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An Evaluation of the Michigan Department of Natural Resources' White-tailed Deer (<u>Odocoileus virginianus</u>) Field Survey Methodologies

presented by

Sarah Laggner Cook

has been accepted towards fulfillment of the requirements for

M.S. degree in Fisheries & Wildlife

Scott A. Winterstein
Major professor

Date May 8, 2001

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AN EVALUATION OF THE MICHIGAN DEPARTMENT OF NATURAL RESOURCES' WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) FIELD SURVEY METHODOLOGIES

By

Sarah Laggner Cook

A THESIS

Submitted to
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ABSTRACT

AN EVALUATION OF THE MICHIGAN DEPARTMENT OF NATURAL RESOURCES WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) FIELD SURVEY METHODOLOGIES

By

Sarah Laggner Cook

The Michigan Department of Natural Resources (MDNR) needs reliable data for public accountability and sound scientific management of the state's white-tailed deer (*Odocoileus virginianus*) herd. Three white-tailed deer field surveys were examined to evaluate the quality of the data collected. The biophysical data (biodata) collected from harvested deer brought to voluntary check stations provides the largest available source of data on Michigan's deer herd, but biases, errors, and insufficient data limit the use of the biodata. However, the biodata can be used in the sex-age-kill estimates of population size, or to develop indices of herd health, track herd or harvest composition, and compare the herd composition of different years or geographic areas. The lactation data do not provide an estimate of annual recruitment, but they can be used to develop an index or minimum estimate of reproductive success. The inconsistent manner in which the winter severity index (WSI) data are collected prevents the index from being a useful tool with which to predict winter mortality or yearling beam diameters. Standardizing the collection process or developing an alternate WSI could make such predictions possible. By improving the quality of the data collected in the field surveys (e.g. by increasing the number of check stations or other methods), the MDNR will be better able to manage Michigan's deer herd and will increase public confidence in their management decisions.

To my parents,
David and Kathi Cook

Who give their children unending love and support

ACKNOWLEDGMENTS

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Several MDNR Wildlife Division personnel provided valuable comments and assistance. Dr. Harry Hill, Dr. William Moritz, and John Urbain reviewed drafts of each chapter and suggested new questions or new interpretations of the data. Brian Frawley provided the mail survey harvest data, and Marshall Strong provided much needed ArcView support.

I would especially like to thank Dr. Scott Winterstein, my major professor. He has provided unending patience, advice, and support throughout the project, and I have greatly enjoyed working with him. The other members of my committee, Drs. Henry R. Campa, Harry Hill, and Robert Tempelman, also deserve thanks and acknowledgement for their guidance.

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CHAPTER 1

INTRODUCTION

In 1996, the Michigan public passed Proposal G, a ballot initiative calling for the scientific management of Michigan's wildlife resources. White-tailed deer (*Odocoileus virginianus*) are one of Michigan's largest wildlife resources, and the Michigan Department of Natural Resources (MDNR) management of the deer impacts virtually every Michigan resident. The MDNR has found that Michigan residents have different opinions of and goals for the deer population (W. Moritz, MDNR, personnal communication). Many hunters prefer a large population of healthy animals with a large proportion of older, larger bucks. Farmers want low deer densities to reduce crop damage. The general public values deer viewing opportunities, but people do not want the deer eating their ornamental shrubs or causing car-deer collisions. With so many different opinions on the desired size and condition of the deer herd, the MDNR needs sound scientific data to develop effective management strategies and to justify its management techniques to the public.

The MDNR collects data on the Michigan deer herd through several different field survey techniques. The annual field surveys of the white-tailed deer population of Michigan allow the MDNR to estimate population size, predict changes in population size due to harvests and winter mortality, and to gather information on the composition and health of the Michigan deer herd. Field surveys are techniques used to collect data from the deer herd to estimate population parameters and to develop population indices (relative measures of population parameters) of wildlife species based on statistical principles. Field surveys allow wildlife managers to approximate the true population parameters based on results of sampling a fraction of the population. The field survey data, however, cannot be used confidently unless they are collected in a consistent and statistically valid manner. I evaluated the procedures used in data collection and analysis of 3 field surveys (the biodata, the lactation survey, and the winter severity index) to determine if they provide the most accurate data possible. I also evaluated the statistical validity of the data at the relevant scales.

The results of the 3 different evaluations are presented in the following 3 chapters. The second chapter of this thesis discusses the evaluation of the check station data. The MDNR runs the voluntary check stations during the deer hunting seasons to collect biophysical data (known as the biodata) on the harvested deer. Chapter 2 is divided into several sections. The first section describes the biodata and the purpose of the evaluation. The following sections present several questions which the evaluation addressed, the methods used to answer each question, and the results of the evaluation. The final section draws conclusions about the quality of the biodata and their potential uses and suggests potential improvements in data use and collection.

The third chapter discusses the evaluation of the lactation survey. The lactation data are collected as part of the biodata, but these data were evaluated separately. Chapter 3 is comprised of 4 sections, organized as a traditional research report. An Introduction describes the lactation data and the purpose of the evaluation. The Methods section describes the methods used to evaluate the lactation survey, and the Results and Discussion sections present the findings of the evaluation and suggestions for the improvement and use of the lactation data.

The fourth chapter presents the evaluation of the winter severity index (WSI). The MDNR collects weather data throughout the winter to try to predict the impact of the winter severity on the deer population. The Introduction of Chapter 4 describes the WSI and the purpose for its evaluation. The Methods section describes the methods used to collect the WSI data and the methods used to evaluate the data. The Results and Discussion sections present the findings of the evaluation, the potential uses of the WSI data, and suggestions for the improvement of the WSI.

Each chapter addresses specific objectives for the individual evaluation, but for each survey, my objectives were to:

1. evaluate the procedures used in data collection and analysis to determine if they provide the most accurate data possible;
2. evaluate the statistical validity of the data at the relevant scales;
3. determine if the survey provides the data necessary to accurately satisfy its present uses; and
4. make recommendations on the improvement of the current data collection and analysis procedures or on the development of new procedures.

By meeting the above objectives, each evaluation will insure the quality of the data and the analyses in which the data are used. The recommendations will also suggest more accurate and efficient survey methodologies, resulting in a more effective use of MDNR resources.

CHAPTER 2

THE BIODATA EVALUATION

Introduction

Michigan's current white-tailed deer population estimate greatly exceeds the MDNR's deer population goal of 1.3 million deer (W. Moritz, MDNR, personal communication). The current estimated population of approximately 2 million deer is split fairly evenly among Michigan's three regions (MDNR 2000a; see Figure 1 for regional boundaries). The primary means of managing the deer herd to achieve the desired population goal lies in regulating the annual deer harvest, during which Michigan hunters have recently harvested more than 500,000 deer in a single year (Frawley 2000). For the 2000 deer hunting season, the MDNR created harvest regulations to try to meet a target harvest ratio of 3 antlerless deer for every 2 antlered to reduce population growth (MDNR 2000b). The annual harvest is divided among several different seasons, which always include the split archery season from October 1 through November 14 and December 1 through early January, the firearm season from November 15-30, and the muzzleloader season in early December in the Upper Peninsula (UP) and mid December in the Lower Peninsula (LP) (MDNR 2000b). Recently the MDNR has also instituted some special Early and Late Firearm seasons for antlerless deer only to try to further reduce the deer population in areas with especially high deer densities.

The MDNR needs a source of biological information to create a profile of the annual deer harvest, draw inferences about the state's deer herd, develop population estimates, and examine the effects of current management practices. The largest source of such data is the biophysical data, known as the biodata, collected from voluntary deer

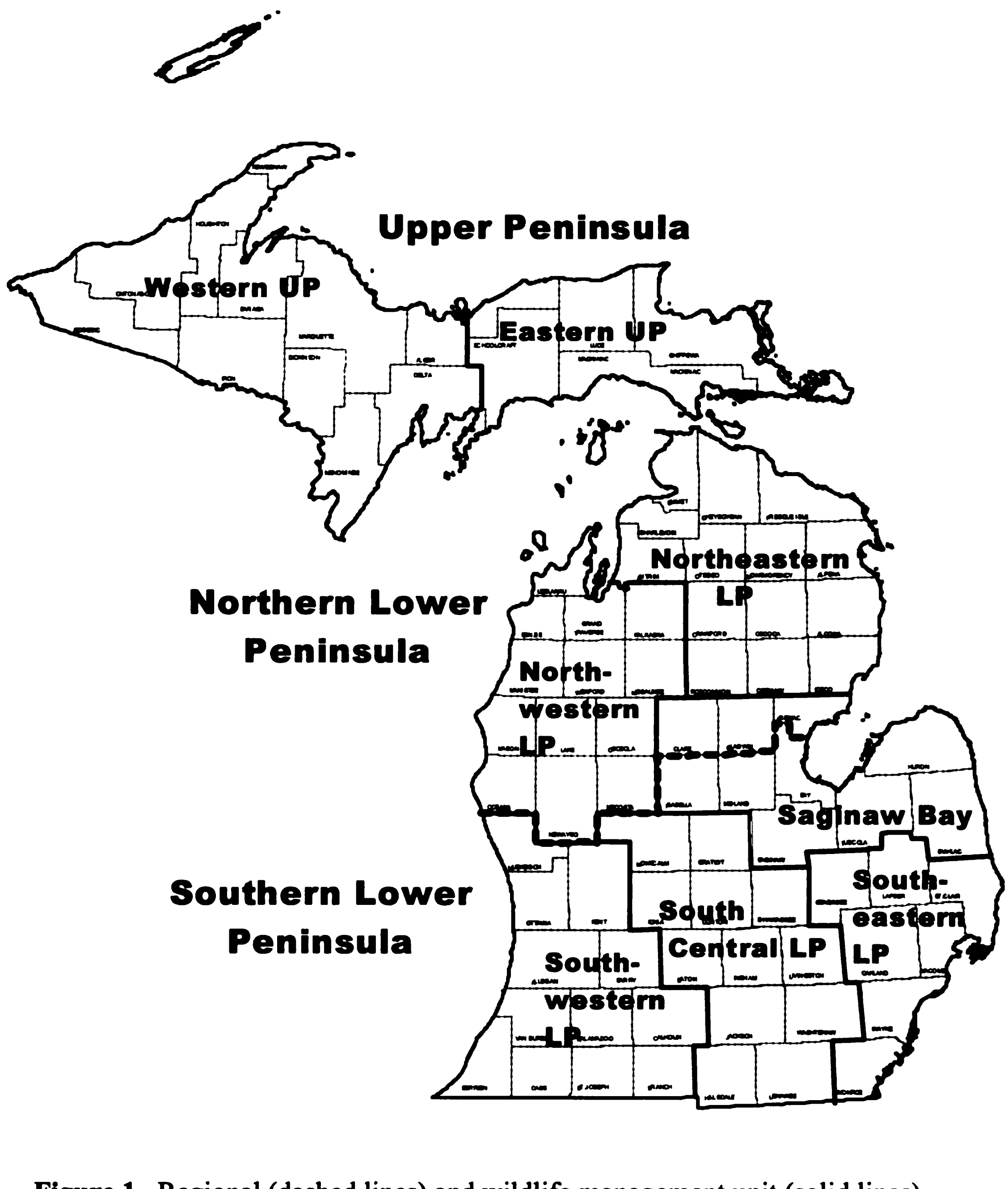


Figure 1. Regional (dashed lines) and wildlife management unit (solid lines) boundaries.

check stations. The goal of the voluntary check system is not to develop a harvest estimate, but rather to collect information on the harvest composition and the biological characteristics of the deer herd. Hunters in Michigan are not required to register their deer. Instead, they are encouraged to voluntarily bring their deer to a MDNR check station where the biodata are collected. To encourage participation in the voluntary deer checking system, the MDNR provides a patch for every deer a hunter brings to a check station. The check stations are distributed across the state. In 1999, the MDNR maintained 4 highway stations and 75 field stations at field offices and state parks, game areas, and recreation areas (Figure 2). During several days of the firearm season, the four highway check stations (circled in Figure 2) are located along three major southbound arteries and at the Mackinac Bridge. The other check stations are scattered throughout the state. The exact number and location of check stations varies slightly from year to year and has generally been increasing.

The check stations are run by MDNR employees and other volunteers who have participated in annual training sessions. The check station workers are trained to collect a variety of data on each deer brought into the check station. Data are collected from each hunter and deer on the location and season of harvest, as well as the sex, age, antler size, lactation status (since 1993), and bovine tuberculosis (TB) status based on chest cavity inspection (since 1996). An example of a check station data sheet is in Appendix 1. Once all of the season's data are collected, they are transcribed into an SPSS data file. Descriptions of each variable in the SPSS data file and the data contained within them can be found in Appendix 2. These data provide a wealth of information about the Michigan deer herd and annual harvest.

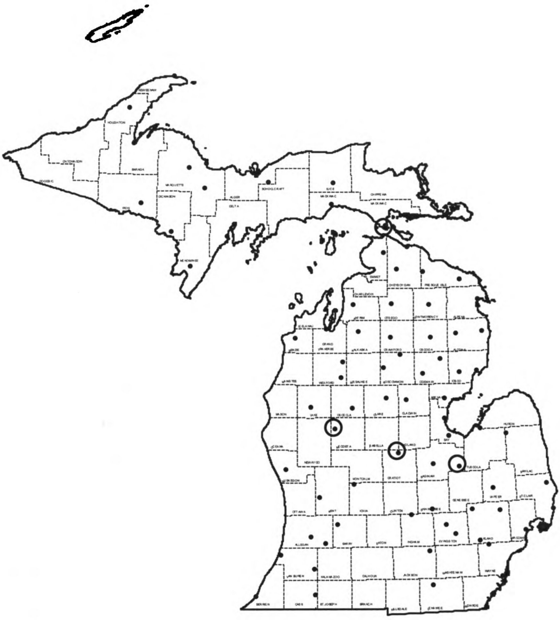


Figure 2. Locations of the 1999 check stations. Highway check stations are circled.

Harvest data are also collected through the annual mail survey of Michigan deer hunters. The mail survey is sent to thousands of randomly selected people who purchased Michigan deer hunting licenses. In 1999, the survey was sent to 5.7% of license buyers and had a 76% response rate (Frawley 2000). The survey asks for information on where the respondent hunted and what the respondent harvested. The statistical design of the random sampling method of the mail survey ensures that it provides a more accurate representation of the deer harvest than do the voluntary check stations, which are not a statistically designed, random representation. The mail survey does not provide as much data on each deer as the biodata, however. For example, the mail survey data does not include information on the age of the deer harvested. Therefore, although the MDNR also collects information on the deer herd using summer herd observations, winter dead deer surveys, deer-vehicle accident reports, and spring pellet surveys, the biodata represent the most comprehensive source of data on the herd.

This chapter describes the results of an evaluation of the MDNR check station data collected between 1987 and 1999. The quality of these records is first dependent on the procedures used to collect the data. The procedures should insure that the data are random and accurately represent the true state of the parameter they are used to estimate. Biases in the data could result in inaccurate estimates. The distribution of the biodata is entirely dependent on the distribution of harvested and checked deer, but hunters do not tend to harvest a strictly random sample of the deer population. For example, hunters are more likely to harvest male fawns than female fawns (Coe et al. 1980). Hunters are also more likely to check older, antlered deer than younger does (Bull and Peyton 2000). Sampling regimes that favor a particular geographic area, age class, or sex will provide biased data. I evaluated the methodologies used to collect the biodata to identify biases or sources of error in the biodata.

Question 1: Do the biodata represent the composition of the true harvest?

Significance

The biodata would not reflect the true composition of the harvest if they were susceptible to selection bias or measurement error. The biodata are collected from deer checked at voluntary check stations. The checked deer are therefore not likely a random representation of the true population of harvested deer. Due to hunter attitudes, certain sex and age classifications may be more likely to be checked than others. A pilot study (Bull and Peyton 2000) of Michigan deer hunters suggested that larger and older deer are more likely to be checked than smaller, younger deer. Hunters are also more likely to check antlered deer than antlerless deer (Bull and Peyton 2000). The biodata are also susceptible to measurement errors. For example, Ryel et al. (1961) found that Michigan check station agers tend to under-age older deer (4.5 years old and older) and over-age younger deer. Although the mail survey is probably a more accurate representation of the harvest, it does not contain as much information as the biodata. The biodata are the only data available that provide detailed information about the composition and biological condition of the deer herd and harvest. It is necessary, therefore, to identify possible sources of bias and error within the check station survey process.

Methods

Although there is no census of harvested deer, the MDNR conducts an annual mail survey to provide an independent and more reliable and random representation of the annual deer harvest than the check station survey. I compared the biodata to the data collected in the mail survey (hereafter called harvest data) to compare the harvest composition as represented by both surveys. I had to first assume that the mail survey provides an unbiased, random representation of the deer harvest. The random sampling procedure used to distribute the mail survey (Frawley 2000) should ensure that the harvest data meets these assumptions. I was able to calculate the percent of deer checked from each county by dividing the number of deer checked from a particular county by the mail survey's county harvest estimate. Using the biodata and the harvest data, I calculated antlerless to antlered[1] ratios (the only designations available in the harvest data) to compare the composition of the checked deer to the composition of the harvested deer. By comparing these two surveys, I was able to identify hunter biases toward checking certain deer and geographic biases in the collection process.

The second possible source of error is in measurement methods. I had little opportunity, however, to check the accuracy of the aging, sexing, and measuring involved in the data collection process. The sole opportunity to check the aging process was in comparing the ages determined in the field to the ages determined at the Rose Lake Wildlife Research Station when deer were tested for TB in 1999. Deer taken for TB testing are first sent to Rose Lake where they are aged by highly experienced agers. At both the check stations and Rose Lake, the deer are aged using the tooth wear and replacement patterns described by Severinghaus (1949). The Rose Lake agers have more experience than the field agers, however, and I assumed the age determined at Rose Lake

[1] Unless otherwise noted, all 'bucks' and 'antlered' deer are deer considered antlered according to a definition set by MDNR harvest regulations (used in the mail survey), rather than the biological definition. The differences between these definitions primarily affect yearling (1.5 year old) males whose antlers may be either short spikes or true antlers. The harvest definition defines a buck as any antlered deer with at least one antler greater than 3 inch spikes, placing some yearling males in the antlerless category. The biological definition describes a buck as any male deer that is not a fawn, placing all yearling males in the buck category.

was the more accurate age. Comparing the two ages allowed me to estimate the aging error of the field data within several different age categories.

Results and Discussion

The counties of the UP and Northern LP checked the greatest percent of harvested deer, especially those counties with intensive TB surveillance (Figure 3). The percent of deer checked peaked in 1994 (Figure 4) when the MDNR celebrated 100 years of licensed deer hunting in Michigan (MDNR 1994). Since dropping again in 1995, the percent of harvested deer checked has increased dramatically in the Northeast LP (Figure 4). The counties with the lowest percentages of deer checked in the Southern LP were also generally those counties without check stations (mostly along the border of the Southwestern management unit) (Figure 3 compared to Figure 2). The recent emphasis on checking deer from the Northeastern LP for signs of TB (since the TB testing began in 1996) has caused the higher checking rates in the Northern LP. The MDNR sent mailings to hunters in the TB surveillance region asking them to check their deer (W. Moritz, MDNR, personal communication). The TB outbreak was probably also at least partly responsible for the 1999 increase in the percent of deer checked from all management units (Figure 4) as hunters wanted to assure themselves that their deer were not diseased

The greater checking rates in the northern regions of the state and the severe under-representation of the deer from the Southern LP in the biodata will cause statewide data to be biased in favor of the northern areas. The under-representation of the Southern LP also suggests that hunters from the southern counties were less likely to check their

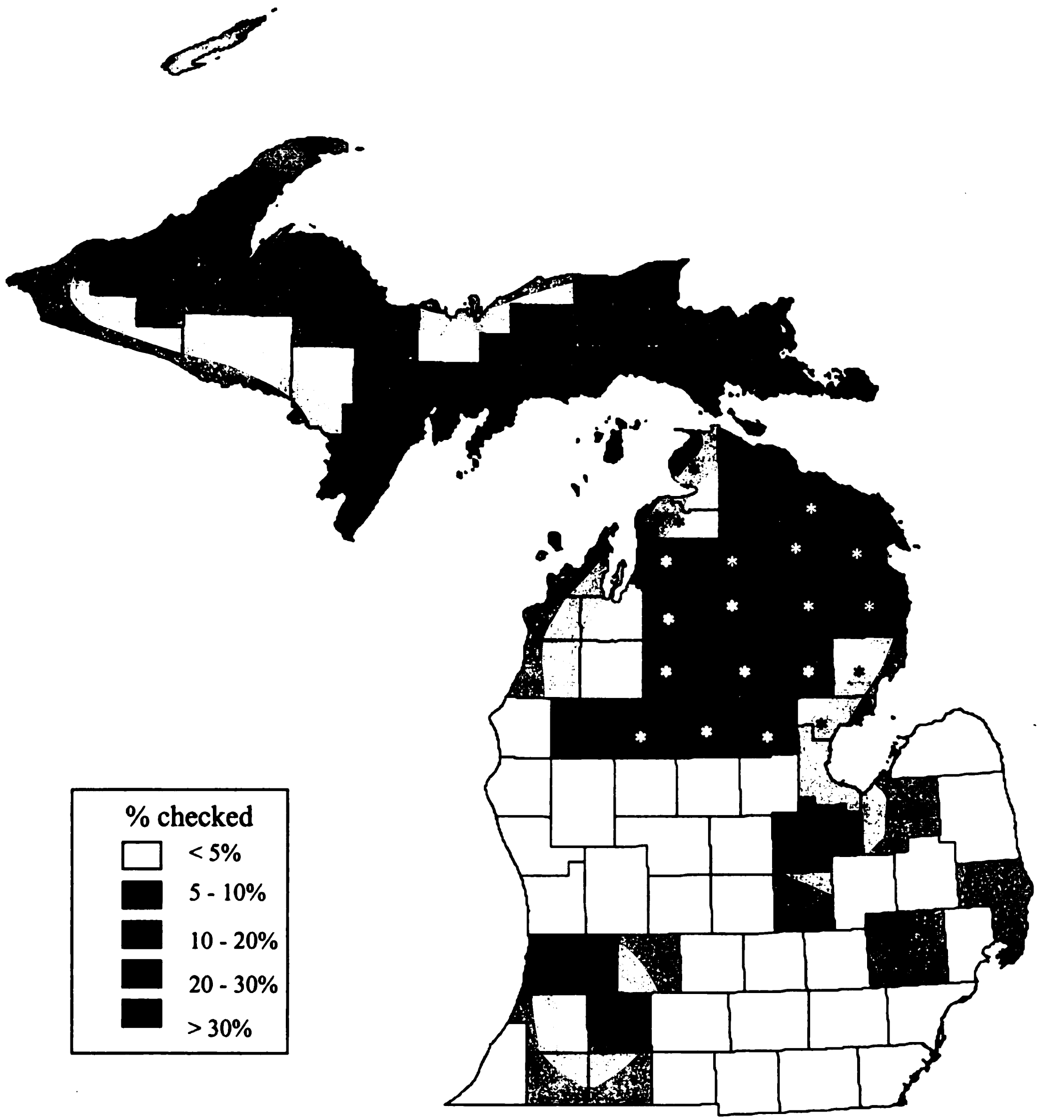


Figure 3. Percent of harvested deer checked by county during 1999. The 1999 TB surveillance counties are marked with a "*".

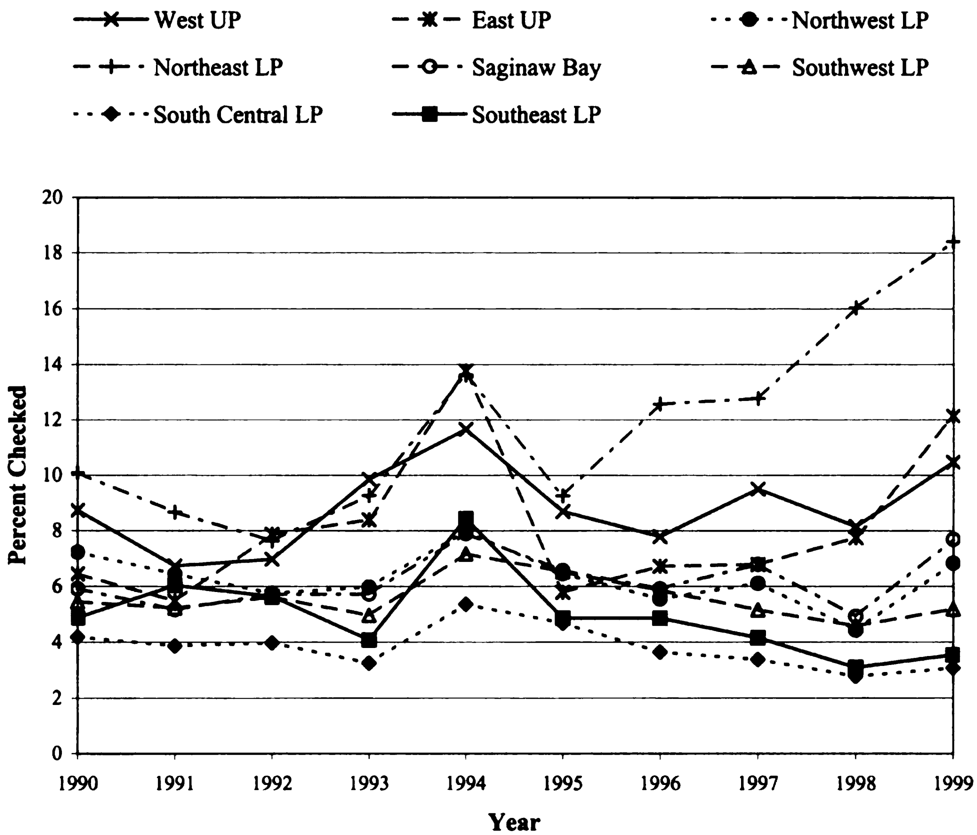


Figure 4. Percent of all harvested deer checked from each management unit.

deer, therefore not providing enough data to analyze much of the Southern LP on the county level (see Question 9). Many of the southern counties could provide adequate sample sizes for county-level analyses, if a greater proportion of hunters checked their deer from these counties. The tendency of southern Michigan hunters to check their deer may increase, however, if the number and convenience of check stations increases (see Question 3). The disproportionate number of deer checked from the TB counties will cause the data for the Northern LP region and the Northeastern LP management unit to be biased toward the TB counties. If the deer of the TB positive counties are not similar to the deer of the entire Northern LP, regional averages will reflect the status of the Northeastern LP, rather than the entire region. The biodata's bias toward the TB counties could therefore be of some concern when examining the data at the management unit or regional scales.

I next compared the annual trends in the number of deer checked within each region to the estimated harvest numbers. Within the UP, the trends deviated from one another during the early 1990s, but recently have closely tracked one another (Figure 5a). In the Northern LP, the harvest and check numbers follow the same general trend, but their relative positions reversed in 1999 (Figure 5b). In the Southern LP, the number of deer harvested increased dramatically beginning in 1995, but the number of deer checked remained steady (Figure 5c). The lack of sufficient check stations in the Southern LP may explain the absence in a corresponding increase in the number of deer checked as the harvest numbers increased (Figure 2). The number of deer checked in the Southern LP is also significantly less than 10% of deer harvested in every year, although in the UP and Northern LP the number of deer checked is only slightly less than or even greater than

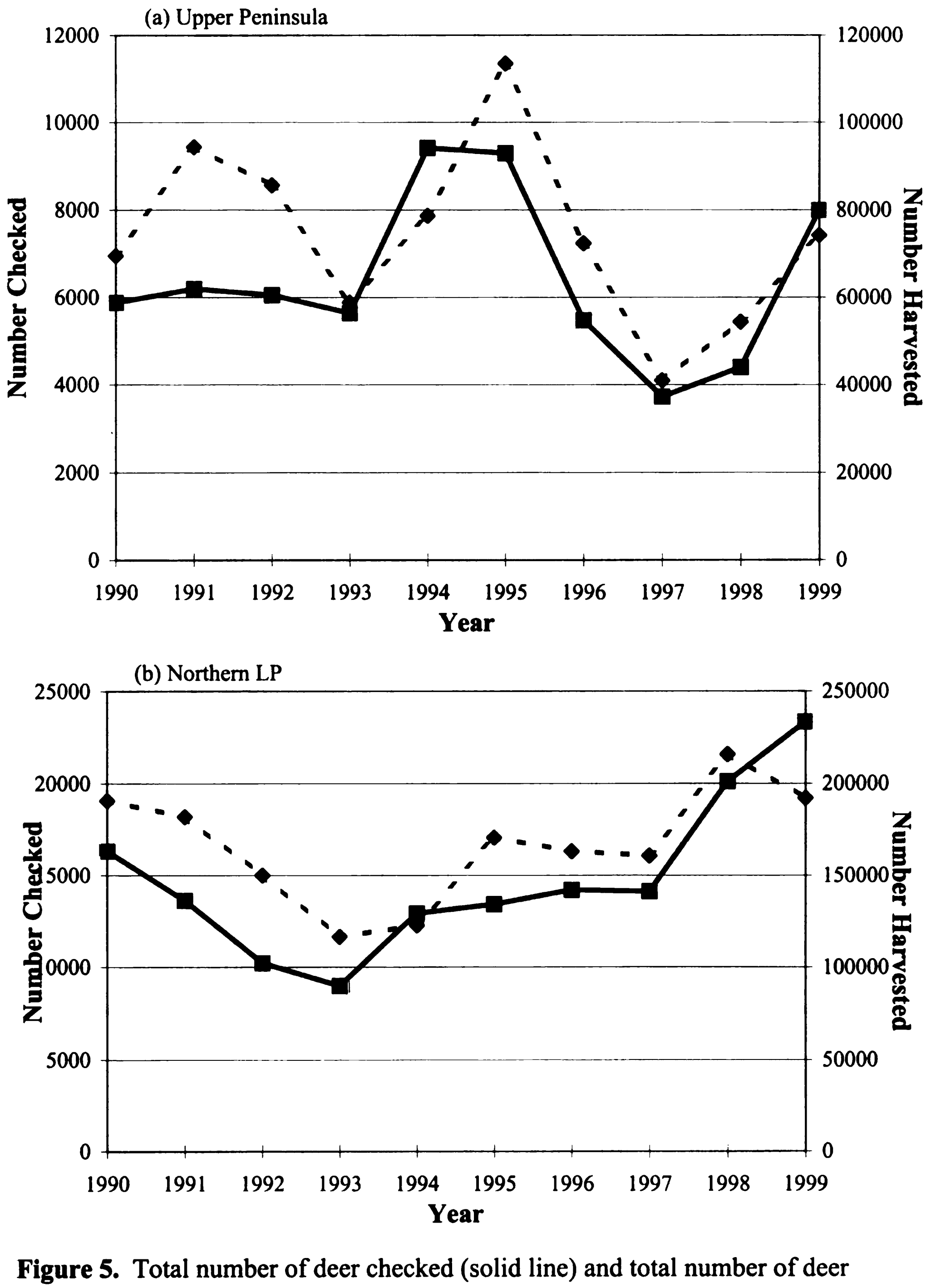
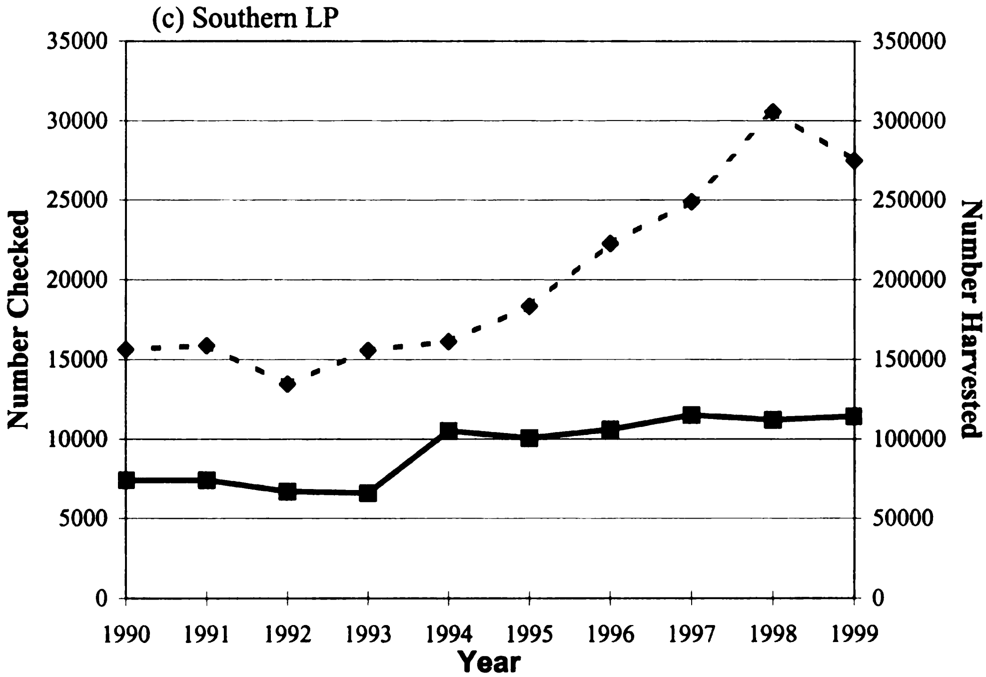


Figure 5. Total number of deer checked (solid line) and total number of deer harvested (broken line) in each region.



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10% of the deer harvested (Figures 5a-c). The relationship between the total number of deer checked to the total number of deer harvested is very similar to the relationship between the number of antlered or antlerless deer checked and the number of antlered or antlerless deer harvested (Figures 6a-c). Any discrepancies between the trends of the number of deer checked and harvested are therefore due to differences in both the antlered and antlerless deer numbers.

The fairly consistent relationship between the number of deer checked and harvested in the northern areas of the state suggests that the biodata from these regions have represented a similar subset of the harvest over the past ten years. Annual data are therefore comparable to one another. The parallel patterns also indicate that the biodata were not dependent on the same group of hunters each year. As more hunters were successful, more hunters checked their deer. The dramatic increase in the harvest data, accompanied by only a slight increase in the check data from the Southern LP indicates that recently a large portion of the harvest has gone unchecked. As this was not the case during the first half of the decade, the earlier data may not be comparable to the most recent data.

Although the hunters may have checked an adequate percentage of the harvested deer to theoretically represent the true harvest, the distribution of the checked deer did not appear to be random and the composition of the deer harvested may not be equivalent to the composition of the deer checked. To address this issue, I compared the harvest data's and biodata's antlerless to antlered ratios. Although the MDNR uses only the data from the yearling population to calculate the adult buck and doe composition, the total antlerless to antlered ratio was the only ratio I was able to calculate using the harvest

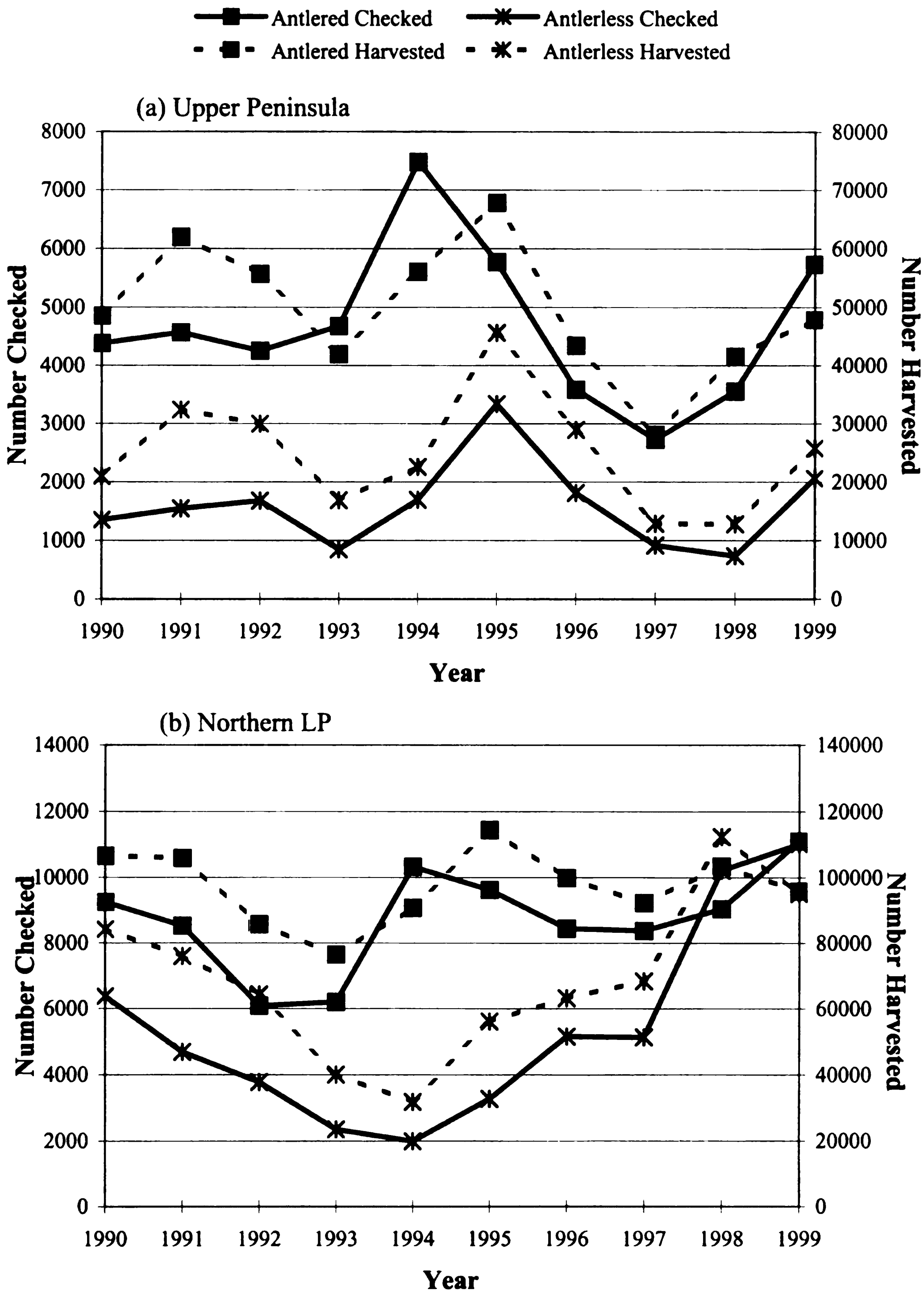


Figure 6. Total number of antlered and antlerless deer checked and harvested in each region.

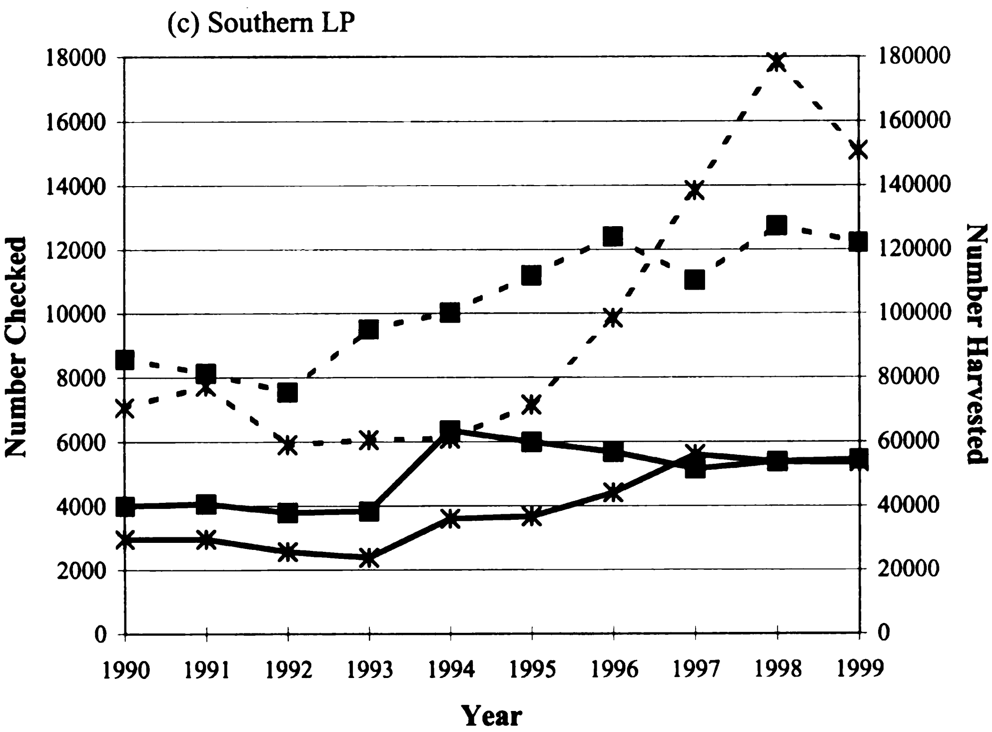


Figure 6 (cont'd).

data. If the biodata and the harvest data represented the same population of harvested deer, the shape of the distributions in Figure 7 would be normal; there should be some variation, but the distribution should peak at 0 (the ratios are the same) and fall off symmetrically on either side. Such a pattern would indicate that the ratio of antlerless to antlered deer was similar between each county's biodata and harvest data. The distribution of the difference between the harvest ratio and the checked ratio tended to be skewed to the right, however, indicating that counties more frequently had a higher harvest antlerless to antlered ratio than checked ratio (Figure 7). Hunters, therefore, checked a greater proportion of antlered deer than antlerless ones. The biodata do not appear to represent the same population of deer as the complete harvest, which may provide an inaccurate view of the state of the deer herd. Management decisions based on information contained within the biodata could be affected, leading to undesired effects on the composition of the deer herd.

