	4. <b>Other hunters:</b> Expected impacts on hunting opportunity/long term								
	5. <b>Landowners:</b> Impacts and/or support as noted in comments					X		Example Survey from 2009	Example - 75% of landowners are opposed to this type of regulation
	6. <b>Non-hunters:</b> Impacts and/or support as noted in comments								
	7. Fiscal impacts to constituents								
<b>Agency Considerations</b>	8. Impacts on hunter retention and recruitment	X						Example - License data	Example - Similar regulation changes have not impacted license sales in the past
	9. Impacts on enforceability	X						Example - DLE comments	Example - LE staff feels this change will improve ability to enforce regulations
	10. Impacts on ability to monitor changes in the deer herd								
	11. Impacts to agency administration								
	12. Impacts on regulation complexity								
	13. Fiscal impacts to NCWRC								
	14. Other:								
	15. Other:								
Comments:									

## Timeline

### Evaluating Proposed Changes in Deer Season Regulations

<b>Deadline</b>	<b>Task</b>
November through January NCWRC Meeting	DWM staff and NCWRC Big Game Committee develop regulation change proposals based on management needs and public input.
Mid-January	All proposals related to deer, whether originated by staff or Commissioners, are due to the DWM Rules Biologist.
Early February	Evaluation Group (i.e., DWM Deer Committee and biologists from affected areas) meets to make biological evaluations and preliminary non-biological evaluations.  Proposals receiving a negative (-) biological score do not continue forward, but are returned to originator with explanation and comments regarding how to improve the proposal if submitted in a future regulation cycle.
Mid-February	All non-deer proposals are due to DWM Rules Biologist.
March 1-31	District meetings. Evaluation sheets for biological evaluations and preliminary non-biological evaluations are presented for staff consideration and comment.
Mid-April	DWM rules meeting. Final non-biological evaluation (if different from preliminary evaluation made by Evaluation Group) is made based on input from district meetings.
Mid-April	Central staff meeting
May NCWRC Meeting	Commissioners receive a handout with the proposals and explanations for each. The 1-page evaluation sheets (both biological and non-biological) are attached to deer proposals in this handout. This is an informational handout only with no action required by the NCWRC.
July NCWRC Meeting	NCWRC meeting to vote on proposals to send to public hearings.
August 1 to October 1	Public comment period
September	Public Hearings
October NCWRC Meeting	NCWRC reviews public comments
November NCWRC Meeting	NCWRC votes on proposals
December	Rules Review Commission reviews proposals
August 1st of following year	Approved proposals go into effect

## Biological Objectives and Current Herd Status

Herein, we describe our recommended biological objectives and evaluate the current status of the deer herd. The data are the result of multiple collection techniques across the state. The numbers may be biased in certain ways based on the method by which the data were collected. The interpretation of the data thus must be made with the understanding of how and to what extent some of the collection biases might affect these numbers. Meeting all objectives may not be feasible in areas where hunting is limited by land-use practices, soil productivity is poor, or deer habitat is suboptimal.

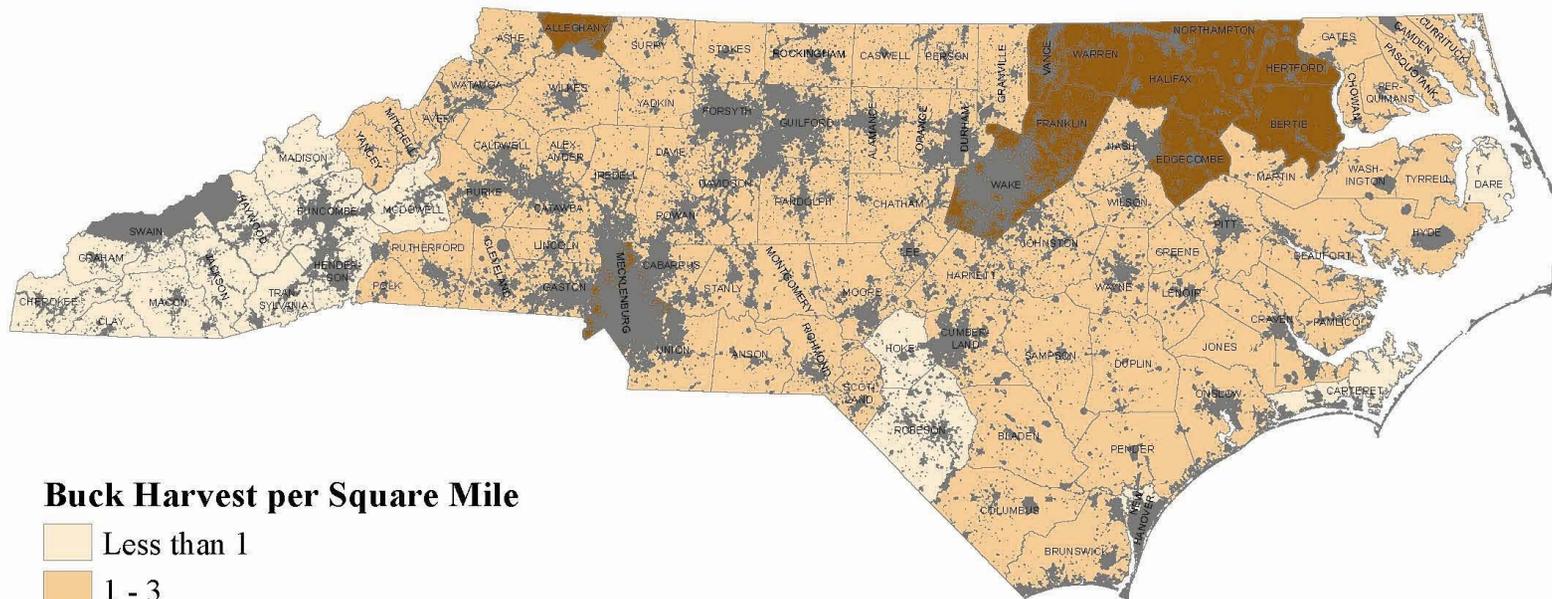
**Biological Objective #1: Harvest of at least 1.0 antlered buck/mi<sup>2</sup>, or if less than 1.0 antlered buck/mi<sup>2</sup> the area has a stable or increasing trend.**

**Justification:** In general, a harvest of 1.0 antlered buck/mi<sup>2</sup> is indicative of a minimum deer density consistent with our stated deer management goal.

**Data Reliability:** While reported harvest may not exactly reflect actual harvest, reporting rates and associated biases are relatively consistent over time. This is our most useful information with respect to relative deer abundance at this time.

**Current Status of Herd:** Currently, all counties within the state exhibit an antlered buck kill of >1 antlered buck/mi<sup>2</sup>, except for a few low productivity areas (Figure 1). However, in these areas antlered buck harvest remains stable or is slowly increasing.

**Figure 1. Reported Antlered Buck Harvest per Huntible Square Mile  
(3-Year Average, 2007-2009)**



**Buck Harvest per Square Mile**

- Less than 1
- 1 - 3
- Greater than 3
- Unhunting Areas

*Where conventional hunting may be limited or prohibited:*  
 Federal and State Parks, Municipal Boundaries,  
 Water Bodies, Human Density greater than 1 person per 2 acres

**Population modeling indicates the following relationship:**

- Less than 1 buck/sq mi corresponds to an average of 10 deer/sq mi
- Between 1 and 3 bucks/sq mi corresponds to an average of 30 deer/sq mi
- Greater than 3 bucks/sq mi corresponds to an average of 50 deer/sq mi

**Biological Objective #2: Total adult doe harvest (excluding fawns) is comprised of 30 - 35% does that are 1.5 years old.**

**Justification:** The percentage of yearling does (1.5 years old) in the adult doe harvest is a good indicator of the harvest pressure placed on the doe segment of the population and is indicative of expected future population trends. Populations are expected to remain relatively stable at a density consistent with our stated deer management goal when yearling does comprise 1/3 of adult doe harvest. Conversely, in areas of low productivity where a population increase is desired, the percentage should remain below 30% (Downing and Guynn 1985).

**Data Reliability:** Current data is limited in some areas because of low sample size and distribution of samples.

**Current Status of Herd:** Although data are somewhat limited, harvest pressure on the doe segment across the state appears to be approaching the lower end of the desired range.

Table 1. Yearling Representation in Total Adult Doe Harvest (3-year average, 2007-2009).

Season Framework	Percentage of Yearling Does in Total Adult Doe Harvest
Western	30
Northwestern	29
Central	26
Eastern	29

**Biological Objective #3: Total buck harvest (excluding button bucks) is comprised of no more than 30% yearling bucks (1.5 years old).**

**Justification:** The percentage of yearling males (1.5 years old) in the antlered male harvest is a good indicator of harvest pressure placed on adult males within the hunting season (Downing and Guynn 1985). Regulations and management techniques aimed at creating a more biologically balanced male age structure should strive to minimize harvest pressure on yearling bucks when possible (Keyser et al. 2006).

**Data Reliability:** These data are very sensitive to bias in data collection methods and can be affected by hunter selectivity. For example, data collected via DMAP likely reflects a preference for harvesting older age class bucks. Much of the data in the Eastern framework comes from DMAP clubs, and therefore likely underestimates yearling harvest.

**Current Status of Herd:** Although data are somewhat limited, yearling buck harvest appears to be substantially higher than desired across the state.

Table 2. Yearling Representation in Total Antlered Buck Harvest (3-year average, 2007-2009).

Season Framework	Percentage of Yearling Bucks in Total Adult Buck Harvest
Western	45
Northwestern	49
Central	37
Eastern	35

**Biological Objective #4: Total harvest is comprised of at least 50% does.**

**Justification:** The percent of does in the total harvest is a good indicator of the effects of the annual harvest on population trends (Hayne and Gwynn 1977). Achieving this objective will also result in more balanced sex ratios. However, in areas of low productivity where a population increase is desired, the percentage should remain well below 50%.

**Data Reliability:** While reported harvest may not exactly reflect actual harvest, reporting rates and associated biases are relatively consistent over time. This variable is heavily dependent on the actual number of bucks killed. The percentage of does in the harvest can vary substantially if buck harvest is impacted by changes in regulations, hunter selectivity, or other factors.