In one instance I was able to check the biodata against itself. I looked at the trend of the number of antlerless deer checked as the number of antlerless permits increased (Table 1). When an entire county issued antlerless permits following a year in which no antlerless permits were issued (except block permits) the number of antlerless deer checked increased an average of 622%. When the area of a county that issued antlerless permits increased by at least two-thirds of the county's area, the number of antlerless deer checked increased an average of 261%. These results suggest that the biodata do not just include records from the same successful hunters every year. When more antlerless permits were available, more hunters were successful, and the number of checked antlerless deer increased.

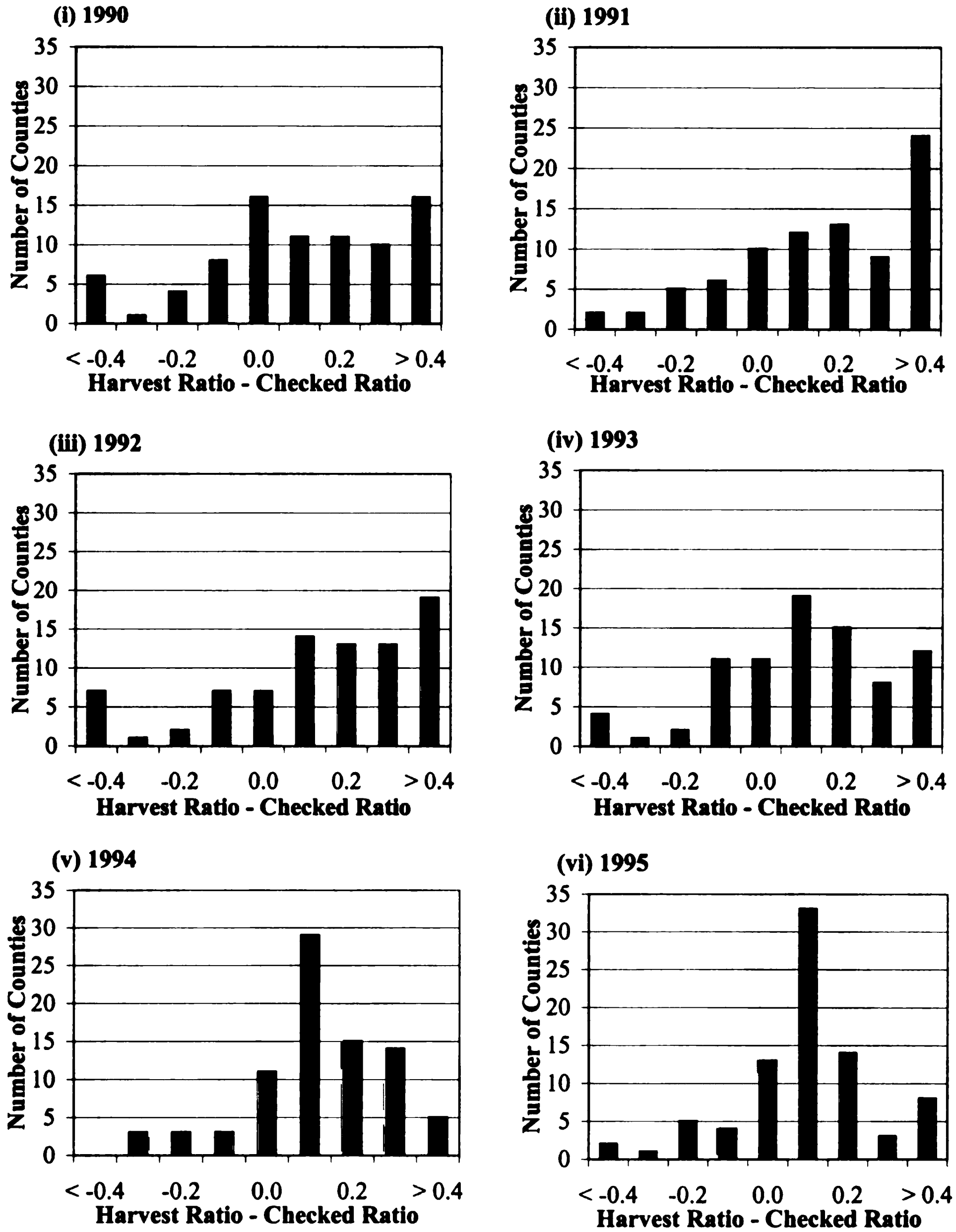


Figure 7. Histograms of the number of counties whose difference between the harvest estimates and biodata estimates of the anterless to antlered ratio falls within the listed categories.

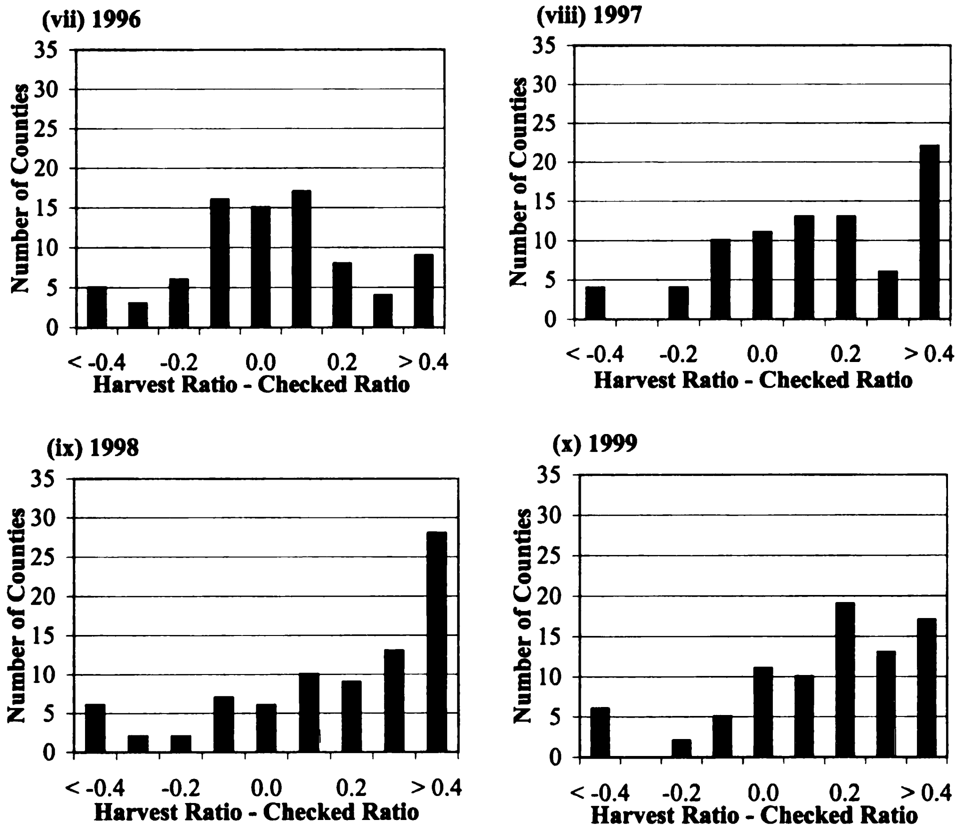


Figure 7 (cont'd).

Table 1. Increase in the number of antlerless deer checked when antlerless hunting was permitted on at least two-thirds more of the county in Year 2 than in Year 1.

County	Year 1	Year 2	Area Yr 1[1]	Area Yr 2[2]	% increase[3]
Mason	1994	1995	0	1	206.25
Mecosta	1994	1995	0	1	796.55
Newaygo	1994	1995	0	1	285.96
Emmett	1994	1995	0	1	1200.00
average					**622.19**
Gogebic	1998	1999	0	2/3	185.71
Iron	1998	1999	0	2/3	436.59
Kalkaska	1994	1995	0	2/3	100.00
Lake	1994	1995	0	2/3	72.22
Mackinac	1998	1999	0	2/3	1171.43
Missaukee	1994	1995	0	2/3	192.50
Ontonogon	1998	1999	0	2/3	217.65
Houghton	1998	1999	0	2/3	500.00
Muskegon	1987	1988	1/3	1	0.00
Osceola	1994	1995	1/3	1	128.89
Montmorency	1995	1996	1/3	1	405.45
Wayne	1997	1998	1/3	1	0.00
Otsego	1998	1999	1/3	1	175.73
Alpena	1994	1995	1/3	1	109.52
Benzie	1994	1995	1/3	1	537.50
Dickinson	1994	1995	1/3	1	174.26
Iron	1994	1995	1/3	1	411.50
Cheyboygan	1995	1996	1/3	1	156.25
Manistee	1995	1996	1/3	1	250.00
Benzie	1997	1998	1/3	1	37.50
Cheyboygan	1997	1998	1/3	1	431.82
Grand Traverse	1997	1998	1/3	1	45.00
average					**260.89**

1. The area of the county for which antlerless permits were issued in Year 1.
2. The area of the county for which antlerless permits were issued in Year 2.
3. The percent increase in the number of antlerless deer checked from Year 1 to Year 2.

The final check of the biodata against the true harvest was the check of the accuracy of the aging techniques. When compared to the age determined at Rose Lake (assumed to be the true age), the age determined in the field decreased in accuracy with increasing age (Table 2). Field personnel always aged fawns correctly and aged yearlings correctly 94.85% of the time (male ages may be more accurate than female ages due to field agers use of antlers as additional evidence). When separated into their individual age categories, deer 2.5 years old or older were aged incorrectly more than 25% of the time in almost all categories. Deer 2.5 years old or younger tended to be overaged (assigned higher than true ages) at the check stations, while older deer tended to be underaged (assigned lower than true ages) at the check stations (Figure 8).

The field-determined ages could be used to lump the older deer into a single 2.5+ category with 93.35% accuracy (males ages were less accurate than female ages in this category). Although reducing the number of age categories to three (fawns, yearlings, and 2.5+) would potentially increase the accuracy of the aging process, knowing the complete age structure of population is still necessary to address landscape level issues. Determining the true age of the deer may also be important for public relations issues, because many hunters are interested in knowing the exact age of their deer (H. Hill, MDNR, personal communication).

Table 2. Percent of deer aged incorrectly by field personnel according to the ages determined by Rose Lake personnel in 1999. Bold lines indicate deer of several ages were grouped in a single category.

Age	Male		Female		Total	
(in field)	N	% Incorrect	N	% Incorrect	N	% Incorrect
fawn	31	0.00	24	0.00	55	0.00
1	547	2.93	171	12.28	718	5.15
2	120	26.67	140	30.00	260	28.50
2+	**170**	**15.88**	**386**	**2.59**	**556**	**6.65**
3	40	40.00	96	29.17	136	28.46
3+	**50**	**28.00**	**246**	**7.72**	**296**	**11.15**
4	7	71.43	60	43.33	67	46.27
5	2	50.00	33	36.36	35	37.14
6+	**1**	**100.00**	**57**	**17.54**	**58**	**18.97**

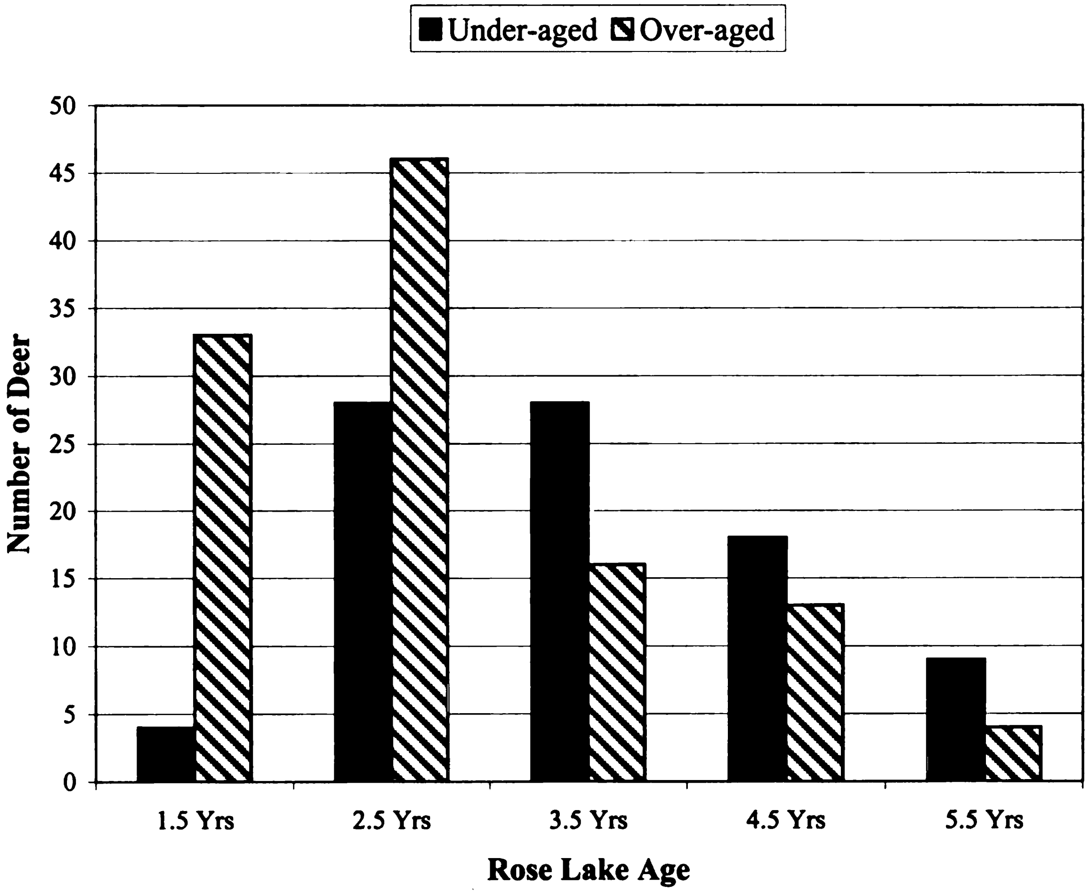


Figure 8. Number of deer given younger ages at the check stations than at Rose Lake (under-aged) or given older ages at the check stations than at Rose Lake (over-aged) in 1999.

Question 2: Do the biodata represent the composition of the true population?

Significance

Data collected from harvested deer, whether at the voluntary check stations or the more structured mail survey, are not necessarily representative of the entire Michigan deer herd. Hunting regulations strictly control the number of antlerless deer that can be harvested. Hunter attitudes also affect harvest composition. Many hunters would rather take a "big buck" than a fawn or a doe (Bull and Peyton 2000). Some deer are also more susceptible to harvest than others. Males may be more susceptible to harvest due to larger home ranges and greater movements (Roseberry and Klimstra 1974). Lone fawns may also be highly susceptible to harvest (Coe et al. 1980). The biodata collected from the harvest may, therefore, not be useful for creating estimates of the true population parameters, but the data may be useful to indicate general trends in the herd.

Methods

If the biodata represent even a moderately accurate picture of the state's herd, they should present general trends in antler size and the percent of does lactating (hereafter refered to as the lactation rate for simplicity) that the literature suggests is true of deer biology. I examined the lactation trends of the checked deer by age class and geographic region to compare them to what the literature suggests the true trends should be. I similarly examined beam diameters of checked deer. If the patterns presented in the literature are reflected in the biodata, then the biodata could possibly provide an indicator of general trends among the population as a whole. Eberhardt (1960) also developed a method to check for the accurate representation of fawns in the harvest by comparing the female fawn to 1.5+ doe ratio of one year to the 1.5 doe to 2.5+ doe ratio of the following year. I was unable to perform Eberhardt's (1960) analysis, however, because necessary assumptions were not satisfied. First, Bull and Peyton (2000) found that hunters are less likely to check fawns than older deer so the biodata would not represent the proportion of fawns in the true harvest. The analysis also assumes that mortality rates are consistent from 6 months to 18 months and from 18 months to 30 months. Fawns are more susceptible to predation and harsh winter conditions than older deer, however. I was therefore unable to check how well the biodata may represent the age structure of the deer population.

Results and Discussion

The percent of does lactating (Figure 9) and mean beam diameter (Figure 10) both increased with increasing age, according to the biodata. Although there is some error associated with the ages of the older deer (Question 1), the general trends of lactation and antler size are still apparent. Scanlon and Urbston (1978) found that higher lactation rates among adults than among yearlings in South Carolina. Ozoga et al. (1994) also found that, in Michigan, older deer are more likely to breed than younger deer, especially under stressful conditions. Increases in beam diameter with increasing age were also expected based on results in the literature (Severinghaus et al. 1950; McCullough 1982; Ozoga et al. 1994).

The geographic variations in the lactation rates and antler size are most apparent among the yearlings. The percent of lactating does decreased with increasing latitude

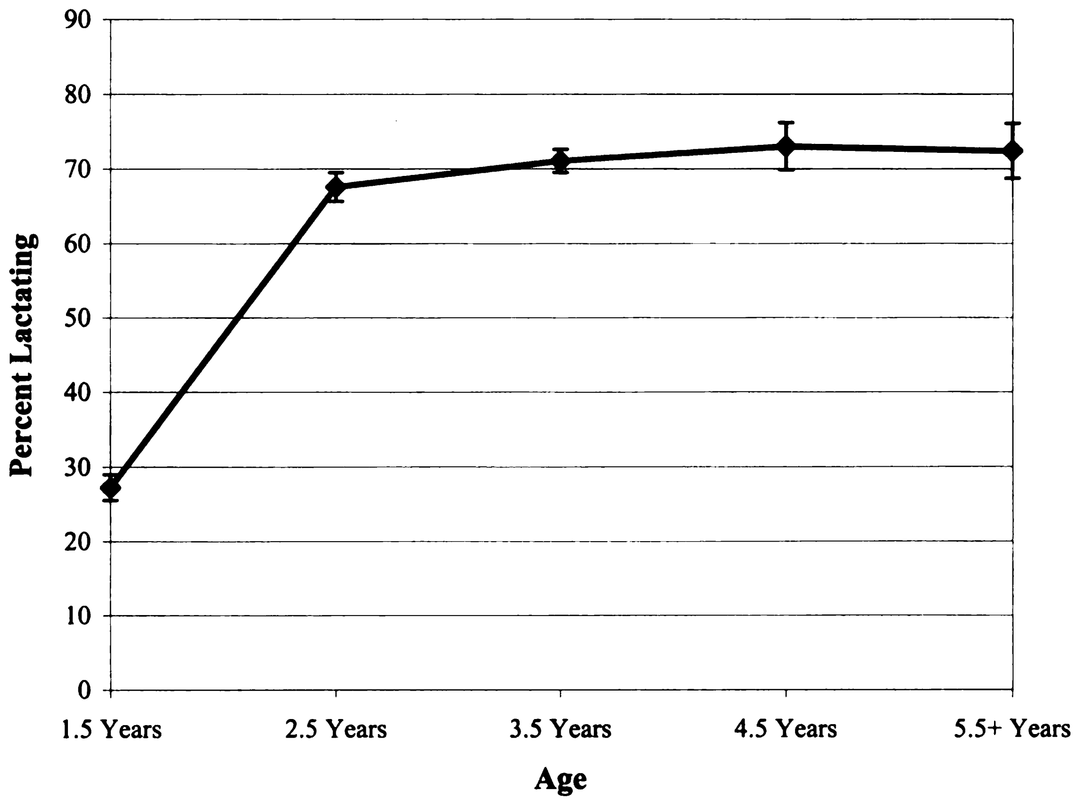


Figure 9. Percent of does lactating in Michigan, averaged from 1993-1999 (using October data). Error bars are ± 1 standard error.

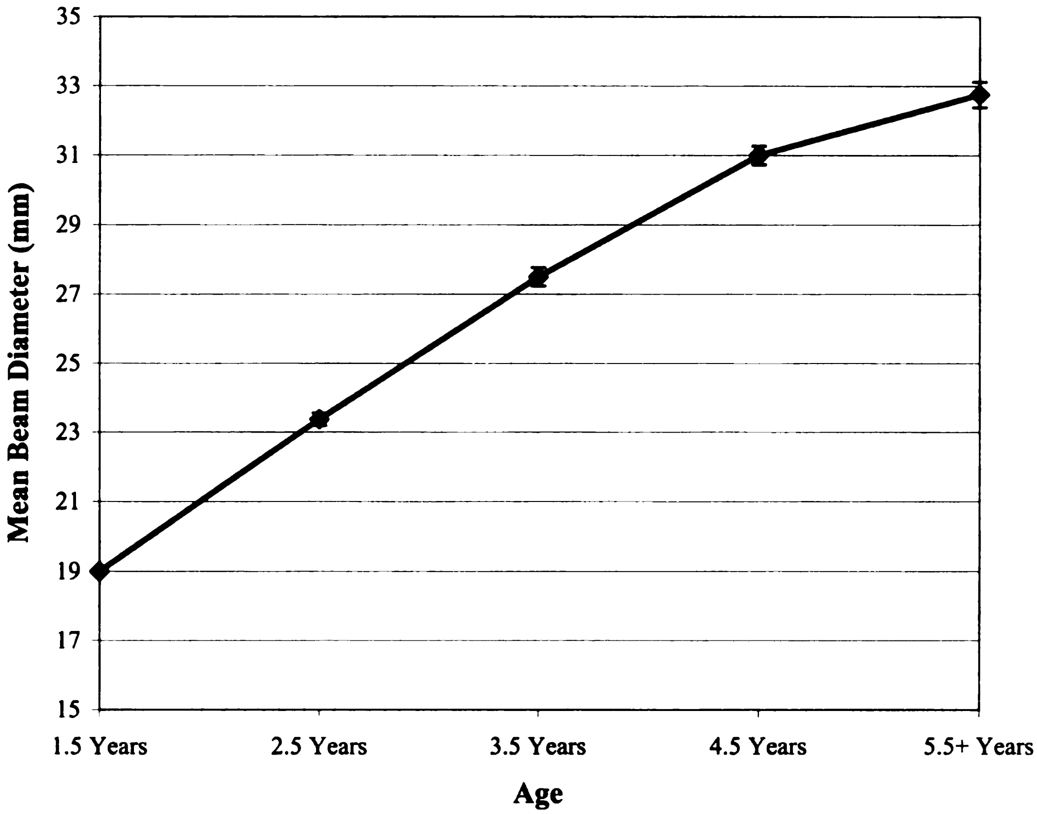


Figure 10. Average beam diameter of all antlered deer checked in Michigan, averaged from 1992-1999. Error bars are ± 1 standard error.

(Figure 11); fewer deer were lactating in the northern than in the southern regions. Ozoga et al. (1994) describe the same pattern and suggest it is due to the greater stress in the more northern regions. Northern Michigan has harsher winters, less productive soils, and less farmland, on which deer could find abundant food, than southern Michigan. The pattern is similar for yearling beam diameters. The deer of the Southern LP had larger average beam diameters than the deer of the Northern LP and UP (Figure 12). As with the lactation trends, the patterns of beam diameters may be due to the quality of the deer habitat or population density across the state. Severinghaus et al. (1950) found that antler development was related to the availability of forage due to habitat quality and deer density in New York. As Ozoga et al. (1994) report, the Northern LP and UP have higher deer population densities than the Southern LP, but poorer deer habitat.

The trends of lactation rates and beam diameter in the biodata reflect the trends expected from the literature. The data also support the concern that the recent heavy bias of the data collection in favor of the Northeastern LP, which is not representative of the entire state, could bias the data, leading to erroneous conclusions about the condition of the herd. These results support the use of the biodata to provide an index of the true condition of the state's entire herd, rather than just the harvested population. If the checked animals were grossly misrepresenting the population as a whole, the trends in lactation and antler size would not follow expected patterns.

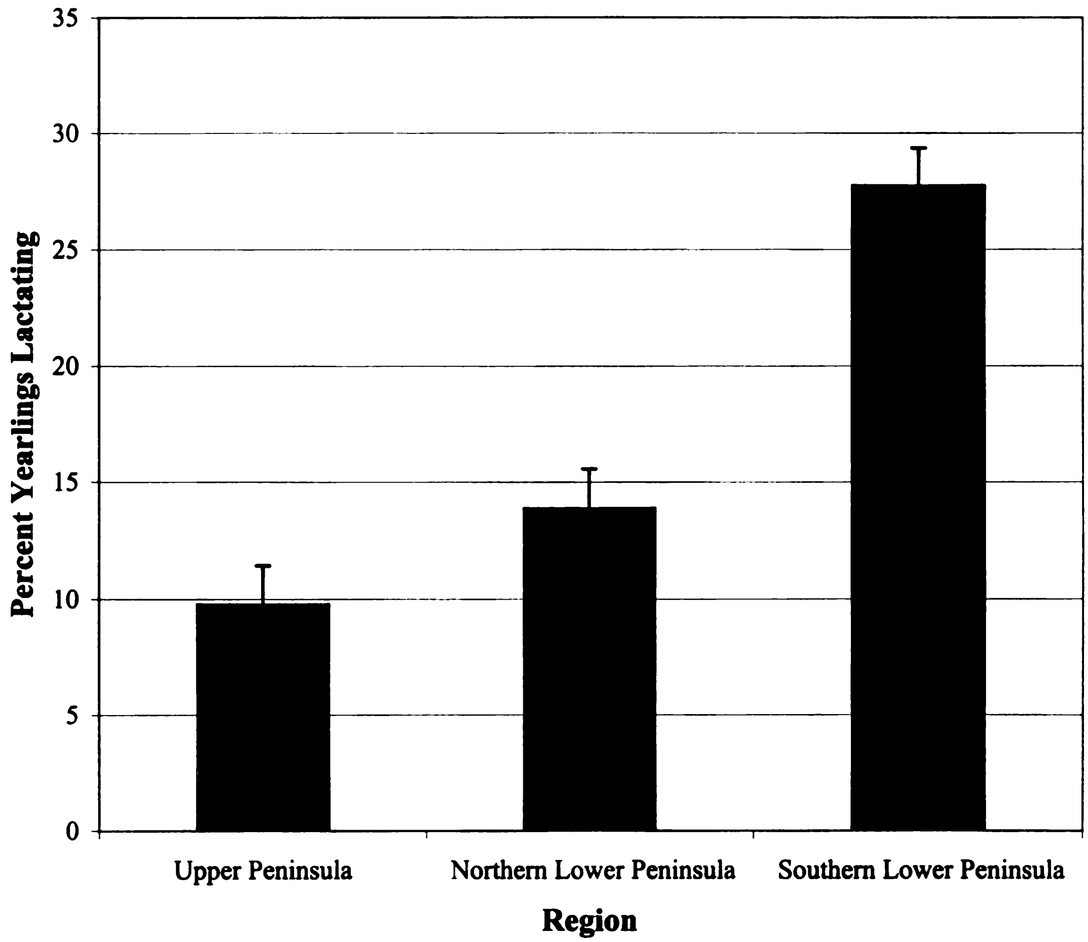


Figure 11. Percent of yearling does lactating in each region averaged from 1993-1999 (data from first week of firearm season). Error bars are + 1 standard error.

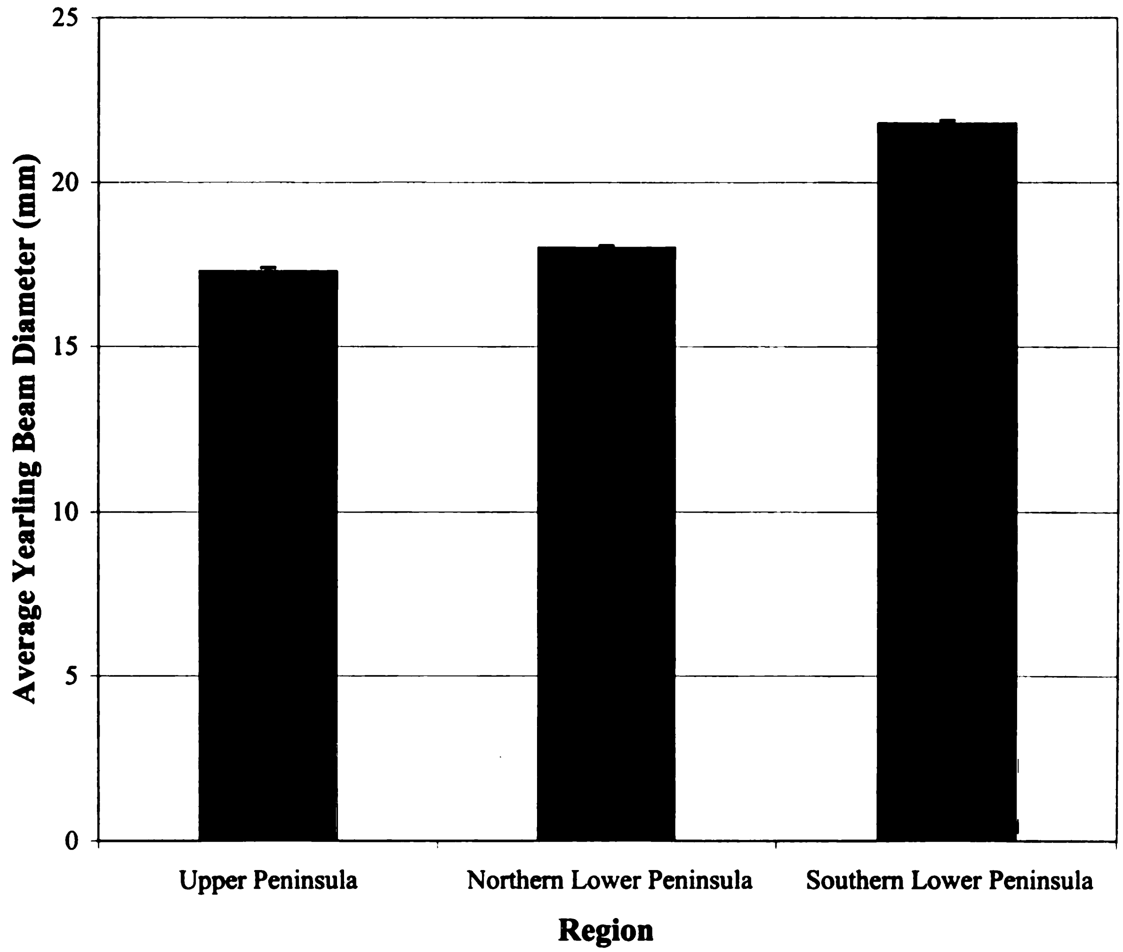


Figure 12. Average yearling beam diameter in each region averaged from 1987-1999. Error bars are + 1 standard error.

Question 3: How do the locations of the check stations affect the spatial distribution of the biodata?

Significance

Many of the problems associated with the biodata are due to under-representation of certain geographic areas or to generally low sample sizes. The only way to improve the situation is to collect additional data from those areas that are under-represented. One way to increase data collection may be to add additional check stations, a tactic that will work only if the location of the check stations affects the tendency of hunters to check their deer. If hunters will check more deer if check stations are more convenient, then the distribution of the check stations across the state may play a large role in the spatial distribution of the biodata. A pilot study of Michigan check stations (Bull and Peyton 2000) found that hunters who check their deer are more likely to live within 16 miles of a check station than do hunters who do not check their deer. Hunters also expressed the importance of the convenience of checking a deer, both in terms of location and the amount of time it takes, in their decision to check a deer (Bull and Peyton 2000). The results of the pilot study suggest that if increasing the number of check stations increases the accessibility and decreases the time it takes to check a deer, hunters will be more likely to check their deer.

Methods

Accurate lists of check station locations were available for only as far back as 1996 (Table 3), so I first identified any counties in which check stations were added since

Table 3. Locations of the check stations from 1996 through 1999.

Station Name	1996	1997	1998	1999
Algonac State Park	x	x	x	x
Allegan State Game Area	x	x	x	x
Alma HighwayStation	x	x	x	x
Alpena Field Office	x	x	x	x
Atlanta Field Office	x	x	x	x
Bald Mtn. Recreation Area	x	x	x	x
Baldwin Field Office	x	x	x	x
Baraga Field Office	x	x	x	x
Barry State Game Area	x	x	x	x
Bay City Office	x	x	x	x
Bellaire Field Office				x
Big Rapids Highway Station	x	x	x	x
Birch Run Highway Station	x	x	x	x
Brighton Recreation Area	x	x	x	x
Cadillac Field Office	x	x	x	x
Cass City Field Office	x	x	x	x
Cheboygan Field Office	x	x	x	x
Crane Pond State Game Area	x	x	x	x
Crystal Falls Field Office	x	x	x	x
Curran Check Station			x	x
Escanaba Field Office	x	x	x	x
Evart Field Office	x	x	x	x
Fish Point Wildlife Area			x	x
Flat River State Game Area	x	x	x	x
Fort Custer Recreation Area	x	x	x	
Fort Wilkins State Park		x	x	x
Gaylord Field Office	x	x	x	x
Gladwin Field Office	x	x	x	x
Grand Rapids Field Office	x	x	x	
Grayling Field Office	x	x	x	x
Gwinn Field Office	x	x	x	x
Harrison Field Office	x	x	x	x
Harsen's Island	x	x	x	x
Holly Wildlife Area	x	x	x	x
Houghton Lake Field Office				x
Indian River Field Office	x	x	x	x
Ishpeming Field Office	x	x	x	x
Island Lake Recreation Area	x	x	x	x
Kalkaska Field Office	x	x	x	x
Lake Hudson Recreation Area	x			
Lapeer State Game Area	x	x	x	x
Lincoln Field Office	x	x	x	x
Livonia Office	x	x	x	x
Mackinac Bridge Highway Station				x
Manton Field Office	x	x	x	x
Marquette Field Office	x	x	x	x

Table 3 (cont'd).

Maybury State Park	x	x	x	x
McLain State Park	x	x	x	x
Mio Field Office	x	x	x	x
Mitchell State Park	x	x		
Morrice Field Office	x	x	x	x
Mt. Clemens Field Office	x	x	x	x
Muskegon State Game Area	x	x	x	x
Naubinway Field Office	x	x	x	x
Nayanquing Point Wildlife Area			x	x
Newberry Field Office	x	x	x	x
Norway Field Office	x	x	x	x
Onaway Field Office			x	x
Paris Field Office	x			
Pellston Field Office				x
Plainwell Office	x	x	x	x
Platte River Field Office	x	x	x	x
Porcupine Mtn. State Park	x	x	x	x
Port Huron Field Office	x	x	x	x
Posen Check Station			x	x
Pte. Mouillee State Game Area	x	x	x	x
Rifle River Recreation Area	x	x	x	x
Roscommon Field Office	x	x	x	x
Rose Lake Field Office	x	x	x	x
Sand Lakes Corners				x
Sault Ste. Marie Field Office	x	x	x	x
Shingleton Field Office	x	x	x	x
St. Charles Field Office	x	x	x	x
Standish Field Office	x	x	x	x
Stephenson Field Office	x	x	x	x
Tawas Point State Park	x	x	x	x
Traverse City Field Office	x	x	x	x
Van Buren State Park	x	x	x	x
W J Hayes State Park	x	x	x	x
Warren Dunes State Park	x	x	x	x
Waterford Field Office	x	x		
Waterloo State Game Area	x	x	x	x
West Branch Field Office			x	x
West Walker Sportsman Club				x
Wolf Lake Fish Hatchery	x	x	x	x

1996. I then compared the number of deer checked from a particular county for the year the station was added to the number of deer checked in the previous year. I also compared the number of deer harvested (based on the mail survey estimates) from the same counties in the same years to determine if any trends found in the number of deer checked was due to similar changes in the number of deer harvested.

Results and Discussion

The number of deer checked in a county increased by an average of 88.21% following the addition of a check station to the county (Table 4). The increase in the number of checked deer was accompanied by only a 17.19% increase in the number of deer harvested in the corresponding counties and years (Table 4). The number of deer checked decreased in both Keweenaw and Bay counties following the addition of a check station. The Keweenaw decrease was probably due to the larger decrease in the number of deer harvested. The decrease in the number of checked deer in Bay County is not due to a decrease in harvest, but the total number of deer checked between the two years differs only by seven deer, suggesting the decrease is not as great as it may appear. Adding a check station, therefore, tended to increase the percent of deer checked from the county in which the station was added. Increasing the number of check stations may decrease the pressure on any individual station, reducing the amount of time necessary to check a deer. Perhaps more importantly, adding check stations increases the convenience of checking a deer for the hunters by reducing the amount of time they must drive to reach a check station. The distribution and placement of check stations could be altered

Table 4. Change in the number of deer checked and harvested following the addition of a check station to a county.

County	Station(s) Added	Year added	% Change Checked	% Change Harvested
Cheboygan	Cheboygan Field Office	1999	53.79	-4.15
Mackinac	Mackinac Bridge	1999	290.52	107.23
Emmet	Pellston Field Office	1999	228.09	4.93
Antrim	Bellaire Field Office	1999	130.77	24.38
Iosco	Sand Lake Corners	1999	50.81	-12.39
Roscommon	Houghton Lake Field Office	1999	80.42	6.84
Presque Isle	Posen Check Station and Onaway Field Office	1998	89.18	29.64
Alcona	Curren Check Station	1998	127.11	71.06
Ogemaw	West Branch Field Office	1998	24.89	33.24
Bay	Nayanquing Point Wildlife Area	1998	-8.14	9.21
Tuscola	Fish Point Wildlife Area	1998	8.98	18.50
Keweenaw	Fort Wilkins State Park	1997	-17.95	-82.20
Average			**88.21**	**17.19**

to increase the sample size of biodata in different counties or to balance the unequal emphasis on certain counties within the biodata.

Question 4: Does the spatial distribution bias the biodata?

Significance

Due to the voluntary nature of deer checking, the location of check stations, and the distribution of lands available for deer hunting, not all counties are represented equally in the biodata. Each county does not contribute equally to the deer harvest, however, so each county need not check an equivalent number of deer. Ideally the distribution of the biodata would be equivalent to the distribution of the harvest data. For several reasons, however, certain counties may account for more or less of the biodata than they may of the harvest data, potentially biasing the biodata.

Methods

I calculated the percent of total check station records that each county contributed to the biodata within a particular wildlife management unit in 1999. I then did the same for the harvest data and compared the distribution of the check station data within a management unit to the distribution of the harvest data. Chi-squared tests, comparing the observed biodata distribution to the expected distribution based on the harvest data, determined the statistical significance of the differences between the distributions.

Results and Discussion

Chi-square tests revealed a statistically significant difference between the distribution of the biodata and the distribution of the harvest data among the counties within all eight management units (Table 5). In the Western UP, the largest differences

Table 5. Results of chi-squared tests comparing the 1999 distribution of the biodata to the distribution of the harvest data within the counties of each management unit.

Management Unit	d.f.	χ^2	p-value
Western UP	10	135.541	<0.001
Eastern UP	3	38.418	<0.001
Northwestern LP	12	1865.851	<0.001
Northeastern LP	13	2468.658	<0.001
Saginaw Bay	9	3980.185	<0.001
Southwestern LP	11	2389.501	<0.001
Southcentral LP	11	531.97	<0.001
Southeastern LP	6	419.457	<0.001

were in Dickinson and Gogebic counties where the percent harvested exceeds the percent checked (Figure 13a). Both could be due to inaccessibility of check stations; Gogebic did not have a check station in 1999, and Dickinson's check station was located on the extreme southern edge of the county (Figure 2). In the Eastern UP, the greatest differences were in Chippewa and Mackinac counties (Figure 13b). Mandatory deer checking on Drummond Island probably caused the greater percent of deer checked in Chippewa. The difference in Mackinac is difficult to explain. The placement of the new Mackinac Bridge check station should allow a greater percentage of the harvested deer to be checked.

Many of the counties in the Northwestern LP exhibited large differences between the percent deer checked and harvested (Figure 13c). Mecosta, Newaygo, Mason, and Oceana counties were all under-represented in the biodata, probably due to the lack of check stations in the area (Figure 2). Osceola, Lake, Missaukee, and Kalkaska counties may have been over-represented in the biodata because they contained several check stations among them, and they are located near the TB surveillance area. The TB positive counties in the Northeastern LP were all over-represented in the biodata due to hunters checking their deer for TB test results (Figure 13d). The over-representation in these counties caused under-representation in the remaining counties of this management unit. In the Saginaw Bay management unit, the counties without check stations (Figure 2) tended to be underrepresented in the biodata (Figure 13e). Clare was over-represented due to a quality deer management project which required participating organizations to check a minimum number of deer (J. Urbain, MDNR, personal communication), while Saginaw's two check stations may have contributed to its dominance in the biodata.