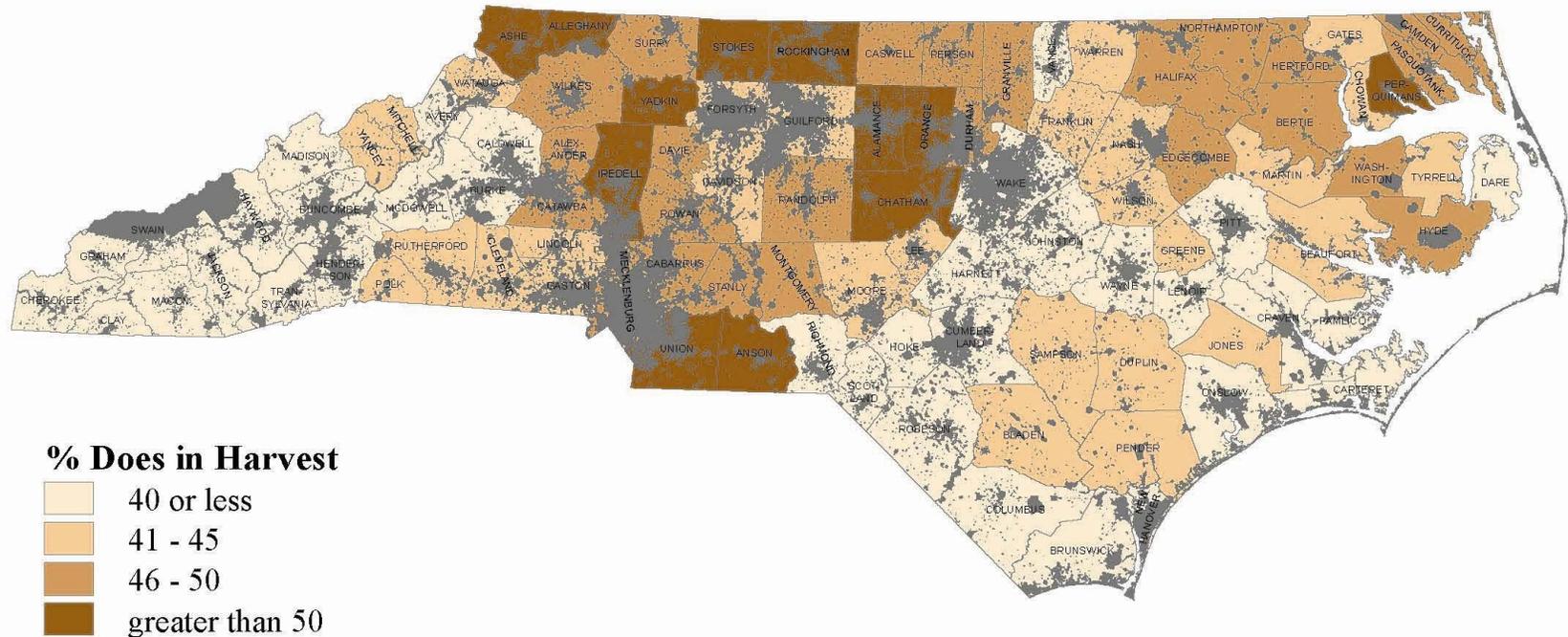
**Current Status of Herd:**

Current 3 year trends indicate that two of the four frameworks are approaching 50%. Limited either-sex opportunities in the Western Season account for lower numbers, which is appropriate in low productivity areas where a population increase is desired (Figure 2).

Table 3. Sex Composition of Total Harvest (3-year average, 2007-2009).

Season Framework	Percentage of Does in Total Harvest
Western	37
Northwestern	49
Central	49
Eastern	42

**Figure 2. Percentage of Does in Total Reported Deer Harvest**  
(3-Year Average, 2007-2009)



**% Does in Harvest**

- 40 or less
- 41 - 45
- 46 - 50
- greater than 50

**Unhuntable Areas**

*Where conventional hunting may be limited or prohibited:*  
Federal and State Parks, Municipal Boundaries,  
Water Bodies, Human Density greater than 1 person per 2 acres

**Biological Objective #5: Sex composition of harvest that occurs prior to peak breeding is at least 50% does.**

**Justification:** Achieving this objective will ensure that does are not overrepresented in the population at peak breeding periods. This ensures adequate breeding of females during the first estrous period, fawn births occur during an optimal and relatively short span of time, and increases available food resources later in the season (Gruver et al. 1984).

**Data Reliability:** While reported harvest may not exactly reflect actual harvest, reporting rates and associated biases are relatively consistent over time. Peak breeding dates are approximate, and may differ somewhat across areas within deer season frameworks (Weber 1966).

**Current Status of Herd:** The percentage of does in the pre-breeding harvest falls short of the objective in all deer season frameworks. This is due to both a difference in when breeding occurs across the state and also a long standing tradition of hunting bucks early in the season and shooting does later. However, it should be noted that values for the Northwestern Season are close to meeting the objective.

Table 4. Sex Composition of Pre-Breeding Harvest (3-year average, 2007-2009).

Season Framework	Approximate Date of Peak Breeding	Percentage of Does in Harvest That Occurs Prior to Peak Breeding
Western	November 28	36
Northwestern	November 21	47
Central	November 15	42
Eastern	November 1	37

**Biological Objective #6: No more than 20% of the total buck harvest (excluding button bucks) occurs before the time of peak breeding.**

**Justification:** In areas with appropriate levels of buck harvest, achieving this objective will ensure that successful yearling buck dispersal is adequate (Rosenberry et al. 1999). This objective also ensures adequate breeding of females during the first estrous period and fawn births occur during an optimal and relatively short span of time (Gruver et al. 1984).

**Data Reliability:** While reported harvest may not exactly reflect actual harvest, reporting rates and associated biases are relatively consistent over time. Peak breeding dates are approximate, and may differ somewhat across areas within deer season frameworks. These numbers are greatly influenced by the amount and type of hunting opportunity before and after peak breeding.

**Current Status of Herd:** This variable has not been met in any of the deer season frameworks.

Table 5. Buck Harvest in Relation to Date of Peak Breeding (3-year average, 2007-2009).

Season Framework	Approximate Date of Peak Breeding	Percentage of Total Antlered Buck Harvest That Occurs Prior to Peak Breeding
Western	November 28	61
Northwestern	November 21	44
Central	November 15	38
Eastern	November 1	34

**Biologic Objective #7: Deer are a naturally occurring product of the land, there is no genetic manipulation, and movements are not restricted.**

**Biologic Objective #8: The risk of disease transmission is reduced.**

These final two biological objectives apply more appropriately when considering new or proposed regulation changes. Avoiding genetic manipulation by minimizing the potential impacts of selective harvest and ensuring natural genetic flow across the landscape is paramount to sound deer management (Strickland et al. 2001). Furthermore, protecting or minimizing the risk of disease introduction and/or spread remains a significant objective of the deer management program (Williams et al. 2002). In general, these objectives are met equally well across all season frameworks. Regulations regarding baiting, supplemental feeding, Chronic Wasting Disease, and captive cervids all impact these objectives.

## Recommendations

Division of Wildlife Management staff recommends that:

- the NCWRC adopt the following goal statement:

The NCWRC's goal for deer management and hunting is to use science-based decision making and biologically-sound management principles to assure long-term viability of deer populations at desirable levels of health, herd composition, and density with respect to land cover type and use, hunter satisfaction, and overall social acceptance;

- the NCWRC approve and implement the regulation change proposal evaluation process for deer management and hunting presented herein; and
- the Division of Wildlife Management
  - identify known data limitations and implement strategies for improvement,
  - assess habitat quality statewide and delineate appropriate deer management units, and
  - set specific biological objectives for deer management units and, if applicable, develop regulations to achieve those objectives.

## **Ad-hoc Deer Season Evaluation Committee**

Christopher D. Kreh – District 7 Wildlife Biologist, **Committee Chair**

Scott Anderson – GIS Biologist

Joffrey Brooks – Management Biologist, Mountain Region

David Cobb – Chief, Division of Wildlife Management

Brad Gunn – Administration and Planning Section Manager

Isaac Harrold – Public and Private Lands Section Manager

Brad Howard – Private Lands Program Coordinator

Tommy Hughes – Supervising Wildlife Biologist, Coastal Region

David Sawyer – Surveys and Research Program Coordinator

Jonathan Shaw – District 6 Wildlife Biologist

Evin Stanford – Surveys and Research Biologist, Deer/Turkey/Wild Boar

Perry Sumner – Wildlife Diversity/Surveys and Research Programs Section Manager

Chris Turner – District 1 Wildlife Biologist

John Wooding – Surveys and Research Biologist, Small Game

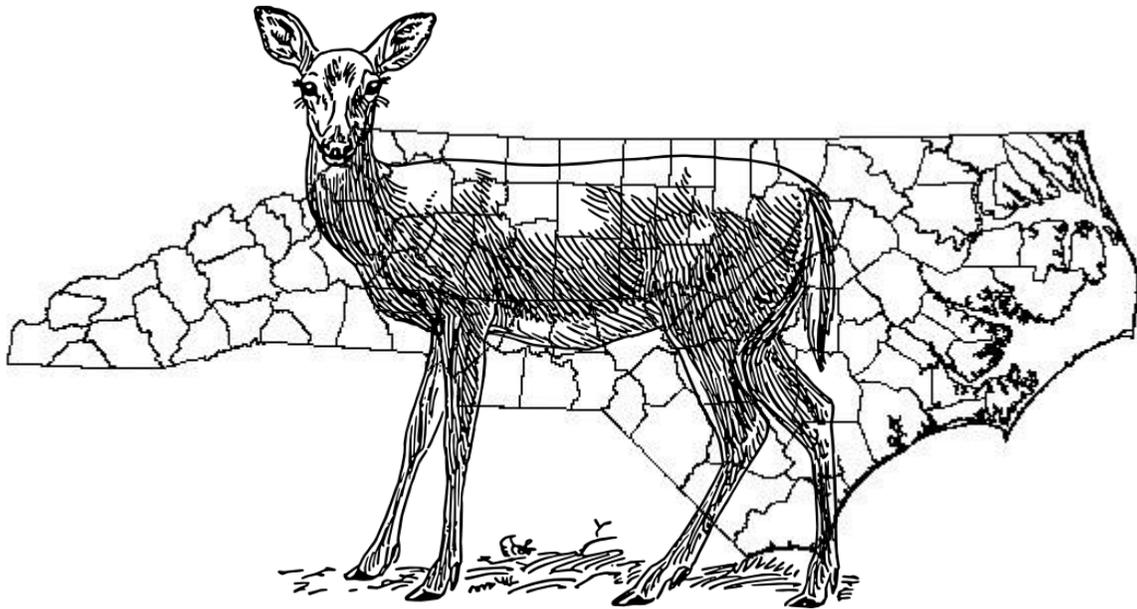
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**Appendix II**  
**Development of Biologically-based Deer Management Units**  
**in North Carolina**

February 2015



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## **1. Historical Deer Management Zones and Issues with Historical Deer Biological Data**

### *(1.1) Historical Deer Management Zones*

In 1982, Division of Wildlife Management (DWM) biological staff developed 15 deer management zones across the state based largely on professional knowledge of general habitat, geography, and herd characteristics. This effort was designed to enable biologists to more effectively analyze deer harvest and biological data, evaluate population trends and the effects of regulation changes, and make future recommendations regarding regulation changes all at a refined scale. From a deer herd monitoring perspective, the size of the management zones was advantageous because it was larger than the scale of a single county, but much smaller than the scale of a region (i.e., coastal plain, piedmont, mountains). However, the intent of these management zones was never to establish them as regulatory units, and deer regulations were not consistently applied to counties within the zones. Rather, these management zones were simply used to track deer population dynamics and other biological variables so staff could monitor biological changes in the deer herd at local scales. Over time these management zones lost utility to agency staff as deer herd dynamics and regulatory structures evolved, hunter dynamics and demographics changed, and more information and tools became available to assist with our agency's deer management efforts. These deer management zones have not been used since the mid-2000s.

### *(1.2) Issues With Historical Deer Biological Data*

The collection of biological data (i.e., age, weight, antler measurements, and reproductive information) from all hunter harvested deer has never been mandatory in North Carolina. Historical deer biological data had many precision and accuracy issues which limited its utility. Additionally, historical datasets often suffered from low sample sizes, unrepresentative sample distributions, and biased sampling sources.

Prior to the late-1990s when deer populations were low and not distributed statewide, and hunters had great interest in intensive management and growth of the deer herd, our agency was able to obtain data from a relatively large percentage of the harvest through the Deer Management Assistance Program (DMAP) and agency check stations in areas with traditional deer populations. Non-DMAP hunt clubs, military bases, U.S. Fish and Wildlife Service refuges, and other sources were also used to collect data and register harvests. However, over time it became increasingly challenging to obtain adequate sample sizes of biological data due to widespread availability of alternative harvest reporting systems (e.g., telephone reporting), increased staff resource demands, increased antlerless harvest opportunity which led to decreased participation in DMAP, and reduced hunter and landowner interest in intensive monitoring of the deer herd as populations became widely distributed and well established. Long-term reductions

in the relative volume of data collected over time have made it increasingly harder to evaluate certain biological trends. For example, the percentage of harvested deer from which we were able to collect biological data decreased steadily from 1995 through 2010, with 5.9%, 4.3%, 3.9% and 3.4% sampled in 1995, 2000, 2005, and 2010, respectively.