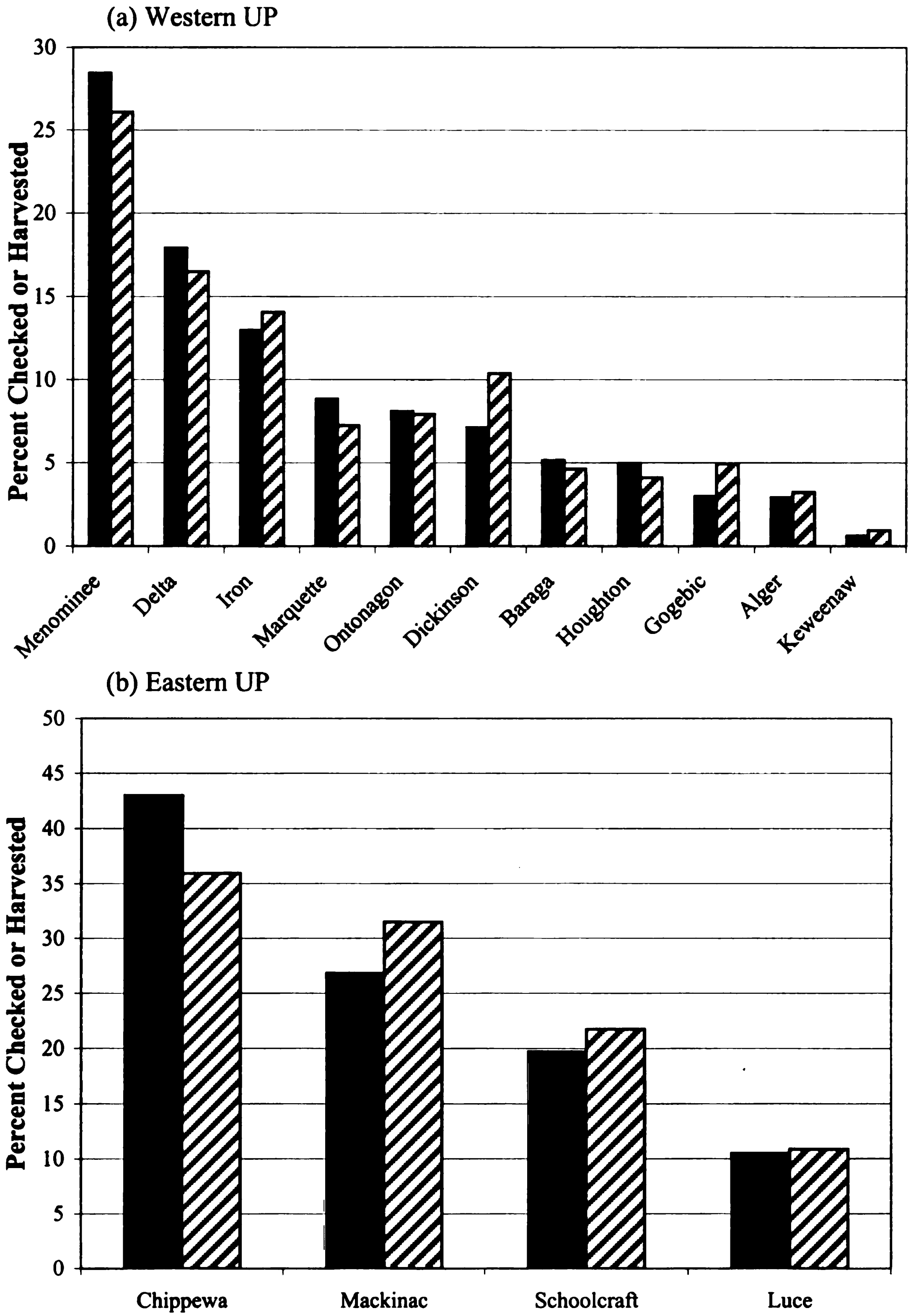


Figure 13. The percent that each county contributed to the total number of deer checked (solid) and harvested (striped) in each management unit in 1999.

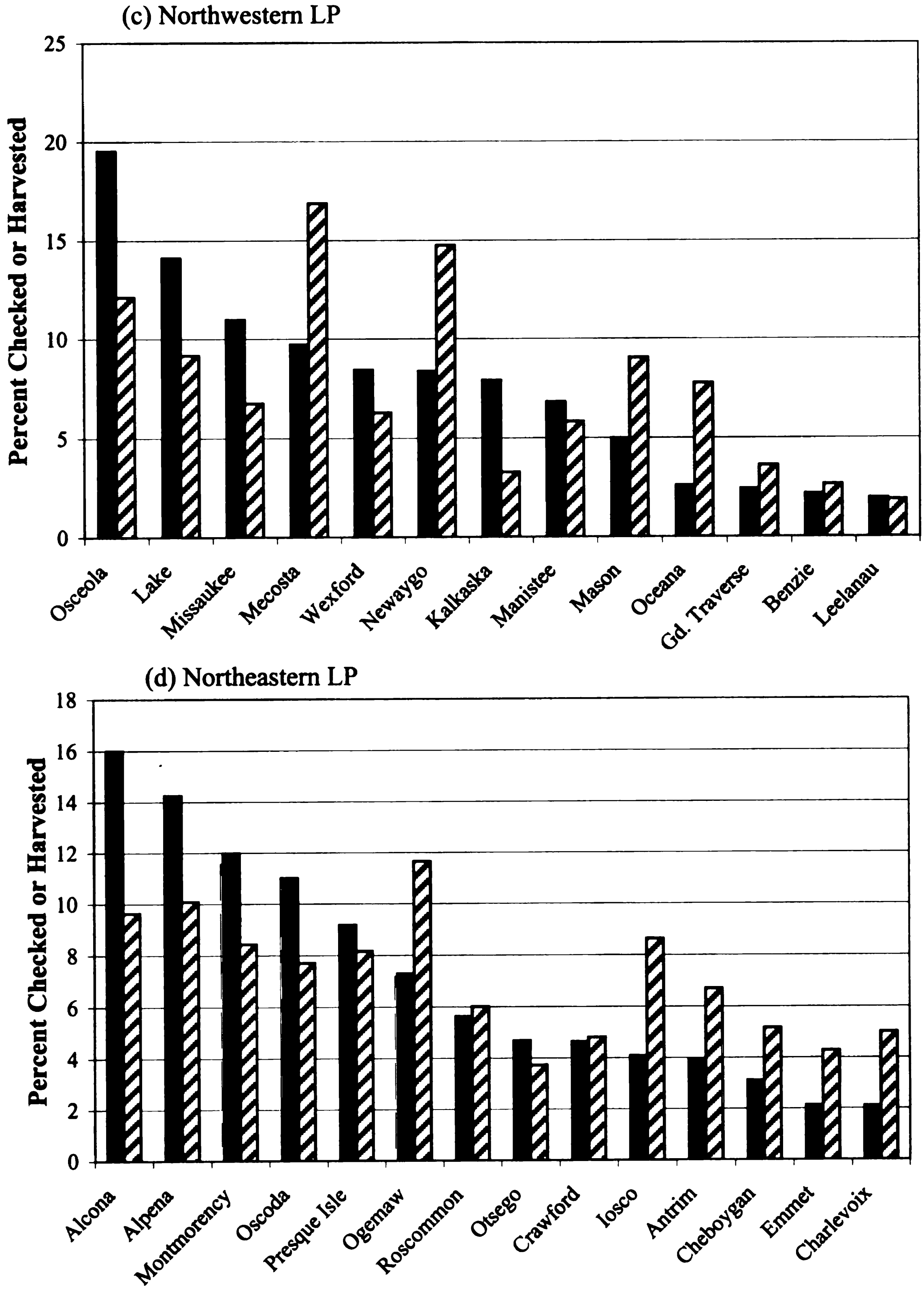
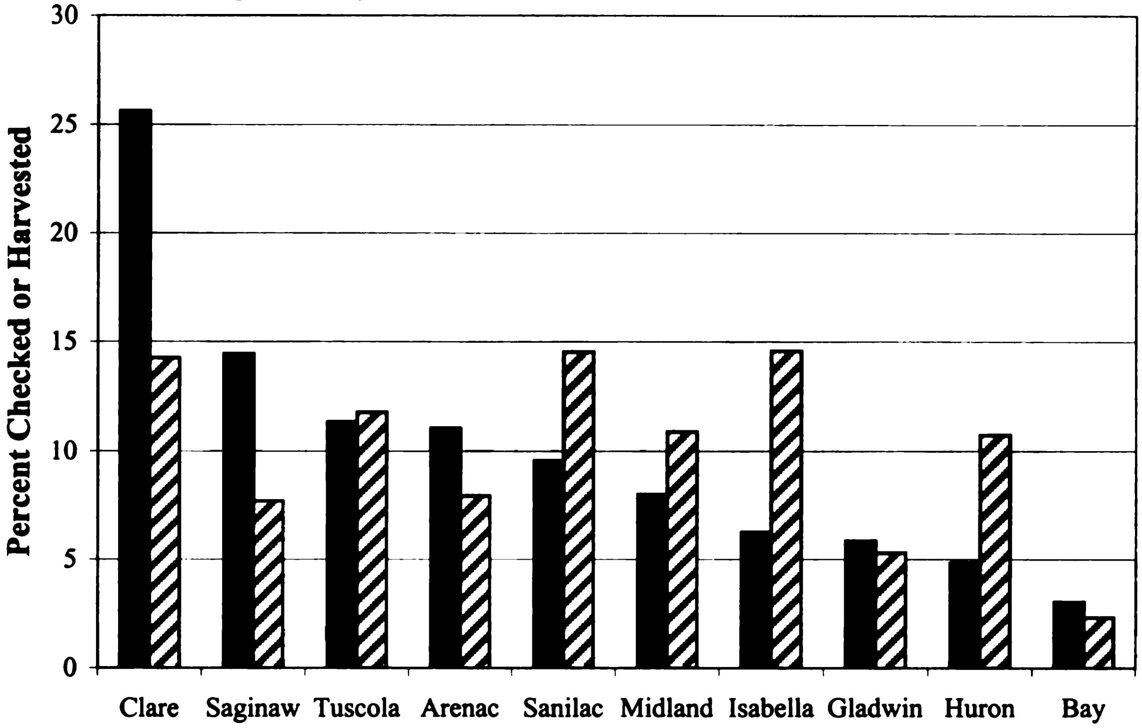
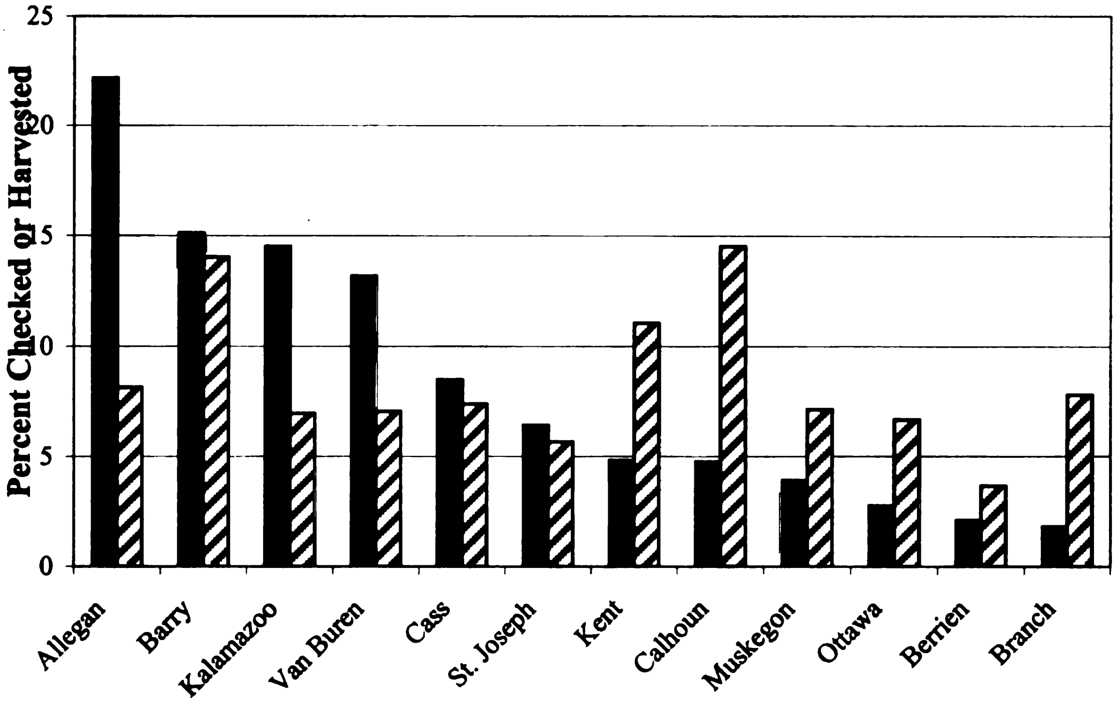


Figure 13 (cont'd).

(e) Saginaw Bay



(f) Southwestern LP



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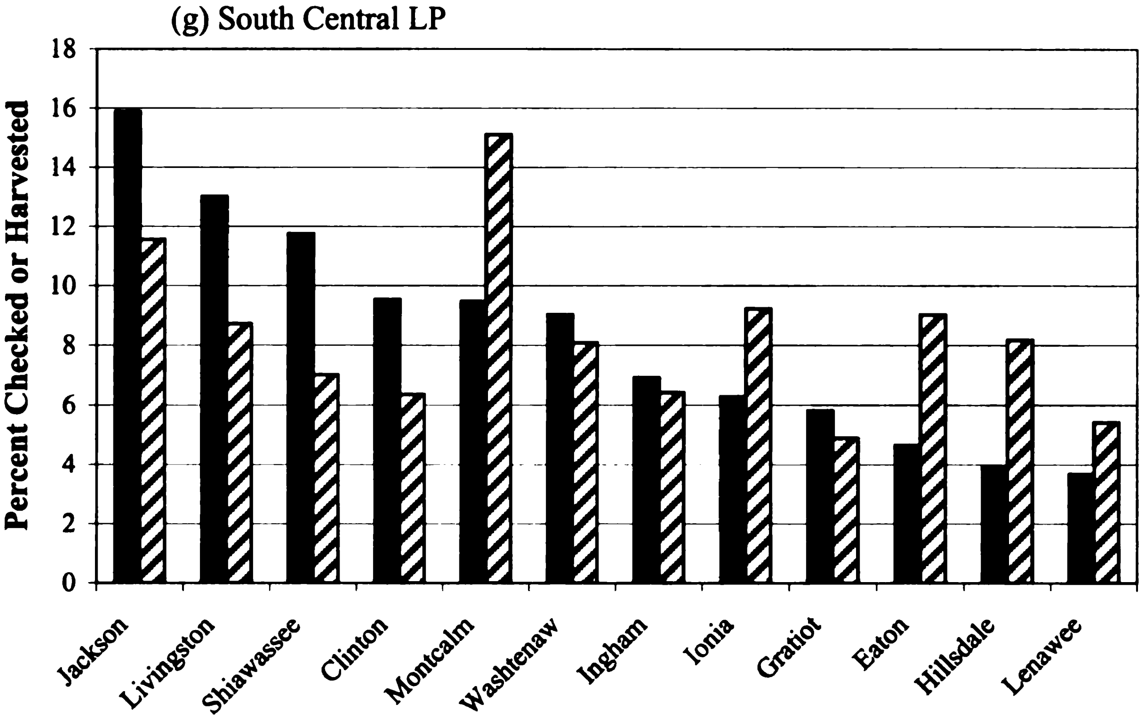


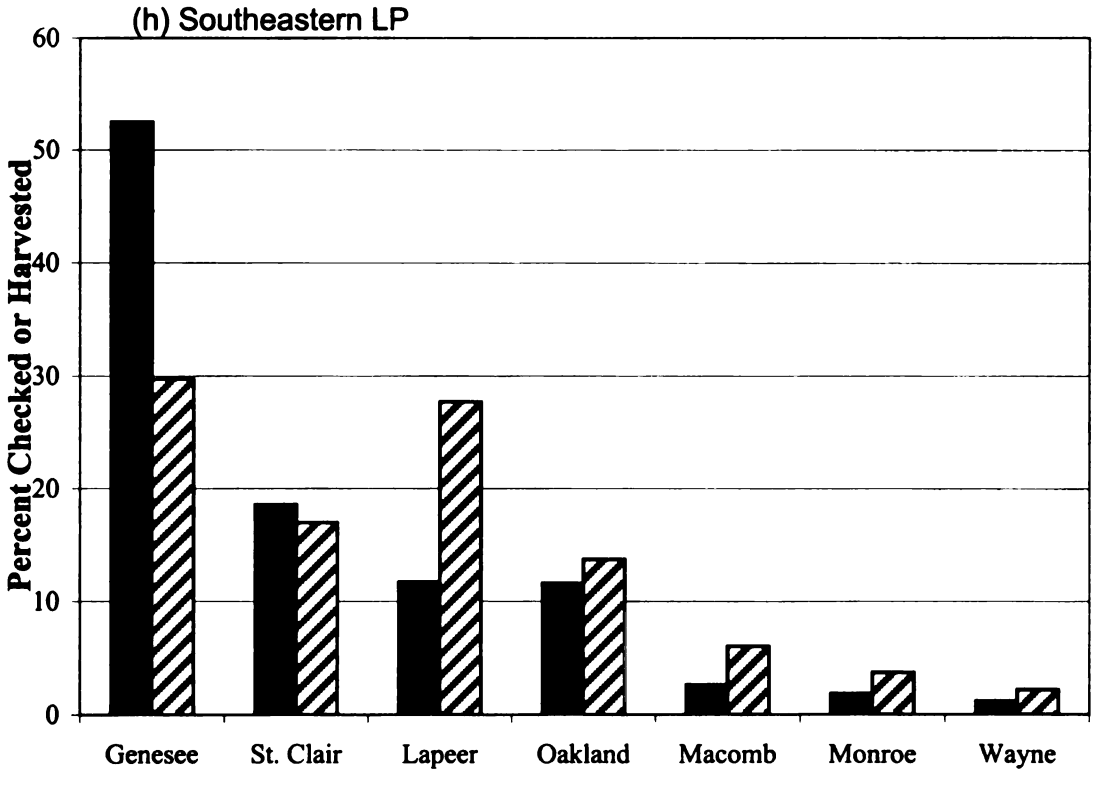


Figure 13 (cont'd).

Areas with low check-station density are under-represented in the biodata (i.e. Sanilac, Isabella, and Huron counties).

In the Southwestern LP, Allegan and Van Buren counties both had two check stations (Figure 2) and were over-represented in the biodata (Figure 13f), while Kalamazoo had no check stations and yet was also over-represented. The border counties of the Southwestern management unit (Branch, Calhoun, and Kent) lacked sufficient check stations and so tended to be under-represented in the biodata. The South Central management unit had the same problem with the western border counties (Hillsdale, Eaton, Ionia, Montcalm) (Figure 13g). The distribution of the biodata and harvest data in the Southeastern LP (Figure 13h) did not appear to be related to the distribution of check stations; Genesee county had no check stations and yet was over-represented in the biodata, while Lapeer did have a check station and was under-represented.

Generally, the management units provide the most practical and statistically valid division for combining and averaging the biodata. Ideally the distribution of the data within each management unit should reflect the harvest distribution as closely as possible. The over- and under- representation of particular counties within the biodata is usually due to the distribution of check stations. Opening new check stations in areas that are under-represented (such as many counties in the Southern LP) could balance the distribution of the biodata throughout the management units.

Question 5: Does the seasonal distribution bias the biodata?

Significance

The majority of the biodata are collected from deer harvested during the firearm season, both because the majority of the deer are harvested during the firearm season and because the highway check stations are only open during the firearm season. If the data harvested during the firearm season do not represent the same population as the deer harvested during the other seasons, especially the archery season, then the biodata could be biased in favor of the population harvested during the firearm season.

Methods

Although the majority of the biodata come from deer harvested during the firearm season, the second largest source of data is the archery season. I therefore compared the composition of the firearm season and archery season to explore any differences between the two seasons in the age structure of the antlered and antlerless harvest separately and the harvest composition (antlered vs. antlerless). All comparisons were made using Pearson's chi-squared test for each region and year separately. I also compared the biodata ratio of antlerless to antlered deer in the archery season, firearm season, and all seasons combined to the corresponding harvest ratio of the same seasons.

Results and Discussion

Generally, over 80% of the biodata were collected from deer harvested during the firearm season, although usually no more than 70% of the harvest came from the firearm season (Figure 14). The difference in the percent of data from the firearm season and the percent of deer harvested during the firearm season is probably due to the highway check stations. The highway check stations provide a convenient location for many hunters to check their deer. Over 15% of the firearm biodata have been collected at highway check stations over the past thirteen years (Figure 15). The majority of the non-firearm season biodata are collected from deer harvested during the archery season.

In most cases, the composition of the firearm harvest was significantly different from the composition of the archery harvest. For the past decade, the antlered to antlerless ratio of the archery season has differed significantly from that of the firearm season every year (Table 6). The firearm season generally had a higher proportion of antlered deer than the archery season, except for a few year in the Southern LP. The age structure of the buck harvest was significantly different between the two seasons in all cases except recently in the UP (Table 7). Generally, the archery harvest consisted of a higher proportion of yearlings than the firearm harvest. The two seasons differed less in the composition of the antlerless harvest. Although the Northern LP always presented significant differences in the antlerless harvest (except in 1999), the significance of the differences in the UP and the Southern LP tended to fluctuate (Table 8). Mattson Hansen (1998) reported similar results in her comparison of Michigan's archery and firearm data using smaller geographical units. As Mattson Hansen (1998) reported, the causes of these differences are unknown but could be related to biological factors, equipment biases, or hunter selection biases that differ between archery and firearm season.

The significant differences in the composition between the archery and the firearm season indicate that when the data of the two seasons are combined in a single

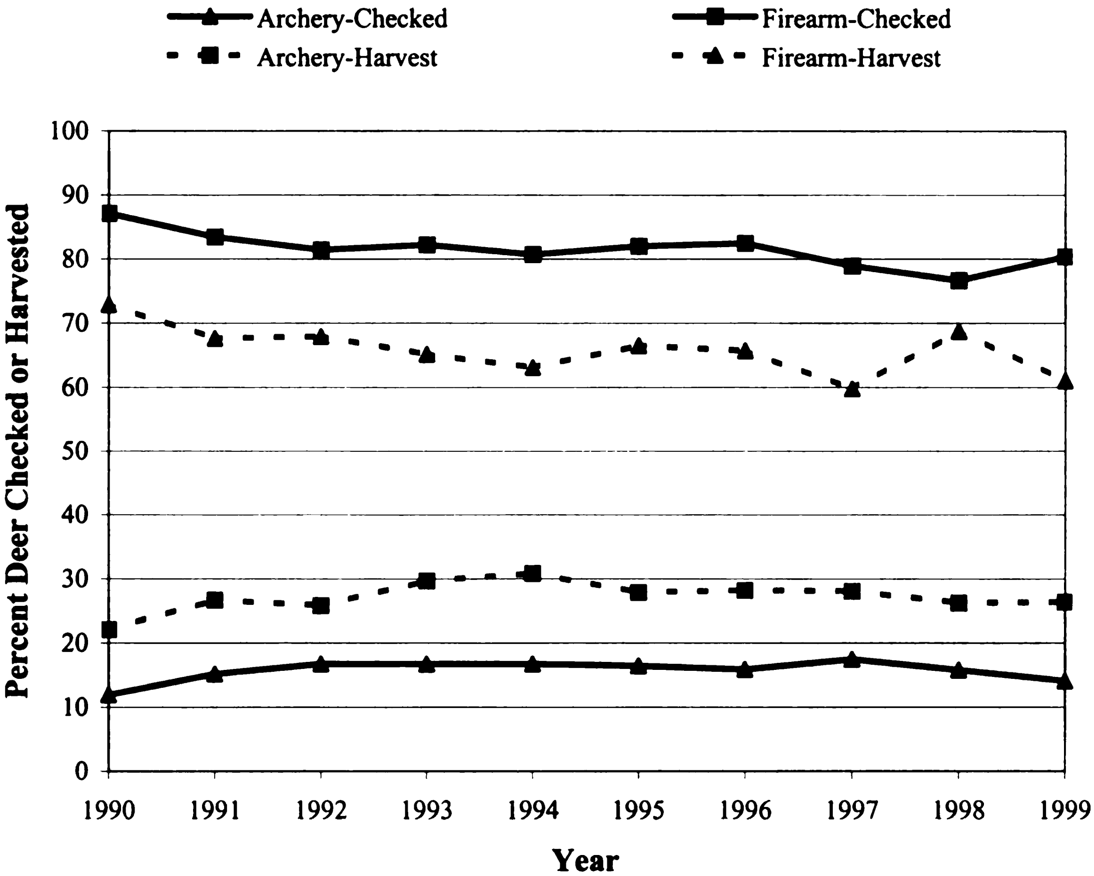


Figure 14. Percent of deer checked during firearm and archery season and percent of deer harvested during archery and firearm season in Michigan.

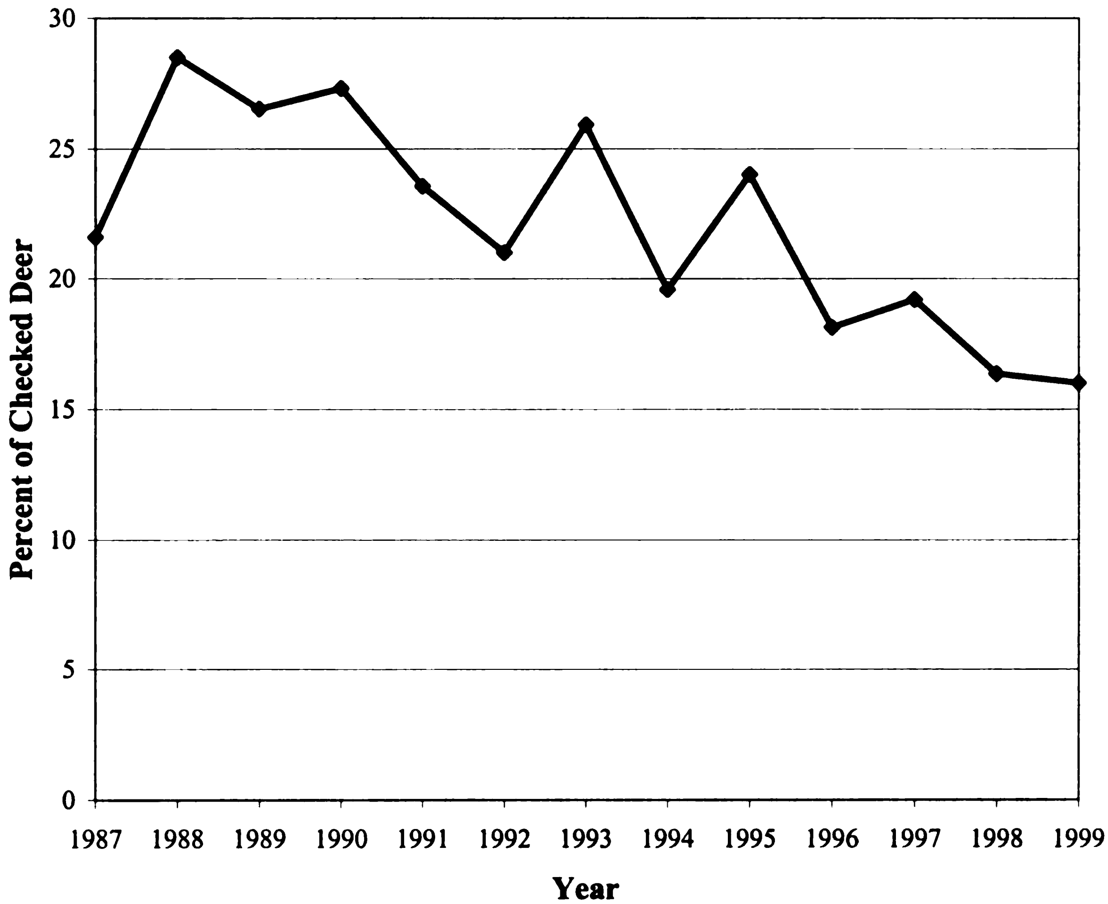


Figure 15. Percent of the checked deer harvested during firearm season that are checked at highway check stations: Alma, Big Rapids, Birch Run, and the Mackinac Bridge (added in 1999).

Table 6. The number (and proportion) of deer of each harvest-type category checked from each region and season. The chi-squared tests compared the composition of the firearm and archery seasons in the biodata. All tests have 1 degree of freedom.

		Firearm		Archery			
Year	**Region**	**Antlered**	**Antlerless**	**Antlered**	**Antlerless**	χ^2	**p-value**
1987	**UP**	3900 (0.6)	2566 (0.40)	137 (0.49)	141 (0.51)	13.508	<0.001
	NLP	8325 (0.70)	3605 (0.30)	731 (0.43)	979 (0.57)	489.864	<0.001
	SLP	3165 (0.63)	1849 (0.37)	554 (0.61)	350 (0.39)	1.111	0.292
1988	**UP**	4344 (0.83)	904 (0.17)	143 (0.51)	137 (0.49)	174.788	<0.001
	NLP	8739 (0.64)	4983 (0.36)	727 (0.44)	933 (0.56)	247.543	<0.001
	SLP	3484 (0.58)	2475 (0.42)	616 (0.63)	362 (0.37)	7.099	0.008
1989	**UP**	4430 (0.78)	1217 (0.22)	200 (0.52)	183 (0.48)	138.421	<0.001
	NLP	7053 (0.60)	4656 (0.40)	753 (0.41)	1076 (0.59)	235.536	<0.001
	SLP	3810 (0.56)	2958 (0.44)	743 (0.59)	519 (0.41)	2.885	0.089
1990	**UP**	4175 (0.79)	1141 (0.21)	182 (0.51)	176 (0.49)	144.377	<0.001
	NLP	8358 (0.61)	5327 (0.39)	871 (0.47)	993 (0.53)	139.967	<0.001
	SLP	3215 (0.57)	2449 (0.43)	748 (0.64)	426 (0.36)	19.286	<0.001
1991	**UP**	4339 (0.78)	1232 (0.22)	194 (0.39)	304 (0.61)	366.491	<0.001
	NLP	7658 (0.71)	3183 (0.29)	836 (0.37)	1394 (0.63)	893.241	<0.001
	SLP	3288 (0.60)	2237 (0.40)	727 (0.55)	593 (0.45)	9.644	0.003
1992	**UP**	3962 (0.74)	1396 (0.26)	197 (0.44)	248 (0.56)	178.209	<0.001
	NLP	5353 (0.67)	2622 (0.33)	719 (0.39)	1122 (0.61)	499.408	<0.001
	SLP	2907 (0.62)	1782 (0.38)	830 (0.57)	623 (0.43)	11.056	0.001
1993	**UP**	4424 (0.90)	514 (0.10)	239 (0.42)	331 (0.58)	893.77	<0.001
	NLP	5567 (0.78)	1542 (0.22)	616 (0.44)	783 (0.56)	691.601	<0.001
	SLP	2922 (0.63)	1691 (0.37)	863 (0.59)	595 (0.41)	8.136	0.004
1994	**UP**	6967 (0.87)	1052 (0.13)	427 (0.41)	620 (0.59)	1308.37	<0.001
	NLP	9180 (0.92)	812 (0.08)	1076 (0.49)	1137 (0.51)	2525.739	<0.001
	SLP	4856 (0.67)	2435 (0.33)	1276 (0.62)	794 (0.38)	17.555	<0.001
1995	**UP**	5297 (0.65)	2807 (0.35)	426 (0.47)	482 (0.53)	119.88	<0.001
	NLP	8479 (0.80)	2101 (0.20)	1111 (0.49)	1136 (0.51)	925.71	<0.001
	SLP	4641 (0.64)	2587 (0.36)	1232 (0.58)	876 (0.42)	23.242	<0.001
1996	**UP**	3325 (0.69)	1471 (0.31)	227 (0.44)	294 (0.56)	140.608	<0.001
	NLP	7514 (0.65)	4100 (0.35)	915 (0.48)	975 (0.52)	183.77	<0.001
	SLP	4174 (0.55)	3355 (0.45)	1407 (0.62)	848 (0.38)	34.262	<0.001
1997	**UP**	2545 (0.79)	664 (0.21)	146 (0.39)	224 (0.61)	282.381	<0.001
	NLP	7419 (0.66)	3881 (0.34)	941 (0.44)	1206 (0.56)	365.449	<0.001
	SLP	3742 (0.47)	4222 (0.53)	1307 (0.56)	1039 (0.44)	55.21	<0.001
1998	**UP**	3319 (0.88)	441 (0.12)	222 (0.44)	284 (0.56)	623.186	<0.001
	NLP	7816 (0.48)	8490 (0.52)	1154 (0.43)	1554 (0.57)	26.363	<0.001
	SLP	3964 (0.49)	4143 (0.51)	1306 (0.59)	902 (0.41)	72.999	<0.001
1999	**UP**	5287 (0.77)	1577 (0.23)	412 (0.50)	419 (0.50)	290.665	<0.001
	NLP	9825 (0.51)	9516 (0.49)	1217 (0.49)	1287 (0.51)	4.279	0.039
	SLP	3845 (0.48)	4133 (0.52)	1510 (0.62)	938 (0.38)	136.415	<0.001

Table 7. The number (and proportion) of antlered deer of each age category checked from each region and season. The chi-squared tests compared the antlered deer age composition of the firearm and archery seasons in the biodata. All tests have 1 degree of freedom.

		Firearm		Archery			
Year	**Region**	**1.5**	**2.5+**	**1.5**	**2.5+**	χ^2	**p-value**
1987	**UP**	2110 (0.58)	1542 (0.42)	100 (0.76)	32 (0.24)	16.955	<0.001
	NLP	5797 (0.72)	2290 (0.28)	521 (0.76)	164 (0.24)	6.000	0.014
	SLP	2111 (0.69)	964 (0.31)	405 (0.78)	111 (0.22)	20.389	<0.001
1988	**UP**	2252 (0.52)	1882 (0.48)	97 (0.70)	41 (0.30)	13.494	<0.001
	NLP	5791 (0.68)	2679 (0.32)	512 (0.77)	149 (0.23)	23.685	<0.001
	SLP	2396 (0.71)	998 (0.29)	464 (0.80)	117 (0.20)	21.109	<0.001
1989	**UP**	1630 (0.43)	2137 (0.57)	116 (0.63)	69 (0.37)	27.001	<0.001
	NLP	3404 (0.39)	2152 (0.61)	506 (0.78)	140 (0.22)	72.302	<0.001
	SLP	2472 (0.69)	1122 (0.31)	544 (0.78)	154 (0.22)	23.453	<0.001
1990	**UP**	1714 (0.43)	2291 (0.57)	113 (0.65)	61 (0.35)	33.238	<0.001
	NLP	5159 (0.64)	2933 (0.36)	584 (0.74)	206 (0.26)	32.575	<0.001
	SLP	2109 (0.68)	1011 (0.32)	550 (0.78)	154 (0.22)	30.058	<0.001
1991	**UP**	1899 (0.47)	2165 (0.53)	103 (0.57)	79 (0.43)	6.805	0.009
	NLP	4882 (0.66)	2517 (0.34)	598 (0.78)	173 (0.22)	42.395	<0.001
	SLP	2095 (0.66)	1074 (0.34)	510 (0.75)	171 (0.25)	19.752	<0.001
1992	**UP**	1389 (0.38)	2249 (0.62)	118 (0.63)	70 (0.37)	45.260	<0.001
	NLP	3308 (0.65)	1799 (0.35)	499 (0.77)	147 (0.33)	39.843	<0.001
	SLP	1859 (0.66)	959 (0.34)	592 (0.77)	181 (0.33)	31.551	<0.001
1993	**UP**	1765 (0.42)	2435 (0.58)	132 (0.59)	91 (0.41)	25.484	<0.001
	NLP	3206 (0.59)	2201 (0.41)	396 (0.73)	149 (0.27)	37.023	<0.001
	SLP	1758 (0.62)	1059 (0.38)	575 (0.72)	220 (0.28)	26.678	<0.001
1994	**UP**	3798 (0.57)	2832 (0.43)	286 (0.71)	119 (0.29)	27.860	<0.001
	NLP	5739 (0.66)	3003 (0.34)	718 (0.74)	253 (0.26)	26.989	<0.001
	SLP	3003 (0.65)	1592 (0.35)	873 (0.76)	275 (0.24)	47.855	<0.001
1995	**UP**	2600 (0.53)	2276 (0.47)	272 (0.72)	106 (0.28)	49.158	<0.001
	NLP	5888 (0.73)	2185 (0.27)	807 (0.82)	172 (0.18)	40.887	<0.001
	SLP	2913 (0.67)	1410 (0.33)	825 (0.76)	267 (0.24)	27.191	<0.001
1996	**UP**	897 (0.29)	2168 (0.71)	92 (0.46)	109 (0.54)	24.340	<0.001
	NLP	4599 (0.63)	2667 (0.37)	639 (0.76)	206 (0.24)	50.281	<0.001
	SLP	2827 (0.70)	1190 (0.30)	1004 (0.78)	288 (0.22)	26.168	<0.001
1997	**UP**	678 (0.28)	1760 (0.72)	42 (0.35)	77 (0.65)	3.142	0.076
	NLP	4562 (0.64)	2594 (0.36)	622 (0.74)	216 (0.26)	36.100	<0.001
	SLP	2435 (0.67)	1200 (0.33)	887 (0.75)	300 (0.25)	25.004	<0.001
1998	**UP**	1991 (0.62)	1230 (0.38)	127 (0.62)	79 (0.38)	0.002	0.963
	NLP	5001 (0.66)	2592 (0.34)	773 (0.74)	270 (0.26)	28.168	<0.001
	SLP	2542 (0.66)	1290 (0.34)	929 (0.77)	281 (0.23)	46.735	<0.001
1999	**UP**	3007 (0.58)	2178 (0.42)	225 (0.60)	147 (0.40)	0.884	0.347
	NLP	5905 (0.62)	3608 (0.38)	818 (0.73)	309 (0.27)	47.841	<0.001
	SLP	2540 (0.69)	1163 (0.31)	1101 (0.79)	295 (0.21)	52.423	<0.001

Table 8. The number (and proportion) of antlerless deer of each age category checked from each region and season. The chi-squared tests compared the antlerless composition of the firearm and archery seasons in the biodata. All tests have 2 degrees of freedom.