Over time biological samples also proved to be less representative of the statewide deer harvest due to distribution inequities between counties. Deer biological data often were not historically well distributed across the landscape, and many counties were underrepresented in the data collection program. The lack of county conception data was one of the largest deficits within deer biological datasets. The paucity of conception data collected prior to 2011 (Figure 1) and variation in other deer biological variables often complicates the ability to make inferences at the county level, and combining biological data from multiple counties to make accurate inferences at larger scales may also be problematic.

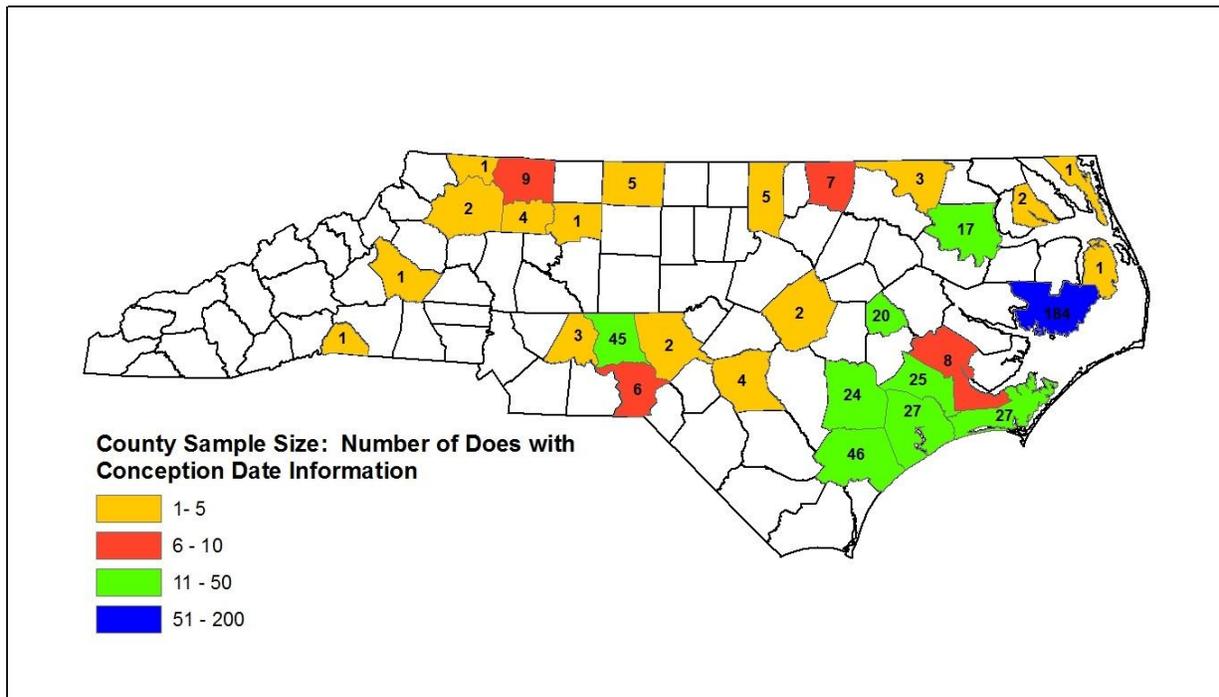


Figure 1. Number and distribution of does with estimated conception date collected prior to 2011.

There were also sampling issues within counties when all of the data originated from just one or two localized sources within the county. This particularly became an issue with DMAP clubs in counties where few or no other data sources historically existed. These occurrences often resulted in certain data sources introducing strong biases into county data that did not reflect the general hunter harvest or deer population dynamics of the county. The use of these data to make inferences about county trends or trends at larger landscape scales may be inappropriate. A prime example is that from 1995 through 2010 71% of the deer our agency obtained biological

data came from participants in our agency's DMAP. During that time period the percentage of 2.5-year-old and older bucks in the DMAP antlered buck harvest steadily increased (47.7%, 60.2%, 68.7% and 74.8% in 1995, 2000, 2005, and 2010, respectively). Agency staff suspected that this increase did not directly mirror trends occurring in the general hunter harvest outside of DMAP. Although it is likely that hunters are generally becoming more selective with respect to the age class of bucks they harvest, staff believe that DMAP participants have shown a greater interest in managing for older age class bucks than the overall hunter population.

## **2. Preliminary Delineation of Biological Deer Management Units, 2011**

### *(2.1) Evaluation of Potential Variables to Include in the Delineation of Preliminary Deer Management Units*

During the March 21, 2011, DWM Deer Committee meeting the committee discussed issues associated with deer population dynamics, statewide land use patterns, and hunter demographics, and determined that a target number of DMUs would ideally range from two to six. This range of DMUs should explain an adequate level of biological variation within collected data without creating an excessive number of units that would be an administrative burden or would be confusing or undesirable to our hunter constituency. At the May 24, 2011, Deer Committee meeting the committee determined that the following types of variables and information should initially be considered in the delineation of DMUs:

- reproductive characteristics (conception date),
- deer density index,
- measure of habitat productivity,
- land use, and
- minimum number of counties or area size that should constitute a DMU.

The committee identified conception date as the most important variable in the delineation of the DMUs. The timing of deer harvest relative to peak breeding is an important aspect of deer management, and timing of peak breeding is used to evaluate two objectives in the agency's deer regulation evaluation tool. Counties were identified as the basic geographic units for the final delineation of the DMUs because county boundaries are definitive and reported harvest and most biological data are collected at the county level. Minimum DMU area size considerations were driven by deer herd manageability and regulation complexity issues. The Deer Committee recognized that small DMUs consisting of a single county or some minimum number of counties would be challenging to administer, would likely hinder overall deer management efforts, and would be undesirable for our hunter constituency.

A subcommittee of the Deer Committee was formed and began to evaluate potential variables used to delineate the preliminary DMUs. The subcommittee met with Dr. Beth Gardner at NC

State University to discuss data evaluation issues and to obtain guidance related to statistical methodologies for evaluating data and delineating DMUs. A multitude of variables were considered throughout the evaluation process, including antlered buck harvest per square mile (ABH), doe weights, antlered buck antler beam diameter, fawn recruitment, soil type, and conception date. Land use variables considered for evaluation included parcel size, human density, land cover type, agricultural statistics, and forest statistics.

*(2.2) Variables Considered in Data Analyses and Methodology Used to Evaluate the Selected Variables*

Many variables were removed from consideration as the subcommittee determined some were not related to critical aspects of deer biology or management. Variables were also removed from consideration because quality data were not available or the variables did not show definitive trends or adequate geographic variation needed to delineate DMUs. The biological variables that were selected for use in the preliminary DMU analyses included average conception date, ABH, average buck antler beam diameter, and average doe weights. Land use variables selected for the analyses included parcel size, percent agriculture, square miles of harvested cropland, and square miles of forest. Indirect measures of habitat productivity also included grain and forest production values. Spatial variables were also considered and included the centroid latitude and longitude value and region classification (i.e., coastal plain, piedmont, mountains) for each county.

Many counties had historically poor samples sizes for age-specific buck antler beam diameter and doe weight data. To accommodate this deficit and ensure an adequate volume of data existed for the majority of counties, data for these variables were averaged for all adult deer while statistically controlling for age class. The intent of this approach was to allow all antlered buck antler beam diameter and adult doe weight data to be used in the analyses while accounting for differences in age class distribution among all the state's counties.

Incorporation of conception date information into the analyses proved extremely challenging because data were scarce for most counties across the state (Figure 1). However, as previously mentioned, the DWM Deer Committee determined at their March 21, 2011 committee meeting that conception date should be the most important contributing variable in the analyses. To serve as a substitute, historical records from the agency's fawn-rearing facility at Caswell Depot were obtained. These records indicated the county origin and date received for each fawn. Contacts were made with current and retired staff that worked at the fawn-rearing facility to determine approximate holding times for fawns before they were transferred to the fawn-rearing facility. Inconsistencies existed related to general procedures for holding and transferring fawns at the agency District level. Strong assumptions about the age of fawns were made to estimate conception dates at the county level by back calculating holding times and estimated birth dates.

Staff recognized those assumptions were likely violated and realized the need for more reliable conception data. However, it was decided the dataset still had value for providing an index of this critical variable needed to delineate DMUs.

Latitude and longitude were considered due to two factors. Staff realized the weakness in the conception date data, but also knew that conception dates in North Carolina generally peak earliest on the lower coastal plain and progressively later moving westward across the state. This trend is supported by observations of our field staff, as well as a Commission study on fawning times conducted from 1962-1964. Staff believed that incorporating longitude would potentially help compensate for weaknesses in the conception data by providing another variable that had an east-to-west gradient. Both longitude and latitude were considered together because staff realized the importance of DMUs consisting of contiguous counties. Otherwise clustering would likely result in clusters consisting of scattered counties across the state.

Data were evaluated using hierarchical cluster analysis (HCA) in the statistical program R. Variables were scaled such that all data were referenced on a scale from 0 to 1 to maintain relative comparisons. Weighting of select variables was also applied in some analyses.

### *(2.3) Results of Analyses and Final Delineation of Preliminary Deer Management Units*

Initial analyses were run without incorporating the centroid latitude and longitude value, and without weighting any variables, to determine if the results would cluster DMUs into contiguous county groups. The initial results of all such analyses did not produce clearly delineated DMUs. Several variables were consistently found to have limited value in the delineation of DMUs, including variables related to parcel size and various agricultural and forest statistics.

Results of analyses using conception date, ABH, adult doe weights, and buck antler beam diameter provide an example of an analysis that resulted in counties for individual DMUs being dispersed across the state (Figure 2). Most of the analyses involving other variable combinations resulted in greater dispersion of counties within clusters. As analyses were run, it became clear that the centroid latitude and longitude value for each county, as well as some type of weighting factor, would have to be included to ensure results would produce DMUs that consisted of groups of contiguous counties.

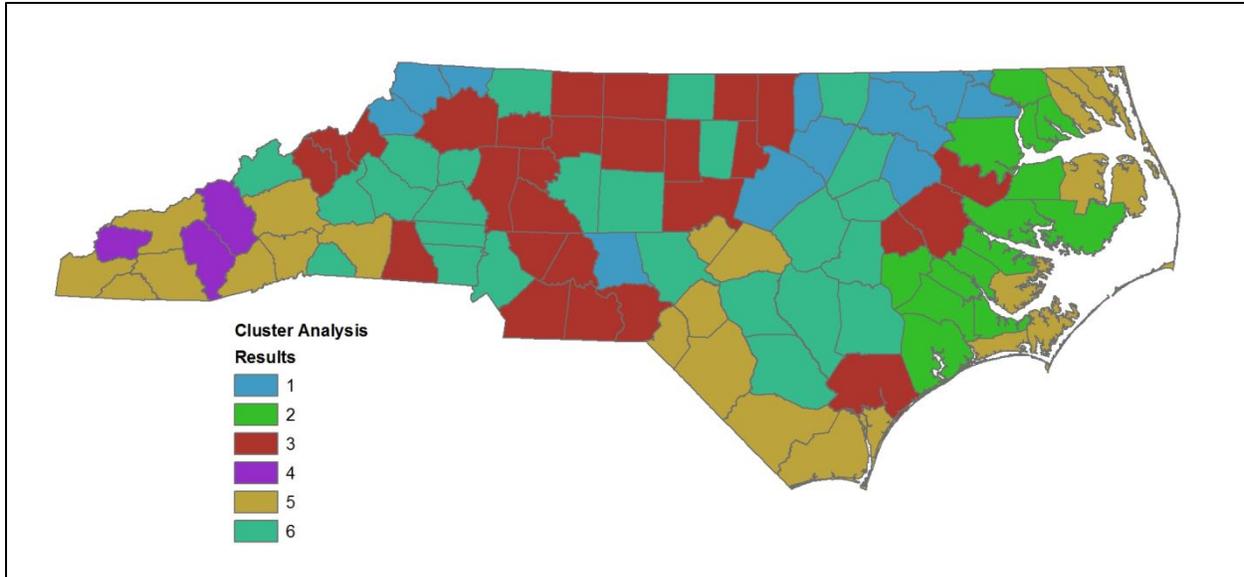


Figure 2. North Carolina deer management unit cluster analysis results using the following variables: conception date, antlered buck harvest per square mile, adult doe weights, and antlered buck antler beam diameter.