		Firearm			Archery				
Year	**Reg.**	**0.5**	**1.5**	**2.5+**	**0.5**	**1.5**	**2.5+**	χ^2	**p-value**
1987	**UP**	1086 (0.43)	368 (0.15)	1051 (0.42)	43 (0.33)	21 (0.16)	67 (0.51)	5.852	0.054
	NLP	1330 (0.38)	737 (0.21)	1461 (0.41)	420 (0.45)	206 (0.22)	313 (0.33)	21.928	<0.001
	SLP	801 (0.44)	443 (0.24)	576 (0.32)	156 (0.46)	90 (0.27)	91 (0.27)	2.961	0.227
1988	**UP**	284 (0.34)	168 (0.20)	387 (0.46)	33 (0.26)	34 (0.27)	59 (0.47)	4.503	0.105
	NLP	1779 (0.37)	1095 (0.23)	1970 (0.41)	351 (0.40)	258 (0.29)	269 (0.31)	35.673	<0.001
	SLP	1049 (0.43)	631 (0.26)	763 (0.31)	174 (0.50)	82 (0.23)	94 (0.27)	5.81	0.055
1989	**UP**	392 (0.41)	144 (0.15)	431 (0.45)	45 (0.26)	46 (0.27)	79 (0.46)	20.369	<0.001
	NLP	1639 (0.42)	707 (0.18)	1546 (0.40)	431 (0.44)	223 (0.23)	318 (0.33)	20.154	<0.001
	SLP	1217 (0.43)	732 (0.26)	895 (0.31)	250 (0.50)	114 (0.23)	135 (0.27)	9.257	0.010
1990	**UP**	344 (0.32)	235 (0.22)	484 (0.46)	50 (0.29)	43 (0.25)	78 (0.46)	1.054	0.590
	NLP	1915 (0.37)	1095 (0.21)	2199 (0.42)	422 (0.46)	232 (0.25)	271 (0.29)	54.717	<0.001
	SLP	987 (0.41)	604 (0.25)	795 (0.33)	199 (0.48)	105 (0.25)	108 (0.26)	9.487	0.009
1991	**UP**	405 (0.36)	175 (0.16)	543 (0.48)	93 (0.33)	59 (0.21)	130 (0.46)	4.702	0.095
	NLP	1245 (0.40)	553 (0.18)	1303 (0.42)	618 (0.47)	288 (0.22)	422 (0.32)	41.333	<0.001
	SLP	941 (0.43)	481 (0.22)	775 (0.35)	245 (0.44)	141 (0.25)	171 (0.31)	5.147	0.076
1992	**UP**	425 (0.34)	238 (0.19)	584 (0.47)	64 (0.29)	62 (0.28)	94 (0.43)	9.645	0.008
	NLP	930 (0.37)	548 (0.22)	1032 (0.41)	406 (0.39)	264 (0.25)	375 (0.36)	9.537	0.008
	SLP	765 (0.44)	428 (0.24)	555 (0.32)	288 (0.49)	137 (0.23)	168 (0.28)	4.298	0.117
1993	**UP**	208 (0.42)	93 (0.19)	194 (0.39)	91 (0.32)	69 (0.24)	127 (0.44)	8.607	0.014
	NLP	568 (0.38)	295 (0.20)	637 (0.42)	352 (0.48)	161 (0.22)	216 (0.30)	35.43	<0.001
	SLP	707 (0.43)	396 (0.24)	558 (0.34)	235 (0.42)	154 (0.27)	173 (0.31)	3.217	0.200
1994	**UP**	389 (0.38)	212 (0.21)	415 (0.41)	194 (0.33)	131 (0.22)	264 (0.45)	4.661	0.097
	NLP	296 (0.38)	155 (0.20)	333 (0.42)	447 (0.42)	242 (0.23)	385 (0.36)	8.462	0.015
	SLP	988 (0.42)	564 (0.24)	814 (0.34)	345 (0.46)	185 (0.25)	216 (0.29)	7.974	0.019
1995	**UP**	940 (0.37)	503 (0.20)	1079 (0.43)	104 (0.24)	135 (0.31)	195 (0.45)	40.339	<0.001
	NLP	627 (0.31)	487 (0.24)	881 (0.44)	410 (0.39)	296 (0.28)	347 (0.33)	36.576	<0.001
	SLP	956 (0.38)	606 (0.24)	928 (0.37)	364 (0.44)	213 (0.26)	257 (0.31)	12.004	0.002
1996	**UP**	390 (0.29)	255 (0.19)	714 (0.53)	66 (0.24)	55 (0.20)	156 (0.56)	2.721	0.256
	NLP	1119 (0.28)	871 (0.22)	1965 (0.50)	293 (0.33)	255 (0.28)	351 (0.39)	34.735	<0.001
	SLP	1341 (0.41)	729 (0.22)	1226 (0.37)	339 (0.42)	186 (0.23)	278 (0.35)	1.854	0.396
1997	**UP**	237 (0.37)	112 (0.18)	285 (0.45)	46 (0.24)	32 (0.16)	117 (0.60)	15.408	<0.001
	NLP	1132 (0.30)	721 (0.19)	1918 (0.51)	327 (0.29)	257 (0.23)	537 (0.48)	7.978	0.019
	SLP	1613 (0.39)	969 (0.23)	1580 (0.38)	336 (0.34)	262 (0.26)	397 (0.40)	9.198	0.010
1998	**UP**	151 (0.35)	89 (0.21)	188 (0.44)	68 (0.25)	69 (0.25)	138 (0.50)	8.774	0.012
	NLP	2668 (0.32)	1635 (0.20)	3914 (0.48)	447 (0.31)	360 (0.25)	639 (0.44)	18.896	<0.001
	SLP	1635 (0.41)	898 (0.22)	1480 (0.37)	355 (0.41)	201 (0.23)	305 (0.35)	0.746	0.689
1999	**UP**	423 (0.28)	278 (0.18)	808 (0.54)	79 (0.20)	99 (0.25)	217 (0.55)	14.744	0.001
	NLP	2671 (0.29)	1967 (0.21)	4578 (0.50)	348 (0.29)	274 (0.22)	597 (0.49)	0.821	0.663
	SLP	1613 (0.40)	897 (0.22)	1519 (0.38)	330 (0.37)	238 (0.27)	325 (0.36)	8.195	0.017

analysis, the results of the analysis will be heavily biased by the effect of the firearm season data. For example, Mattson Hansen (1998) found that SAK model estimates differ when the firearm and archery seasons' data are combined or when the firearm season's data are considered separately. I found that the firearm and archery data considered separately provide a more accurate view of the true harvest of their respective seasons, than the combined data provide of the entire harvest (Figure 16). The antlerless to antlered ratios from the firearm and archery seasons' biodata generally match more closely to the same ratio calculated using the harvest data than does the combined season data (Figure 16). The biodata do appear to be biased in favor of the firearm data. The composition of the biodata is not equal to that of the true harvest, and combining the data of both the archery and firearm seasons may provide a less accurate picture of the true harvest than considering them separately.

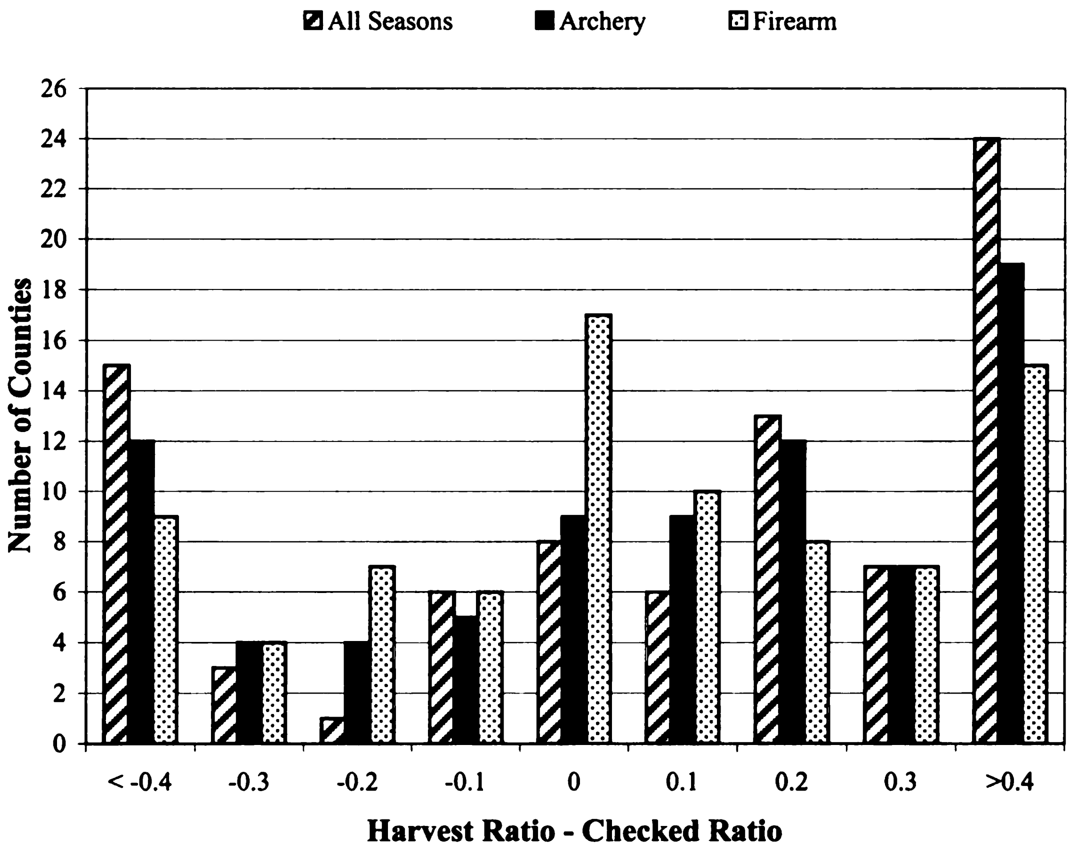


Figure 16. Histogram of the number of counties in the archery season, firearm season, and all seasons combined whose difference between the harvest estimates and biodata estimates of the antlerless to antlered ratio falls within the listed catgories in 1999.

Question 6: Does the composition of checked deer differ between private and public lands?

Significance

Many hunters believe that the public land deer harvest has a different age and sex composition from that of the private land harvest. The tendencies of hunters to check their deer are also thought to differ between those hunting on private and public land (H. Hill, MDNR, personal communication). If the composition of the harvest differed between public and private lands, and the checking tendencies differed between public and private land hunters, then the biodata could be biased. Since 1998, therefore, the MDNR has collected information on whether checked deer were taken on private or public land (data collected since 1997 in the harvest data) so it is now possible to identify differences in the checking tendencies and composition between private land and public land harvests.

Methods

Although Michigan has separate quotas for public and private land harvests, the MDNR has collected data on the private or public land harvest classification only since 1998 in the biodata and since 1997 in the harvest data. The 1997 and 1998 harvest data were not available, so I restricted the evaluation to the 1999 data. I compared the private land harvest composition to the public land harvest composition as reported in the biodata, and I compared the harvests reported in the mail survey and biodata on public and private lands. All comparisons were made using Pearson's chi-squared tests. One potential error in the data is the identification of Commercial Forest Reserve (CFR) lands as public lands. These private lands get a tax exemption if they are open to hunting, and many hunters may report CFR lands to be public lands since they are usually open to hunting (W. Moritz, MDNR, personal communication). The errors should be consistent between the biodata and the harvest data, however, and should have little effect on the relative relationships between the two datasets.

Results and Discussion

Statewide, approximately 17% of the deer harvest was taken on public lands in 1999 according to the mail survey. The distribution of the harvest across private and public lands varied among the regions as the availability of public lands varies. More than one third of the UP's harvest came from public lands (Table 9) where public land is abundant (Figure 17). In the Southern LP, however, there is very little public land (Figure 17) and less than 10% of the harvest came from public lands (Table 9). The percent of deer checked from public lands greatly exceeded the percent of deer harvested from public lands in both regions of the LP, implying that hunters were more likely to check their deer taken from public lands than from private lands in these regions (Table 9). Hunters hunting on public land have to leave their property and are more likely to pass a check station while transporting their deer than hunters hunting on private land. Check stations also tend to be located on public land hunting areas, which could increase the tendency of public land hunters to check their deer. In the UP, however, the percent of deer checked from public lands was only slightly higher than the percent of deer harvested from public lands (Table 9). In all regions, more deer were checked and

Table 9. The number (and percent) of deer harvested and checked from private and public lands in 1999.

Region	Public		Private	
	Harvested	Checked	Harvested	Checked
Upper Peninsula	23657 (31.7)	2577 (32.9)	51001 (68.3)	5247 (67.1)
Northern Lower Peninsula	46314 (23.5)	7111 (30.9)	150626 (76.5)	15873 (69.1)
Southern Lower Peninsula	23394 (8.8)	1524 (13.6)	242579 (91.2)	9705 (86.4)

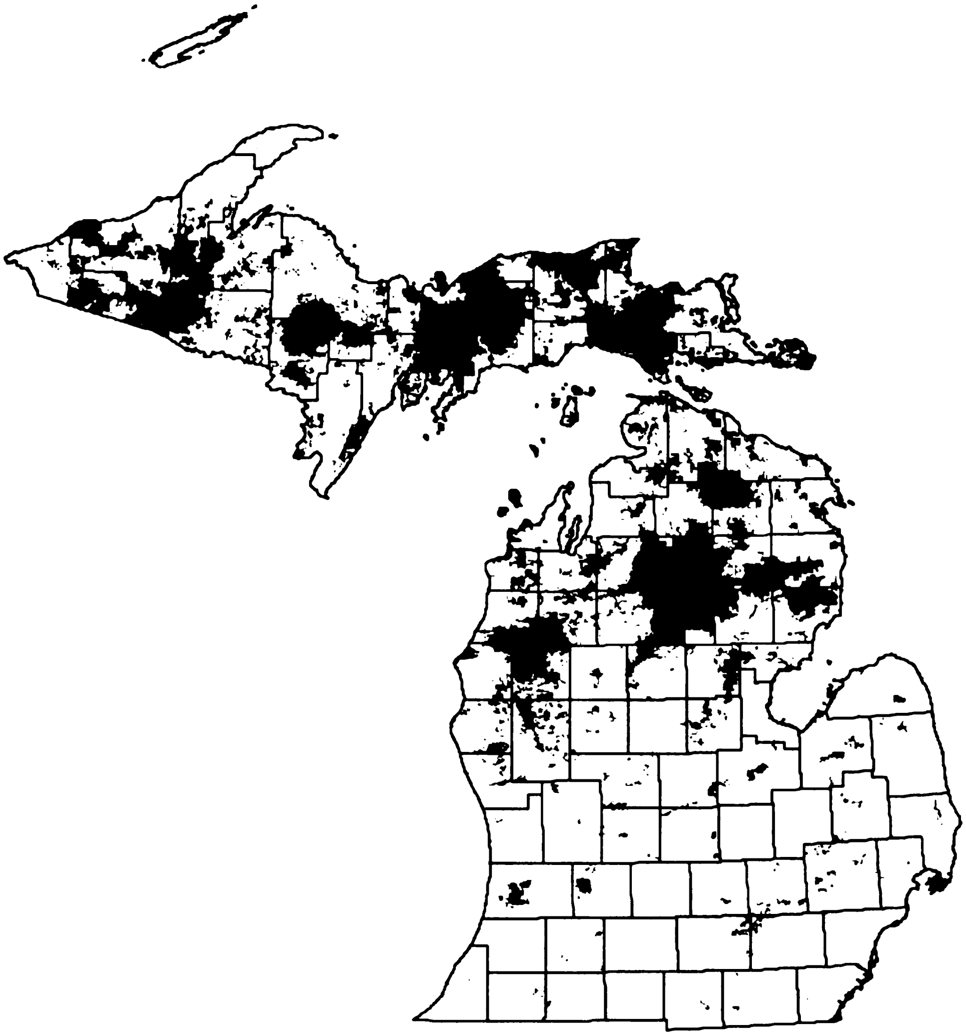


Figure 17. Distribution of public lands (shaded areas) in Michigan.

harvested from private lands than from public lands. On both public (Table 10) and private (Table 11) lands, the harvest composition differed significantly between the mail survey results and the biodata results. The biodata, therefore, do not represent the true harvest composition on either private or public land.

The biodata also suggest there are significant differences in the age composition of the deer harvested on private and public land. The age composition of the antlered and antlerless deer differed significantly between private and public land in all regions except the antlerless harvest in the Southern LP (Table 12). The harvest composition also differed significantly between private and public lands in all regions except the Southern LP (Table 13). These differences between the private and public lands indicate that, because the majority of deer are harvested and checked from private lands, the biodata reflect the condition of the deer harvested on private lands, which is different from that of the deer harvested on public lands. The situation may not be as serious as these results imply. In much of the state, hunters are more likely to check deer from public lands than private lands. The motivation for checking deer may be different for private and public land hunters. Private land hunters may check their deer to get accurate sex, age, and beam measurements so they can keep track of the deer herd on their lands. Public land hunters may check their deer to cooperate with the MDNR. Different motivations may skew the picture of the herd composition the biodata provides. The biodata do not represent the true harvest, so the differences seen between the composition of the deer checked from private and public lands may only be an artifact of checking habits and not a reflection of true differences in the harvest.

Table 10. The 1999 numbers (and proportions) of antlered and antlerless deer harvested on public land according to the mail survey and the number (and proportion) checked from public land in the biodata. The chi-squared tests compare the public land harvest composition as reported in the mail survey to that reported in the biodata.

Region	Harvest	Mail	Biodata	χ^2	d.f.	p-value
Upper Peninsula	Antlered	19006 (0.80)	2154 (0.86)	49.149	1	<0.001
	Antlerless	4632 (0.20)	345 (0.14)			
Northern LP	Antlered	26720 (0.58)	3538 (0.53)	59.019	1	<0.001
	Antlerless	19606 (0.42)	3174 (0.47)			
Southern LP	Antlered	10366 (0.44)	724 (0.50)	19.039	1	<0.001
	Antlerless	13056 (0.56)	720 (0.50)			

Table 11. The 1999 numbers (and proportions) of antlered and antlerless deer harvested on private land according to the mail survey and the number (and (proportion) checked from private land in the biodata. The chi-squared tests compare the private land harvest composition as reported in the mail survey to that reported in the biodata.

Region	Harvest	Mail	Biodata	χ^2	d.f.	p-value
Upper	Antlered	30310 (0.59)	3448 (0.67)	117.62	1	<0.001
Peninsula	Antlerless	20676 (0.41)	1681 (0.33)			
Northern	Antlered	70946 (0.47)	7410 (0.49)	22.422	1	<0.001
LP	Antlerless	79684 (0.53)	7676 (0.51)			
Southern	Antlered	108536 (0.45)	4652 (0.51)	125.25	1	<0.001
LP	Antlerless	134055 (0.55)	4531 (0.49)			

Table 12. The 1999 numbers (and proportions) of antlered and antlerless deer of each age category checked from private and public land. The chi-squared tests compare the public land composition to that of private land.

Region	Harvest Type	Private 0.5	Private 1.5	Private 2.5+	Public 0.5	Public 1.5	Public 2.5+	χ^2	d.f.	p-value
Upper	Antlered		1906 (0.93)	143 (0.0.7)		1268 (0.94)	84 (0.06)	4.317	1	0.038
Peninsula	Antlerless	414 (0.52)	298 (0.37)	88 (0.11)	90 (0.47)	85 (0.45)	15 0.08)	9.963	2	0.007
Northern	Antlered		4576 (0.95)	256 (0.05)		2086 (0.94)	132 (0.06)	8.074	1	0.004
LP	Antlerless	2066 (0.51)	1573 (0.39)	374 (0.09)	930 (0.53)	662 (0.38)	149 (0.09)	6.101	2	0.047
Southern	Antlered		3121 (0.96)	130 (0.04)		525 (0.97)	17 (0.03)	7.26	1	0.007
LP	Antlerless	1721 (0.60)	996 (0.35)	166 (0.06)	290 (0.62)	157 (0.33)	24 (0.05)	2.065	2	0.356

Table 13. The 1999 numbers (and proportions) of antlered and antlerless deer checked from private and public lands. The chi-squared tests compare the private land harvest composition to that of public lands.

Region	Harvest	Private	Public	χ^2	d.f.	p-value
Upper Peninsula	Antlered	3448 (0.67)	2154 (0.86)	309.964	1	<0.001
	Antlerless	1681 (0.33)	345 (0.14)			
Northern LP	Antlered	7410 (0.49)	3538 (0.53)	23.99	1	<0.001
	Antlerless	7676 (0.51)	3174 (0.47)			
Southern LP	Antlered	4652 (0.51)	724 (0.50)	0.135	1	0.713
	Antlerless	4531 (0.49)	720 (0.50)			

Question 7: Does the composition of checked deer differ between highway and field check stations?

Significance

Most of Michigan's check stations are field stations located at MDNR field offices, and state parks, game areas, and recreation areas. Traditionally, however, the MDNR has maintained three highway check stations at Birch Run, Alma, and Big Rapids. In 1999, a fourth highway check station was added at the Mackinac Bridge. These four check stations are located along major southbound arteries in Michigan (Figure 2) and are meant to be a convenient place for hunters who hunt in the UP or Northern LP to stop and check their deer on their way home to southern Michigan. Unlike the field stations, the highway check stations are only open during several days of the firearm season, but they check thousands of deer every year. The Alma highway check station will close after the 2000 hunting season due to the Michigan Department of Transportation's closing of the rest area and the off-ramp (H. Hill, MDNR, personal communication). The significance of the highway check stations to the collection of the firearm biodata and the impending loss of the Alma check station suggested I should examine any differences between the biodata collected at the highway check stations and the data collected at the field check stations.

Methods

Although not every check station has an individual code in the 'station' variable of the SPSS biodata file, each highway check station does have its own designation

(Appendix 2). I was therefore able to determine whether each record in the biodata was collected at a highway station or a field station. The highway check stations are open only during the firearm season, so in comparing the field data to the highway data I chose to compare only firearm season data. All other seasons were eliminated from the analyses. I then divided the data among the three regions and compared the composition of the biodata collected at the field stations to the data collected at the highway stations among the three regions since 1987. All comparisons were made using Pearson's chi-square test.

Results and Discussion

The data collected at the highway check stations has made up from 16.0% to 28.5% of firearm season biodata and from 13.8% to 25.8% of all biodata collected over the past 13 years (Figure 18). The decrease in the percent of deer checked at the highway check stations over the past several years may reflect the recent increase in the number of field stations. The highway check stations collect data primarily from deer harvested in the UP (Mackinac Bridge station), the Northeastern LP (Birch Run station), and the Northwestern LP (Alma station and Big Rapids station) (Figure 19). Although some people may live and hunt in the counties immediately surrounding each station and simply come to the highway station because it is nearby, many people appear to be checking their deer at the highway stations as they travel home from their hunting grounds. As a consequence, more of the data are collected from public lands at highway stations than at field stations (Table 14). Many hunters from southern Michigan, where there is little public land available for hunting, travel to the Northern LP or the UP to hunt

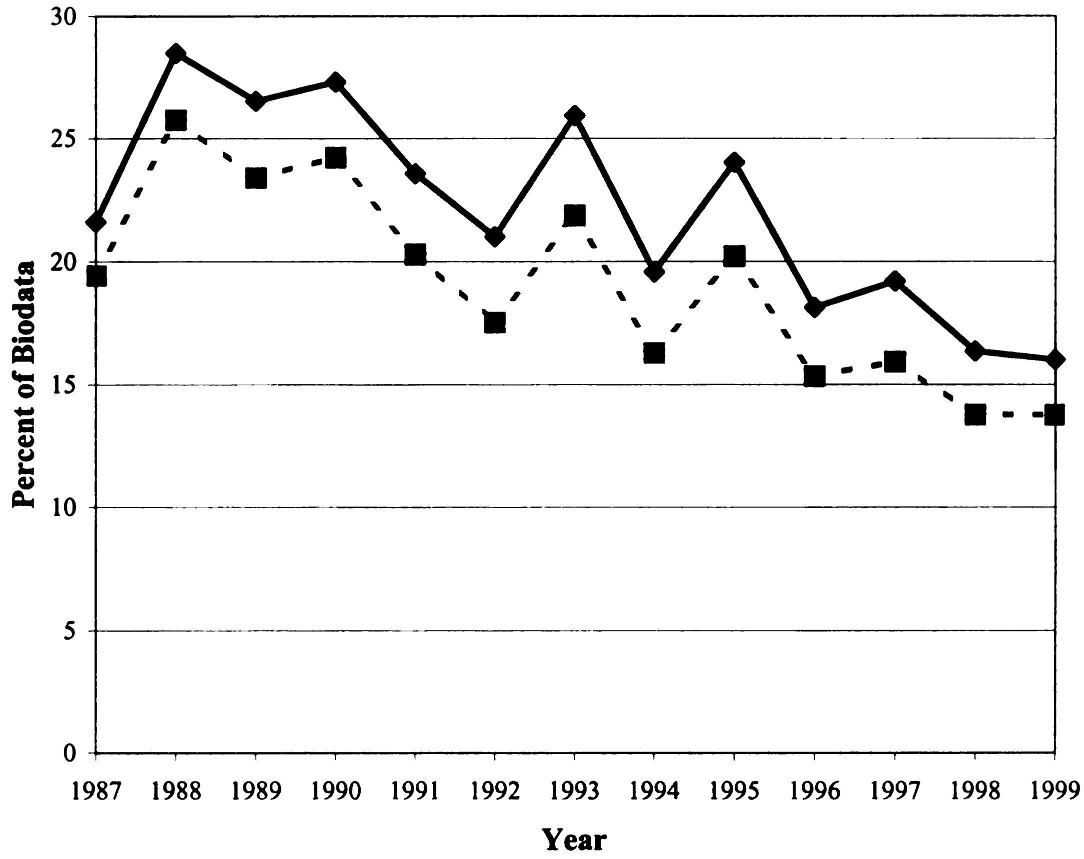


Figure 18. The percent of the firearm (solid line) and total (dashed line) biodata collected at the highway check stations: Alma, Birch Run, Big Rapids, and the Mackinac Bridge (added in 1999).

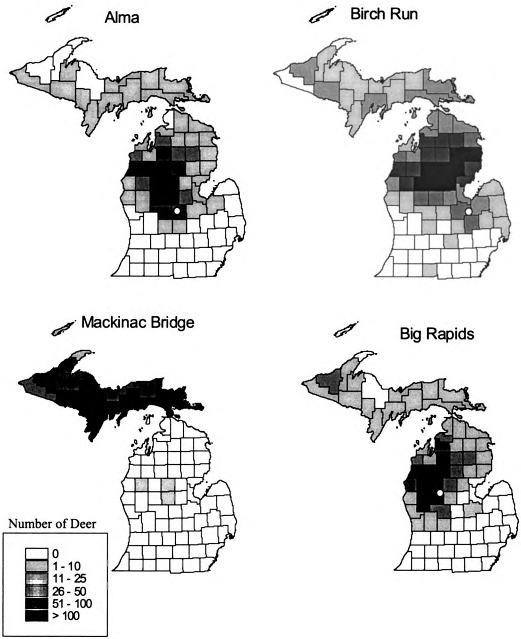


Figure 19. Harvest locations of the deer checked at the four highway check stations in 1999. Approximate station locations are marked as white (Alma, Birch Run, Big Rapids) or black (Mackinac Bridge) circles.

Table 14. The number (and proportion) of deer checked from public and private lands at highway and field stations. The chi-squared tests compare the land-type composition of deer checked at the highway stations to that of those checked at field check stations during the firearm season. All tests have 1 degree of freedom.

		Highway		Field			
Year	**Region**	**Public**	**Private**	**Public**	**Private**	χ^2	**p-value**
1998	**UP**	139 (0.43)	185 (0.57)	1256 (0.36)	2267 (0.64)	6.747	0.009
	NLP	1531 (0.38)	2509 (0.62)	3448 (0.27)	9517 (0.73)	189.989	<0.001
	SLP	40 (0.09)	395 (0.91)	899 (0.11)	6993 (0.89)	1.987	0.159
1999	**UP**	552 (0.48)	589 (0.52)	1662 (0.29)	4110 (0.71)	167.849	<0.001
	NLP	1601 (0.39)	2458 (0.61)	4680 (0.29)	11377 (0.71)	159.971	<0.001
	SLP	48 (0.10)	415 (0.90)	1069 (0.14)	6812 (0.86)	3.855	0.050

on public land. The land-type composition of the harvest seen at the highway check stations could be explained if fewer hunters from southern Michigan travel north to hunt on private land than they do to hunt on public land.

The highway and field check stations differed not only in who checked the deer there, but in what deer were checked. In regions and years with significant differences, hunters tended to check a greater proportion of antlered deer at highway check stations than at field check stations (Table 15). Hunters must, therefore, have checked a greater proportion of antlerless deer at field check stations than at highway stations (Table 15). Although there is a bias against checking antlerless deer (Question 1) hunters who hunt on private land may be more interested in checking all deer they harvest to get accurate data on the deer from their lands. The greater tendency of private land hunters to check their deer at field stations could lead to the difference in the composition of antlered and antlerless checked deer at highway and field check stations.

The age composition of the checked deer also differed between highway and field check stations. The differences in age composition were found primarily among the checked antlered deer (Table 16) while the antlerless deer age compositions tended to be more similar (Table 17). Among the years and regions where there were significant differences, a greater proportion of yearling antlered deer tended to be checked at highway stations than at field stations. The difference in age composition is more difficult to explain than the difference in harvest-type composition, because the pattern is opposite from what I would expect based on the land-type composition (Question 6). There are, however, a few possible explanations. If private land owners were practicing self-imposed Quality Deer Management (QDM) on their own land, they would have

Table 15. The number (and proportion) of antlered and antlerless deer checked at highway and field stations. The chi-squared tests compare the harvest-type composition of deer checked at the highway stations to that of those checked at field check stations during the firearm season. All tests have 1 degree of freedom.

		Highway		Field			
Year	**Region**	**Antlered**	**Antlerless**	**Antlered**	**Antlerless**	χ^2	**p-value**
1987	**UP**	285 (0.93)	22 (0.07)	3615 (0.59)	2544 (0.41)	142.387	<0.001
	NLP	3250 (0.73)	1180 (0.27)	5075 (0.68)	2425 (0.32)	42.862	<0.001
	SLP	222 (0.76)	71 (0.24)	2943 (0.62)	1778 (0.38)	21.374	<0.001
1988	**UP**	549 (0.87)	79 (0.13)	3789 (0.82)	825 (0.18)	10.883	0.001
	NLP	3856 (0.64)	2209 (0.36)	4786 (0.64)	2722 (0.36)	0.041	0.840
	SLP	256 (0.63)	152 (0.37)	3172 (0.58)	2301 (0.42)	3.580	0.058
1989	**UP**	437 (0.80)	111 (0.20)	3991 (0.78)	1106 (0.22)	0.610	0.435
	NLP	3264 (0.61)	2108 (0.39)	3789 (0.60)	2546 (0.40)	1.093	0.296
	SLP	245 (0.54)	206 (0.46)	3550 (0.56)	2737 (0.44)	0.785	0.376
1990	**UP**	363 (0.78)	101 (0.22)	3809 (0.79)	1040 (0.21)	0.026	0.873
	NLP	3597 (0.60)	2375 (0.40)	4720 (0.62)	2913 (0.38)	3.636	0.057
	SLP	157 (0.49)	163 (0.51)	3049 (0.57)	2280 (0.43)	8.175	0.004
1991	**UP**	358 (0.80)	87 (0.20)	3981 (0.78)	1145 (0.22)	1.846	0.174
	NLP	3311 (0.76)	1057 (0.24)	4347 (0.67)	2126 (0.33)	93.989	<0.001
	SLP	196 (0.61)	125 (0.39)	3087 (0.59)	2104 (0.41)	0.318	0.573
1992	**UP**	326 (0.70)	143 (0.30)	3636 (0.74)	1253 (0.26)	5.250	0.022
	NLP	2254 (0.73)	851 (0.27)	3082 (0.64)	1767 (0.36)	69.950	<0.001
	SLP	167 (0.73)	63 (0.27)	2740 (0.61)	1719 (0.39)	11.562	0.001
1993	**UP**	745 (0.88)	104 (0.12)	3676 (0.90)	404 (0.10)	4.190	0.041
	NLP	2578 (0.81)	610 (0.19)	2981 (0.76)	930 (0.24)	22.306	<0.001
	SLP	196 (0.74)	68 (0.26)	2726 (0.63)	1623 (0.37)	14.327	<0.001
1994	**UP**	808 (0.84)	154 (0.16)	6081 (0.88)	864 (0.12)	9.588	0.002
	NLP	3328 (0.93)	264 (0.07)	5815 (0.91)	545 (0.09)	4.571	0.033
	SLP	284 (0.78)	81 (0.22)	4567 (0.66)	2354 (0.34)	21.772	<0.001
1995	**UP**	651 (0.63)	390 (0.37)	4644 (0.66)	2415 (0.34)	4.239	0.040
	NLP	3863 (0.81)	885 (0.19)	4614 (0.79)	1214 (0.21)	7.896	0.005
	SLP	288 (0.75)	95 (0.25)	4336 (0.64)	2478 (0.36)	21.104	<0.001
1996	**UP**	190 (0.57)	141 (0.43)	3135 (0.70)	1330 (0.30)	23.784	<0.001
	NLP	2492 (0.69)	1113 (0.31)	5022 (0.63)	2987 (0.37)	44.887	<0.001
	SLP	273 (0.76)	88 (0.24)	3901 (0.54)	3267 (0.46)	62.532	<0.001
1997	**UP**	181 (0.78)	52 (0.22)	2364 (0.79)	612 (0.21)	0.405	0.525
	NLP	2529 (0.69)	1127 (0.31)	4890 (0.64)	2754 (0.36)	29.682	<0.001
	SLP	249 (0.56)	192 (0.44)	3493 (0.46)	4030 (0.54)	16.830	<0.001
1998	**UP**	280 (0.89)	36 (0.11)	3039 (0.88)	405 (0.12)	0.038	0.846
	NLP	2385 (0.61)	1499 (0.39)	5431 (0.44)	6991 (0.56)	370.795	<0.001
	SLP	266 (0.65)	142 (0.55)	3698 (0.48)	4001 (0.52)	45.681	<0.001
1999	**UP**	936 (0.83)	194 (0.17)	4351 (0.76)	1383 (0.24)	25.774	<0.001
	NLP	2324 (0.60)	1574 (0.40)	7501 (0.49)	7942 (0.51)	152.000	<0.001
	SLP	277 (0.62)	167 (0.38)	3568 (0.47)	3966 (0.53)	37.930	<0.001

Table 16. The number (and proportion) of yearling and adult antlered deer checked at highway and field stations. The chi-squared tests compare the age composition of antlered deer checked at the highway stations to those checked at field check stations during the firearm season. All tests have 1 degree of freedom.

		Highway		Field			
Year	Region	1.5	2.5+	1.5	2.5+	χ^2	p-value
1987	UP	142 (0.52)	120 (0.46)	1968 (0.58)	1422 (0.42)	1.481	0.224
	NLP	2429 (0.76)	769 (0.24)	3368 (0.69)	1521 (0.31)	47.533	<0.001
	SLP	172 (0.79)	47 (0.21)	1939 (0.68)	917 (0.32)	10.713	0.001
1988	UP	326 (0.60)	215 (0.40)	1924 (0.54)	1663 (0.46)	8.310	0.004
	NLP	2774 (0.72)	1054 (0.28)	2951 (0.65)	1597 (0.35)	55.211	<0.001
	SLP	203 (0.80)	51 (0.20)	2148 (0.70)	938 (0.30)	11.984	0.001
1989	UP	153 (0.51)	147 (0.49)	1477 (0.43)	1990 (0.57)	7.933	0.005
	NLP	1541 (0.64)	865 (0.36)	1863 (0.59)	1287 (0.41)	13.832	<0.001
	SLP	118 (0.57)	89 (0.43)	2346 (0.70)	1029 (0.30)	14.208	<0.001
1990	UP	162 (0.46)	187 (0.54)	1551 (0.42)	2102 (0.58)	2.041	0.153
	NLP	2356 (0.67)	1180 (0.33)	2781 (0.62)	1734 (0.38)	21.762	<0.001
	SLP	117 (0.77)	35 (0.23)	1990 (0.67)	969 (0.33)	6.251	0.012
1991	UP	190 (0.54)	165 (0.46)	1709 (0.46)	2000 (0.54)	7.212	0.007
	NLP	2349 (0.72)	917 (0.28)	2533 (0.61)	1600 (0.39)	91.939	<0.001
	SLP	135 (0.70)	59 (0.30)	1956 (0.66)	1014 (0.34)	1.130	0.288
1992	UP	161 (0.50)	158 (0.50)	1228 (0.37)	2091 (0.63)	22.376	<0.001
	NLP	1539 (0.69)	693 (0.31)	1759 (0.62)	1100 (0.38)	30.301	<0.001
	SLP	129 (0.77)	38 (0.23)	1730 (0.65)	921 (0.35)	10.055	0.002
1993	UP	335 (0.47)	380 (0.53)	1428 (0.41)	2055 (0.59)	8.346	0.004
	NLP	1612 (0.64)	924 (0.36)	1588 (0.55)	1275 (0.45)	36.535	<0.001
	SLP	129 (0.68)	60 (0.32)	1629 (0.62)	999 (0.38)	2.952	0.086
1994	UP	476 (0.59)	326 (0.41)	3278 (0.57)	2477 (0.43)	1.646	0.199
	NLP	2227 (0.69)	1023 (0.31)	3486 (0.64)	1969 (0.36)	19.258	<0.001
	SLP	199 (0.71)	81 (0.29)	2801 (0.65)	1509 (0.35)	4.297	0.038
1995	UP	395 (0.61)	248 (0.39)	2203 (0.52)	2028 (0.48)	19.658	<0.001
	NLP	2899 (0.77)	863 (0.23)	2987 (0.69)	1322 (0.31)	60.945	<0.001
	SLP	205 (0.72)	78 (0.28)	2698 (0.67)	1327 (0.33)	3.518	0.061
1996	UP	75 (0.40)	114 (0.60)	822 (0.29)	2054 (0.71)	10.558	0.001
	NLP	1680 (0.68)	799 (0.32)	2919 (0.61)	1868 (0.39)	32.426	<0.001
	SLP	212 (0.79)	57 (0.21)	2615 (0.70)	1133 (0.30)	9.838	0.002
1997	UP	76 (0.44)	97 (0.56)	602 (0.27)	1663 (0.73)	24.106	<0.001
	NLP	1630 (0.65)	865 (0.35)	2932 (0.63)	1729 (0.37)	4.138	0.042
	SLP	191 (0.77)	58 (0.23)	2244 (0.66)	1142 (0.34)	11.418	0.001
1998	UP	196 (0.70)	83 (0.30)	1795 (0.61)	1147 (0.39)	9.213	0.002
	NLP	1691 (0.71)	679 (0.29)	3310 (0.63)	1913 (0.37)	46.135	<0.001
	SLP	180 (0.68)	86 (0.32)	2362 (0.66)	1204 (0.34)	0.227	0.633
1999	UP	595 (0.64)	337 (0.36)	2412 (0.57)	1841 (0.43)	15.946	<0.001
	NLP	1557 (0.68)	731 (0.32)	4348 (0.60)	2877 (0.40)	45.726	<0.001
	SLP	194 (0.71)	80 (0.29)	2346 (0.68)	1083 (0.32)	0.671	0.413

Table 17. The number (and proportion) of fawn, yearling, and adult antlerless deer checked at highway and field stations. The chi-squared tests compare the age composition of antlerless deer checked at the highway stations to that of antlerless deer checked at field check stations during the firearm season. All tests have 2 degrees of freedom.

		Highway			Field				
Year	**Region**	**0.5**	**1.5**	**2.5+**	**0.5**	**1.5**	**2.5+**	χ^2	**p-value**
1987	**UP**	9 (0.45)	0 (0.00)	11 (0.55)	1077 (0.43)	368 (0.15)	1040 (0.42)	3.792	0.150
	NLP	461 (0.39)	227 (0.19)	485 (0.41)	869 (0.37)	510 (0.22)	976 (0.41)	3.188	0.203
	SLP	23 (0.32)	14 (0.20)	34 (0.48)	778 (0.44)	429 (0.25)	542 (0.31)	9.070	0.011
1988	**UP**	30 (0.39)	11 (0.14)	36 (0.47)	254 (0.33)	157 (0.21)	351 (0.46)	2.056	0.358
	NLP	842 (0.38)	439 (0.20)	917 (0.42)	912 (0.35)	642 (0.25)	1042 (0.40)	15.959	<0.001
	SLP	62 (0.41)	37 (0.24)	53 (0.35)	978 (0.43)	584 (0.26)	707 (0.31)	0.910	0.634
1989	**UP**	41 (0.59)	5 (0.07)	24 (0.34)	351 (0.39)	139 (0.15)	407 (0.45)	10.888	0.004
	NLP	773 (0.46)	233 (0.14)	660 (0.40)	865 (0.39)	473 (0.21)	886 (0.40)	40.584	<0.001
	SLP	74 (0.41)	36 (0.20)	70 (0.39)	1139 (0.43)	690 (0.26)	821 (0.31)	5.880	0.053
1990	**UP**	38 (0.38)	16 (0.16)	47 (0.47)	306 (0.32)	219 (0.23)	437 (0.45)	2.962	0.227
	NLP	889 (0.38)	474 (0.20)	984 (0.42)	1017 (0.36)	607 (0.22)	1199 (0.42)	2.329	0.312
	SLP	64 (0.40)	36 (0.23)	60 (0.38)	920 (0.41)	567 (0.26)	733 (0.33)	1.519	0.468
1991	**UP**	24 (0.29)	18 (0.21)	42 (0.50)	381 (0.37)	157 (0.15)	501 (0.48)	3.455	0.178
	NLP	403 (0.39)	203 (0.20)	435 (0.42)	842 (0.41)	350 (0.17)	868 (0.42)	3.268	0.195
	SLP	44 (0.35)	38 (0.30)	43 (0.34)	897 (0.43)	440 (0.21)	727 (0.35)	6.345	0.042
1992	**UP**	48 (0.34)	29 (0.20)	66 (0.46)	377 (0.34)	209 (0.19)	518 (0.47)	0.149	0.928
	NLP	274 (0.32)	183 (0.22)	388 (0.46)	655 (0.39)	364 (0.22)	642 (0.39)	14.631	0.001
	SLP	24 (0.38)	17 (0.27)	22 (0.35)	741 (0.44)	411 (0.24)	533 (0.32)	0.853	0.653
1993	**UP**	43 (0.41)	24 (0.23)	37 (0.36)	161 (0.42)	68 (0.18)	156 (0.41)	1.787	0.409
	NLP	216 (0.35)	123 (0.20)	271 (0.44)	350 (0.39)	172 (0.19)	366 (0.41)	2.527	0.283
	SLP	30 (0.45)	12 (0.18)	25 (0.37)	677 (0.42)	384 (0.24)	533 (0.33)	1.398	0.497
1994	**UP**	65 (0.42)	32 (0.21)	57 (0.37)	309 (0.37)	177 (0.21)	343 (0.41)	1.458	0.482
	NLP	104 (0.40)	48 (0.18)	110 (0.42)	191 (0.37)	107 (0.21)	221 (0.43)	0.863	0.650
	SLP	24 (0.30)	24 (0.30)	33 (0.41)	964 (0.42)	540 (0.24)	781 (0.34)	5.114	0.078
1995	**UP**	163 (0.42)	74 (0.19)	150 (0.39)	777 (0.36)	429 (0.20)	927 (0.43)	4.699	0.095
	NLP	286 (0.33)	208 (0.24)	372 (0.43)	341 (0.30)	278 (0.25)	508 (0.45)	1.775	0.412
	SLP	30 (0.32)	26 (0.27)	39 (0.41)	923 (0.39)	576 (0.24)	882 (0.37)	2.000	0.368
1996	**UP**	52 (0.37)	23 (0.16)	65 (0.46)	338 (0.28)	232 (0.19)	649 (0.53)	5.442	0.066
	NLP	329 (0.30)	242 (0.22)	533 (0.48)	790 (0.28)	629 (0.22)	1432 (0.50)	1.846	0.397
	SLP	36 (0.41)	17 (0.19)	35 (0.40)	1305 (0.41)	712 (0.22)	1191 (0.37)	0.483	0.786
1997	**UP**	20 (0.40)	8 (0.16)	22 (0.44)	217 (0.37)	104 (0.18)	263 (0.45)	0.196	0.907
	NLP	363 (0.33)	203 (0.18)	550 (0.49)	769 (0.29)	518 (0.20)	1368 (0.52)	4.815	0.090
	SLP	70 (0.36)	36 (0.19)	86 (0.45)	1543 (0.39)	933 (0.24)	1494 (0.38)	4.523	0.104
1998	**UP**	17 (0.47)	5 (0.14)	14 (0.39)	134 (0.34)	84 (0.21)	174 (0.44)	2.717	0.257
	NLP	550 (0.37)	304 (0.20)	638 (0.43)	2118 (0.31)	1331 (0.20)	3276 (0.49)	20.132	<0.001
	SLP	57 (0.40)	33 (0.23)	51 (0.36)	1578 (0.41)	865 (0.22)	1429 (0.37)	0.092	0.955
1999	**UP**	71 (0.37)	45 (0.23)	77 (0.40)	352 (0.27)	233 (0.18)	731 (0.56)	16.628	<0.001
	NLP	517 (0.33)	328 (0.21)	721 (0.46)	2154 (0.28)	1639 (0.21)	3857 (0.50)	15.736	<0.001
	SLP	67 (0.40)	36 (0.22)	64 (0.38)	1546 (0.40)	861 (0.22)	1455 (0.38)	0.057	0.972

harvested a greater proportion of larger, older bucks than hunters hunting on public land. (QDM is a program in which hunters take fewer yearling bucks and more antlerless deer to try to balance the sex ratio of the deer population [MDNR 2000b].) Private landowners may also have been more familiar with the deer available on their land and so could be more selective in choosing the deer they harvest.

Question 8: How does aging deer as 'A' or 'AA' affect the biodata?

Significance

Although MDNR personnel are trained in aging deer prior to the start of the season, determining the exact age of a deer can be difficult due to variability in wear and replacement patterns. Check station agers may also not be able to determine the age of a deer because the head is frozen and the jaw cannot be examined. When agers cannot determine the age to a specific year, they record the age as either 'A' (not a fawn) or 'AA' (older than a yearling). I examined the effect this practice has on the biodata.

Methods

I examined the true ages, as determined at the Rose Lake Wildlife Research Station (see Question 1) of deer aged as 'A' by field personnel. The sample size was too small to conduct similar analyses on deer aged as 'AA.' I determined the true age structure of the 'A'-aged deer in both sexes and compared it to the age structure of all known-age checked deer. I also tracked the change in the percent of deer aged as 'A' or 'AA' over time and examined how it differed between highway check stations and other check stations.

Results and Discussion

Annually, an average of 1500 deer are placed in the 'A' age category and almost 2000 are placed in the 'AA' age category, leaving an average of greater than 10% of the checked deer without known ages (Table 18). The loss of these data may be unavoidable.

Table 18. Number and percent of checked deer aged as 'A' or 'AA' each year.

Year	A	AA	Total Deer	% A or AA
1987	967	1954	27948	10.45
1988	1071	2023	29264	10.57
1989	4026	3639	29022	26.41
1990	1068	2297	29611	11.36
1991	1172	2282	27224	12.69
1992	1302	1889	22966	13.89
1993	923	1585	21213	11.82
1994	1701	2188	32853	11.84
1995	2287	2096	32780	13.37
1996	1418	1721	30267	10.37
1997	1153	1427	29351	8.79
1998	1407	1327	35718	7.65
1999	1570	1455	42769	7.07
average	**1543**	**1991**	**30076**	**12.02**

The only cause for concern would be if the true age distribution of the unaged deer was different from that of the true age distribution of the known-age deer. The Rose Lake aging procedure identified almost 6% of the 'A'-aged deer as fawns, which should not be included in this age category at all. These results are somewhat surprising, as the fawn age category was the only category in which the field personnel achieved 100% accuracy in the Rose Lake aging analysis (Table 2). The age composition of the remaining deer (Figure 20) matched fairly closely with that of the true age structure of the checked deer (Figure 21). The 'A'-aged male deer's true age distribution matched more closely to the actual age distribution than that for females probably because agers can use the antlers to help determine the ages of the younger males. Although the true age distribution of the 'A'-aged deer did not match exactly with that of the aged deer, the differences were not great and do not seem cause for concern. If the differences had been larger, the loss of information resulting from unaged deer could have been affecting certain age categories more than others, causing the aged deer to present a false age distribution. The minor differences and small sample sizes involved do not appear to cause a problem, however. I can only assume the same is true for the 'AA'-aged deer, but a similar analysis is not possible due to small sample sizes of 'AA'-aged deer sent to Rose Lake.

Recently, the percentage of deer categorized as 'A' or 'AA' has decreased (Table 18). Although the percent of deer aged as 'A' has remained constant (Figure 22a), the percent of deer aged as 'AA' has decreased over the past several years, leading to the overall decrease in the percent of deer with unknown age (Figure 22b). The decrease may indicate that agers are becoming more confidant in their aging ability due to experience or increased training. Highway check station agers tend to categorize deer as

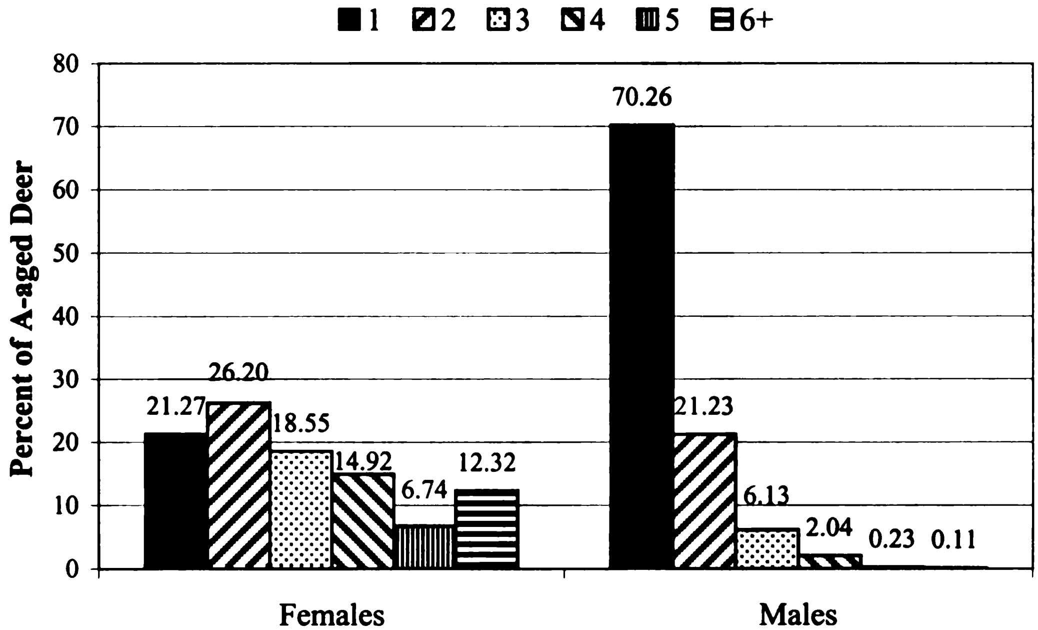


Figure 20. Age structure of the female and male deer classified as 'A' and aged at Rose Lake (in 1999), excluding fawns.

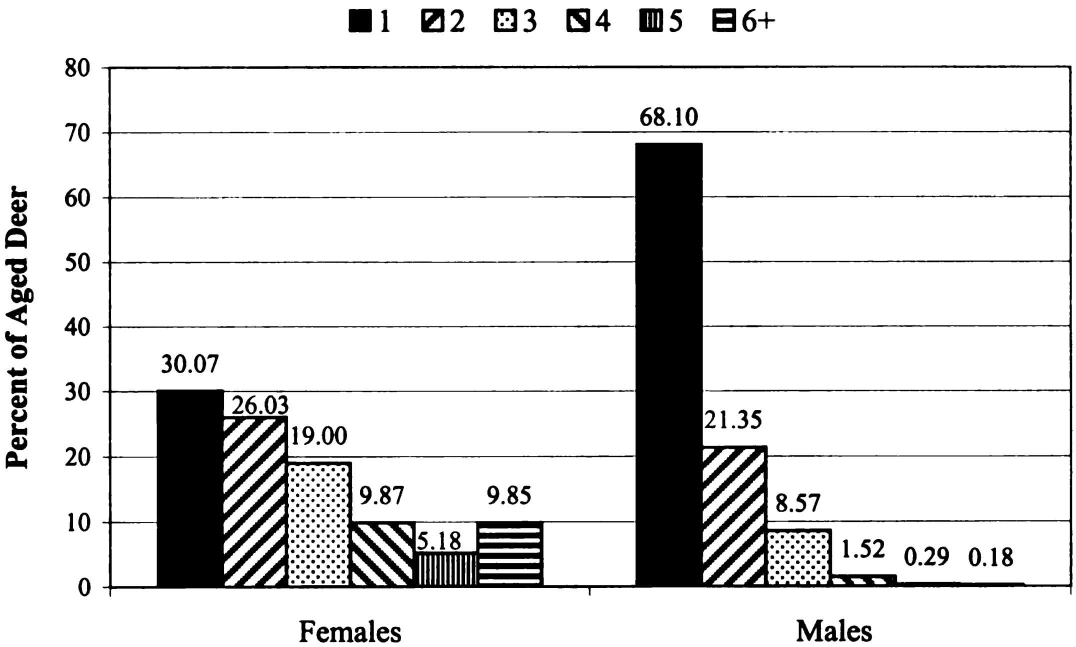


Figure 21. Age structure of all female and male deer checked during 1999, excluding fawns.

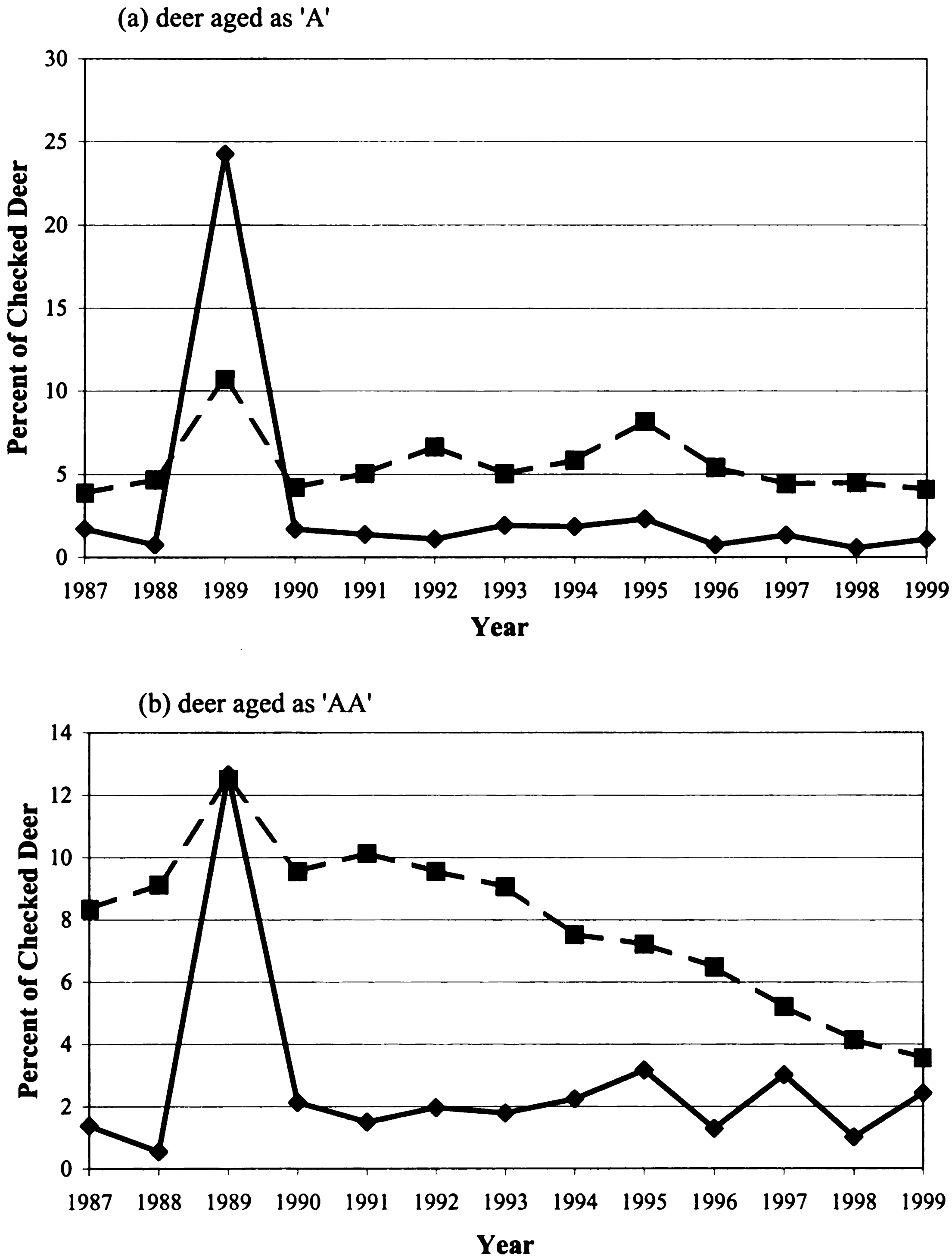


Figure 22. Percent of checked deer aged as (a) 'A' or (b) 'AA' during all seasons at highway check stations (solid line) and other check stations (broken line).

‘A’ or ‘AA’ with less frequency than do agers working at other check stations (Figure 22). The only exception to these trends was in 1989 when weather conditions resulted in a higher than normal proportion of frozen deer and aging was difficult (H. Hill, MDNR, personal communication). Highway station agers may age fewer deer as ‘A’ or ‘AA’ because there are generally more personnel working at highway stations at any given time than at field stations. If questions arise as to the age of a particular deer, a highway ager can ask the opinions of others while the field ager may not have that opportunity.

Question 9: At what level do sample sizes provide the desired level of precision for statistical analyses?

Significance

When the biodata are collected, information is recorded on where each deer was harvested. The location information is recorded as township and range, deer management unit, and county. Based on the county designation, the data can then be combined into the eight wildlife division management units and the three ecoregions (see Figure 1 for boundaries). The location information can then be used to stratify the data for statistical analyses based on several different spatial scales. Statistical analyses are most valid when the data fulfill minimum sample size requirements. I examined several subsets of the biodata to determine what scales provide the minimum required sample sizes.

Methods

In most cases, the biodata are used to determine proportions (proportion of antlered vs. antlerless, fawns vs. does, lactating vs. non-lactating, etc.). In such binomial situations, the minimum required sample size can be approximated using the following equation:

$$n = (z^2_{\alpha/2}p(1-p))/E^2$$

where n is the required sample size, $z_{\alpha/2}$ is the value on the standard normal curve that corresponds to $(1-\alpha)$ percent confidence, p is the proportion of interest, and E is the desired margin of error (Wackerly et al. 1996). The margin of error can be quantified using either relative error or absolute error. Relative error is expressed as some percent of the proportion of interest. For example, a proportion of 0.30 with a relative margin of error of 20% would have a confidence interval of 0.30 ± 0.06, because 0.06 is 20% of 0.30. Absolute error is expressed as a number of percentage points. For example, a proportion of 0.30 with an absolute margin of error of 20% would have a confidence interval of 0.30 ± 0.20. The values for relative error change with each estimated proportion, so I used absolute error in all calculations.

Assuming maximum variance ($p = 0.5$), to achieve a 20% margin of absolute error with 95% confidence, at least 24 deer must be sampled from the area of interest, whether it is a county, management unit, or region. The required sample size for a 10% margin of error with 95% confidence is 96 deer. The required sample size for a 5% margin of error is 385 deer. These numbers reflect the worst case scenario. If information is already available on the proportion of interest, the preliminary data can be used to provide an estimate of p, and the resulting required sample size will be smaller than those described above.

I divided the biodata into several different categories based on season harvested, age, sex, and harvest type, and on several different levels (county, management unit, region, and, in one case, township and range). Although the DMUs may provide the most useful divisions for management purposes, they are generally too small and too variable to be of practical use for statistical comparisons. I first evaluated the data based on the above selected sample sizes. I then calculated several ratios that may be of greatest interest to MDNR managers to determine whether or not the data are sufficient to provide 5%, 10%, or 20% margins of error.

Results and Discussion

Although the biodata are collected throughout all deer seasons, the data are sometimes sub-divided and examined separately by season. The most common divisions are between the archery season and the firearm season. The number of deer checked from archery season has doubled since 1987, but the archery season generally provides fewer data than the firearm season in all categories (Figure 23). The sample size of the archery data could be especially significant for analysis of the lactation data. The archery season provides the most accurate data for lactation analyses because does start to wean their fawns during the fall and generally stop lactating sometime during the fall or early winter (Scanlon and Urbston 1978). Therefore, the archery data may provide lactation data before a large proportion of does have stopped lactating. The archery season provides much smaller sample sizes than the later firearm season, however, providing less precise estimates. The appropriate scale for analysis of the lactation data is discussed more completely in Chapter 3. The rest of this section will focus on the sample sizes from firearm season only or all seasons combined.

The UP has the smallest sample sizes among the regions, although all regions contain at least 100 records in almost all categories (Table 19). The UP has the lowest harvest levels (Figure 24) and the fewest check stations (Figure 2) among the regions, leading to the fewest checked deer. The regional sample sizes are sufficient across almost all categories, however, to calculate several different ratios with a margine of absolute error of less than 5% (Table 20). The ratio of lactating to non-lactating does using the October data is the only ratio whose absolute error exceeds 5% in two regions (Table 20).

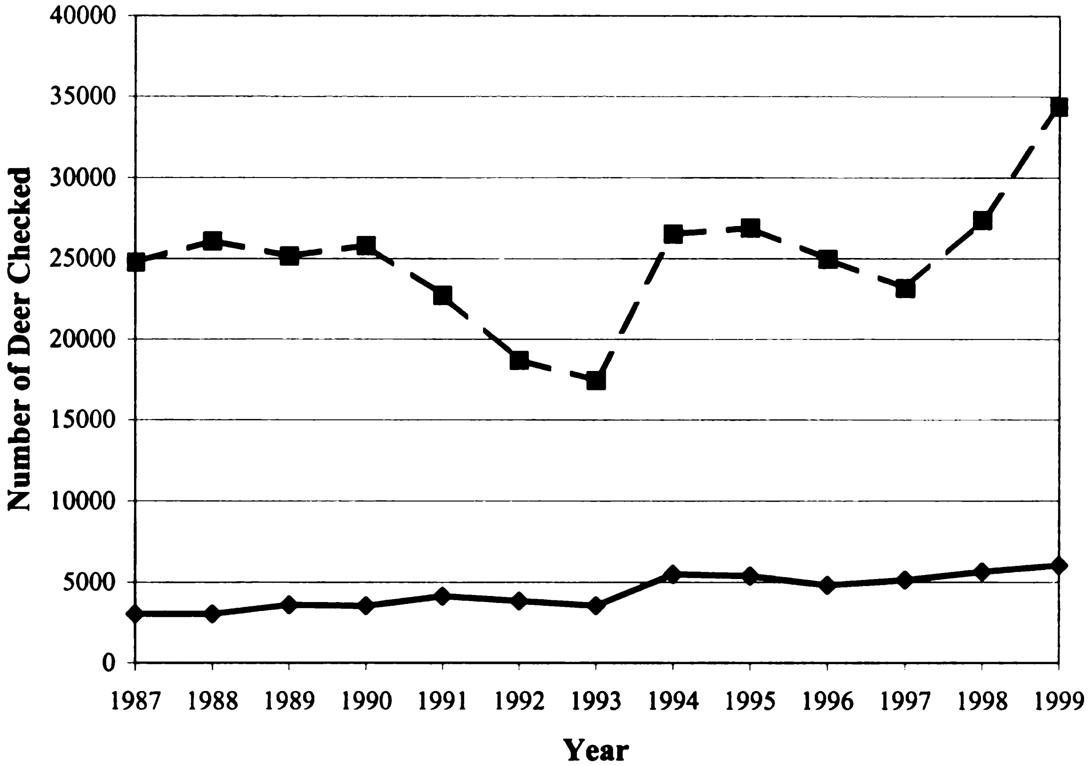


Figure 23. Number of deer checked from archery (solid line) and firearm (broken line) seasons from 1987 through 1999.

Table 19. Examples of some regional sample sizes from 1999 biodata.

Region	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Upper Peninsula	7994	5734	2059	515	3250	388	3470	1207
Northern Lower Peninsula	23352	11104	11022	3055	6757	2270	9613	6180
Southern Lower Peninsula	11423	5452	5359	2046	3692	1181	3568	2865

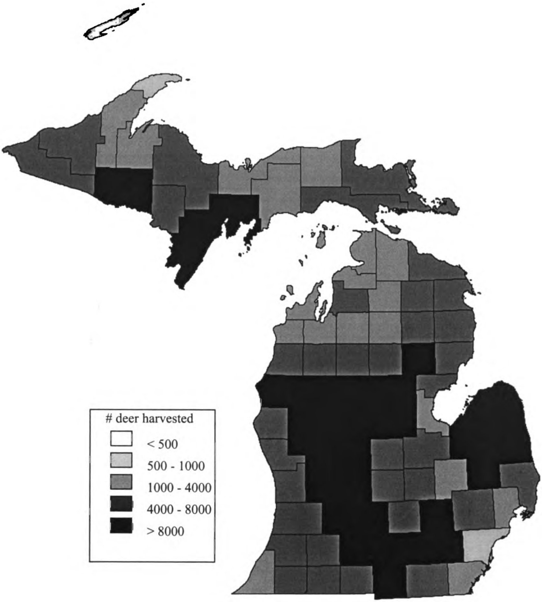


Figure 24. Estimates of the number of deer harvested by county from the 1999 mail survey.

Table 20. The number of counties missing data necessary to calculate the listed ratios, and the number of counties, management units, and regions whose sample sizes are sufficient to calculate the listed ratios with a margin of absolute error (E) of 5%, 10%, or 20%. All numbers are based on 1999 data.

		Counties (N=83)				Mng't Units (N=8)			Regions (N=3)		
Ratio	**Season**	**no data**	**E=5%**	**E=10%**	**E=20%**	**E=5%**	**E=10%**	**E=20%**	**E=5%**	**E=10%**	**E=20%**
Fawn:Doe	All	2	13	58	77	7	8	8	3	3	3
Fawn:Doe	Firearm	4	11	47	75	6	8	8	3	3	3
Yearling M:F	All	3	40	70	79	8	8	8	3	3	3
Yearling M:F	Firearm	4	36	63	77	8	8	8	3	3	3
Lactation +:-	All	2	5	33	68	6	8	8	3	3	3
Lactation +:-	October	18	0	4	15	1	5	8	1	3	3
Lactation +:-	FA Week 1	4	1	19	55	6	6	8	3	3	3
Males 1.5:2.5+[a]	Firearm	0	30	71	82	8	8	8	3	3	3

a. This ratio is equivalent to the % yearling bucks calculated by the MDNR.

The Southeastern LP and the Eastern UP contain the fewest records among the management units (Table 21). The Southeastern LP is geographically the smallest management unit, and the greater metropolitan area of Detroit makes up a large fraction of the management unit, leaving little area available for deer harvest. The Eastern UP has the second smallest area of the management units and contains none of the counties with the highest harvest levels (Figure 24). There are also very few check stations in the Eastern UP compared to other areas of the state (Figure 2). Other than the Southeastern LP and the Eastern UP, the management units have recently contained at least 100 records in almost all categories (Table 21). The number of checked deer has fluctuated greatly over the past 13 years, and most of the management units saw dramatic increases in 1999 (Figure 25). The recent increases in the number of checked deer are probably due primarily to the increased interest in checking deer for TB, but they provide greater sample sizes for greater statistical precision. In general the management units do provide sufficient data to analyze the data with margins of error less 10%, although many management units do not have sufficient data to calculate ratios with absolute margins of absoluate error of less than 5% (Table 20).

Although the regions and management units provide large samples with which to statistically analyze the deer harvest and population, such analyses may be most useful when conducted by county or even smaller units. Analysis at such fine scales may not always be practical, however. When plotted by township and range coordinates, the buck data reveal that very few units contained more than 40 checked bucks (Figure 26). The distribution of the checked bucks suggests that analysis on the township level would not be statistically valid, especially outside the Northern LP. Analysis on the county level

Table 21. Examples of some management unit sample sizes from 1999 biodata.

Management Unit	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Western UP	6305	4414	1742	418	2434	314	2847	1046
Eastern UP	1689	1320	317	97	816	74	623	161
Northwestern LP	6604	3674	2590	780	2485	492	2381	1502
Northeastern LP	13735	5983	7072	1832	3313	15161	6150	3996
Saginaw Bay	5814	2831	2650	910	1921	538	1932	1402
Southwestern LP	4174	1959	1983	759	1309	419	1398	1052
South Central LP	3180	1510	1481	606	1029	331	932	756
Southeastern LP	1267	599	605	214	392	155	388	337

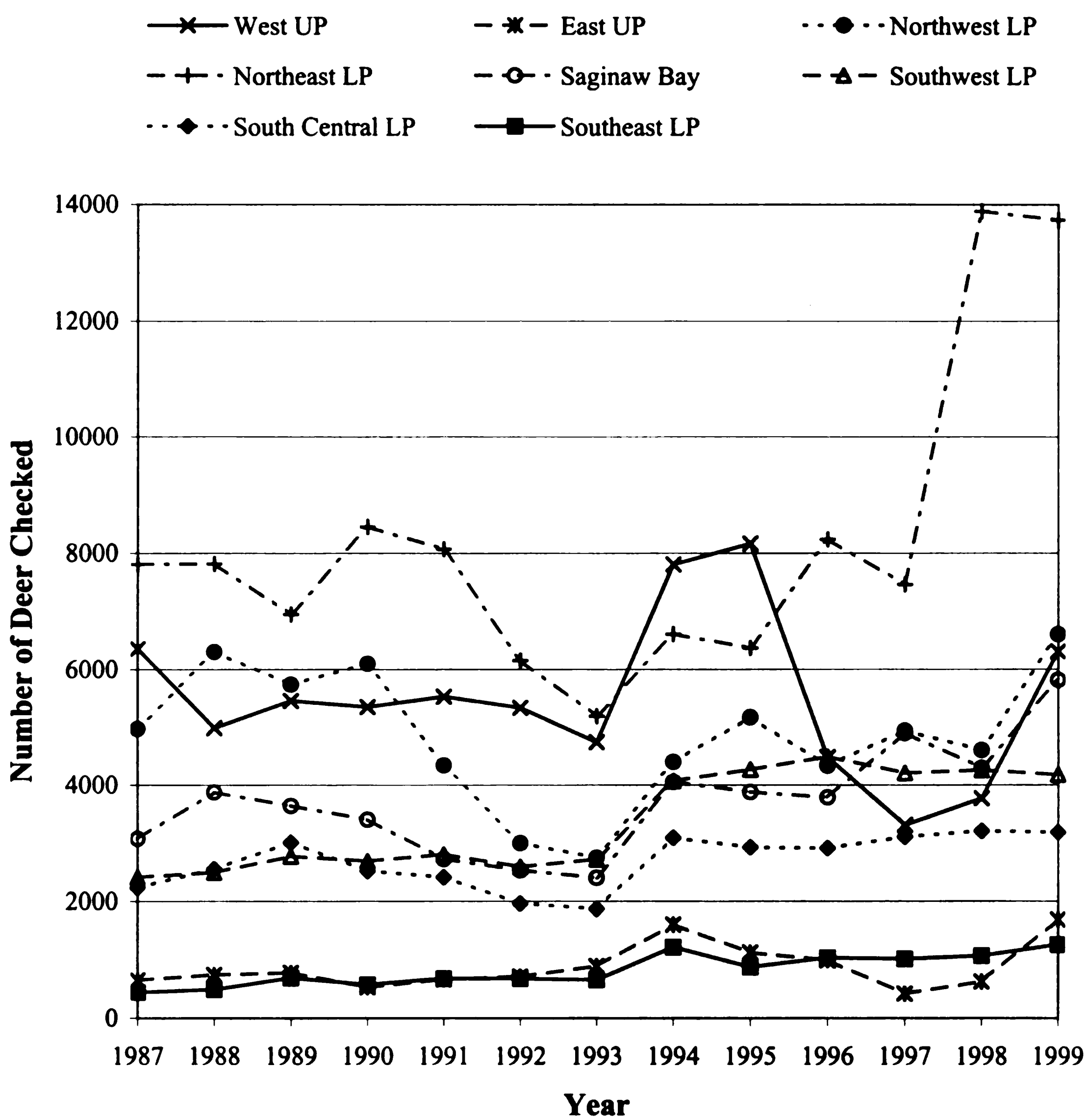


Figure 25. Total number of deer checked from each management unit between 1987 and 1999.

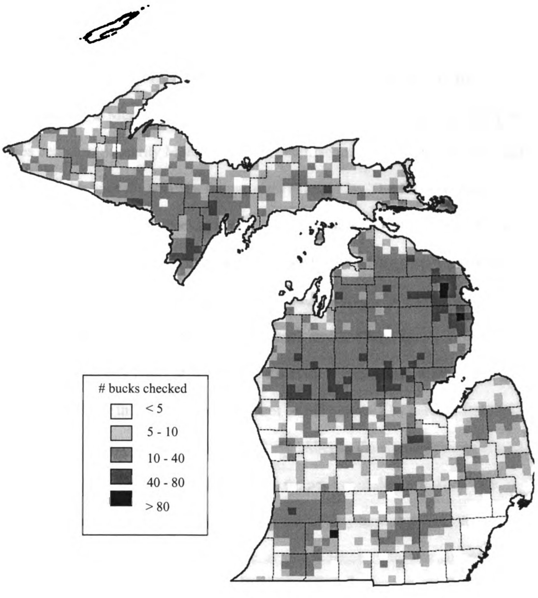


Figure 26. Number of bucks checked in 1999 by township and range coordinates.

may be more feasible, however, and may be gaining more significance for managers, even though the county boundaries are not ecologically meaningful. The DMU boundaries, on which harvest regulations are based, have begun to match county boundaries, especially in the Southern LP, setting a precedent for county level analysis.

Several counties have shown consistently high or low sample sizes of checked deer. In almost all cases, the TB surveillance counties and Lake, Osceola, Clare, Gladwin, Allegan, and Menominee counties provide the highest samples sizes, while the Detroit area counties (primarily Monroe, Wayne, and Macomb) and Brand, Berrien, and Keweenaw counties have the smallest sample sizes (Table 22). The TB surveillance counties have high numbers of checked deer due to high harvest levels (Figure 24) and especially because of the emphasis that has been placed on checking deer from these counties to test for TB. The high sample sizes in Lake, Osceola, Clare, and Gladwin are probably due to their proximity to the TB surveillance area and high harvest levels (Figure 23). Menominee County also has a large harvest (Figure 24), but the high number of checked deer in Allegan County cannot be fully explain by harvest numbers, which generally do not fall within the highest levels. Allegan County has abundant land for public hunting, however, which could increase the percent of deer checked. The Detroit area counties, Berrien County, and Keweenaw County have especially low harvest numbers (Figure 24), resulting in low checking numbers. The low sample sizes of Branch County are probably due to the lack of check stations in the immediate area, rather than to especially low harvest numbers (Figure 2).

Due to the great variability in the number of deer checked from each county, county-level analyses should be treated with caution. In several cases, counties contain

Table 22. Examples of some county sample sizes from 1999 biodata.

(a) Western Upper Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Alger	181	175	2	0	114	0	65	1
Baraga	319	287	25	5	155	6	143	15
Delta	1111	706	386	83	375	61	546	262
Dickinson	442	316	122	30	157	21	214	67
Gogebic	186	107	65	16	68	13	70	38
Houghton	308	259	42	4	160	11	121	24
Iron	806	566	220	55	304	44	356	123
Keweenaw	38	35	2	0	15	0	20	1
Marquette	548	452	64	13	239	14	254	40
Menominee	1765	928	805	214	487	141	825	472
Ontonagon	502	429	54	11	259	12	198	35

(b) Eastern Upper Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Chippewa	726	524	174	53	336	49	261	96
Luce	177	168	6	2	117	0	53	3
Mackinac	453	352	89	22	200	15	184	49
Schoolcraft	333	276	48	20	163	10	125	13

Table 22 (cont'd).

(c) Northwestern Lower Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Benzie	143	95	43	12	50	8	51	27
Gd. Traverse	160	102	40	14	67	16	41	21
Kalkaska	520	307	180	52	201	39	197	114
Lake	928	539	346	87	373	52	331	227
Leelanau	129	54	71	28	25	14	57	14
Manistee	448	312	115	45	209	15	149	57
Mason	328	185	135	38	132	21	120	86
Mecosta	640	319	290	92	228	53	231	159
Missaukee	722	393	283	80	237	56	301	174
Newaygo	550	288	230	67	207	43	201	122
Oceana	171	88	77	36	63	24	42	36
Osceola	1284	628	588	176	454	121	437	355
Wexford	555	359	167	51	238	33	194	93

Table 22 (cont'd).

(d) Northeastern Lower Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Alcona	2196	855	1242	275	428	295	1053	585
Alpena	1958	867	991	213	531	210	886	655
Antrim	540	284	231	59	193	64	182	154
Charlevoix	289	155	125	39	84	26	123	78
Cheboygan	426	261	153	44	159	22	183	67
Crawford	637	301	295	84	168	64	279	169
Emmet	292	192	93	33	115	15	123	55
Iosco	561	309	223	46	192	64	232	133
Montmorency	1646	529	1033	318	234	194	774	551
Ogemaw	1001	458	463	114	308	116	374	279
Oscoda	1512	411	1041	311	185	218	720	548
Otsego	643	327	284	74	195	58	270	187
Presque Isle	1260	565	649	159	282	119	599	387
Roscommon	774	469	248	63	239	51	352	147

Table 22 (cont'd).

(e) Saginaw Bay

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Arenac	539	297	206	71	212	36	173	117
Bay	148	74	61	17	44	14	61	35
Clare	1249	565	606	184	352	120	495	320
Gladwin	285	261	20	3	169	4	105	6
Huron	236	92	137	46	70	31	67	76
Isabella	305	164	124	48	109	16	104	64
Midland	390	160	209	91	91	32	147	96
Saginaw	704	374	296	94	291	74	190	199
Sanilac	466	244	210	74	163	58	120	122
Tuscola	553	276	253	97	194	51	161	128

Table 22 (cont'd).

(f) Southwestern Lower Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Allegan	925	449	430	177	325	80	287	224
Barry	631	317	289	94	224	50	236	182
Berrien	87	43	41	20	17	10	32	11
Branch	75	33	42	14	22	8	28	19
Calhoun	199	91	96	36	58	17	71	53
Cass	354	161	176	73	87	34	136	82
Kalamazoo	606	265	296	113	191	68	186	167
Kent	201	100	87	36	72	21	60	46
Muskegon	163	74	78	19	47	17	72	46
Ottawa	115	53	46	10	39	16	37	27
St. Joseph	268	132	127	53	88	22	91	61
Van Buren	550	241	275	114	139	76	162	134

Table 22 (cont'd).

(g) South Central Lower Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Clinton	303	154	133	54	111	31	85	77
Eaton	148	68	69	35	48	12	37	27
Gratiot	185	103	71	30	87	15	42	38
Hillsdale	126	57	62	28	29	16	36	29
Ingham	220	98	103	33	70	24	68	64
Ionia	200	85	104	36	58	20	73	51
Jackson	505	230	248	109	145	53	163	124
Lenawee	117	57	55	21	38	12	36	32
Livingston	414	196	203	90	121	45	105	89
Montcalm	301	155	121	42	111	30	98	64
Shiawassee	374	164	185	76	123	43	104	100
Washtenaw	287	143	127	52	88	30	85	61

Table 22 (cont'd).

(h) Souteastern Lower Peninsula

County	Total Deer	Bucks	Antlerless	Fawns	Yearling Antlered	Yearling Antlerless	2.5+ Total Deer	Lactation
Genesee	1224	585	548	188	395	106	414	245
Lapeer	273	134	124	49	91	27	81	66
Macomb	61	35	23	10	19	6	16	10
Monroe	43	18	22	11	13	5	9	11
Oakland	270	133	124	47	89	27	83	66
St. Clair	433	163	261	81	107	71	148	155
Wayne	27	14	11	2	6	3	10	8

no records in a particular category or the data is insufficient to provide estimates with absolute error of less than 5%, 10%, or even 20% (Table 20). Less than half of the counties provide sufficient sample sizes to calculate any of the ratios in Table 18 to within 5%. These problems are not as significant on the management unit or regional levels. On all levels, although the data may appear to provide an accurate picture of the deer that are checked, the accuracy does not extend to a picture of the total harvest or the total deer population. As discussed earlier, the population of checked deer is not necessarily similar to the population of harvested deer.

Question 10: What errors does the database contain?

Significance

The MDNR field personnel record the biodata on datasheets (Appendix 1), which are then collected at the Lansing offices and transcribed into the computerized database (Appendix 2). Although several checks are run to check for logical errors (such as inconsistencies in the location information), the final SPSS data file may contain errors or inconsistencies that make data analysis difficult.

Methods

While working with the biodata, I discovered several problems that made some analyses difficult without additional cleaning of the data. Some of my observations are of errors or inconsistencies within the data. Others, however, are comments on missing information whose inclusion into the database may make possible several analyses that cannot currently be performed.

Results and Discussion

Quality checks are run on the biodata immediately after they are entered to check for inconsistencies in the location data (for example, checking for township and range coordinates that do not fall within the reported county). The checks, however, do not identify inconsistencies between the date reported in the "remarks" column and the season in which the deer was harvested. The date in the "remarks" column identifies the date on which the hunter or ager observed the lactation status of the deer. Although the date of harvest is not recorded in the biodata, the lactation date provides a close estimate of the harvest date for a small subset of the biodata. The lactation date should fall within the boundaries of the season in which the deer was harvested, or a few days thereafter, as it most likely reports the date on which the hunter dressed the deer. A comparison of the dates of the firearm and archery seasons and the date reported in the "remarks" column reveals that 2.87% of the regular firearm deer and 1.58% of the archery deer fall outside the bounds of their respective season (a total of 871 deer from 1993-1999). Although a few of these inconsistent records are probably caused by hunters not checking the deer until after the season ends, it is unlikely that this is true for all the deer, especially those reported several weeks after the season ended. This explanation also could not apply to deer reported *before* the season in which they were supposedly harvested. The hunters may be reporting the date wrong, or the recorder may be writing the date down wrong. These results suggest that a more accurate date to record for lactation status would be the date on which hunters harvest their deer, not the date they field-dress their deer.

Many of the variables contain inconsistencies that make comparisons among different categories within the variable or comparisons between different variables difficult. The most common is the notation used to indicate missing or illegible data. For many of the variables, '99' indicates missing data, but blanks are also used, and in the "tb" variable, '0' is used to indicate no data could be collected. Several different annotations for missing data make it difficult to determine exactly how many records are missing data. Compounding the problem is the practice of leaving the "cseason" column blank to indicate the deer was harvested during firearm season. When examined in the context of the rest of variables, the blank would appear to indicate the season is unknown.

In the comparison of the season dates and "remarks" dates, the firearm season had a greater percentage of inconsistencies than the archery season. The difference may be due to the fact that some "cseason" entries were left blank if the season was not reported or was unknown. The blanks would automatically place the deer in the firearm season, causing greater inconsistency in the firearm season than the archery season.

One easily remedied inconsistency is found in the annotation of dates. Dates are recorded in both the "remarks" column and the "date" column. In both cases, numbers less than 10 are recorded as both single and double digits (with a leading zero). For example, the date of January 1 may read as '1/1,' '01/01,' '01/1,' or '1/01.' Some dates in both columns may also include the year while others do not. These inconsistencies make recoding these dates into the "sep1days" column (number of days since September 1) and picking out individual dates difficult and tedious.