At the DWM Deer Committee meeting on August 18, 2011, committee members were presented with several cluster analyses results to evaluate. Many of these analyses included centroid latitude and longitude values for each county and/or weighting of one or more variables. After much discussion the committee decided the best analysis included the following variables: latitude, longitude (weighted X 2), ABH (weighted X 2), conception date, female weight, and antlered buck antler beam diameter (Figure 3).

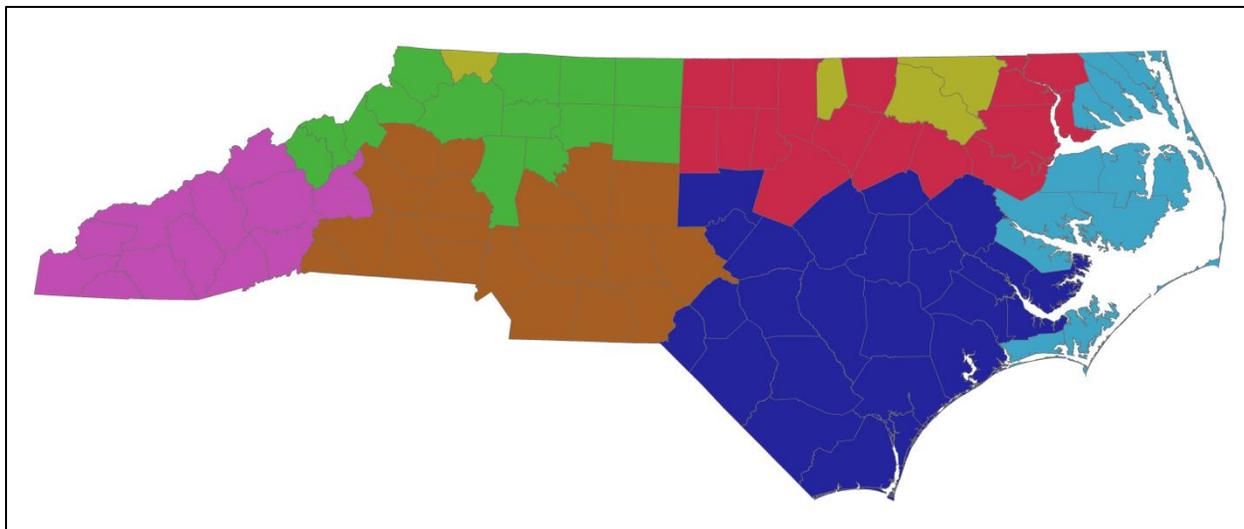


Figure 3. North Carolina deer management unit cluster analysis final model selection using the following variables: latitude, longitude (weighted X 2), adult buck harvest/square mile (weighted X 2), conception date, female weight, and antlered buck antler beam diameter.

Although conception date was previously identified as the most important contributing variable in the delineation of the DMUs, staff recognized the strong weaknesses in the manipulated data from the fawn-rearing facility at Caswell Depot. Because of quality issues associated with the conception date data, ABH was reprioritized as the most important variable in this analysis. The ABH variable was considered our most accurate variable because it is derived directly from reported harvest, and is our best indicator of relative deer density at the county level. For these reasons staff provided additional weight (X 2) to the ABH variable in the final model.

The centroid latitude and longitude variables were included to drive clustering of counties in the delineation of the DMUs. Longitude was weighted because of the east-to-west gradient inherent in the relatively poor quality conception date data. Weighting of longitude (X 2) helped compensate for weaknesses in the conception date data and helped push geographic clustering in an east-to-west fashion.

Female weight and antlered buck antler beam diameter data were included in the analysis because these variables were adequate indicators of habitat productivity and herd quality. Because two variables were included to represent habitat productivity and herd quality, adding an additional weighting factor to either of these variables was not justified.

This analysis resulted in Alleghany, Vance, Northampton, and Halifax counties being disjunct or “outlier” counties that did not form a DMU consisting of contiguous counties (Figure 3). The DWM Deer Committee determined the best course of action was to absorb those counties into the DMUs that surrounded them. The result of the final delineation of DMUs, as well as the initially-assigned name for each DMU, is shown in Figure 4.

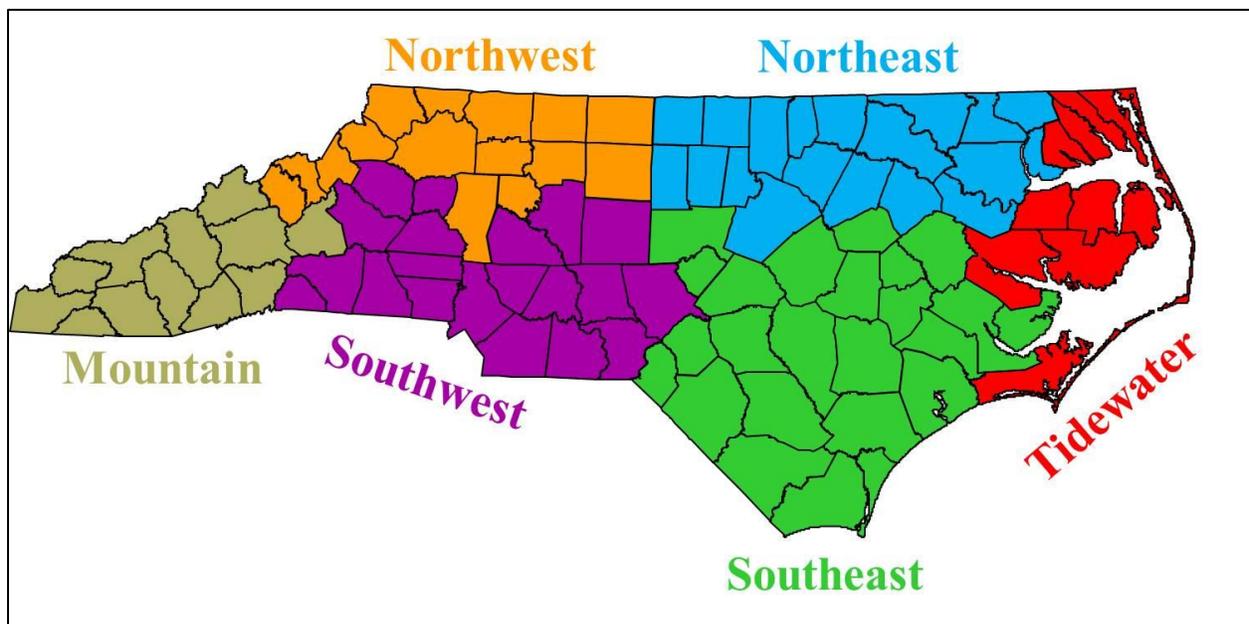


Figure 4. Preliminary results of North Carolina deer management unit delineation.

*(2.4) Issues with Final Delineation of Preliminary Deer Management Units and Reclassification as Deer Sampling Units*

Throughout the process of evaluating data for the delineation of DMUs, the weaknesses and limitations of our various biological datasets became abundantly clear. Because of these many concerns, biologists had limited confidence in the overall robustness of our various datasets and the appropriateness of using them to delineate DMUs. Recognizing the limitations in the datasets used to delineate the DMUs, delineated zones were designated as deer sampling units (DSU) and collection of biological data from deer was increased proportionately within the DSUs over the course of three hunting seasons (2011 – 2013 deer seasons). Efforts were taken throughout the three-year sampling period to increase the volume of deer biological data that were annually collected, to maximize sample distributions, and to diversify data sources. This approach reduced biases in our datasets and increased overall quality of the data collected. A particular emphasis was placed on the collection of conception date information, which is a variable that has historically received very little emphasis in our agency's deer biological data collection program. Biological data were re-evaluated upon completion of the three-year data collection effort to determine whether the existing DSU delineation was appropriate, or if new analyses should be conducted to delineate DMUs.

**3. Three-Year Biological Data Collection Effort within Deer Sampling Units, 2011 – 2013**

*(3.1) Deer Sampling Unit Data Collection Objectives*

Intensive data collection occurred during the 2011, 2012, and 2013 deer hunting seasons. For this three-year period, strategic efforts were taken to increase data collection in areas with historically low samples, decrease biases in various datasets, and increase the overall quality of collected data. Objectives included: collection of appropriate data for delineation of DMUs and collection of data for possible development of management objectives and regulation proposals for the DMUs.

*(3.2) Collection of Conception Data*

Conception data were an important component of the final DMU delineation and will be important in future deer regulatory evaluations, but this information was lacking for most of the state prior to 2011 (Figure 1). Conception date is estimated from fetal length; therefore fetal sample collections became a major focal point of the three-year intensive data collection effort.

The objective of fetal sample collections was to determine the peak conception date +/- 5 days for each DSU at a 95% confidence level. To achieve this objective, field staff attempted to

collect fetal samples from 200 or more does from each unit. Staff attempted to spread samples locations throughout each DSU to ensure collected data accurately represented the entire DSU. Because peak county conception dates were largely unknown, development of the collection protocols was an adaptive process. The few historic records and sample means from the initial 2011 season served as the initial foundation for defining the collection date protocols. Collection dates were further refined as more samples became available.

Refinement of the fetal data collection dates aimed to capture the full representative spectrum of breeding dates and to reduce potential bias associated with nutritional differences across the state. The preferred time to evaluate fetuses is when the majority of adult does are bred and fetuses are measureable (>40 days after peak conception, average 5mm length). Fetal collections were also limited to the first 114 days (average 240mm length) after peak conception to reduce potential biases in fetal development rate which could be related to nutritional differences among does. Eighty percent of fetal development is known to occur during the last 90 days of the roughly 200 day gestation period. During this time, differences in nutrition availability for does could potentially affect fetus size and accuracy in determining conception date. The optimal time period to collect fetal data in each DSU, based on conception data compiled throughout the three-year intensive data collection effort, ranges from November 16 to March 29 (Table 1).

Table 1. Optimal time period to collect deer fetal data for the estimation of conception date in North Carolina deer sampling units.

<b>Deer Sampling Unit</b>	<b>Peak Conception Date</b>	<b>Earliest Collection Date</b>	<b>Latest Collection Date</b>
Tidewater	October 07	November 16	January 29
Southeast	November 01	December 11	February 23
Northeast	November 06	December 16	February 28
Northwest	November 19	December 29	March 13
Southwest	November 20	December 30	March 14
Mountain	December 05	January 14	March 29

Field staff collected fetuses from various mortality sources including hunter harvest, road kills, and depredation harvest. Deer densities, landscape features, the timing of the hunting seasons in relation to optimal fetal collection times, and sociological factors made sampling by conventional methods (e.g., collecting fetus from hunter kills) difficult within some DSUs. In some of these problematic DSUs, sharp shooting was employed as a method to collect fetal data. During sharp shooting collection events staff made efforts to fully use sampled deer. Venison was donated to charitable organizations when possible, and Chronic Wasting Disease (CWD) samples and other biological data were collected in addition to fetal samples.

Field staff sampled fetuses from 1,468 does from 2009 to 2014 (Table 2). Historical fetal data from reliable sources collected during the preferred sampling time frame prior to the 2011 –

2013 collection effort were included in the sampling quotas. While the range of breeding dates can be influenced by herd demographics, peak breeding date is primarily determined by photoperiod. Therefore, conception date data may be pooled across years. The sample size objective was met for each DSU, except the Mountain DSU where low deer densities and the optimal sampling time frame made fetal collections difficult. Only those samples collected during the defined collection dates (Table 1) were considered for the final analysis.

Table 2. Deer Sampling Unit fetal data collection sample sizes for 2009-2014.

<b>Deer Sampling Unit</b>	<b>Number of Does With Fetuses Sampled</b>
Tidewater	371
Southeast	386
Northeast	219
Northwest	204
Southwest	256
Mountain	32
<b>Total</b>	<b>1,468</b>

In addition to meeting the sample size objectives for all but one DSU, agency field staff also succeeded in distributing samples across the units. Prior to the three-year data collection effort, four or more samples existed in only 23 counties primarily located in the North Carolina’s coastal physiographic region. Upon completion of the three-year data collection effort, four or more samples existed in 86 of the state’s 100 counties.

*(3.3) Collection of Age Data*

Age data from hunter harvested deer are also an important component of the deer regulation evaluation tool, and were an additional focal point during the intensive 3-year data collection effort. Efforts were made to collect a minimally biased sample that accurately represented the age structure of hunter harvested deer.

The objective of age structure sampling was to determine the percentage of yearling bucks and does in the adult harvest with a 2% margin of error and a confidence level of 95% for all DSUs, except the Mountain DSU. Due to low deer densities in the Mountain DSU and difficulties collecting biological data there, the objective was to determine the percentage of yearling bucks and does in the adult harvest with a 5% margin of error and a confidence level of 95%. To achieve this objective over the three-year sampling period, NCWRC field staff attempted to collect age data from 700 hunter harvested adult deer (1.5+ years of age) from the Mountain DSU, and 4,000 hunter harvested adult deer (1.5+ years of age) from each of the other five DSUs.

Biological data were collected from 22,560 deer during the three-year data collection effort. Of these, 16,928 (75%) met the sampling criteria of being known-age hunter harvested adult (i.e.,  $\geq 1.5$  years of age) deer (Table 3). During the 2013/2014 data collection period, Field staff also collected and submitted 3,814 CWD samples from free-ranging cervids across state. The majority of these CWD samples came from hunter harvested deer from which age and other biological data were also collected. CWD surveillance protocols provided sampling quotas and sample spacing requirements at the county level, which further increased diversification of biological data collection sources and the distribution of data across the landscape.

Data collection could not have occurred without cooperation from many hunters and deer processors. The sample size objectives were exceeded in the Mountain and Southwest DSUs, but in spite of significant effort from staff the remaining DSUs fell short of 4,000 animal sample size objectives (Table 3). Much effort was expended by staff to obtain biological data from some data sources that ultimately resulted in little data being collected. Even though sample size objectives were not met in these DSUs, sampling was sufficient to estimate age class proportions for those DSUs with 2.2-3.1% margin of error at a 95% confidence level.

Table 3. Number of known-age hunter harvested adult deer (i.e.,  $\geq 1.5$  years of age) that biological data were collected from, by Deer Sampling Unit, during the 2011-2013 North Carolina deer hunting seasons.

<b>Deer Sampling Unit</b>	<b>Number of Hunter Harvested Adult Deer of Known Age</b>
Tidewater	1,702
Southeast	3,233
Northeast	3,207
Northwest	3,005
Southwest	5,049
Mountain	732
<b>Total</b>	<b>16,928</b>

*(3.4) Other Biological Data Collection Considerations*

Both doe weight and buck antler beam diameter variables were included in the cluster analysis used to identify the DSUs. However, collection of age and conception data was more critical for the delineation of DMUs and evaluation of management objectives than the collection of doe weight and antler data. Therefore, no guidelines or sampling objectives were established for the collection of deer weights and antler measurements, and these data were collected opportunistically as other biological data were collected. Effort was taken to increase the collection of these data in counties where sample sizes for these variables were historically low and in DSU border counties identified as potential outliers in the initial DSU cluster analysis.

*(3.5) Improvements and Refinements in Data Management and Collection Protocols*

Prior to the 2011 deer hunting season, agency deer biological data forms and databases did not capture the full spectrum of key data sources or causes of mortality. Agency biological staff developed a new standardized biological datasheet that could be used for all data collection purposes immediately prior to the intensive three-year data collection effort. The new datasheet captured information previously unrecorded and was an important step in addressing potential biases in data collection.

The estimated age structure of the harvest would not accurately represent the population if deer ages collected from the main sampling sources were not representative of the overall hunter harvest. DWM Deer Committee members initially categorized “less biased” sampling sources as meat processors, PAWS-identified harvests, and employee harvests, due to the cross section of hunters likely represented in each of these sources. Sources categorized as “more biased” included DMAP, jawbone mail survey, voluntary check stations, taxidermists, voluntary hunt clubs, and voluntary hunter submissions. Staff suspected that hunters represented in some “more biased” sources may have had greater harvest selectivity than the average hunter, and other “more biased” sources may have had a tendency to receive deer from age classes that were not representative of the overall harvest.

After the 2011 deer hunting season, Chi-square comparisons were used to determine if there were significant proportional differences in deer types (i.e., does, button bucks, and antlered bucks) between deer harvest sampling sources. The proportions of antlered bucks, does, and button bucks within the statewide reported harvest were compared to those proportions found in different sampling sources. Significant differences were used to infer the higher likelihood that sampling bias existed ( $P > 0.05$ ). Results verified the initial categorization of “more biased” and “less biased” sources. “More biased” sources included DMAP, voluntary hunt clubs (non-DMAP), jawbone surveys, voluntary check stations, and taxidermists. “Less biased” sources included meat processors, voluntary hunter submissions, employee harvests, and random hunter harvest identified through the PAWS big-game reporting system.

Coastal Region staff historically relied heavily on DMAP and voluntary hunt clubs for representative samples of deer biological data. In 2012, a survey was sent to successful deer hunters in the Southeast and Tidewater DSUs to determine the proportion that these sources represented in each region’s overall harvest. Fifty and 33% of hunters from the Southeast and Tidewater DSUs, respectively, indicated they primarily hunted on large hunt clubs (DMAP or other hunt clubs >500 acres). If data collected from DMAP or Voluntary Hunt Clubs were not representative of the total harvest, then biases in these data could be accounted for by sampling at a rate proportional to each source’s contribution to the harvest as a whole.

Recognizing sample distribution inequities in our data stream, agency field staff were encouraged to diversify sampling sources and collect age data from three or more sources within each DSU. Staff were instructed to collect 33% or more of age data from “less biased” sources. Collections could originate from potentially “more biased” sources, but no more than 50% of age data could be collected from any one “more biased” source. Additionally, efforts were made to spread the locations of age samples collected from individual DSUs, with particular emphasis given to counties along borders of DSUs and counties with historically low sample sizes.

Overall, source diversification improved in all DSUs and sampling was less dependent on “more biased” sources during the 2011– 2013 deer hunting seasons when compared to the 2008– 2010 seasons (Table 4). Staff met the source requirements for all DSUs, with the exception of the Tidewater DSU. In the Tidewater DSU 74% of samples came from “more biased” sources, primarily from DMAP clubs (61%). Deer processors, an ideal source for the efficient collection of “less biased” samples, were lacking over much of the coastal region, which made meeting the sample size, source, and distribution objectives problematic.

Table 4. Proportion of deer biological data from “more biased” data sources for each Deer Sampling Unit

<b>Deer Sampling Unit</b>	<b>2008-2010 Deer Hunting Seasons</b>	<b>2011-2013 Deer Hunting Seasons</b>
Tidewater	95%	74%
Southeast	91%	60%
Northeast	94%	60%
Northwest	52%	23%
Southwest	79%	45%
Mountain	63%	52%

Age structure comparisons were conducted using pooled data for the three DSUs that consisted of 60% or more data from “more biased” sources (Tidewater, Northeast, Southeast). The effect that “more biased” sources may have had on the sample means for the yearling age class estimates was examined by comparing age structure proportions between “more biased” and “less biased” sources. Despite previous differences in proportions of reported harvest of antlered bucks, does, and button bucks found between sources, the proportion of yearling does in the adult doe harvest did not differ between “more biased” and “less biased” sources (Table 5). However, a relatively small but significant difference was detected in the proportion of yearling bucks in the total adult buck harvest between “more biased” and “less biased” sources (Table 5). Interpretation of buck age structure results must include a consideration of this difference.

Table 5. Comparison of proportion of yearling bucks and does in biological data samples from “more biased” and “less biased” sources in the Tidewater, Northeast, and Southeast deer sampling units.

	<b>% Yearling Bucks in Adult Buck Biological Data Samples</b>	<b>% Yearling Does in Adult Doe Biological Data Samples</b>
<b>"More Biased" Data Source*</b>	28.3 (+/- 1.9)	25.7 (+/- 1.6)
<b>"Less Biased" Data Source**</b>	35.0 (+/- 2.3)	27.6 (+/-2.4)
<b>Z-test</b>	Z=4.379, p<0.01	Z=1.281, p=0.20

\*DMAP, voluntary hunt clubs, jawbone surveys, voluntary check stations, and taxidermists

\*\*Meat processors, voluntary hunter submissions, employee harvests, and random harvest identified through the PAWS big-game reporting system

Agency field staff substantially improved the statewide distribution of samples from hunter harvested deer. During the 2008– 2010 deer hunting seasons, 30 or more samples were collected from 74 individual counties. During the intensive 2011–2013 biological data collection effort, 30 or more samples were collected from 90 of the state’s 100 counties.

#### **4. Evaluation of Data and Final Delineation of Biological Deer Management Units**

##### *(4.1) New Data Analysis Approach*

After three years of adaptive sampling techniques and gaining insight from a newly acquired biological dataset, new perspectives and evaluation approaches were used for the final delineation of DMUs. Larger and more accurate biological datasets guided staff to reprioritize the original biological variables. Contracting with a professional statistician also provided further clarity into more appropriate clustering and other data analysis techniques. The cluster analysis technique originally used to delineate the DSUs was considered, but an alternative technique focusing on variable prioritization was used instead. This new approach reduced modeling complexity and simplified the clustering evaluation for individual county assessments.

Final biological clustering analyses and results were developed in conjunction with Dr. Paul Vos, Chair, Department of Biostatistics at East Carolina University. As with the delineation of DSUs, DMU delineations only evaluated biological and landscape variables. Social or political variables were not considered. A different data analysis approach was used which removed the need for scaling and subjective weighting of variables. This approach also allowed for removal of latitudinal and longitudinal variables which were used within the initial DSU delineation to force the horizontal and vertical clustering of contiguous county units. For counties in which samples were limited or confidence in the data was low, the new approach provided a structured process to delineate the DMUs. The use of institutional knowledge to interpret and evaluate the

biological data was strongly recommended by Dr. Vos, as he deemed that approach to be more appropriate than using a standardized hierarchical statistical technique. Inflexible characteristics associated with the hierarchical clustering technique used to delineate the DSUs did not take into account intrinsic biological and non-biological considerations with the available biological datasets.