Since 1997, the MDNR has held late firearm seasons, generally sometime during the last two weeks of December through the first week of January. During the first year, data collected during the late season was recorded as the 'H' season (holiday season) while the season was recorded as 'L' (late season) during the following years. The different symbols made the data appear to have come from different seasons. In a similar case, some (fewer than 50 records) of the original data under the "prv_pub" variable were coded as '11' and '22' rather than 'PB' or 'PT' with no indication as to which code stood for private land and which stood for public land.

Other problems I observed in the database concerned the omission of data that may be necessary to include. One significant omission is the check station location for each deer. Each datasheet gives the name of the check station from which the data were collected. When the data are transcribed in the computer database, however, the check stations are lumped according to the district (1987-1997) or management unit (1998-1999) in which the station is located. Even the combinations are not consistent, however. Several check stations are recorded individually, including all highway check stations, the Marquette, Roscommon, and Lansing Field Offices, Drummond Island, and the Houghton Lake, Cusino, and Rose Lake Wildlife Research Stations. Identifying the individual stations at which each deer was checked would allow the MDNR to determine patterns of check station usage and identify those areas that need additional check stations or check stations that may be underused. Knowing the check station location for each deer could also aid in determining how many heads each station receives for TB testing to aid in planning to meet TB testing quotas. Check stations could also be individually evaluated for quality control. The original datasheets also include individual page and line numbers, which provides each entry with an individual code. Although these page and line numbers are included in the individual yearly databases, the comprehensive database of all years does not include these variables. This omission makes it impossible to track an entry back to the original datasheet if a question arises about the data.

A third type of data problem is the coding used to determine the antler status of the deer. Antlered deer are those deer with at least one antler greater than 3 inches long. All other deer are antlerless. Although this definition appears straightforward, two different variables code the deer into the 'antlered' and 'antlerless' categories and are not always consistent with one another. The original variable, "killtype," first lists antlered deer as all males that are not fawns, A, or AA. It then determines that all antlerless deer are all females (not age A or AA), all male fawns, and all males with spikes. All others (including only all A and AA deer) are considered unknown. I developed a second variable, "antler," which first lists antlered deer as all males with points but not short spikes. Antlerless deer are then listed as all females, all male fawns, and all males with spikes. The unknowns are then all non-fawn males missing points data (including those coded as '99' in the "points" column) and all males with a 'B' in the "points" column. The primary inconsistencies in the two variables lie in the 'unknown' category. If "antler" and "killtype" described antler status in the same manner, Table 23 would have totals along the diagonal and zeros elsewhere. As they stand, the variables are not consistent with one another. The "killtype" variable lists five deer as 'bucks' which the "antler" variable lists as 'antlerless,' but the primary inconsistencies in the two variables lie in the 'unknown' designation. The "killtype" variable describes only deer of unknown age as having unknown antler status (Table 23). The "antler" variable codes deer with unknown age in the same manner as deer with known ages, and describes only males with broken antlers as having unknown antler status.

Table 23. Crosstabulation of records between the "antler" variable and the "killtype" variable.

		"Antler"			
		Unknown	**Antlered**	**Antlerless**	**Total**
"Killtype"	**Unknown**	1625	32061	12176	**45862**
	Bucks	14553	203432	0	**217985**
	Antlerless	184	5	126965	**127154**
	Total	**16362**	**235498**	**139141**	**391001**

Conclusions

The check station biodata can be used to estimate population parameters and to develop population indices of Michigan's deer population. Direct counts of the total deer population are impossible and impractical due to the size of the state and the number of deer in the population. Hawn and Ryel (1969) compared a direct count survey with a sampling survey of harvest estimates in Michigan and found that the sampling survey was more efficient and more accurate than the direct count. Measurements of such aspects of the deer population as antler dimensions or lactation status are likewise impossible on every individual deer. The check station surveys can therefore save valuable financial and personnel resources while providing accurate data. The biodata allow wildlife managers to draw inferences about the true population based on data collected from a fraction of the population. The biodata, however, cannot be used confidently unless their biases and limitations are understood.

This evaluation identified several compositional, spatial, and seasonal biases in the biodata.

- Hunters tend to check a greater proportion of the harvested antlered deer than of the harvested antlerless deer.
- Counties with at least one check station tend to have a greater number of checked deer than those without check stations.
- The TB surveillance counties check a greater percentage of their harvested deer than other counties.
- Deer harvested during the firearm season are more likely to be checked than deer harvested during the archery season.

- In the LP, hunters are more likely to check deer harvested on public land than those harvested on private land.

Although some biases are inherent in the voluntary checking system, the biodata can still provide valuable information about Michigan's deer. The lactation data or beam diameter data could be used to provide indices of herd health. Other data could be used to compare the harvest composition between different years or geographic areas. The geographic distribution of the biodata could also be examined in conjunction with ecological data to delineate ecologically significant areas that contain sufficient sample sizes for statistical analyses. Such areas could take the place of the current DMUs, which are too variable and sometimes too small for statistical analyses. Burgoyne (1981) argues that biased data can still be used in developing estimates or indices of population size.

The quality of the biodata can also be improved, and the effects of biases can be reduced. Estimates derived using the biodata may have greater precision if the values are weighted by the harvest levels of the particular geographic area or by the seasonal distribution of the data. Further study is necessary to determine if such estimates would be more accurate than those calculated without weights. The distribution of the check stations could be examined and reorganized to increase the percent of deer checked and to decrease the effects of spatial biases. The MDNR could educate hunters on the importance of checking their deer and the value of the data collected. Such an education program could increase participation and decrease compositional or seasonal biases. Increased efforts in personnel training and in planning could also decrease the occurrence of errors in the collection and transcription of the data. The biodata are a valuable resource for Michigan's deer managers and every effort should be made to maintain or improve the quality and utility of these data.

CHAPTER 3

THE LACTATION SURVEY EVALUTION

Introduction

At voluntary deer check stations, the MDNR has collected data since 1993 on the number of female white-tailed deer who show evidence of lactation. Ideally, the data could be used as an indicator of the state of the herd based on the assumption that higher reproductive rates, especially within the yearling population, indicate a healthy herd. Doe fawns will not breed at 6 months old unless they have reached a minimum body size; the quality of the habitat and the density of the herd determine the percentage of doe fawns who reach puberty during their first year (Jacobson 1994). Thus, high yearling reproductive rates would indicate sufficient high quality food for the deer population. Antler measurements are also an indicator of herd health (Severinghaus et al. 1950, Richie 1970). Correlations between average buck antler size and doe lactation rates could support the use of lactation rates as an indicator of herd health. A second projected use of the data is as an estimate of annual recruitment, assuming that only those does whose fawns have survived through the entire summer will still be lactating during the hunting season, when the lactation data are collected. I examined the distribution and abundance of the lactation data, the accuracy of the data, how the data could be used in deer population management, and on what temporal and spatial scales the data provide the most accurate and useful information.

Methods

The source of the data examined in this study are check-station records collected between 1993 (the year lactation data were first recorded in Michigan) and 1999. The records are stored as an SPSS file that contains the biophysical data from all check station records from 1987 to 1999. I eliminated all records that did not contain lactation data, all data from fawns and any deer whose age was recorded as 'A' (not a fawn but cannot be aged), and any record where the date of observation of lactation was recorded as later than the date the form was completed (due to some transcription or typographical error).

I sorted the data to determine how it was distributed among several different categories including age, year killed, geographic location, and season the lactation data were collected. For most analyses the deer were divided into 3 age categories: 1.5 years old, 2.5 years old, and 3.5 years old and older. The division excluded the data from deer classified as 'AA' (2.5 years old or older), which made up less than 10% of the data in each year. Geographic divisions were based on Wildlife Division management units and regions, first designated in 1998 (Figure 1). Data collected before 1998 were assigned to the appropriate management unit based on the county in which the deer was reported killed. The regional boundaries were based on the ecoregions defined by the MDNR (Figure 1). Seasonal divisions used were October 1-31, November 1-14, November 15-22, and November 23-30. Seasonal divisions were assigned based on the date that evidence of lactation was or was not observed, recorded in the "Remarks" column of the Deer Physical Data sheet (Appendix 1).

I chose the divisions used in the final analyses because they contained a sufficient number of records. Minimum required sample sizes were calculated using the following equation:

$$n = (z^2_{\alpha/2}p(1\text{-}p))/E^2$$

where $z_{\alpha/2}$ is the value on the standard normal curve that correlates to (1-α) percent confidence, p is the proportion of lactating does, and E is the desired margin of error (measured as an absolute percent) (Wackerly et al. 1996). In a binomial distribution, if p is unknown, a p value of 0.5 is used to calculated minimum required sample size because it provides maximum variance. Data are already available on the lactation rates, however, and they can provide an estimate of p, which can be used in the above formula to provide smaller required sample sizes.

After determining the appropriate scales on which to analyze the lactation data, I examined the trends in lactation rates associated with age and geographic location. I also tracked annual trends in lactation rates. Finally, I determined the correlation between annual lactation rates of yearlings and adults and the average annual beam diameter of yearlings and adults.

Results

Lactation data are available on approximately 76% of all mature does (1.5 years old and older) that came through the check stations between 1993 and 1998, resulting in a final sample size of 37,100. Annual sample size increased 503% from 1993 (n=1,923) to 1999 (n=9,665), largely due to an increase of 363% in the number of female deer checked during the same years. Hunters' observations of the presence or absence of milk when field dressing the deer provided 98.1% of the lactation data. Check station workers collected the remaining data while completing the physical data sheet entry on the animal. The quality of the lactation data is therefore dependent on the hunters' ability to correctly identify whether or not a deer is lactating and accurately report their observations at the check stations.

If the hunters assign the deer into one category or another without sufficient observation to determine the true state, the data would not adhere to basic biological patterns. The dates of weaning should vary among the deer due to differences in birth date, experience of the mother, and environmental conditions. The variation should cause the percent of deer reported lactating to decrease as the hunting season progresses, if the lactation status is not assigned randomly. The percent of lactating deer does decrease from October to December (Figure 27). Ozoga et al. (1994) report that only 5% to 60% of doe fawns breed each year while more than 95% of older does breed. The available lactation data reflect this situation and show that the percent of lactating yearlings during the hunting season is lower than that of the older does (Figure 28). The above evidence suggests the hunters do not randomly assign lactation status; they appear to be able to determine accurately the lactation status.

Assuming maximum variance, a sample size of 385 gives an estimate accurate to within 5% with 95% confidence. A sample size of 96 gives an estimate accurate to within 10% with 95% confidence. When the available lactation data are used to estimate the true variance, smaller sample sizes are required and vary depending on the estimate used. I looked at both the optimum sample sizes and the estimated required sample sizes

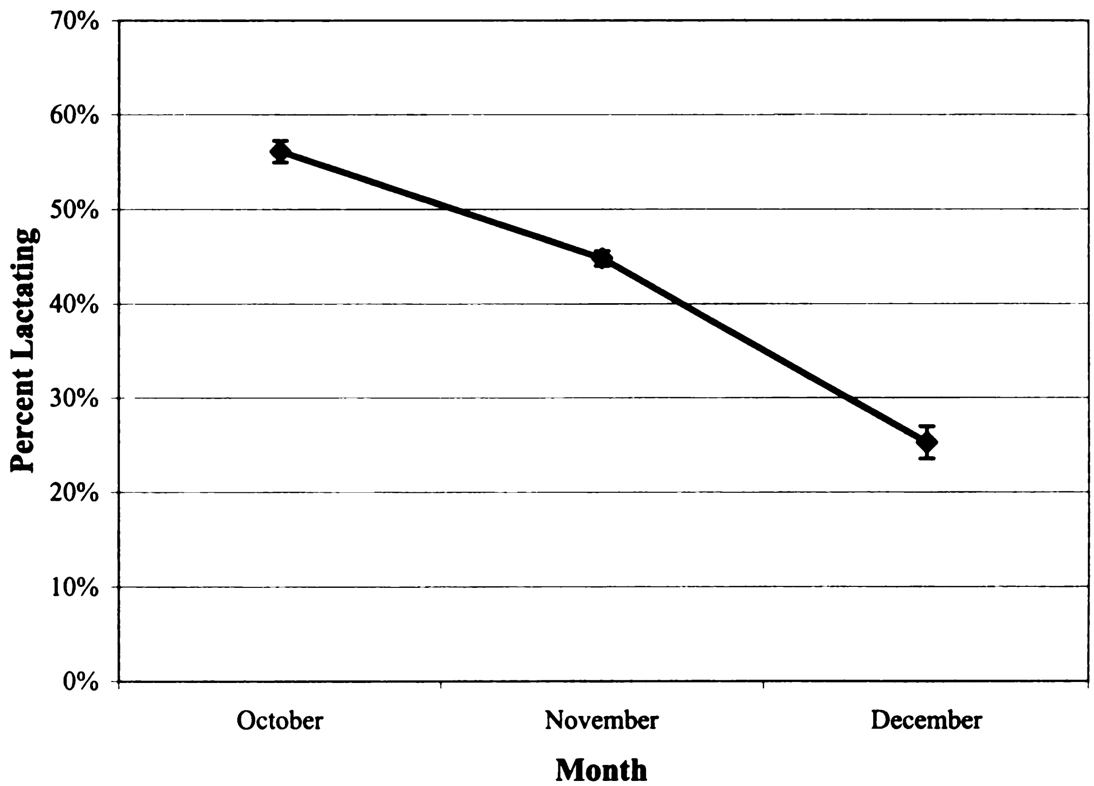


Figure 27. Percent of adult females lactating in Michigan from October to December, averaged from 1993-1999. Error bars are ± 1 standard error.

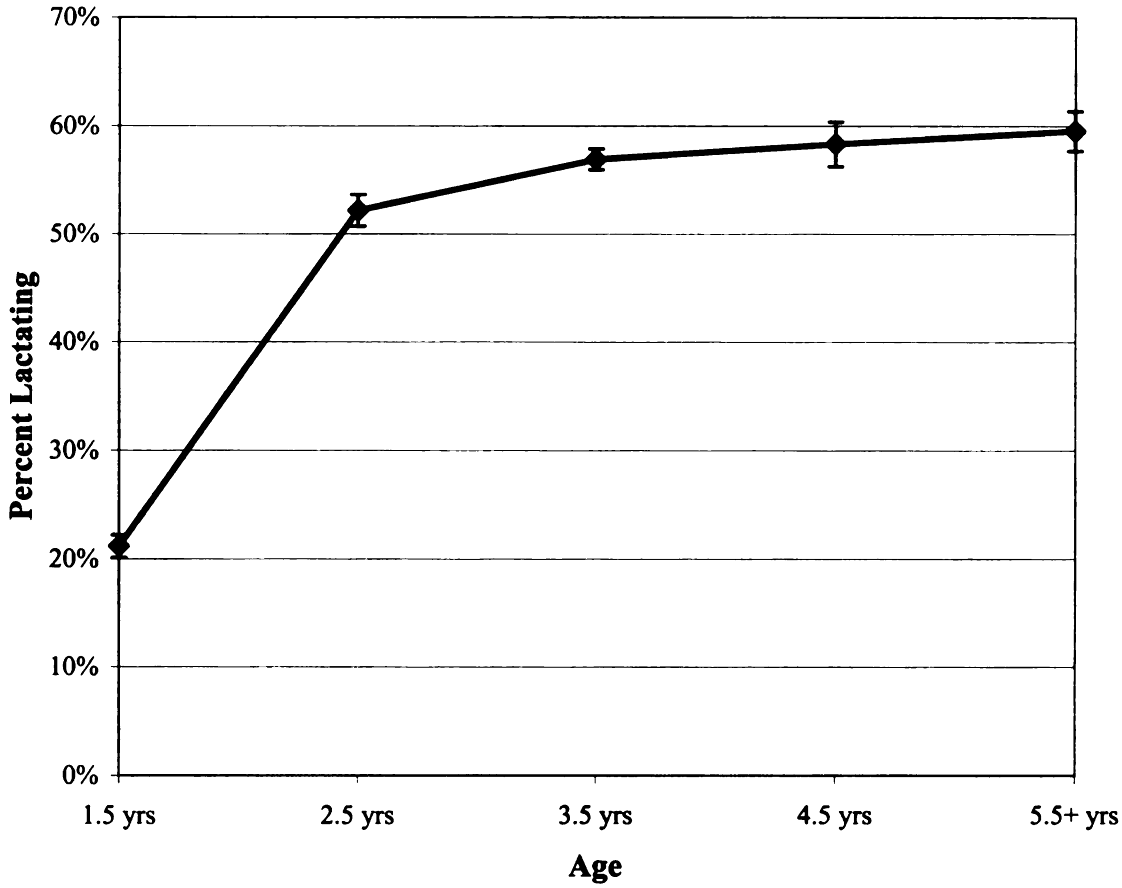


Figure 28. Percent of females in Michigan lactating in each age class (averaged from 1993-1999 using data from all seasons combined). Error bars are ± 1 standard error.

to determine whether the data are sufficiently abundant when divided into different geographical areas, years, and seasons.

The earliest available lactation data should provide the most precise and representative estimate of true reproductive rates because the percent of lactating deer decreases as the season progresses (Figure 27). Data from October and early November would thus be the most useful, but the sample sizes are generally much smaller than those from the November firearm season (November 15-30). The first 2 weeks in November do not provide sufficient data to be statistically useful. A chi-square test demonstrates that there is a significant decrease in the lactation rates from the first to the second week of the firearm season (Table 24). The October data and the first week of firearm season therefore provide the most potentially useful lactation data. The largest sample sizes, and therefore the smallest margins of error, are found in the regional Firearm Week 1 data (Table 25). Among the management units, the Eastern UP and the Southeastern LP sample sizes are generally too small to provide accurate estimates of lactation rates (Table 25).

The October data can be used to estimate the minimum proportion of lactating does in each region. Percent of lactating does increases with increasing age within the 3 regions and decreases with increasing latitude within the state (Figure 29). The lactation rate for 1.5 year old does in the Southern LP is twice that of the 1.5 year old does in the northern regions of Michigan. While the difference is not as dramatic in the older age categories, the percentage of lactating does in the northern regions is consistently lower than in the Southern LP. Between the first and second years of life, reproductive effort

Table 24. Results of a chi-squared test comparing the proportion of lactating does in the first week of firearm season to that of the second week of firearm season.

Region	Age	χ^2 value	df	p-value
Upper Peninsula	**1.5**	0.212	1	0.645
	2.5	0.547	1	0.460
	3.5+	11.313	1	0.001
Northern Lower Peninsula	**1.5**	2.706	1	0.100
	2.5	3.637	1	0.057
	3.5+	10.036	1	0.002
Southern Lower Peninsula	**1.5**	1.181	1	0.277
	2.5	44.254	1	<0.001
	3.5+	22.27	1	<0.001

Table 25. Average annual number of lactation records and the average annual margin of error associated with the estimates of the percent of does lactating in each region and management unit. The margins of error are based on absolute percentages. All values are averaged from 1993-1999.

		October		Firearm Week 1	
Region/Unit	**Age**	**n**	**Error**	**n**	**Error**
UP	1.5	23.9	12.95	92.6	6.44
	2.5+	71.0	11.40	293.1	6.53
Northern LP	1.5	144.9	7.57	389.7	4.33
	2.5+	377.6	6.00	1174.0	3.70
Southern LP	1.5	106.6	9.58	407.3	4.55
	2.5+	154.3	6.82	654.6	3.91
Western UP	1.5	35.0	16.08	138.3	6.58
	2.5+	68.7	12.89	332.0	6.75
Eastern UP[a]	1.5	48.3	11.74	207.9	15.74
	2.5+	125.6	28.42	515.4	21.89
Northwestern LP	1.5	82.9	15.46	166.1	8.75
	2.5+	185.6	10.42	390.9	8.55
Northeastern LP	1.5	32.0	10.47	137.5	5.69
	2.5+	59.4	8.77	299.3	4.90
Saginaw Bay	1.5	48.9	15.01	216.3	8.94
	2.5+	132.5	11.02	543.5	7.00
Southwestern LP	1.5	85.8	15.71	155.2	6.37
	2.5+	201.4	9.23	400.1	5.49
Southcentral LP	1.5	29.4	17.53	136.8	8.97
	2.5+	58.0	15.45	306.9	7.69
Southeastern LP	1.5	53.7	24.66	242.4	20.71
	2.5+	147.3	20.18	616.6	15.80

a. No lactation records were recorded from the Eastern UP during the firearm seasons of 1997 and 1998 so these years are not included in the averages of n and the margin of error.

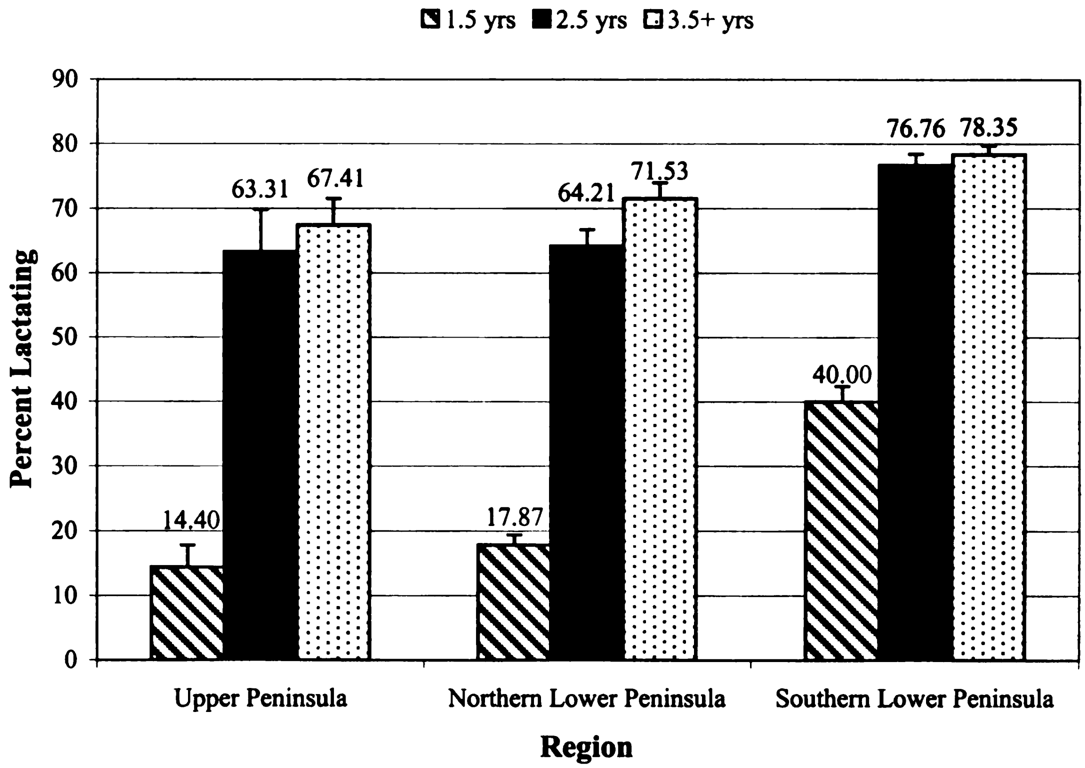


Figure 29. Percent of females lactating in each age class and in each region (averaged from 1993 -1999 using October data). Error bars are + 1 standard error.

apparently doubles in the Southern LP and triples and quadruples in the Northern LP and UP respectively.

Although the large categories are useful for observing general trends, smaller categories, such as by year and management unit, are useful for observing annual fluctuations and developing area specific management plans. Annual division by region provides larger datasets than the management units and provide smaller margins of error (Table 25). October data can also be used for better minimum estimates. Plots of trends in the percent of lactating does over the past 6 years, as measured during October, reveal annual variation, especially in the UP (Figure 30, Table 26). The greater variation in the UP may be due to the smaller sample sizes in the region, or it may reflect greater effects of climatic fluctuation on the deer population. The fluctuations in annual proportion of lactating does of the different age categories track each other fairly closely, indicating that the deer of different age classes are generally affected in the same manner by environmental variations.

When divided by age class, the sample sizes the first week of firearm season provide margins of error of less than 10% in all 8 management units except the Eastern UP and Southeastern LP units (Table 25). The October data provides margins of error of less than 20%, again except in the Eastern UP and the Southeastern LP (Table 25). The firearm data of the management units reflect the same pattern as the regions of increasing lactation rates with increasing age (Table 27). The northern management units also tend to have lower lactation rates (Table 27).

Among the yearling population, there were no significant correlations between lactation rates and antler beam size. Contrary to expectations, the UP and Southern LP

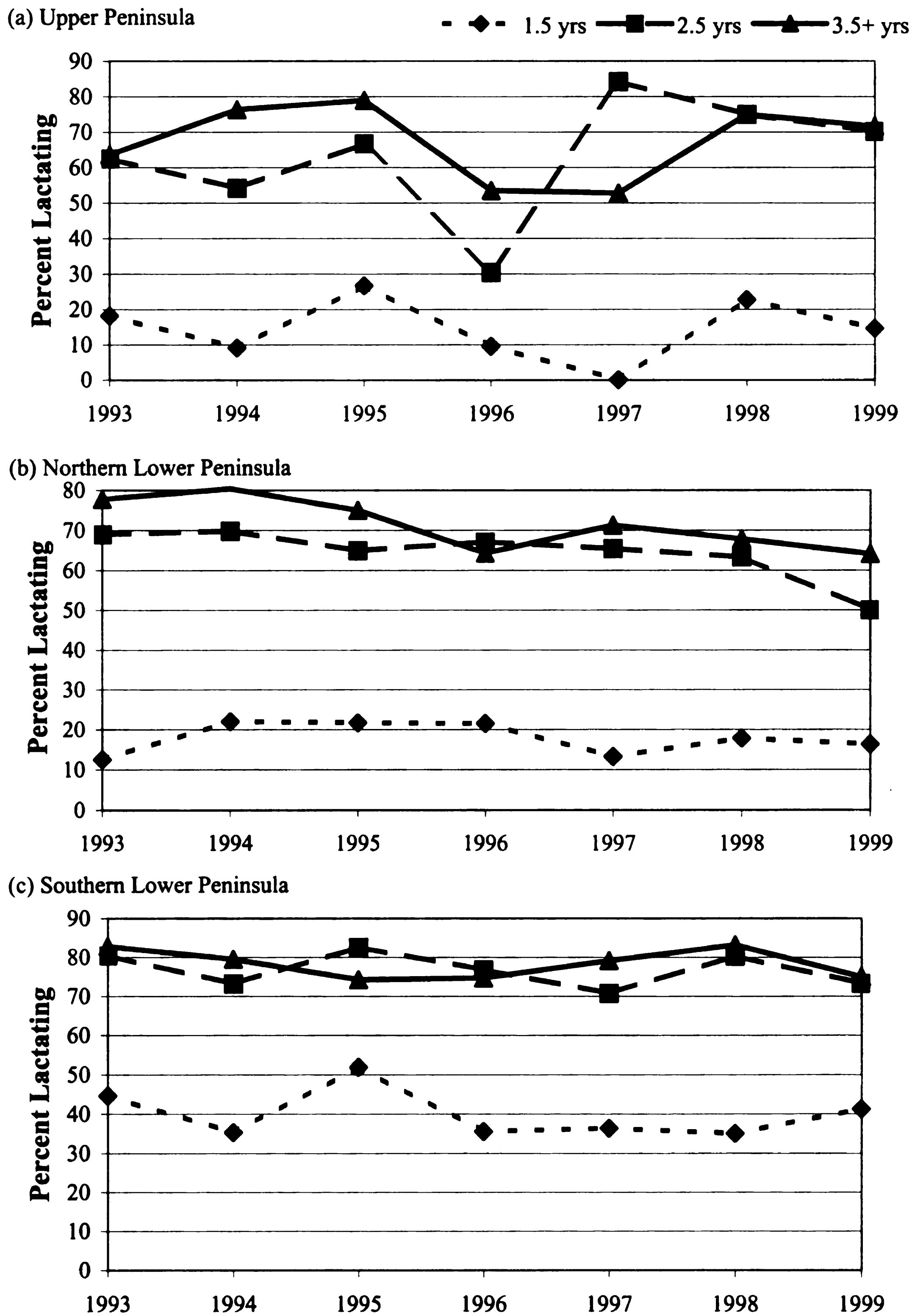


Figure 30. Percent of females lactating from 1993 to 1999 in each age class and in each region (using October data). (Exact values and sample sizes can be found in Table 26.)

Table 26. Percent of does lactating from 1993 to 1999 in each region and associated sample sizes. Data are from October.

		1993		1994		1995		1996		1997		1998		1999	
Region	**Age**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**
UP	**1.5**	18.18	11	9.09	22	26.67	30	9.52	21	0.00	13	22.73	22	14.58	48
	2.5	62.50	16	54.17	24	66.67	15	30.43	23	84.21	19	75.00	8	70.21	47
	3.5+	63.64	22	76.36	55	78.95	38	53.49	43	52.78	36	75.00	36	71.64	67
Northern	**1.5**	12.50	40	22.00	50	21.70	106	21.52	79	13.24	136	17.84	370	16.31	233
LP	**2.5**	68.97	29	69.81	53	64.94	77	67.09	79	65.38	130	63.31	357	50.00	244
	3.5+	77.78	36	80.39	51	75.00	84	64.29	84	71.29	209	67.82	637	64.11	418
Southern	**1.5**	44.62	65	35.29	68	51.89	106	35.56	90	36.36	154	35.00	120	41.26	143
LP	**2.5**	80.43	46	73.17	41	82.54	63	76.81	69	70.75	106	80.28	71	73.33	90
	3.5+	82.76	29	79.49	39	74.24	66	74.70	83	79.12	91	83.13	83	75.00	80

Table 27. Percent of does lactating from 1993 to 1999 in each management unit and associated sample sizes. Data are from Firearm Week 1.

		1993		1994		1995		1996		1997		1998		1999	
MU	**Age**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**	**% Lac**	**n**
Western UP	**1.5**	4.35	46	7.46	67	16.08	199	6.25	80	9.43	53	14.89	47	9.65	114
	2.5	46.67	30	48.28	29	47.65	149	31.52	92	42.11	57	47.22	36	44.44	126
	3.5+	57.97	69	53.97	126	59.42	382	46.94	196	53.21	109	69.57	92	61.09	239
Eastern UP	**1.5**	0.00	1	25.00	4	22.22	9	4.76	21		0		0	0.00	7
	2.5	50.00	2	0.00	1	45.45	11	31.71	41		0		0	28.57	7
	3.5+	25.00	4	50.00	10	48.00	25	53.23	62		0		0	50.00	20
Northwestern LP	**1.5**	4.76	21	20.00	10	16.33	147	19.86	146	17.14	175	14.43	201	15.89	258
	2.5	61.54	26	60.00	5	53.16	79	43.87	155	47.85	186	50.31	159	50.38	262
	3.5+	51.28	39	37.50	8	50.29	173	51.86	295	56.90	348	59.01	322	57.55	457
Northeastern LP	**1.5**	4.60	87	15.38	39	12.82	78	16.22	148	10.42	144	14.25	442	10.38	578
	2.5	47.27	110	38.89	36	48.19	83	46.75	169	42.86	140	40.39	406	44.23	529
	3.5+	62.91	213	66.22	74	57.45	141	57.47	308	56.86	401	50.42	954	48.80	1127
Saginaw Bay	**1.5**	26.92	26	13.73	51	22.06	68	18.67	75	20.13	149	23.50	183	16.59	229
	2.5	50.00	18	58.70	46	64.47	76	48.81	84	60.61	132	57.75	142	51.15	217
	3.5+	76.32	38	59.15	71	58.70	92	58.06	124	61.35	163	67.01	197	59.15	306
Southwestern LP	**1.5**	35.07	134	29.29	140	28.99	207	22.46	236	24.28	243	30.42	240	30.62	209
	2.5	68.83	77	64.94	77	67.86	140	69.66	145	63.64	132	74.44	180	57.65	170
	3.5+	69.74	76	74.77	111	66.42	134	67.06	170	69.95	183	67.96	206	65.28	193
South Central LP	**1.5**	37.50	48	27.85	79	27.66	94	30.00	110	33.10	142	29.87	154	20.00	140
	2.5	59.26	27	64.29	42	72.55	51	56.52	46	60.64	94	56.82	88	53.15	111
	3.5+	68.75	32	63.41	41	65.00	80	59.79	97	54.84	124	63.71	124	59.13	115
Southeastern LP	**1.5**	33.33	6	8.33	12	18.18	11	23.08	13	33.33	33	43.75	32	21.95	41
	2.5	100.00	5	69.23	13	100.00	4	53.85	13	69.23	13	72.22	18	64.29	28
	3.5+	100.00	2	85.71	7	100.00	7	44.44	9	66.67	12	86.36	22	72.22	18

had weak negative correlations (Figure 31). Among the adult (2.5+ years old) population, only the UP had a significant ($p = 0.0028$) correlation between mean beam diameter and the proportion of does lactating (Figure 32). Although the Northern LP and Southern LP had only weak correlations, both correlations were positive.

Discussion

One of the proposed uses of the lactation data is to estimate annual recruitment, the number of fawns who survive from birth until hunting season, by using the assumption that the number of lactating does reflects the number of surviving fawns. Unfortunately, several unknowns and wide variability prevent the use of the lactation data in this way. Does that give birth to 2 or 3 fawns will continue to lactate even if they have lost 1 or 2 fawns, so long as at least one fawn still lives. The lactation data cannot distinguish among these possibilities. One significant unknown is how long a doe continues to produce milk, even after she has lost all her fawns. Does that are lactating in October or November may not have a surviving fawn but may still be producing milk. We also do not know when fawns are weaned. If a doe is not lactating during the hunting season, it could be because she lost her fawn several months earlier, or because her fawn survived to hunting season and has been weaned. The lactation data are therefore not useful as an estimate of deer recruitment.

The data appear to accurately reflect the lactation status of the deer that come through the check stations (see Results), so they may be useful as a minimum estimate or an index of reproductive success. In several categories of the data, the significant decrease in the proportion of lactating deer between the first and second week of firearm

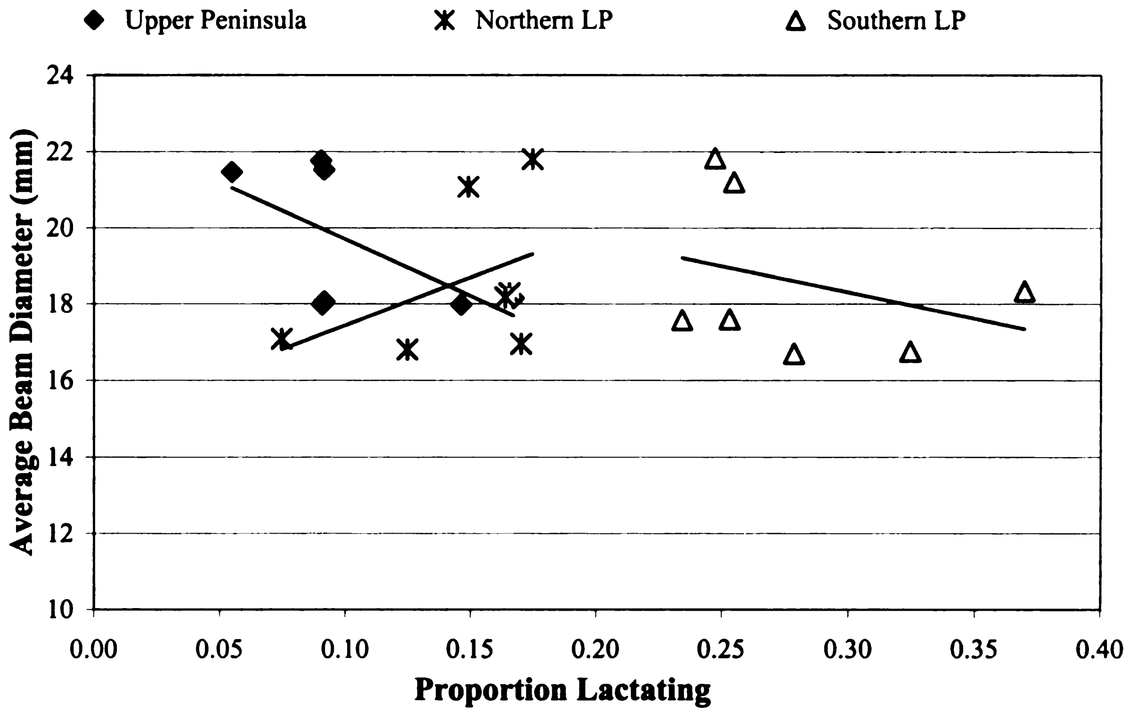


Figure 31. Correlations between the annual average beam diameter and proportion of lactating does (from October data) among yearlings. (UP: r^2=0.3668, p=0.1495; NLP: r^2=0.1929, p=0.3241; SLP: r^2=0.1044, p=0.4796).

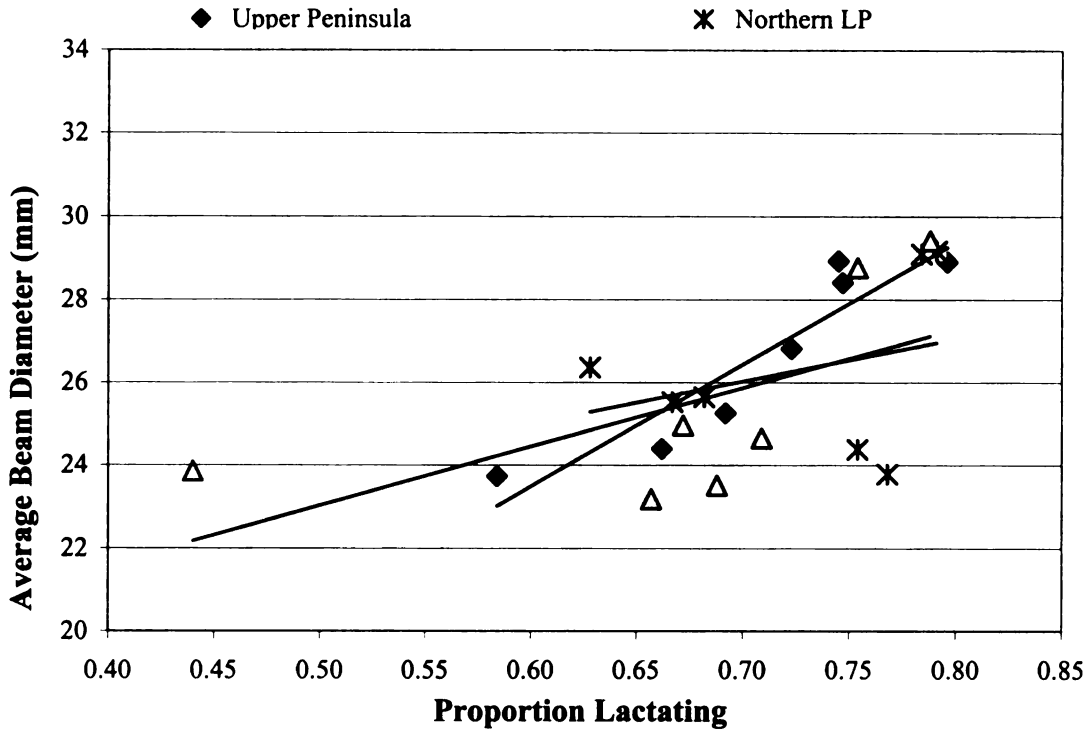


Figure 32. Correlations between the annual average beam diameter and proportion of lactating does (from October data) among adults (2.5+ years old). (UP: r^2=0.8561, p=0.0028; NLP: r^2=0.0971, p=0.4964; SLP: r^2=0.3909, p=0.1332).

season suggests that the first week of firearm season will provide the more precise estimates (Table 24). The October and Firearm Week 1 data provide sufficient sample sizes to be useful (Table 25). The October data are most useful as a minimum estimate of reproductive success, because they provide the earliest available estimates of the number of lactating does. Lactation rates drop dramatically after the minimum duration of lactation of 4 months for does with living fawns (Scanlon 1978). Most Michigan does give birth in late May or early June (Ozoga et al. 1994) so lactation rates would start to decline during October. The November data provide larger sample sizes for a shorter period of time, but by mid November the observed lactation rates no longer accurately reflect the true proportion of does whose fawns survived through the summer. The November data therefore do not reflect even the minimum number of reproductively successful does, but could be used as an index of reproductive success.

The October data show that almost 80% of does 2.5 years old and older are reproductively active in the Southern LP (Table 26). The Southwestern and Southeastern LP deer populations have especially high lactation rates (Table 27). What may be more significant is the high levels of yearling reproductive effort, which reaches a maximum of almost 40% in the Southern LP and at least 15% to 20% throughout the UP and Northern LP (Figure 30, Table 26). Yearlings generally only reproduce when resources are abundant and environmental conditions are favorable (Jacobson 1994). Such high levels of yearling reproductive effort are a sign of a healthy deer herd. The annual variation in the percent of does lactating at both the regional (Figure 30, Table 26) and management unit (Table 27) levels suggests that the health of the herd may be susceptible to climate, population density pressures, or other variable factors. The sudden drop in lactation rates in the fall of 1996, especially in the UP (Figure 30a, Table 26), may reflect the severe winter of 1995-1996 (Langenau 1996). The lower lactation rates in the Northeast LP management unit as compared to the Northwest LP management unit, especially among the 1.5 and 2.5 year old deer (Table 27), may reflect the higher population densities in the Northeast management unit.