#### *(4.2) Variable Selection and Prioritization*

The variables selected for this analysis reflected biological and manageability considerations for deer. Prioritization was given to those metrics referenced in the deer management objectives listed in the agency's deer regulation evaluation tool. Considerations were also given to the quantity and quality of available county data. Prioritized variables selected variables for this analysis were:

1. Median conception date
2. Antlered buck harvest per square mile (ABH)
3. Average parcel size
4. Average weights of 2.5-year-old does
5. Average weights of 1.5-year-old does

County averages for ABH and doe weights were limited to the previous three sampling years (i.e., 2011 – 2013 deer hunting seasons) to minimize potential bias created by data trends over time. Conception date medians included all known records back to January 2009, because conception dates are not affected by environmental changes and are assumed to be fixed through time. Conception medians were used in place of averages because staff felt that average conception dates were strongly influenced by outliers in some counties. Medians for conception date and averages for all other variables were estimated for counties with a minimum sample size of five. Conception dates not collected during the preferred collection times (Table 1) were removed for this analysis. All variables were spatially evaluated to give insight into natural groupings or transitions that may exist across the state.

From the beginning of this project it was apparent that conception date should be the primary foundation for this analysis (Figure 5). Peak conception date is the primary metric for defining two of the biological objectives in the agency's deer regulation evaluation tool. All other priority variables are potentially influenced, either directly or indirectly, by changes in habitat quality or other landscape changes, changes in deer population dynamics, changes in hunter dynamics, or human development.

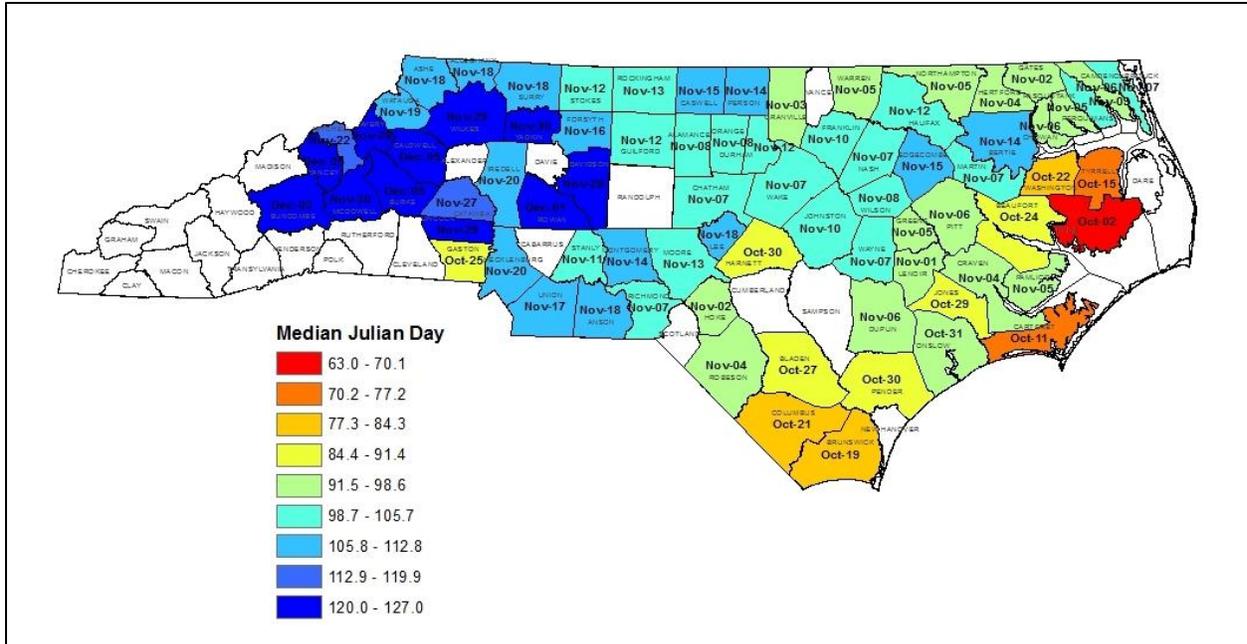


Figure 5. Median conception dates for deer by county in North Carolina. Median county conception dates based on  $n \geq 5$  samples per county, samples derived from collected 1/1/2009-3/26/2014 within preferred collection periods. Shading represents approximate one week equal intervals based on a Julian calendar starting August 1.

ABH was prioritized second in the cluster analysis due to its top ranking biological objective score in the agency’s deer regulation evaluation tool. ABH is assumed to be closely associated with overall deer abundance and is used to delineate the minimum threshold for desirable deer harvest ( $\geq 1.0$  ABH). Even with its relatively high overall priority in the deer regulation evaluation tool, this variable was rated as second in priority for this analysis because the threshold was only relevant to the far western and eastern counties in the Mountain and Tidewater DSUs. Most counties in the state met or exceeded the minimum threshold of 1.0 ABH (Figure 6).

*(4.3) Determining the Appropriate Number of Deer Management Units*

Using conception date and ABH as the primary biological variables in the DMU delineation process, principal component analysis and analysis of variance were used to determine the optimum number of clusters or units. The sum of squares plot was used as a general guide to evaluate the balance between the number of clusters and the amount of variation explained within those two variables (Figure 7). To evaluate the plot, the most efficient number of clusters was determined by identifying the area on the line with the greatest change in slope. The plot revealed that the ideal number of clusters ranged from three to five.

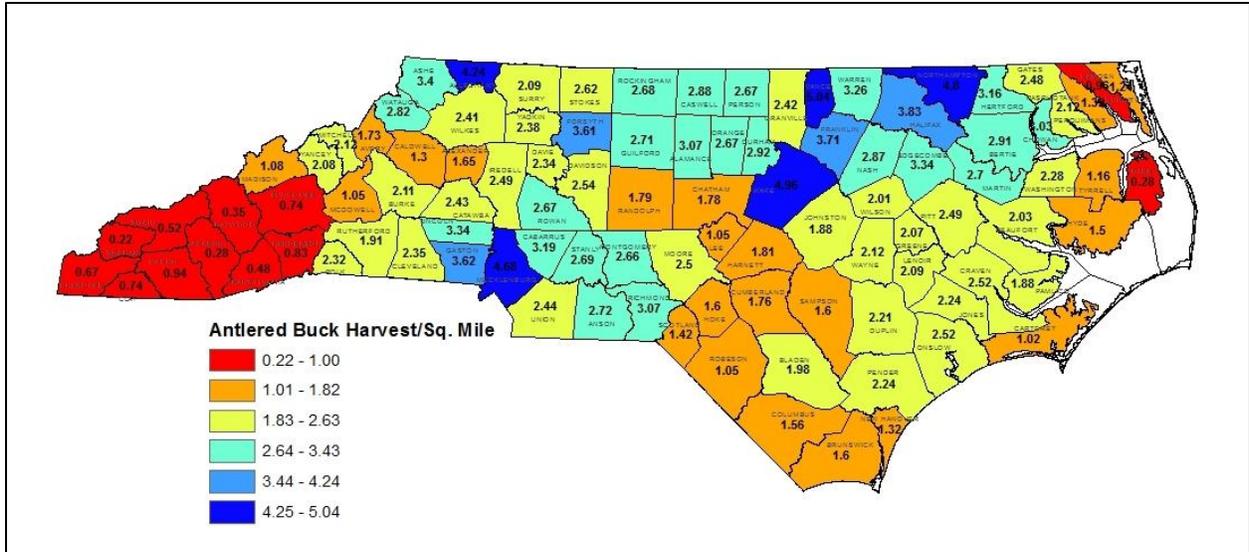


Figure 6. Average annual reported antlered buck harvest per square mile by county in North Carolina, 2011 – 2013 deer hunting seasons. Shading represents equal interval changes in relative harvest.

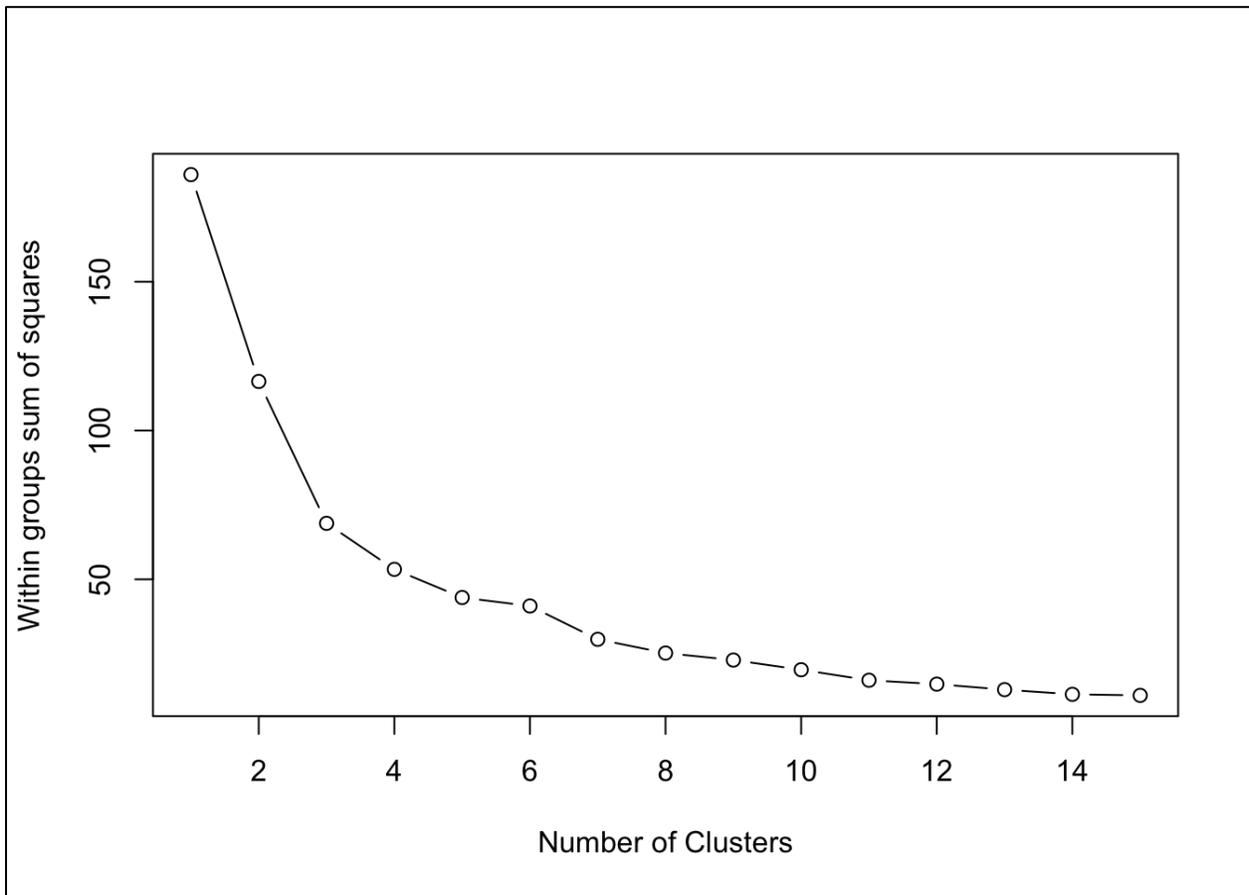


Figure 7. Evaluation of conception date and antlered buck harvest/sq. mi. (priority biological variables) sum of squares for varying numbers of deer management unit clusters.

The number of suggested DMUs fits quite well with previous DMU development guidelines established at the initiation of the project. As outlined by the DWM Deer Committee in 2011, two to six units were initially determined to be the preferred number of units resulting from this process. These results also supported the biologists' original desire to maintain conception date ranges of approximately two weeks for each established DMU, because a 10-week conception date range was found across the state.