Ozoga et al. (1994) suggested using both productivity and antler size as indicators of herd health. Although both productivity rates, as measured by lactation rates, and antler size, as measured by beam diameter, should increase as habitat conditions improve, the 2 indicators are not significantly correlated with one another at all among yearlings (Figure 31) and only in the UP among adults (Figure 32). The same habitat factors that affect the reproductive success of does may not have similar effects on the antler development of bucks. Once a doe has lost her fawn due to harsh winter conditions, she is not able to become pregnant again, so high quality summer habitat and climate conditions will not increase her chance of reproductive success. On the other hand, a buck who has experienced harsh winter conditions can benefit from higher quality summer conditions and still develop large antlers, regardless of the previous winter's conditions. These differences may be contributing to the lack of correlation between lactation rates and beam diameters.

Although the lactation data are not useful as an estimate of deer recruitment, they do provide some indication of the variation of reproductive effort across age, geographic, and annual divisions. More data need to be collected in October from the UP, especially the Eastern UP, and the Southeastern LP to provide more accurate estimates of lactation rates. Data recorded earlier in the autumn would provide more exact estimates of reproductive success, but collecting such data would be expensive and time-consuming. Using the October regional data as a minimum estimate and the Firearm Week 1 management unit data as an index of reproductive success are the most reasonable uses of the available lactation data. These uses would provide sample sizes large enough to examine both annual and regional differences

CHAPTER 4

THE WINTER SEVERITY INDEX EVALUATION

Introduction

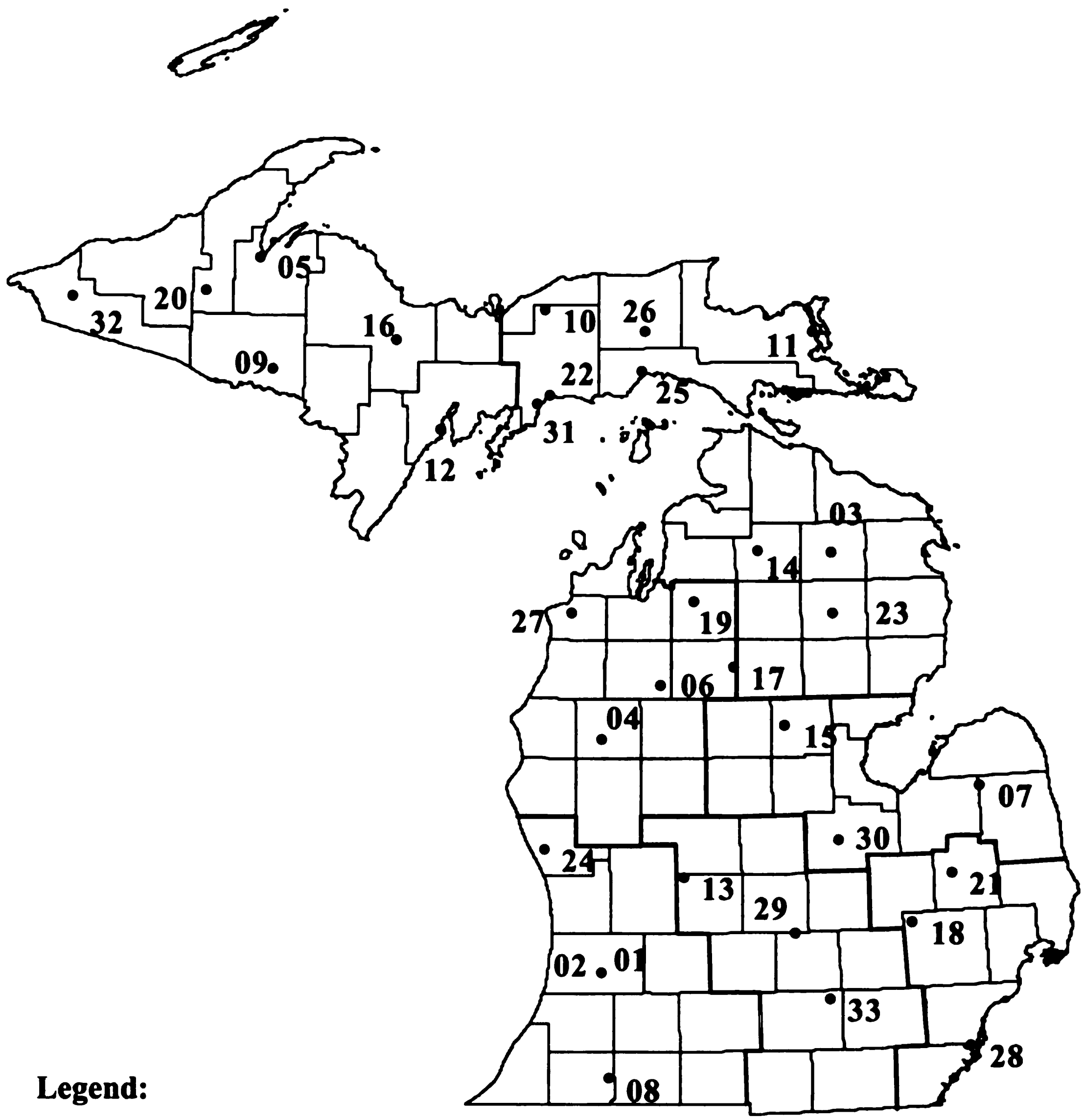
White-tailed deer survive harsh northern winters by taking shelter in cedar swamps and hemlock stands and by supplementing their stored fat reserves with winter browse (Ozoga et al, 1994; Langenau, 1996). Even so, white-tailed deer populations suffer annual winter losses, especially during long or especially severe winters. Cold weather and windy conditions increase body heat loss, and deep snow covers browse and causes deer to expend more energy when searching for food (Verme, 1968). Verme (1968) recognized these conditions as the major factors contributing to winter deer mortality and devised a winter severity index (WSI) to measure the harshness of the winters on a scale that would reflect the conditions actually experienced by the deer.

Using Verme's (1968) index, the MDNR has measured the WSI for the UP and Northern LP since the winter of 1969-1970 (henceforth winters will be identified by the first of the 2 years) and in the Southern LP since 1988. Currently the WSI is used primarily to explain observations of high winter mortality and low reproductive success, especially of yearlings. The WSI could also be useful as a predictive tool of harvest numbers, lactation rates, proportion of yearlings in the population, doe to fawn ratios, and winter losses. Such uses for the WSI are possible only if the data are reliable and collected in a consistent and statistically valid manner. This study examined the methods used to collect the WSI data, the accuracy of the data, and how the data may be useful in predicting various measures of the white-tailed deer population of Michigan.

Methods

The MDNR collects WSI data using the technique devised by Verme (1968). A chillometer measures atmospheric chill, and a compaction gauge measures the potential of the snow for supporting a deer. Weekly measurements from both devices are combined to form a weekly value, and a final cumulative value of all weekly values is determined at the end of the winter. As of 1999, the MDNR collected WSI data from 10 stations in the UP, 8 stations in the Northern LP, and 12 stations in the Southern LP (Figure 33). The exact number and location of stations varies slightly from year to year, however (Figure 34). The data are collected and summed weekly for each station to provide that station's cumulative WSI value. At the end of the winter, the cumulative WSI values from each of the stations in a region are averaged to provide the final WSI value for that region. The MDNR stores the weekly cumulative station values and regional averages in Excel files that contain the WSI data from all years and in individual files separated by year.

The MDNR stores only the cumulative values, so I first created a non-cumulative weekly WSI value for each station. I subtracted from each weekly value the cumulative value of the previous week. In some cases, large negative values resulted from the subtraction; in such cases I eliminated that station's data from that year's average total WSI value because the data must have been gathered or recorded incorrectly. I numbered each data collection date by the number of days since November 1. A plot of the range of data collection days for all years in all regions (Figure 35) shows that the data most consistently cover the time frame from day 42 (December 13) to day 168 (April 18 or April 17 in leap years). I then created new cumulative WSI values (henceforth referred to



Legend:

01 Allegan Forest
02 Allegan Farm
03 Atlanta
04 Baldwin
05 Baraga
06 Cadillac
07 Cass City
08 Crane Pond
09 Crystal Falls
10 Cusino
11 Dunbar
12 Escanaba
13 Flat River
14 Gaylord
15 Gladwin
16 Gwinn
17 Houghton Lake (Porter Ranch)
18 Holly
19 Kalkaska
20 Kenton
21 Lapeer
22 Manistique
23 Mio
24 Muskegon
25 Naubinway
26 Newberry
27 Platte River
28 Pointe Moillee
29 Rose Lake
30 St. Charles
31 Thompson
32 Wakefield
33 Waterloo

Figure 33. The WSI station locations.

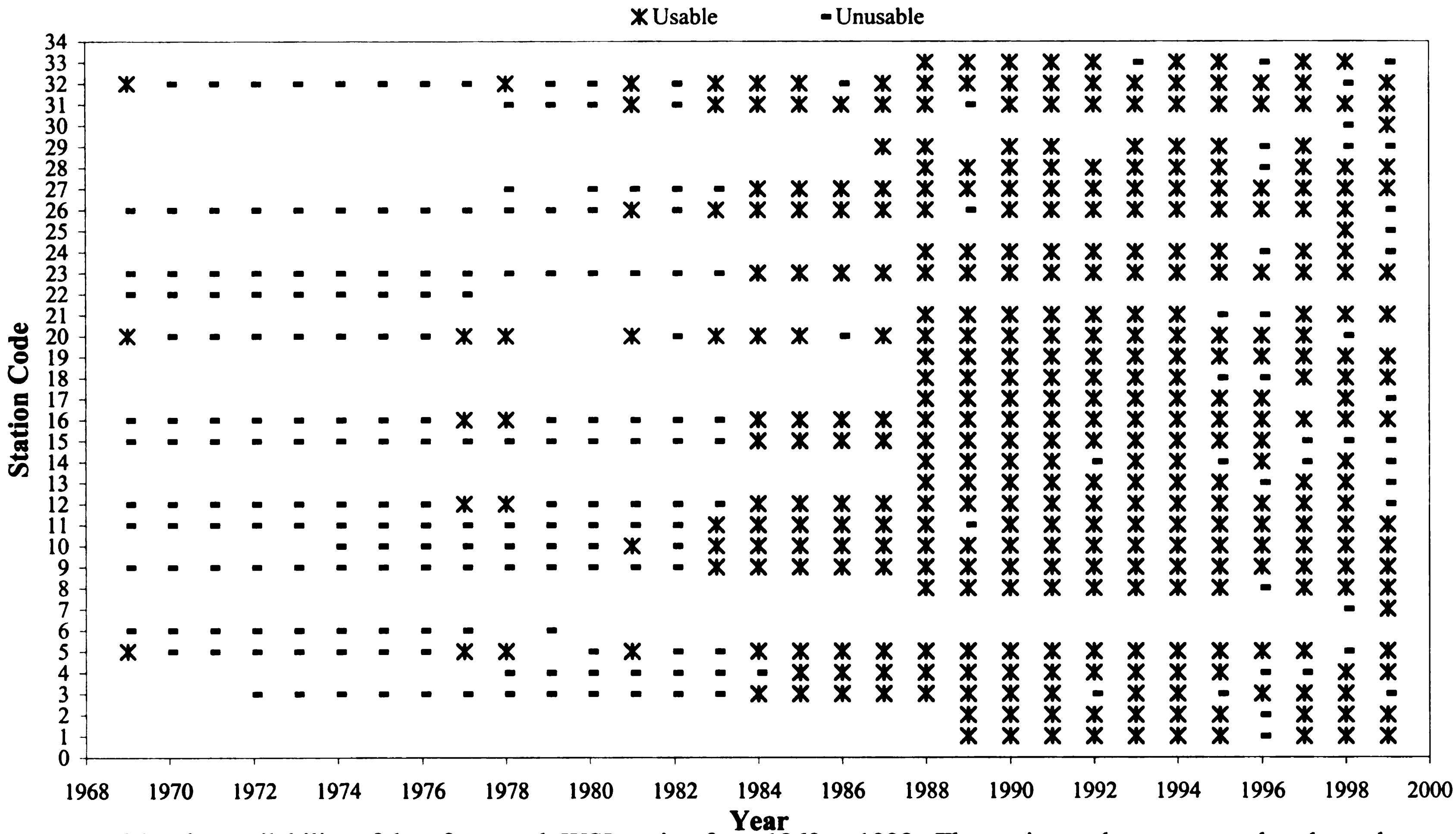


Figure 34. The availability of data from each WSI station from 1969 to 1998. The station codes correspond to the codes from Figure 33. A station with usable data indicates data were collected and used in the corrected WSI value. A station with unusable data indicates data were collected but could not be used in the corrected WSI value. A blank space indicates data were not collected that year.

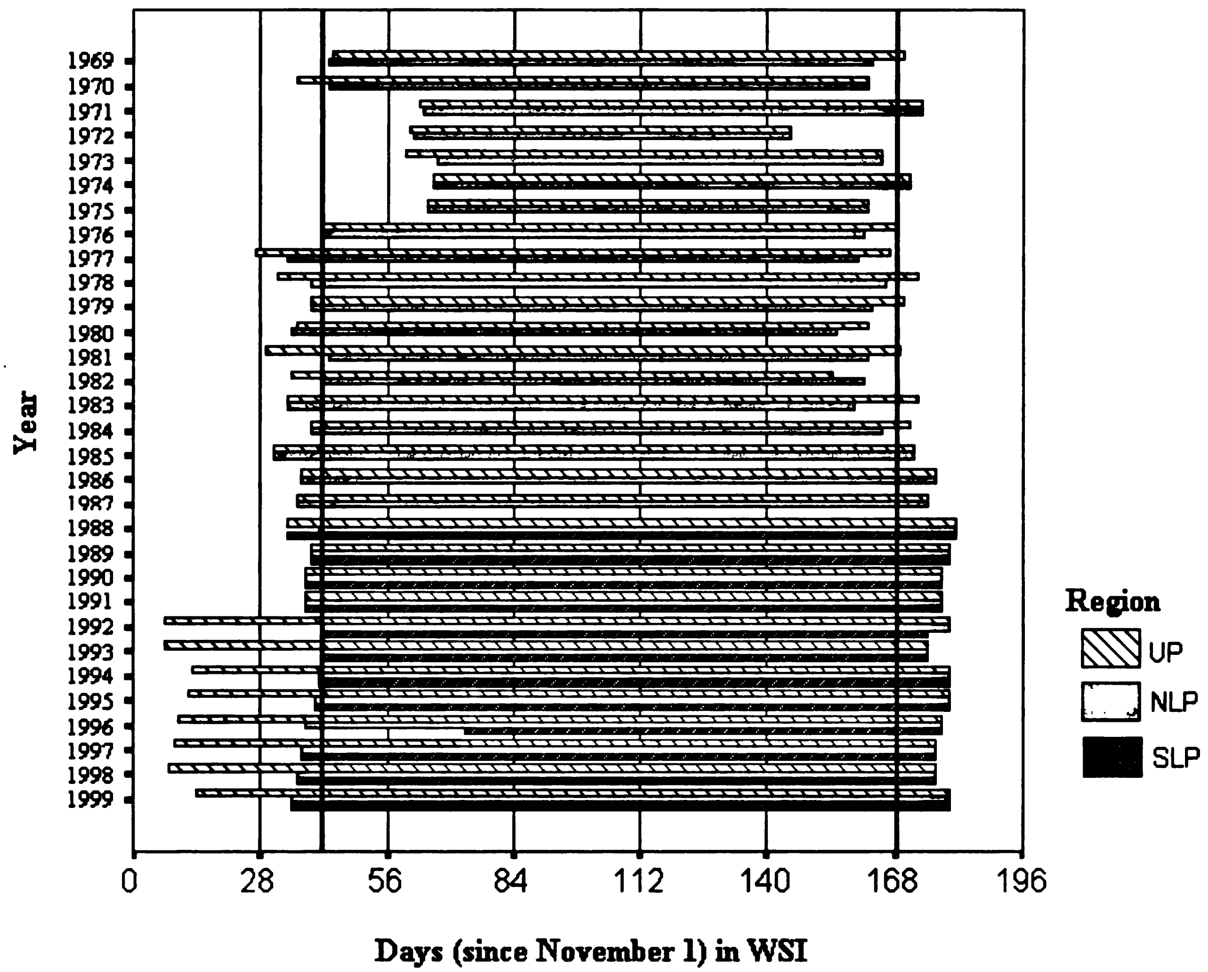


Figure 35. The time period WSI data were collected in each region from 1969 to 1999. The bold lines mark days 42 (December 13) and 168 (April 18).

as the corrected WSI) by summing the weekly values beginning from approximately day 42 until approximately day 168. (All sums include data from the 19 weeks most closely matching the days 42-168 period, although some sums may include a few additional days due to leap year or data collection periods longer than 7 days. Note that although the recorded start date is day 42, the data collected on day 42 covers the week immediately preceding it.) I did not calculate a station's corrected WSI value if data were missing from several weeks during a single year. I also calculated a modified WSI value for each region by summing the weekly values of only days 42-63 (first-month WSI) and days 147-168 (fourth-month WSI).

After finding the annual corrected WSI value for each station, I calculated the average WSI values and the coefficient of variation (CV) for each management unit and region. I regressed several population parameters on the corrected WSI values by region and by management unit and on the first- and fourth-month WSI values for each region. The population parameters include: (from the succeeding autumn's harvest) the buck harvest (uncorrected and corrected for hunter effort); total harvest (uncorrected and corrected for hunter effort); proportion of lactating yearlings, 2.5 year olds, and 3.5+ year olds during the first week of firearm season; proportion of yearling bucks in the entire harvest; and average yearling beam size of deer checked during the following fall's hunting season.

To explore possible alternatives to the current WSI, I developed an alternative index. Minimum temperatures and daily snow depth values from December 1986 through March 2000 were aquired from the National Oceanic and Atmospheric Administration website (www.ncdc.noaa.gov/ol/climate/stationlocator.html). The data were collected from 3 UP stations (Marquette, Manistique, and Ironwood) and 4 Northern LP stations (Alpena, Cheboygan, Houghton Lake, and Traverse City). From the minimum temperature data, the variable Degree<32 was created, which is the sum of the daily differences between minimum temperature and 32 °F. A monthly average was calculated from the snow depth data. A weighted value was then assigned to the monthly average based on the system developed by Leckenby and Adams (1986). I was then able to calculate the B-WSI as follows: Monthly B-WSI = (Monthly Sum Degree<32)*(Snow Depth Weighted Value). The yearly B-WSI is the sum of the Monthly B-WSI values for December through March. The regional values are the average of the individual station values. See Appendix 3 for an example B-WSI calculation. After developing the B-WSI, I examined the correlation between the B-WSI and the MDNR WSI and the correlation between the B-WSI and yearling beam diameter.

Results

The WSI data collection stations are evenly distributed throughout the entire state (Figure 33). Each management unit contains at least 3 stations, although Cass City and St. Charles in the Saginaw Bay management unit only began collecting data in 1998. In the Southwestern management unit, however, 2 of the stations (Allegan Farm and Allegan Forest) are located within a few miles of one another. Allegan Farm and Forest apparently experience similar climatic pressures, creating almost identical trends in annual WSI values (Figure 36), but the trends are usually more than 25 points apart.

WSI values are available for the UP and the Northern LP for the last 30 years and for the last 11 years in the Southern LP. Over the years, however, the time frame for the

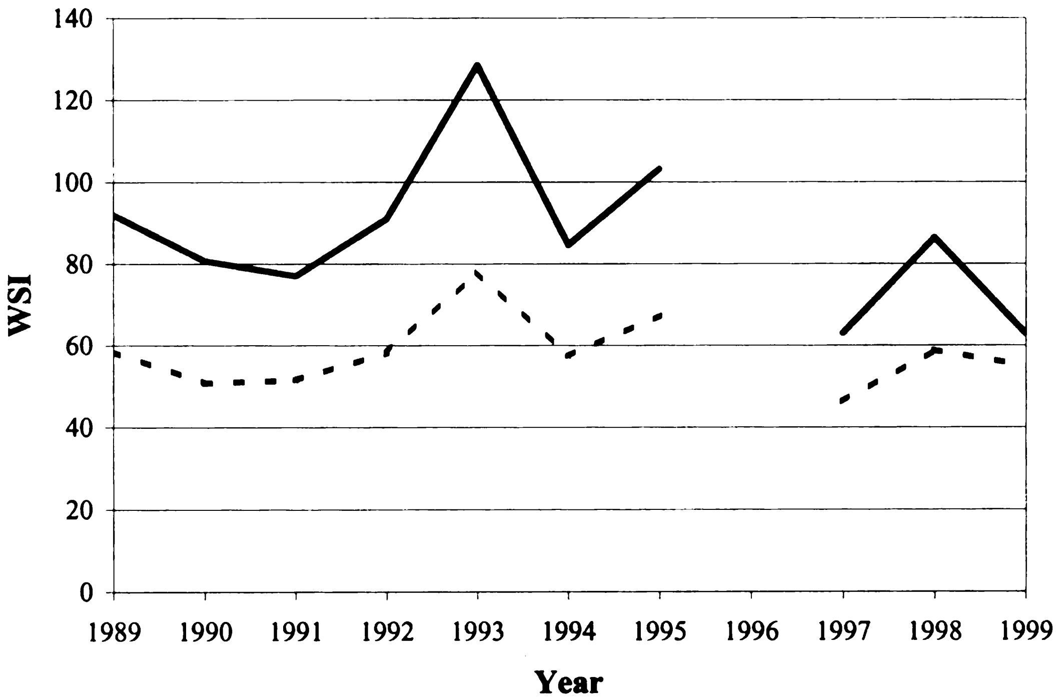


Figure 36. The annual corrected WSI values recorded at Allegan Farm (solid line) and Allegan Forest (broken line).

collection of the WSI data varied (Figure 35). For example, during some years collection did not begin until late December or early January, while recently, collection began in early November in the UP. The length of the collection also varied from 83 days (in 1972 in the Northern LP) to 173 days (in 1992 in the UP). Even for those years when values covered the same number of days, the starting and ending dates were frequently different. Also, the WSI rarely covered the same time frame in the 3 different regions in any single year. Occasionally, data collection did not begin and end on the same date even for different stations within the same region. Such inconsistencies in the current uncorrected data make comparisons between years and regions impossible because the WSI is cumulative, and its final value depends on the number of days and the period for which the data were collected. The time frame covered most consistently was between days 42 and 168 (days since November 1). The corrected WSI values (described above) were used for all of the following analyses.

Calculating the non-cumulative weekly WSI values made it possible to examine trends in winter severity as it fluctuated throughout the season. Each winter has its own pattern of fluctuating WSI values. An example of 3 winters in the UP with similar final WSI values is shown in Figure 37. Currently, the MDNR creates figures similar to Figure 37a to compare the severity of several winters. Such figures may obscure the true differences between the weather patterns of these 3 winters. After the first week, the 1998 winter was more severe than the others in the beginning of the season (Figure 37b). The 1994 winter peaked above the others in the middle and end of the season (Figure 37b). The 1990 winter had a large drop in severity in the middle of the season (Figure 37b). These patterns are not visible in Figure 37a.

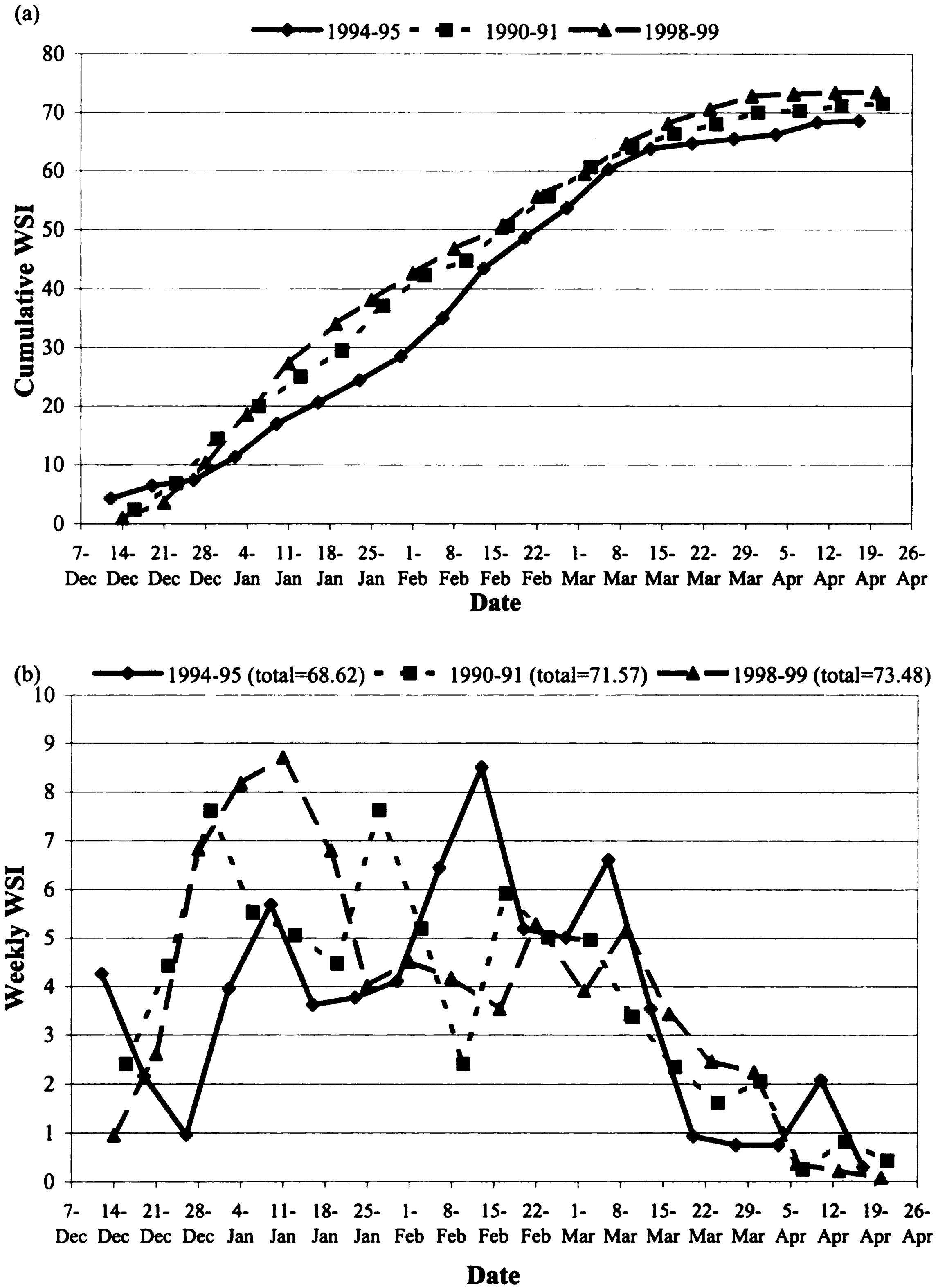


Figure 37. The (a) cumulative and (b) weekly WSI values from three selected years with similar final WSI values in the Upper Peninsula.

Restricting the WSI data to those years that covered the day 42 to day 168 period, reduced the available data to 20 years in the UP, 16 years in the Northern LP, and 11 years in the Southern LP (Figure 38). From the available data, the worst winter on record for the Northern LP and the Southern LP was the winter of 1993. The 1993 winter was of average to below-average severity for the UP, however, where the worst winters were in 1978 historically and 1995 recently. In all 3 regions, the mildest winter on record was the 1997 winter. The Northern LP and Southern LP winters are more similar to one another than either's winters are to the UP, but the WSI values for all 3 regions track one another closely (Figure 38).

The WSI values averaged across the entire region, may not be an accurate reflection of the true winter conditions of the region, especially in the Northern LP and Southern LP. In the UP, when the data were divided into the separate management units, the lines rarely deviated from one another (Figure 39), suggesting that the severity of the winters across the UP was fairly homogeneous. The similarity was also reflected in the CV values (Table 28). The variation of the WSI values for the entire region was no greater than the variation of values for the separate management units. In the Northern LP, however, the WSI values of the Northeastern management unit were generally larger than those of the other 2 management units (Figure 40). But note that Gladwin was the only station that had data from more than one year in the Saginaw Bay management unit (Figure 34), so the Saginaw Bay management unit values were not representative of the entire management unit. The CV values varied across the years within both the average regional and average management unit WSI values (Table 29), perhaps indicating that winter weather varied widely across the region, and was not adequately represented by

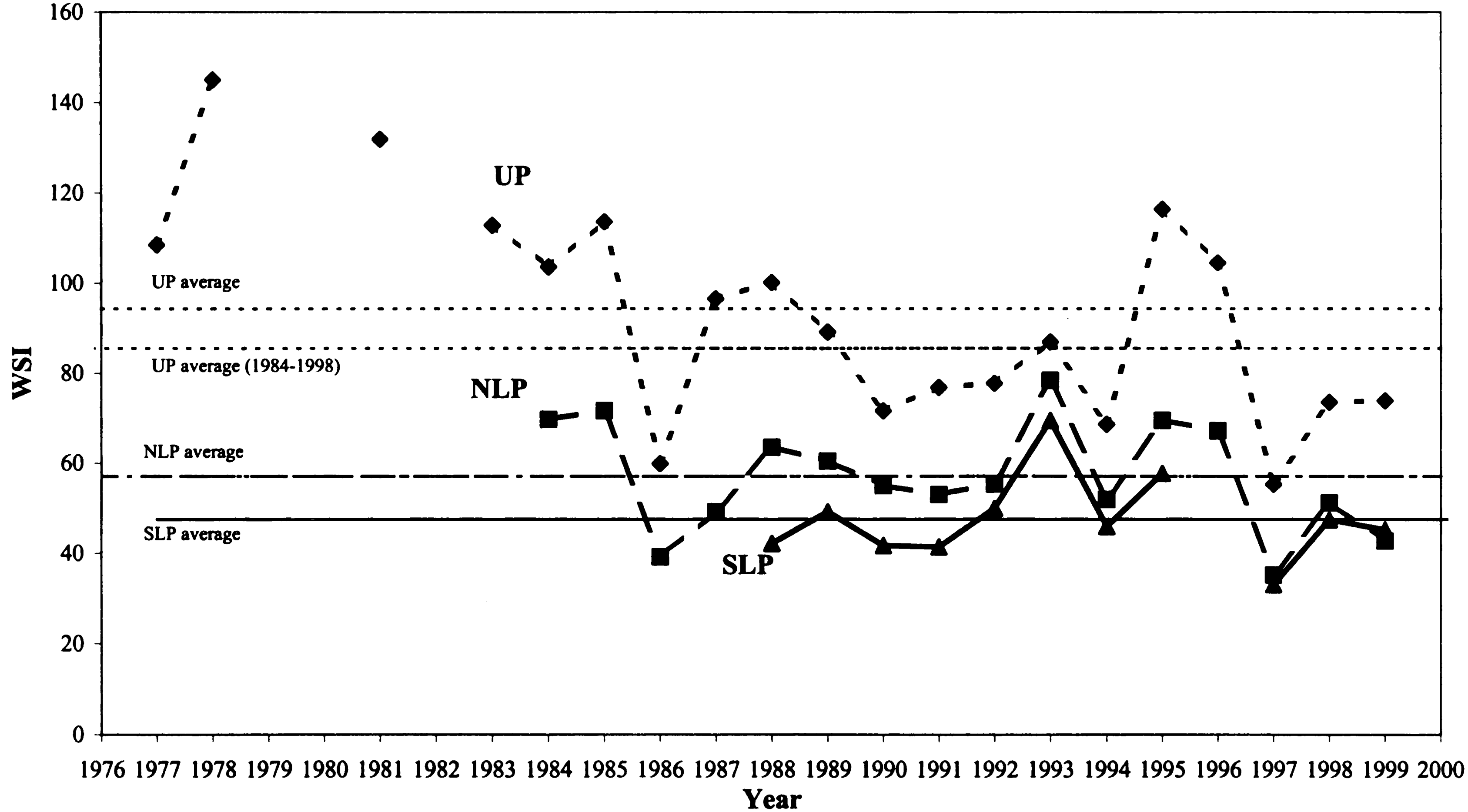


Figure 38. Corrected annual WSI values from 1977 to 1999 in each region.

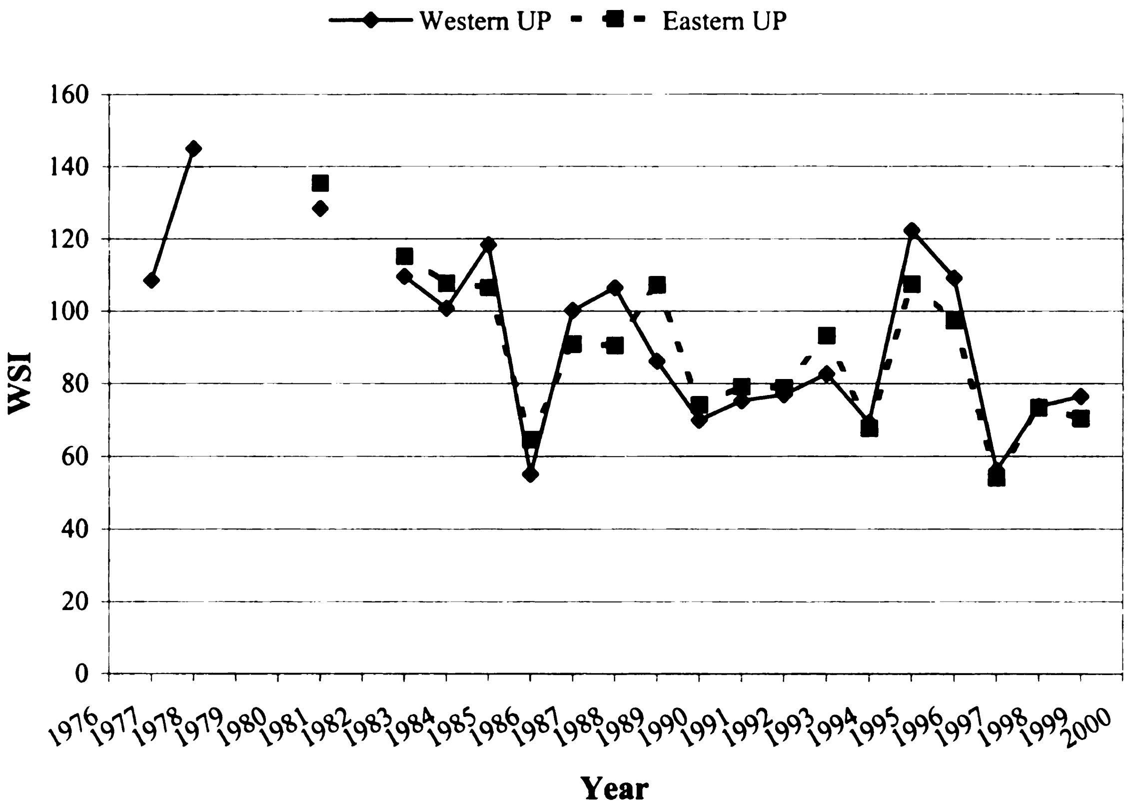


Figure 39. Corrected annual WSI values of the Western UP and the Eastern UP

Table 28. The mean corrected WSI values of the UP, averaged over the stations in the Western UP and Eastern UP management units.

Year	Unit/Region	N	Mean WSI	CV
1969	Western UP	3	114.28	12.7
	Eastern UP			
	UP	3	114.28	12.7
1977	Western UP	4	108.5	19
	Eastern UP			
	UP	4	108.5	19
1978	Western UP	5	145.02	13.5
	Eastern UP			
	UP	5	145.02	13.5
1981	Western UP	3	128.42	19.4
	Eastern UP	3	135.4	14.4
	UP	6	131.91	16.7
1983	Western UP	6	109.6	18.8
	Eastern UP	4	115.23	12.4
	UP	7	112.81	14.1
1984	Western UP	6	100.77	18.2
	Eastern UP	4	107.75	17.7
	UP	10	103.56	17.3
1985	Western UP	6	118.33	16
	Eastern UP	4	106.58	7.2
	UP	10	113.63	14.1
1986	Western UP	4	55.13	27
	Eastern UP	4	64.58	14.7
	UP	8	59.85	21.1
1987	Western UP	6	100.18	23.2
	Eastern UP	4	90.9	10.2
	UP	10	96.47	19.4
1988	Western UP	6	106.48	21.8
	Eastern UP	4	90.48	15.5
	UP	10	100.08	20.8
1989	Western UP	6	86.17	22.7
	Eastern UP	1	107.3	
	UP	7	89.14	21.9
1990	Western UP	6	69.87	23.9
	Eastern UP	4	74.13	18.4
	UP	10	71.57	20.8

Table 28 (cont'd.)

1991	**Western UP**	6	75.2	19.2
	Eastern UP	4	79.18	25.1
	UP	10	76.79	20.6
1992	**Western UP**	6	76.9	21.4
	Eastern UP	4	78.85	24.2
	UP	10	77.68	21.3
1993	**Western UP**	6	82.67	17
	Eastern UP	4	93.29	15.7
	UP	10	86.92	16.7
1994	**Western UP**	6	69.23	22.3
	Eastern UP	4	67.7	19.1
	UP	10	68.62	20
1995	**Western UP**	6	122.25	18.4
	Eastern UP	4	107.51	16.8
	UP	10	116.35	18.2
1996	**Western UP**	6	109.13	18.6
	Eastern UP	4	97.41	19.8
	UP	10	104.45	18.9
1997	**Western UP**	6	56.18	16.4
	Eastern UP	4	54.06	29
	UP	10	55.33	20.6
1998	**Western UP**	3	73.63	21.2
	Eastern UP	5	73.38	17.8
	UP	8	73.48	17.6
1999	**Western UP**	4	76.42	11.4
	Eastern UP	3	70.4	26.4
	UP	7	73.84	17.3

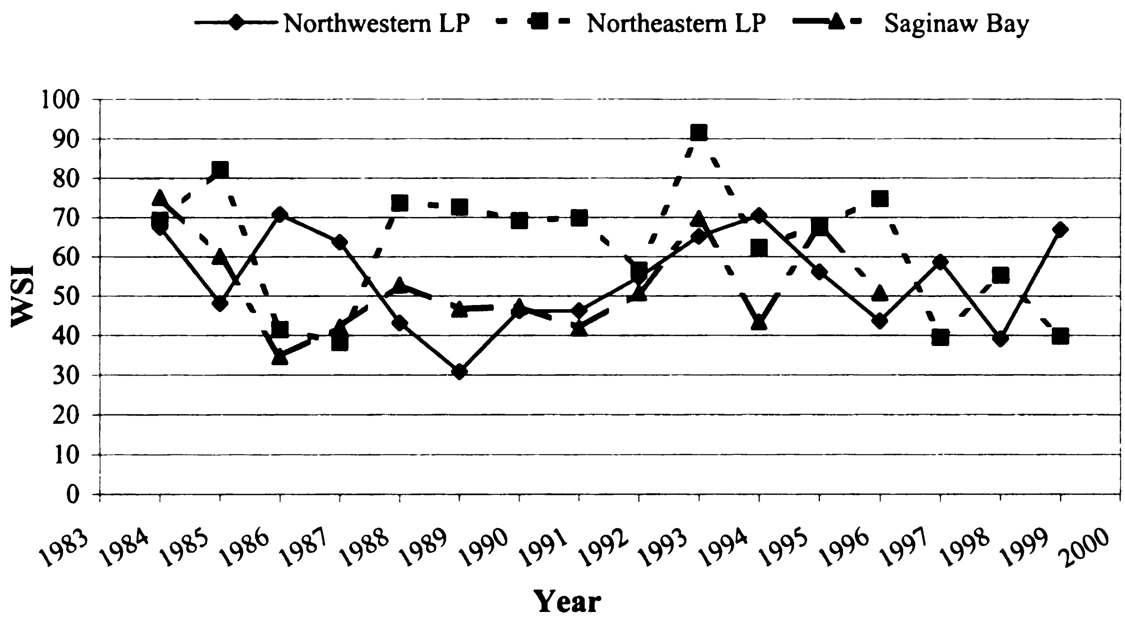


Figure 40. Corrected annual WSI values of the Northwestern LP, the Northeastern LP, and Saginaw Bay.

Table 29. The mean corrected WSI values of the Northern LP, averaged over the stations in the Northwestern LP, Northeastern LP, and Saginaw Bay management units, and the coefficient of variation.