A two-week conception date range was also determined to be optimal based on early hunting season harvest dynamics and intensity, as well as current annual season opening fluctuations resulting from regulatory definitions of season frameworks and annual changes in the calendar date. Hunting season start dates are defined based on specific days of the month and fluctuate up to one week between years. Depending on the length and timing of the season, 10% (Eastern Season) to 40% (Western Season) of antlered buck harvest could occur during the opening week of gun season. The timing of deer season start dates has implications in minimizing variation in breeding dates within a DMU, and is important relative to meeting biological objectives set in the deer regulation evaluation tool. Biological objectives pertaining to conception date timing in the deer regulation evaluation tool require at least 50% does in the harvest and no more than 20% of total antlered buck harvest before the time of peak breeding.

#### *(4.4) Initial Data Driven Clustering Approach*

Dr. Vos conducted initial cluster analyses using the conception and ABH prioritized data. The results explained more of the variation within each of the variables than the previous DSU cluster model. However, as previously seen with the initial DSU evaluations, the strict data driven approach did not create spatially contiguous county clusters (Figure 8). Maintaining contiguous county groupings for each cluster was a critical component to establishing effective DMUs, but was determined to not be possible without relaxing the conception date spread threshold of less than two weeks.

#### *(4.5) Final Delineation of Deer Management Units Based on Variable Prioritization*

As initially recommended by Dr. Vos, it was determined that county conception date values and the two-week conception date spread threshold, as well as institutional knowledge, should be used to begin the process of delineating initial county clusters into DMUs. A second step would be required for counties along DMU borders where biological gradients were unclear or biological data was limited or conflicted with neighboring values. These individual "outlier" counties required a unique "best fit" analysis to determine to which DMU they should be most appropriately assigned.

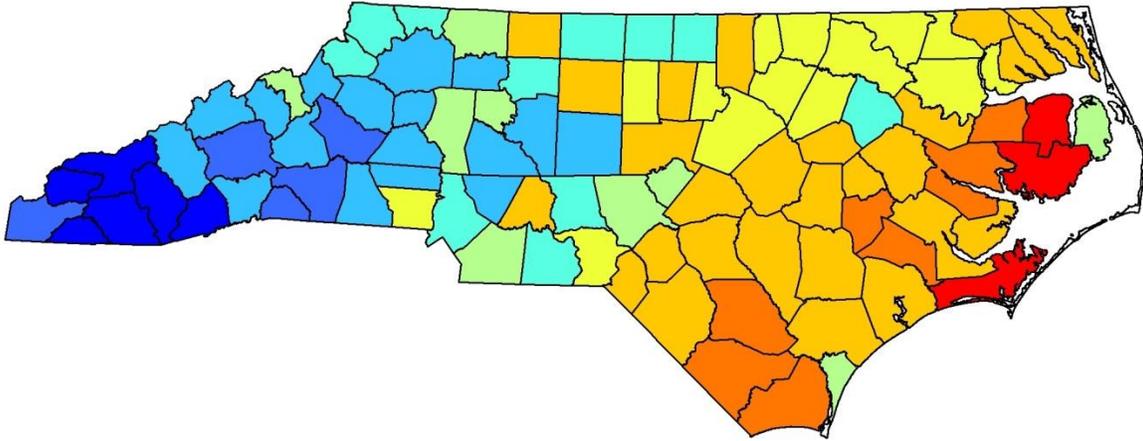


Figure 8. Clustering results using conception date and antlered buck harvest per square mile. Each color represents a separate DMU cluster.

To maintain the highest level of explained variation for the priority variables and to maintain contiguous units for each cluster, clusters were first roughly delineated based on conception dates while attempting to maintain approximately five groupings. Draft delineations were made independently by staff based on significant county conception date transitions, with an effort to minimize peak breeding date ranges ( $\leq 14$  days) within the DMUs. Refinement of cluster borders and discrepancies in staff delineations was resolved on a county-by-county basis. Single county delineations considered the prioritization of the original five variables in a stepwise process (i.e., median conception date, ABH, parcel size, and average weights of 1.5- and 2.5-year-old does). Dr. Vos compared means, medians, and ranges for outlier counties to values for neighboring DMUs to determine the best delineation. If a priority biological variable was missing for a given county, or evaluation of the variable did not result in clear assignment of the county to a DMU, the next highest variable was used, resulting in a final DMU delineation based on this variable prioritization approach (Figure 9). Because adequate conception data were available for most counties, median conception date was the primary variable that contributed to the delineation of the DMUs. ABH, which was the second highest priority variable, was likewise the second most contributing variable in the DMU delineation process. Parcel size and doe weights only provided limited value for the single county evaluations used to delineate DMUs. Weight variables for 1.5- and 2.5-year-old does were highly correlated with each other and parcel size varied little across the state, except for large parcel size averages located in some far eastern counties.



Figure 9. Final biological DMUs based on a variable prioritization approach, 2014.

*(4.6) Evaluation of Priority Biological Variables in the Final Deer Management Unit Delineation*

Final evaluation of the two priority biological variables (median conception date and ABH) was conducted for the delineated DMUs. Each DMU was relatively distinct from a biological perspective and contained a minimal number of outlier counties that greatly deviated from within-cluster biological variable values. Because median conception date was the highest priority variable that drove the initial delineation of clusters, conception dates among DMUs was clearly separated and had the highest level of explained variation (81.6%, Figure 10). ABH also maintained relatively unique distinctions between DMUs with a final level of explained variation at 45.8% (Figure 11).

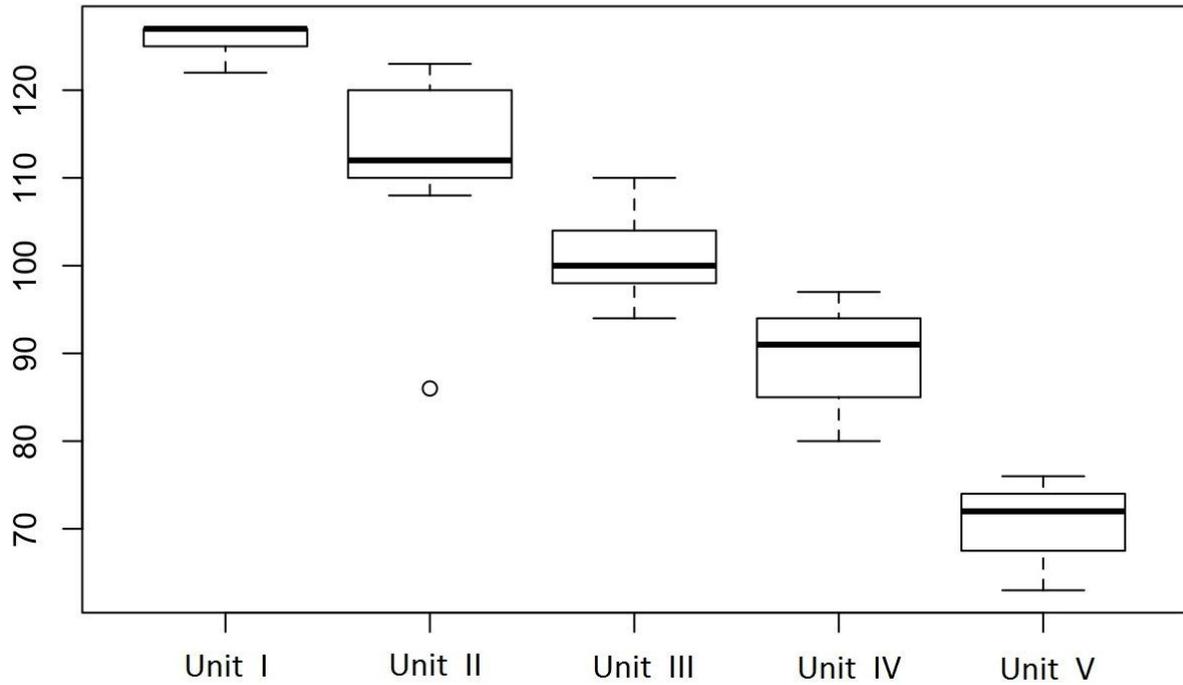


Figure 10. Median conception date distribution for deer management units. Julian date is shown on the y axis, with day 1 starting on August 01.

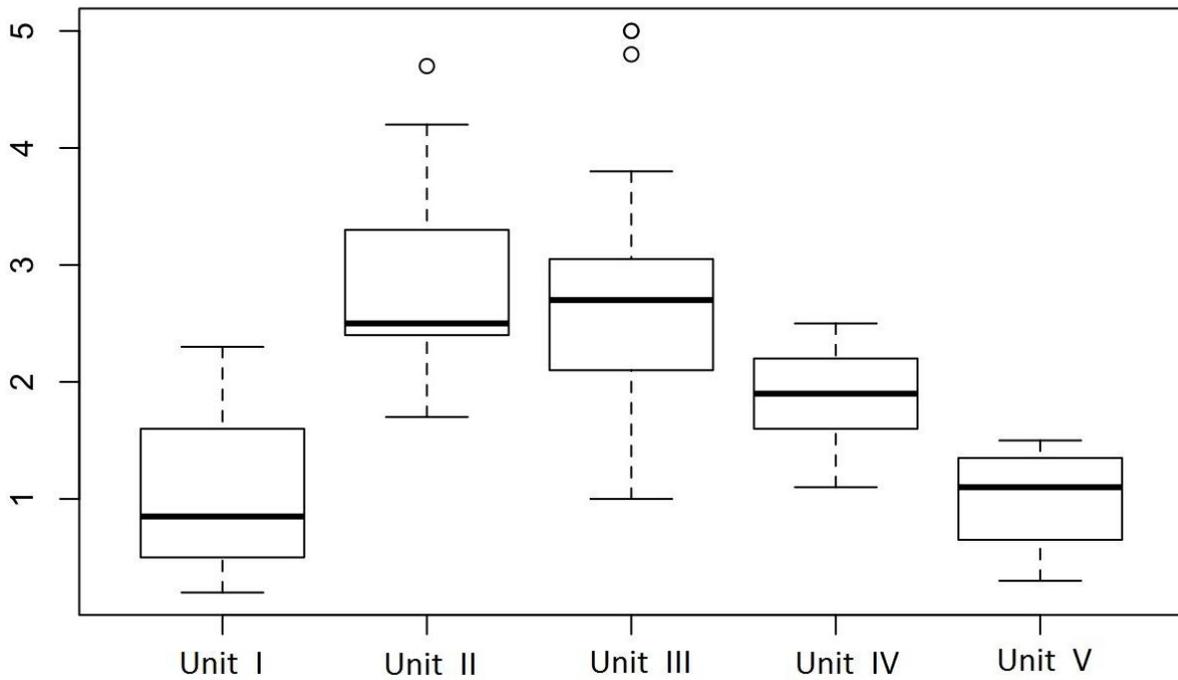


Figure 11. Average antlered buck harvest per square mile (y axis) for Deer Management Units.

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## Appendix III

# Evaluation of Biologically-based Deer Management Units in North Carolina

February 2015



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**Comparison of Biological Deer Management Units with Current Deer Season Frameworks**

One way to evaluate the proposed DMUs is to compare them with our state’s current deer season frameworks. A direct comparison of individual DMUs with our current deer season areas (i.e., western, northwestern, central, and eastern deer season areas) is not appropriate, however, because the county group delineations are different. But, a statistical evaluation can be conducted to quantitatively show how well the delineation of DMUs and the current deer season areas explain inherent variation in biological variables. In general terms, delineated area groupings (i.e., DMUs and current deer season areas) that explain a higher percentage of variation for any biological variable can be considered a better fit for that variable (Table 1).

Compared to the current deer season areas, the DMUs (Figure 1) perform better at explaining the percentage of variation for all biological variables, with the exception of yearling doe weight. However, the 5% decrease in explained variation for the DMU yearling doe weight variable (27.5% for DMUs vs. 32.6% for current deer season frameworks) is overshadowed by the 12% increase in explained variation for the DMU 2.5-year-old doe weight variable. This evaluation indicates that from a biological perspective the DMU delineations are a much better fit with the biological data than the current season frameworks.

Table 1. Comparison of deer management units with current deer season frameworks.

VARIABLES	CURRENT DEER SEASON FRAMEWORKS	DRAFT DMUs
Conception Median Date	56.4%	81.6%
Antlered Buck Harvest/Sq. Mi.	29.1%	45.8%
Parcel Size	29.4%	64.5%
Yearling Doe Weight	32.6%	27.5%
2.5-Year-Old Doe Weight	37.8%	49.6%

\*Percentages in the table reflect the percentage of variation explained for each variable. Percentage of variation explained refers to the sum of squares associated with the variable divided by the total sum of squares (including residuals).



Figure 1. Final biological DMUs based on a variable prioritization approach, 2014.

### Evaluation of Biological Variables for Delineated Deer Management Units

The primary tool for establishing management objectives for each DMU should be the agency’s deer regulation proposal evaluation tool, which provides biological variables that define a well-managed deer herd, and current deer management goals and objectives established by the Commission (and including public input).

Herein, we estimate biological variable values for the proposed DMUs, and to provide insight into which variable values need to be improved. However, our intent in this section is NOT to establish specific management objectives or strategies for proposed DMUs where variable values fall outside of the desired range of values. Specific DMU management objectives and strategies can only be developed as the DMU development process continues and undergoes further input and review.

It is important to note that in counties with low productivity or areas within some DMUs (e.g., DMU I), achieving all of the biological objectives may not be feasible. Management objectives or recommendations that are beneficial to a whole DMU may not be beneficial for some counties or parts of counties therein. The most important biological variables in the deer regulation evaluation tool (i.e., ABH and conception date) are provided increased value scores to help compensate for these instances. However, additional or refined management objectives and strategies may be necessary for some areas within certain DMUs to accommodate areas of low productivity or areas where deer population dynamics differs dramatically from the DMU as a whole.

***Biological Variable # 1: Harvest of at Least 1.0 Antlered Buck/Mi<sup>2</sup>, or if < 1.0 Buck/Mi<sup>2</sup> the Area has a Stable or Increasing Trend***

This variable relates to the relative deer density within each DMU and, in general, a harvest of 1.0 ABH is indicative of a minimum deer density consistent with our agency’s stated deer management goal. The general objective is to keep all areas of the state at or above the threshold of 1.0 ABH. Antlered buck harvest levels below this threshold are typically indicative of extremely low population levels that are below the desired level of our agency’s constituency. The objective for areas with variable values below 1.0 is generally to implement management actions to increase deer population levels or to keep additional population decreases from occurring. No management actions are necessary if this variable value equals or exceeds 1.0, unless the value has been steadily decreasing and is potentially going to soon drop below the minimum threshold. This variable is designed to simply ensure that management actions do not drive deer populations to extremely low densities.

All proposed DMUs are at or above the 1.0 threshold for ABH (Table 2). DMUs I and V are both at the threshold, but both areas have had stable variable values for the past several years. Low deer densities in some counties within DMU I have been a longstanding issue, which has been addressed by current deer season frameworks. Future management objectives for this DMU will have to continue taking this variable value into account to ensure the threshold isn’t violated. The variable value for DMU V is complicated by the fact that much of the area consists of very poor quality habitat (e.g., pocosin, swamp, coastal marsh). For example, Dare County consists almost entirely of very poor quality habitat and has a very low deer harvest relative to other counties in DMU V. These facts drive down the overall DMU variable value, even though deer populations are generally quite robust in areas with better habitat and where most hunting activities occur. For these reasons, modifications of current season frameworks for these areas has not been warranted in the recent past.

Table 2. Biological evaluation variable values for criterion requiring harvest of at least 1.0 antlered buck per square mile.

DMU	2011 ANTLERED BUCK HARV. PER MI <sup>2</sup>	2012 ANTLERED BUCK HARV. PER MI <sup>2</sup>	2013 ANTLERED BUCK HARV. PER MI <sup>2</sup>	2011-13 AVG ANTLERED BUCK HARV. PER MI <sup>2</sup>
I	1.0	1.0	1.1	1.1
II	2.5	2.5	2.8	2.6
III	2.6	2.7	2.8	2.7
IV	1.9	1.9	1.9	1.9
V	1.1	1.0	1.0	1.0

***Biological Variable # 2: Total Adult Doe Harvest (i.e., Excluding Fawns) is Comprised of 30-35% Yearling Does (1.5 Years Old)***

The percentage of yearling does (1.5 years old) in the adult doe harvest is a good indicator of the harvest pressure placed on the doe segment of the population and is indicative of expected future population trends. If fawn recruitment is typical of what is reported for white-tailed deer across most of its range, deer populations for most areas of the state are expected to remain relatively stable at a density consistent with our agency’s stated deer management goal when yearling does comprise approximately one third of the adult doe harvest. A situation in which yearling doe harvest fall below one third of the total adult doe harvest indicates does are facing little harvest pressure and older age classes are overrepresented in the doe population. However, in areas of low deer density where a population increase is desired (i.e., areas where the threshold for biological variable #1 is not met), it is frequently desirable for the percentage of yearling does in the harvest to remain below 30%.

Calculated values of all DMUs fall below the target range for this biological variable (Table 3). Therefore, harvest pressure on the doe segment of the herd should generally be increased to bring this variable in line within desired levels. However, an exception could be made for some areas within DMU I where deer densities are relatively low and the objective is to increase deer densities. Because the objective to maintain 1.0 ABH is given more weight in the biological evaluation tool, efforts should not be made to achieve biological variable #2 if the 1.0 ABH threshold is threatened.

Table 3. Biological evaluation variable values for criterion requiring total adult doe harvest being comprised of 30-35% yearling does.

DMU	2011 % YEARLING DOES	2012 % YEARLING DOES	2013 % YEARLING DOES	2011-13 % YEARLING DOES
I	25.9%	25.6%	26.1%	25.9%
II	27.9%	28.6%	28.6%	28.3%
III	26.1%	25.4%	28.3%	26.6%
IV	20.2%	26.3%	25.2%	23.9%
V	30.7%	25.0%	20.2%	25.8%

***Biological Variable # 3: Total Antlered Buck Harvest (i.e., Excluding Button Bucks) is Comprised of No More than 30% Yearling Bucks (1.5 Years Old)***

The percentage of yearling males (1.5 years old) in the antlered buck harvest is a good indicator of harvest pressure placed on adult bucks. Regulations and management techniques aimed at

creating a more biologically balanced male age structure consistent with our agency’s stated deer management goal should strive to minimize harvest pressure on yearling bucks when possible.

With the exception of DMU IV, all other DMUs fail to satisfy this biological variable (Table 4). Harvest pressure on the yearling antlered buck segment of the deer herd should be reduced in these areas to bring this variable value in line with acceptable levels. It should be noted that much of the data from DMU IV comes from DMAP or other potentially biased sources that may selectively harvest older aged bucks and do not reflect deer harvested by the general hunter population. Therefore, it’s possible this variable value for DMU IV is somewhat higher than that reported in Table 4.

Table 4. Biological evaluation variable values for criterion requiring total adult buck harvest being comprised of no more than 30% yearling bucks.

DMU	2011 % YEARLING BUCKS	2012 % YEARLING BUCKS	2013 % YEARLING BUCKS	2011-13 % YEARLING BUCKS
I	50.3%	57.2%	52.1%	53.3%
II	46.4%	53.3%	55.9%	51.4%
III	36.8%	37.2%	40.1%	38.1%
IV	29.1%	21.9%	30.6%	27.0%
V	37.7%	37.7%	36.4%	37.3%

***Biological Variable # 4: Total Harvest is Comprised of at Least 50% Does***

The percentage of does in the total harvest is a good indicator of the effects of the annual harvest on population trends. Achieving this objective will also result in more balanced sex ratios. However, in areas of low productivity where a population increase is desired, the percentage should remain well below 50% and should not conflict with biological variable #1.

The percentage of does in the harvest is below 50% for all DMUs (Table 5). Therefore, harvest pressure should be increased on the doe segment of the herd, or alternatively should be decreased on the antlered buck segment. In some DMU I areas, and possibly in some DMU V areas, no additional doe harvest pressure is warranted due to relatively low deer densities.

Table 5. Biological evaluation variable values for criterion requiring total harvest to be comprised of at least 50% does.

DMU	2011 % DOES	2012 % DOES	2013 % DOES	2011-13 % DOES
I	36.6%	33.9%	38.3%	36.4%
II	48.6%	46.4%	48.8%	48.0%
III	45.8%	43.6%	46.2%	45.2%
IV	40.7%	38.2%	40.9%	40.0%
V	47.0%	45.8%	45.0%	46.0%

***Biological Variable # 5: Sex Composition of the Harvest that Occurs Prior to Peak Breeding is Comprised of at Least 50% Does***

Achieving this objective will ensure that does are not overrepresented in the population at peak breeding periods. This ensures adequate breeding of females during the first estrous period, that fawn births occur during an optimal and relatively short span of time, and food resources are available later in the season.

This biological variable is not met for any of the DMUs (Table 6). This means that either doe harvest prior to the peak breeding period needs to increase or antlered buck harvest prior to that time period needs to decrease. In areas with undesirably low deer density the objective should be to decrease antlered buck harvest prior to the peak breeding period, as additional doe harvest is not warranted.

Table 6. Biological evaluation variable values for criterion requiring the sex composition of the harvest prior to peak breeding being comprised of at least 50% does. Percentages in the table reflect the percentage of does in the harvest up to the median conception date.

DMU	MEDIAN CONCEPTION DATE	2011 % DOES	2012 % DOES	2013 % DOES	2011-13 % DOES
I	December 05	33.4%	32.1%	37.7%	34.4%
II	November 20	44.8%	42.7%	46.9%	44.7%
III	November 08	40.5%	37.0%	42.4%	40.0%
IV	October 30	35.1%	30.5%	35.2%	33.7%
V	October 11	42.1%	38.1%	29.7%	36.5%

***Biological Variable # 6: No More than 20% of the Total Antlered Buck Harvest (i.e., Excluding Button Bucks) Occurs Before the Time of Peak Breeding***

Achieving this objective will ensure that adult bucks are not under-represented in the population at peak breeding periods, and that successful yearling buck dispersal is adequate. This objective also ensures adequate breeding of females during the first estrous period and that fawn births occur during an optimal and relatively short span of time. Minimizing the span of fawning dates across time may reduce predation of fawns by coyotes and other predators.

With the exception of DMU V, all other DMUs fail to satisfy this biological variable (Table 7). Antlered buck harvest in these areas should be reduced prior to the period of peak breeding and could potentially be shifted to occur after the median conception date. The biological variable is satisfied in DMU V where the median conception date falls much earlier (October 11) than all other DMUs and the majority of gun hunting opportunity currently falls after this date.

Table 7. Biological evaluation variable values for criterion requiring no more than 20% of total antlered buck harvest occurring prior to the date of peak breeding. The table reflects the percentage of total reported antlered buck harvest before the median conception date.

DMU	MEDIAN CONCEPTION DATE	2011 % ANTLERED BUCKS	2012 % ANTLERED BUCKS	2013 % ANTLERED BUCKS	2011-13 % ANTLERED BUCKS
I	December 05	76.8%	82.4%	68.6%	75.7%
II	November 20	44.9%	48.5%	35.6%	42.7%
III	November 08	36.7%	41.1%	36.3%	38.0%
IV	October 30	30.4%	34.6%	38.2%	34.4%
V	October 11	11.8%	18.3%	17.7%	15.9%

*Compiled, written, and edited by: Evin Stanford, Jonathan Shaw, Ryan Myers, and David Cobb.*