Year	Unit/Region	N	Mean WSI	CV
1984	Northwestern LP	2	67.5	7.12
	Northeastern LP	2	69.3	12.4
	Saginaw Bay	1	75.1	
	Northern LP	5	69.74	8.4
1985	Northwestern LP	2	66.9	27.9
	Northeastern LP	2	82.2	16.2
	Saginaw Bay	1	60.1	
	Northern LP	5	71.66	21.2
1986	Northwestern LP	2	39.15	23.7
	Northeastern LP	2	41.5	26.6
	Saginaw Bay	1	34.7	
	Northern LP	5	39.2	19.7
1987	Northwestern LP	2	63.65	11
	Northeastern LP	2	38.25	29.4
	Saginaw Bay	1	42.1	
	Northern LP	5	49.18	30.2
1988	Northwestern LP	4	58.6	21.7
	Northeastern LP	3	73.63	17.9
	Saginaw Bay	1	52.8	
	Northern LP	8	63.51	21.9
1989	Northwestern LP	4	54.73	16.1
	Northeastern LP	3	92.67	24.2
	Saginaw Bay	1	46.7	
	Northern LP	8	60.45	25.2
1990	Northwestern LP	4	46.25	14.4
	Northeastern LP	3	69.2	21.3
	Saginaw Bay	1	47.3	
	Northern LP	8	54.99	26.9
1991	Northwestern LP	4	43.15	12.7
	Northeastern LP	3	69.9	25.7
	Saginaw Bay	1	41.9	
	Northern LP	8	53.03	32.7

Table 29 (cont'd).

1992	**Northwestern LP**	4	46.25	20.4
	Northeastern LP	1	56.6	
	Saginaw Bay	1	50.8	
	Northern LP	6	55.28	16.5
1993	**Northwestern LP**	4	70.75	10.7
	Northeastern LP	3	91.53	25.9
	Saginaw Bay	1	69.7	
	Northern LP	8	78.41	22.2
1994	**Northwestern LP**	4	46.25	16
	Northeastern LP	3	62.33	27
	Saginaw Bay	1	43.5	
	Northern LP	8	51.94	25.8
1995	**Northwestern LP**	4	70.45	19
	Northeastern LP	1	67.9	
	Saginaw Bay	1	67.4	
	Northern LP	6	69.52	15.1
1996	**Northwestern LP**	3	65.12	17.4
	Northeastern LP	3	74.77	21
	Saginaw Bay	1	50.8	
	Northern LP	7	67.21	21.1
1997	**Northwestern LP**	2	30.85	13.5
	Northeastern LP	2	39.55	5.9
	Saginaw Bay			
	Northern LP	4	35.2	16.3
1998	**Northwestern LP**	4	48.13	8.3
	Northeastern LP	3	55.27	22.9
	Saginaw Bay			
	Northern LP	7	51.19	17
1999	**Northwestern LP**	3	43.67	21.3
	Northeastern LP	1	39.9	0
	Saginaw Bay			
	Northern LP	4	42.73	18.3

the chosen stations. In the Southern LP, the WSI values of the Southwestern management unit were consistently several points higher than those of the South Central and Southeastern management units, although all follow the same general pattern (Figure 41). The regional CV values were greater than the management unit CV values in almost every year (Table 30). The Southwestern LP appeared to experience more severe winters than the rest of the Southern LP and its WSI values were inflating the regional average.

The results of the regression analyses varied drastically and showed few obvious patterns on either the regional or management unit scales (Table 31). Generally the p-values were lower and the r^2 values were higher for the UP and its management units than for the other regions and management units. No population parameters were significantly correlated with the WSI for all regions. The slopes of the regression lines even varied in sign in several of the categories. Correcting the buck and total harvest for hunter effort generally decreased the significance and the fit of the regression line. In a few cases, using the WSI values summed for only the first and fourth month improved the fit of the regression line, but generally there was little change from the regressions using the total WSI values (Table 31).

The B-WSI correlated well with the MDNR WSI in the UP (r=0.9067) and only moderately well with the MDNR WSI in the Northern LP (r=0.8108). Regressions against yearling beam diameters using the yearly B-WSI values provided similar results to the regressions using the MDNR WSI (Table 32 as compared to Table 31). Using just the UP February and Northern LP March monthly B-WSI values, however, provided stronger correlations with yearling beam diameter than using the yearly B-WSI values (Table 32).

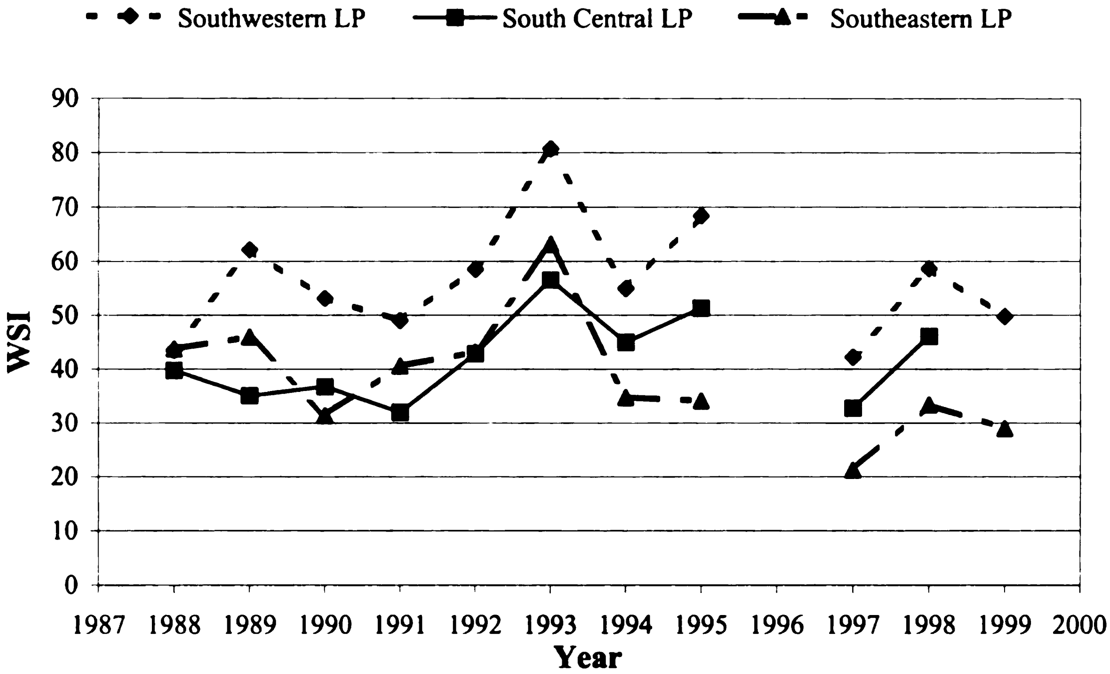


Figure 41. Corrected annual WSI values of the Southwestern LP, South Central LP, and the Southeastern LP.

Table 30. The mean corrected WSI values of the Southern LP, averaged over the stations in the Southwestern LP, South Central LP, and Southeastern LP, and the coefficient of variation.

Year	Unit/Region	N	Mean WSI	CV
1988	Southwestern LP	1	41.7	
	South Central LP	4	41.1	23.7
	Southeastern LP	3	43.7	11.4
	Southern LP	8	42.16	16.7
1989	Southwestern LP	3	68.2	24.8
	South Central LP	4	37.3	19
	Southeastern LP	3	46	23.3
	Southern LP	10	49.17	36.6
1990	Southwestern LP	3	57.5	29.3
	South Central LP	4	37.5	6.8
	Southeastern LP	3	31.4	33.6
	Southern LP	10	41.68	37.8
1991	Southwestern LP	3	53.9	33.2
	South Central LP	4	32.6	6.9
	Southeastern LP	3	40.6	14.8
	Southern LP	10	41.37	34.5
1992	Southwestern LP	3	63	33.6
	South Central LP	3	43.6	3.7
	Southeastern LP	3	43.1	38.4
	Southern LP	9	49.91	36.6
1993	Southwestern LP	3	88.5	33.1
	South Central LP	3	56.8	1.3
	Southeastern LP	3	63.2	28.1
	Southern LP	9	69.49	35.6
1994	Southwestern LP	3	59.9	32.1
	South Central LP	4	43.8	18.1
	Southeastern LP	3	34.7	21.3
	Southern LP	10	45.88	35.5
1995	Southwestern LP	3	75.3	26.9
	South Central LP	4	50.4	15.3
	Southeastern LP	1	34.1	
	Southern LP	8	57.71	36.5

Table 30 (cont'd).

1997	**Southwestern LP**	3	48.7	22.1
	South Central LP	4	30.2	27.5
	Southeastern LP	3	21.2	33.2
	Southern LP	10	33.05	43.3
1998	**Southwestern LP**	3	65.3	23.3
	South Central LP	3	43.6	10.4
	Southeastern LP	3	33.3	28.5
	Southern LP	9	47.41	37.4
1999	**Southwestern LP**	3	49.73	32.7
	South Central LP			
	Southeastern LP	3	28.97	33.2
	Southern LP	8	45.18	39.4

Table 31. Results of the regression analyses of total annual WSI values and the first and fourth month annual WSI values against several dependent variables.

		Total Annual WSI					1st & 4th Month Annual WSI			
Dep. Var.	**Region/Unit**	**N**	**Int.**	**Slope**	***p***	**r^2**	**Int.**	**Slope**	***p***	**r^2**
Buck Harvest	**UP**	16	78376	-348.23	0.062	0.262	67894	-761.11	0.038	0.312
	Western UP	16	63557	-294.62	0.011	0.356				
	Eastern UP	16	15675	-88.956	0.003	0.467				
	Northern LP	13	107927	-193.47	0.387	0.058	93221	207.84	0.668	0.015
	Northwest LP	13	44899	-23.017	0.849	0.003				
	Northeast LP	13	39265	43.564	0.658	0.016				
	Southern LP	8	95414	122.7	0.859	0.004	106208	-341.03	0.813	0.007
	Southwest LP	8	23246	149.85	0.305	0.131				
	South Central LP	8	30312	172.52	0.564	0.043				
	Southeast LP	8	16684	-171.64	0.133	0.259				
Total Harvest	**UP**	16	121544	-587.73	0.076	0.240	101587	-1200.3	0.069	0.249
	Western UP	16	98103	-490.84	0.023	0.298				
	Eastern UP	16	20080	-114.91	0.015	0.336				
	Northern LP	13	238920	-1339.8	0.041	0.285	167448	-375.18	0.805	0.005
	Northwest LP	13	91569	-339.34	0.411	0.053				
	Northeast LP	13	82666	-186.83	0.380	0.060				
	Southern LP	8	272155	-1662.4	0.410	0.087	223154	-2104.6	0.624	0.032
	Southwest LP	8	61426	18.719	0.965	0.000				
	South Central LP	8	96741	-598.86	0.543	0.048				
	Southeast LP	8	37707	-486.26	0.079	0.336				
Buck Harvest per Thousand Hunter Hours	**UP**	11	37.512	-0.023	0.886	0.002	38.0602	-0.1016	0.763	0.010
	Western UP	11	41.041	-0.0331	0.812	0.006				
	Eastern UP	11	34.215	-0.1117	0.367	0.082				
	Northern LP	10	23.328	-0.024	0.748	0.011	21.288	0.0397	0.795	0.007
	Northwest LP	10	19.503	0.0503	0.541	0.039				
	Northeast LP	10	22.123	0.0036	0.947	0.001				
	Southern LP	8	14.607	0.031	0.723	0.017	15.784	0.0211	0.909	0.002
	Southwest LP	8	13.02	0.0475	0.279	0.145				
	South Central LP	8	12.883	0.1026	0.401	0.090				
	Southeast LP	8	15.12	-0.1124	0.266	0.152				
Total Harvest per Thousand Hunter Hours	**UP**	11	55.124	-0.0323	0.891	0.002	53.339	-0.0388	0.938	0.001
	Western UP	11	64.023	-0.0799	0.717	0.014				
	Eastern UP	11	41.388	-0.1067	0.472	0.053				
	Northern LP	10	54.965	-0.2962	0.127	0.217	38.84	-0.054	0.898	0.002
	Northwest LP	10	39.838	-0.0234	0.926	0.001				
	Northeast LP	10	49.023	-0.157	0.220	0.146				
	Southern LP	8	41.187	-0.2227	0.419	0.083	32.85	-0.1593	0.787	0.010
	Southwest LP	8	32.615	-0.0327	0.828	0.006				
	South Central LP	8	40.942	-0.1958	0.634	0.030				
	Southeast LP	8	35.047	-0.3843	0.143	0.248				
% 1.5 yrs Lactating	**UP**	6	20.473	-0.1284	0.143	0.376	16.529	-0.2825	0.112	0.426
	Northern LP	6	5.7661	0.1388	0.320	0.196	8.5992	0.3309	0.339	0.182
	Southern LP	5	35.528	-0.1495	0.439	0.156	37.681	-0.7117	0.213	0.354

Table 31 (cont'd).

% 2.5 yrs Lactating	**UP**	6	62.108	-0.2216	0.023	0.675	56.244	-0.5273	0.001	0.894
	Northern LP	6	43.639	0.0722	0.435	0.126	48.62	-0.0479	0.839	0.009
	Southern LP	5	68.516	-0.0959	0.637	0.061	72.074	-0.6159	0.310	0.253
% 3.5+ yrs Lactating	**UP**	6	81.523	-0.3007	0.004	0.840	69.685	-0.5529	0.026	0.664
	Northern LP	6	46.871	0.1595	0.229	0.273	55.291	0.0562	0.874	0.006
	Southern LP	5	60.956	0.0803	0.545	0.098	69.749	-0.3467	0.397	0.183
% Yearling Bucks in Harvest	**UP**	11	74.245	-0.3791	0.024	0.449	63.092	-0.861	0.010	0.540
	Western UP	11	69.13	-0.3261	0.017	0.450				
	Eastern UP	11	72.151	-0.3097	0.010	0.500				
	Northern LP	12	61.869	-0.0766	0.549	0.037	61.69	-0.2592	0.334	0.094
	Northwest LP	12	72.779	-0.1517	0.464	0.055				
	Northeast LP	12	56.665	-0.0391	0.722	0.013				
	Southern LP	9	55.504	0.0515	0.383	0.110	55.269	0.1879	0.105	0.331
	Southwest LP	9	52.224	0.1367	0.121	0.308				
	South Central LP	9	56.241	0.0207	0.796	0.010				
	Southeast LP	9	54.483	-0.101	0.258	0.178				
Average Yearling Beam Size	**UP**	15	-1815.4	24.051	0.004	0.478	-1815.4	24.051	0.004	0.478
	Western UP	13	18.431	-0.0133	0.021	0.397				
	Eastern UP	13	19.055	-0.017	0.072	0.264				
	Northern LP	13	18.651	-0.01	0.149	0.179	18.452	-0.0224	0.128	0.197
	Northwest LP	13	19.101	-0.0079	0.323	0.089				
	Northeast LP	13	17.911	-0.0065	0.177	0.159				
	Southern LP	10	22.996	-0.0266	0.017	0.533	21.981	-0.0176	0.523	0.053
	Southwest LP	9	23.386	-0.0283	0.000	0.851				
	South Central LP	10	22.955	-0.0177	0.217	0.183				
	Southeast LP	10	22.61	-0.0147	0.444	0.075				

Table 32. Results of regression analyses of monthly and annual B-WSI values against yearling beam diameter. Monthly and annual B-WSI values were divided by 10 and 25, respectively, to place them on a scale similar to that of the MDNR WSI.

B-WSI	Region	N	Int.	Slope	p-value	r^2
December	UP	13	17.509	0.0042	0.4295	0.0576
	Northern LP	13	18.167	0.0055	0.2702	0.1096
January	UP	13	17.654	0.0042	0.3557	0.0779
	Northern LP	13	18.151	0.0017	0.69	0.022
February	UP	13	18.299	0.0139	0.0064	0.5061
	Northern LP	13	18.197	0.0031	0.3936	0.0669
March	UP	13	17.71	0.0093	0.1122	0.2132
	Northern LP	13	18.403	0.0183	0.0018	0.6039
Annual	UP	13	18.1	0.0091	0.043	0.3222
	Northern LP	13	18.302	0.0052	0.1379	0.1888

Discussion

The quality of the WSI data depends on how well the data represent the true winter conditions across Michigan and the consistency of the data collection process. On a geographic scale, the data present few concerns. The stations are scattered evenly throughout the management units (Figure 33). Although historically only Gladwin has represented the Saginaw Bay management unit, the recent addition of St. Charles and Cass City will provide a more accurate average WSI of this management unit (Figure 33). The average WSI value of the Southwestern management unit is heavily biased in favor of the winter conditions within the Allegan area. Although the Allegan Farm and Allegan Forest stations provide consistently different WSI values (Figure 36), probably due to higher snowfall at Allegan Farm, they may not provide independent data because of their close proximity to one another.

Although the geographic distribution of the WSI data is generally sound, the inconsistencies in the dates of data collection detract from the quality of the data. The WSI is a cumulative index, and annual values cannot be compared unless each station collects the data for the same time period each year. I had to calculate corrected annual WSI values because of the variation in the collection times (Figure 35). Using the corrected values reduced the number of years in the historical record in some regions by almost half (Figure 34). The choice of the day 42 to day 168 time period was based solely on the condition of the available data, and I do not recommend using this time period for all future WSI surveys. Future data collection time periods should be determined by MDNR personnel familiar with Michigan's winter conditions and should cover all months during which winter conditions are expected. The time period used in the corrected value eliminated the early winter values from the index. Winter arrives early in the UP, and including data from November and early December would increase the accuracy of the index. If early winter data are used in the UP, statewide comparisons cannot be made unless the UP WSI values are corrected for the time period covered by the Lower Peninsula data. Data must also be collected on the same dates at every station. If a station is missing data from even just a few weeks throughout the season, that station's data must be eliminated from the regional average for the entire season.

Once each station's data are standardized, the final values can be averaged to determine a WSI value for each management unit or region. Averaging over such large geographical areas may not make sense, however. The UP has fairly homogeneous winter weather patterns (Figure 40, Table 28), but the Northern LP (Figure 40) and the Southern LP (Figure 41) each contain a management unit whose winter severity differs from the other two management units in the region. These results imply that using the WSI on the management unit level would be more accurate than on a regional level. The regression analyses do not reflect this, however; the regressions against the management unit WSI values do not generally provide better fits than those against the regional values (Table 31). In several cases, regressions against the management unit values were not possible due to insufficient data (in the dependent variables). Whatever spatial division is used in the WSI, other data must be available on the same scale for such correlational studies.

Verme (1968) suggested that a critical WSI value can be determined for each area to mark when winter losses will reach significant levels. He observed that in the UP, a WSI value of greater than 100 led to moderate to severe losses in deer as reported by field biologists. When the index did not reach 100, winter losses were insignificant. Based on Verme's (1968) critical value of 100 for the UP (which covers the same time period as the corrected WSI of this study), few recent winters should have resulted in severe winter losses (Figure 38). Similar critical values can be determined for the Northern LP and Southern LP based on climate, habitat carrying capacity, and population density (Verme, 1968). The MDNR would then be able to predict moderate to severe winter losses when a region's WSI value passed its critical value.

In its present form, the WSI can produce similar final values for years whose winter weather patterns are different from one another (Figure 37). Severinghaus (1947) found that severe weather during the early months of spring has a greater adverse effect on the deer than a similar pattern occurring earlier in the year. As winter progresses, deer gradually use up their fat stores and will not survive the winter if spring and its new food sources come too late (Mautz, 1978). Early onset of winter will also decrease the length of time deer have to accumulate their fat supplies. In the example presented in Figure 36, I might expect higher deer mortality following the 1994 winter. The winter began and ended more severely than the others (Figure 37b). The current index gives the 1994 winter the lowest WSI value of the 3 winters presented, however (Figure 37a).

Verme and Ozoga (1971) recognized the greater effect the beginning and end of winter has on deer and compared a WSI of the first and fifth months of winter weather to the total WSI value. They found that the first and fifth month index provided much better correlations with deer physical condition and fawn mortality than the total WSI value. Using the first and fourth month (probably comparable to Verme and Ozoga's (1971) second and fifth month) WSI value increased the quality of the fit of the regression in a few cases, but did not demonstrate a consistent pattern of better fit (Table 31). The index might have provided a better fit if the first month included data from November or early December, rather than mid December to January.

An accurate winter severity index that reflects the true winter conditions of Michigan could be used to predict over-winter deer losses and the percentage of pregnancies that are carried to term in spring. The current WSI cannot be used in this manner. This evaluation highlights several options for the future of the WSI. The current system could be maintained with improvements made in the collection process. The dates of collection must be standardized across the state and across years. Additional evaluations may also be necessary to determine what combinations of months will provide the best index. The number of collection stations could be increased to reduce the influence of any one station on the average and decrease the variance of the regional means. The location of the stations could also be evaluated to determine if they are placed in the areas with the highest deer population levels.

A final option would be to explore other methods of collecting similar data. Other severity indices for use in big game management have been developed based on daily maximum temperatures and snow depth (Picton and Knight, 1971); the number of days of winter stress (Roper and Lipscomb, 1973); the deviation from monthly temperature and precipitation means (Picton, 1979); weekly air temperature, air movement, snow cover, and snow depth (Leckenby and Adams, 1986); and previous winters' snow (Mech et al, 1987). Data collected by the weather service such as daily snowfall, average daily temperature, and daily minimum and maximum temperatures may provide such a solution. The data would be available from more stations throughout the state to increase the number of replicates, would not require MDNR personnel to collect the data, and would be more easily standardized.

As an example of the possibilities for such an alternative WSI, I developed a preliminary alternative index, which I named the B-WSI. The B-WSI is not strongly correlated with the current WSI, but the differences appear to make it a stronger predictor of yearling beam diameters (Table 32). Single monthly values of the B-WSI (Table 31) are more strongly correlated with yearling beam diameter than either the yearly MDNR WSI or the first and fourth month MDNR WSI (Table 31). The B-WSI is also calculated from a reliable and standardized data source that is easily accessible. Further exploration into the development of a new winter severity index may be the best alternative to the current WSI system.

CHAPTER 5

CONCLUSION

The voluntary check stations, the lactation survey, and the winter severity index can all provide valuable data to the MDNR for the management of Michigan's white-tailed deer. The check stations provide data that can be used in the SAK estimates of population size, in deriving indices of herd health, and in tracking herd or harvest composition. The lactation data are perhaps the least affected by hunter-derived bias and provide useful data on the proportion of lactating does. The winter severity index can be used to predict antler development, a possible indicator of herd health. All three surveys have not reached their full potential, however. All can be improved to increase the quality of the resulting data and the manner in which those data are used. The biodata also faces possible significant changes as the MDNR discusses mandatory deer registration.

The evaluation of the check station data suggests several management recommendations that could improve the quality of the biodata:

- Increasing the number of check stations, especially in the Southern LP where checking rates are low, could increase the number of deer checked and reduce geographic biases. As the number of check stations increases, the convenience of checking deer will increase, encouraging more hunters to check their deer. Checking convenience can also be increased by opening check stations during the evening or weekend hours. Longer hours of operation may be especially important in collecting additional data from the archery season when the convenient highway check stations are not open.

- If the number of check stations are increased, however, the number of qualified agers will have to also increase through more intensive training methods. Current aging practices lead to acceptable error rates if deer are classified as fawns (0.5 years), yearlings (1.5 years), or adults (2.5+ years). Divisions into older age classes severely reduces accuracy. If individual age classes are deemed necessary, more intensive training could increase the number of people qualified to age deer, making more check stations possible, and could increase the accuracy of the aging deer into older age categories and decrease the number of deer aged as 'A' or 'AA.'
- While the lactation and beam diameter data follow expected trends and could be used as indices of herd health, additional research should be conducted to determine exactly how these indices could be calculated and used.
- Additional research could also be conducted to explore the possibility of weighting the biodata by the distribution of the biodata records across a geographic region or a the different seasons to provide more precise estimates. Such weights could counter the effect of observed geographic and seasonal biases.
- Until sample sizes are increased through the addition of check stations or other means, most analyses should not be conducted on the county level. Many counties do not have sufficient sample sizes to make calculations within an acceptable margin of error.
- The data transcription process could be revised to eliminate inconsistencies or to include data that could be useful in the analysis of the biodata.

Most of these recommendations are valid only for the current voluntary checking system. If Michigan institutes mandatory deer registration, the biodata could change drastically.

The results of the biodata evaluation do not suggest that a mandatory registration system is necessary to collect accurate and useful data on Michigan's harvested deer. The current data have several valuable uses, and implementing the above recommendations can only improve their quality and value.

The lactation data, as a subset of the biodata, will also benefit from many of the recommendations listed above for improving the biodata. The evaluation of the lactation survey found that, while the data may not be useful as an estimate of annual recruitment or even as an estimate of the number of reproductive does, they may provide a useful index of reproductive success. Additional research could answer questions as to when fawns are weaned and how long a doe continues to lactate after her fawn dies. Such information could be used in conjunction with the lactation data to develop estimates of recruitment. By increasing the total number of deer checked, the MDNR should also be able to increase the number of does checked during October to provide more accurate estimates of the number of reproductively active females on smaller geographic scales, such as by management unit or possibly county.

The WSI is entirely separate from the check station data and would not be affected by improvements to the biodata. The evaluation of the WSI did suggest several management recommendations that could improve the quality of the winter severity data. The MDNR must first decide whether the current WSI should be maintained with greater quality control measures, or whether an alternate WSI should be developed. The current WSI could be vastly improved by standardizing the data collection process, but such improvements may not necessarily increase the value of the WSI. By exploring alternative WSIs, the MDNR could develop an index that incorporates easily collected data but that provides valuable predictive power for winter mortality, beam diameters, or other measures of herd health.

By improving and standardizing data collection and analysis processes and by increasing the geographic and temporal coverage of each field survey, the MDNR will be able to collect more accurate and precise data on Michigan's white-tailed deer herd. These data can then be used to track the success of current management practices or to determine the necessity for changes in management practices. The MDNR will also be able to justify their management decisions to the public by providing high quality data as supporting evidence. Improving the quality of the field surveys can increase the confidence the MDNR has in their management practices and the confidence the public has in the MDNR.

APPENDICES

Appendix 1. The data sheet used to record the 1999 biodata.

Michigan DNR

MICHIGAN DEPARTMENT OF NATURAL RESOURCES – WILDLIFE BUREAU

1999 DEER PHYSICAL DATA

Please print clearly with a number 2 pencil

1	2	3	4	LOCATION TAKEN			8	9	ANTLERS			13	14	15	16	17	
				5	6	7			BEAM DIA mm		12						
									10	11							
V or C	B M E L	PRIVATE OR PUBLIC LAND	DEER MGT UNIT (DMU)	COUNTY CODE	TOWN	RANGE	SEX M or F	AGE (Yrs)	LEFT	RIGHT	TOTAL POINTS	SPIKES LESS THAN 3" ✓	LACTATION CODE	LACTATION DATE OR REMARKS	TB	AGER NO	LINE NO
		☐ PVT ☐ PUB			N S	W E											1
		☐ PVT ☐ PUB			N S	W E											2
		☐ PVT ☐ PUB			N S	W E											3
		☐ PVT ☐ PUB			N S	W E											4
		☐ PVT ☐ PUB			N S	W E											5
		☐ PVT ☐ PUB			N S	W E											6
		☐ PVT ☐ PUB			N S	W E											7
		☐ PVT ☐ PUB			N S	W E											8
		☐ PVT ☐ PUB			N S	W E											9
		☐ PVT ☐ PUB			N S	W E											10
		☐ PVT ☐ PUB			N S	W E											11
		☐ PVT ☐ PUB			N S	W E											12
		☐ PVT ☐ PUB			N S	W E											13
		☐ PVT ☐ PUB			N S	W E											14
		☐ PVT ☐ PUB			N S	W E											15
		☐ PVT ☐ PUB			N S	W E											16
		☐ PVT ☐ PUB			N S	W E											17
		☐ PVT ☐ PUB			N S	W E											18
		☐ PVT ☐ PUB			N S	W E											19
		☐ PVT ☐ PUB			N S	W E											20

18 STATION	STATION NUMBER	19 DATE	20 UNIT OR STATION SUPERVISOR'S SIGNATURE
		Mo Day Yr	

MAIL COMPLETED FORM PROMPTLY TO
Wildlife Field Surveys • Michigan Department of Natural Resources
Box 30030 • Lansing, Michigan 48909-7530

R-2064 (Rev 7/19/1999)

Appendix 1 (cont'd).

INSTRUCTIONS FOR DEER PHYSICAL DATA SHEET

EXPLANATION OF DATA ENTRIES - Each line on the form is for recording information about *one* deer.

1. **VISIBLE or CONCEALED**: Highway check stations *only*. Write "**V**" if the deer would be visible to an observer standing off the road on the passenger side of the vehicle. Write "**C**" if it is not visible from that location.

2. **B, M, E or L**: Leave blank if the deer was killed during the regular firearm deer season. Otherwise write "**B**" for bow season, "**M**" for muzzleloader season, "**E**" for early season, or "**L**" for late antlerless season.

3. **PRIVATE or PUBLIC LAND**: Check "**PVT**" for private land or "**PUB**" for public land.

4. **DEER MANAGEMENT UNIT**: For each deer checked, assign a ***three-digit*** Deer Management Unit (DMU). The DMU should reference the unit where the deer was tagged, not where the hunter had a permit.

5. **COUNTY CODE**: Record the code number for the county in which the deer was killed. The county code should be a two digit number, i.e. Alcona County should be recorded as 01.

6-7. **TOWNSHIP and RANGE**: Record the location where the deer was killed. Township and range should be recorded as two digit numbers. Circle direction, i.e. "**N**" or "**S**" for township and "**W**" or "**E**" for range.

8. **SEX**: Record the sex of the deer. Use "**F**" for female or "**M**" for male, and no other symbols.

9. **AGE**: Use the following age classes: 1/2, 1-1/2, 2-1/2, 3-1/2, etc., but ***record these as 1/2, 1, 2, 3***, etc. If the deer is not a fawn, but cannot be aged to the nearest year, age as follows: "A" (adult: not a fawn but can't be aged) or "AA" (adult-adult: 2-1/2-years-old or older). Inexperienced agers should only use the codes "1/2" (fawn), "1" (yearling), or "AA" (older than yearling).

10-11. **BEAM DIAMETERS**: Record the diameter of each antler measured one inch above the burr. Each record is the average of two measurements taken at the greatest and smallest diameters. If either antler is less than one inch long, record "**B**" (broken). The beam diameter of spikes should be measured even if spikes are less than three inches in length. *Beam diameters should be recorded for **all** bucks.*

12. **TOTAL POINTS**: Record the total number of points on the two antlers. Spike deer should be included. *Do not estimate the number of points*: if one or both antlers is broken, record "**B**" (broken). Leave this column blank for antlerless deer.

13. **SPIKES LESS THAN THREE INCHES**: Check (✓) this column if the longest spike is less than three inches. Measure from the skull, not from the burr. Be sure to ***record beam diameters*** *of all spike bucks*. *DO NOT* check this column for **button bucks.**

14. **LACTATION CODE**: Code "**HM+**" if the hunter saw milk, "**HM–**" if the hunter saw no milk, "**M+**" if you saw milk and "**M–**" if no milk was present.

15. **LACTATION DATE OR REMARKS**: Write the date the milk was or was not seen; *the date is critical*. Also use this space to record anomalies, tag numbers, specimen bag numbers, ager names, etc.

16. **TB • WILDLIFE BUREAU PERSONNEL ONLY**: Deer that come into any deer check station should have their rib cage examined for TB tubercles (see laminated pictures). Record a "**+**" if pea-sized tan or yellow nodules or lumps are seen on the inside of the rib cage. If no nodules are seen, record a "**–**". If you could not examine the rib cage, record a "**o**". If tubercles are present, collect the head and a section of the rib cage, and record the hunter's name, address and telephone number in the remarks column.

17. **AGED BY**: Fill in the ager's code number. The ager's code number should be filled in for each deer. Do not use ditto marks. If the ager does not have a number, leave the number column blank, but be certain to record the full name (first, middle initial and last) in the column marked Lactation Date or Remarks (column 15).

18-20. **BOTTOM OF PAGE**: Record the station name, number and date checked. Wildlife Management Unit or station supervisor should check each form for errors before signing.

Appendix 2. Descriptions of the variables contained in the SPSS biodata file '8799bio.'

year: year during which the deer was harvested and checked (January harvests are listed under the previous year with the rest of that year's harvest)

cseason: categorical code for the season during which the deer was harvested

blank = firearm
B = bow (archery)
M = muzzleloader
E = early season
L = late season

dmu: deer management unit in which the deer was harvested (these boundaries change each year)

county: numerical code for the county in which the deer was harvested

cage: categorical code for the age of the deer

A = not fawn
AA = not fawn or yearling
00 = fawn
01 = 1.5 years old
etc.

clbeam: categorical code for the diameter (in mm) of left beam at 1 inch above the burr, recorded for only yearlings through 1991

B = beam is broken (less than 1 inch long)

crbeam: same as above for right beam

cpoints: categorical code for the total number of points on the two antlers

B = one or more antlers broken

staff: ager number

agerdiv: ager division code, recorded through 1998

blank = Wildlife Division
1 = Forest Management
2 = Parks and Recreation
3 = Administrative Services
4 = Fisheries
5 = Law
6 = DEQ
7 = Volunteers
8 = all other DNR divisions
9 = US Fish and Wildlife Service, US Forest Service, or US Park Service

Appendix 2 (cont'd).

station: station where deer was checked (district and management unit codes are conglomerates of all check stations within those areas)

1 = Alma highway check station
2 = Birch Run highway check station
3 = Mackinac Bridge highway check station
4 = Big Rapids highway check station
8 = ?
10 = ?
11 = District 1
12 = District 2
13 = District 3
14 = District 4
15 = District 5
16 = District 6
17 = District 7
18 = District 8
19 = District 9
20 = District 10
21 = District 11
22 = District 12
23 = District 23
25 = Marquette Office
26 = Roscommon Office
27 = ?
29 = Drummond Island
30 = Lansing Office
31 = Houghton Lake Wildlife Research Station
32 = Cusino Wildlife Research Station
33 = Rose Lake Wildlife Research Station
41 = Western UP Management Unit
42 = Eastern UP Management Unit
43 = Northeastern LP Management Unit
44 = Northwestern LP Management Unit
45 = Saginaw Bay Management Unit
46 = Southwestern LP Management Unit
47 = South Central LP Management Unit
48 = Southeastern LP Management Unit
99 = unknown

remarks: date lactation status observed

cspike: marked with '1' if antlers were spikes < 3 inches long

Appendix 2 (cont'd).

tb: TB status of the deer as observed by the ager, collected since 1996
+ = signs of TB observed in ribcage
- = no signs of TB observed in ribcage
0 = rib cage could not be examined
blank = no observation made

lactate: lactation status of does, collected since 1993
HM+ = hunter saw milk on the date recorded in **remarks**
HM- = hunter looked but did not see milk on the date recorded in **remarks**
M+ = ager saw milk on the date recorded in **remarks**
M- = ager looked but did not see milk on the data recorded in **remarks**

prv_pub: land type on which the deer was harvested, collected since 1998
PB = public land
PT = private land
Blank = unknown

town and **range**: town and range where the deer was harvested, collected since 1998 in the UP and since 1999 in the LP

section: section of township in which the deer was harvested (this data has never been collected in the general biodata)

vorc: recorded at highway check stations only
v = deer would be visible to an observer standing off road on the passenger's side
c = not visible from that position (concealed)

season: numerically coded season variable
1 = firearm season
2 = bow season
3 = muzzleloader season

sex: numerically coded sex variable
1 = male
2 = female

age: numerically coded age variable
0 = 0.5 years old
1 = 1.5 years old
...
5 = 5.5+ years old
6 = A
7 = AA

Appendix 2 (cont'd).

lbeam: numerical equivalent to **clbeam**, with B's eliminated

rbeam: numerical equivalent to **crbeam**, with B's eliminated

points: numerical equivalent to **cpoints**, with B's eliminated

date: data recorded when datasheet was complete (not date of harvest or check)

avebeam: average of **lbeam** and **rbeam**

mgtunit: management unit in which the deer was harvested (determined by **county**)
1 = Western UP
2 = Eastern UP
3 = Northwestern LP
4 = Northeastern LP
5 = Saginaw Bay
6 = Southwestern LP
7 = South Central LP
8 = Southeastern LP

muregion: region in which the deer was harvested, determined by **county** not **mgtunit** so the Saginaw Bay Management Unit is split between the NLP and SLP)
1 = Upper Peninsula
2 = Northern Lower Peninsula (all counties of MU 3 and MU 4 plus Clare, Gladwin, and Arenac counties)
3 = Southern Lower Peninsula (all counties of MU 6, MU 7, and MU 8, plus Isabella, Midland, Bay, Saginaw, Tuscola, Huron, and Sanilac counties)

killtype: antlered and antlerless determination
1 = Bucks = if male and not fawn, 'A,' or 'AA'
2 = Antlerless = if female and not 'A' or 'AA,' or if male fawn or male with spikes
0 = unknown = all others

Appendix 3. An example calculation of the B-WSI.

1. The data necessary for the B-WSI are the minimum daily temperatures and the daily snow depth of December through March. These data are available at the NOAA website at www.ncdc.noaa.gov/ol/climate/stationlocator.html.

2. First calculate the Degree<32 variable which is the number of degrees less than 32 degrees F of the minimum daily temperature. Then find the sum of the Degrees<32 for the entire month. See the example below from the 1986-1987 winter in Manistique.

Minimum temperature on 12/1/86 according to NOAA.

Degrees<32=32-daily minimum temperature (here Degrees<32=32-11=21).

		DAY																														
Mo.	**Variable**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**Sum**
12	**Tmin**	11	23	17	15	17	10	13	4	7	-5	4	0	-4	8	18	7	20	21	17	5	4	21	17	20	25	20	20	18	20	23	23	
	Deg.<32	21	9	15	17	15	22	19	28	25	37	28	32	36	24	14	25	12	11	15	27	28	11	15	12	7	12	12	14	12	9	9	573
1	**Tmin**	27	25	23	18	24	28	21	15	11	20	22	18	15	23	8	-7	-9	2	3	8	-2	-7	-12	-16	-10	-15	11	-1	0	18	17	
	Deg.<32	5	7	9	14	8	4	11	17	21	12	10	14	17	9	24	39	41	30	29	24	34	39	44	48	42	47	21	33	32	14	15	714
2	**Tmin**	22	24	17	3	2	19	17	2	0	17	10	12	10	8	6	3	8	0	14	7	21	28	15	10	8	12	24	21				
	Deg.<32	10	8	15	29	30	13	15	30	32	15	22	20	22	24	26	29	24	32	18	25	11	4	17	22	24	20	8	11				556
3	**Tmin**	20	16	11	8	28	33	33	19	7	8	13	7	-4	20	8	13	16	22	28	20	18	31	34	36	36	31	31	26	20	8	7	
	Deg.<32	12	16	21	24	4	-1	-1	13	25	24	19	25	36	12	24	19	16	10	4	12	14	1	-2	-4	-4	1	1	6	12	24	25	388

3. Next, calculate the average snow depth for the month and assign the month a weighted snow depth value according to the system developed by Leckenby and Adams (1986). See the continued example below from the 1986-1987 winter in Manistique.

The snow depth averaged across the month.

The depth of the snow on 12/1/86 according to NOAA.

		DAY																														
Mo.	**Variable**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**Avg.**
12	**Depth**	2	2	7	6	5	4	4	5	5	5	5	5	5	5	5	5	4	4	4	4	3	3	2	2	2	2	2	2	2	2	2	3.71
1	**Depth**	2	3	4	4	4	4	6	6	6	6	8	7	7	7	7	8	7	7	7	8	8	9	13	12	11	10	9	9	9	14	13	7.58
2	**Depth**	13	13	17	16	15	13	13	14	17	13	13	13	13	19	19	18	17	16	16	14	14	15	15	15	15	15	15	14				15.00
3	**Depth**	19	19	19	19	19	17	14	9	10	10	9	7	7	6	5	4	14	3	1	0	0	0	0	0	0	0	0	0	1	6	4	7.16

The weighted values assigned to a month with the corresponding average snow depth (from Leckenby and Adams, 1986).

Inches of Snow	Weighted Value
0.0	+0.25
0.1-2.0	-0.10
2.1-6.0	-0.25
6.1-12.0	-0.50
>12.1	-1.00

December had an average snow depth of 3.71 inches so the corresponding weighted value is -0.25.

Month	Avg. Depth	Weighted Value
12	3.71	-0.25
1	7.58	-0.50
2	15.00	-1.00
3	7.16	-0.50

5. The monthly B-WSI value can then be calculated by multiplying the monthly sum of Degrees<32 by the monthly weighted snow depth value. The annual B-WSI for Manistique is then the sum of the monthly values.

B-WSI=Degrees<32*Snow Depth (here B-WSI=573*-0.25=-143.25).

Month	Degrees<32	Snow Depth	B-WSI
12	573	-0.25	-143.25
1	714	-0.50	-357
2	652	-1.00	-652
3	388	-0.50	-194
Annual			**-1346.3**

The annual B-WSI value is the sum of the monthly values.

6. The regional B-WSI values are the average of the B-WSI values of all stations within the region of interest.

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