White-tail deer management at Montour Preserve

Colleen M. Heisey
Department of Biology
Lycoming College
Williamsport, PA 17701

Project Supervisor: Dr. Mel Zimmerman

Abstract

This is the first year of a long-term study on the effects of white-tailed deer, *Odocoileus virginianus*, on understory vegetation at the Montour Preserve in Montour County, Pennsylvania, through the use of exclosures and vegetation analysis. The vegetation of three 500 ft^2 (46.5 m^2) exclosures have been analyzed to provide a baseline for future comparison. These are compared against four 10th-acre control plots per exclosure to which the same analysis is made. A total of 35 plant species were identified for Site 1, 41 for Site 2, and 31 for Site 3. The deer population was observed through the use of spotlight surveying. Results for the September, November, and February surveys were 41.5, 109.8, and 61.1 deer per square mile of land, respectively. Additionally, a browse survey was performed; 26%, 23%, and 12% of the vegetation were browsed at Sites 1, 2, and 3, respectively. Each of the results have implications regarding deer management.

Introduction

Management of local resources has always been a controversial issue; none may be as controversial to Pennsylvania as the management of the white-tailed deer (*Odocoileus virginianus*) herd. Woolf and Roseberry (1998) indicate that deer managers have at their disposal a large base of knowledge developed from research and experience but are facing more challenges than ever before to their management skills. The challenges and criticisms arise from the many different stakeholders who each want fewer or more deer at the same place at the same time. Each of these stakeholders is actively interested in the goals, methods, and outcomes of deer management strategies. Any form of current ecosystem management integrates knowledge of ecological relationships while considering sociological and political values (McShea et al, 1997). Education and effective communication are important tools in improving sociopolitical relations. The idea that wildlife professionals should "market" scientific deer research, an

idea originating from Diefenbach and Palmer (1997), implies a more interactive approach between biological and social science. Woolf and Roseberry (1998) further assert that incorporating human dimensions into resource management is an integral component of resource management.

The Montour Preserve was established in the Appalachian hills of northcentral Pennsylvania in conjunction with the development of the Montour Steam Electric Station in 1972. Part of PP&L's program for the Montour Preserve is the responsible management of its land and of the practices used on the land. Some of the areas owned by PP&L are managed by the Preserve as multiple-use lands. The Preserve dictates soil and water conservation, wildlife habitat enhancement, and protection of open space and natural areas. Not only does it house an education complex and provide recreational space to the public, but it also coordinates land uses such as farming, timber harvesting, and reforestation. Intrinsic to the mission of the Preserve is research into conservation and land management issues. An important topic to the Preserve and at the forefront of issues in the region, is the management of the white-tail deer.

In response to concerns regarding the local deer population on the Montour Preserve and surrounding areas, Pennsylvania Power and Light (PP&L), initiated a series of deer population surveys. The initial survey was coordinated and performed by the Natural Resource Consultants, Inc. of Conestoga, PA. The evaluation presented the Preserve with an opportunity to continue to gather information necessary to make land management decisions, an integral part of the Preserve's function. The Preserve began performing an annual September census the subsequent year, 1995. Additionally, during the Summer of 1997, they erected three, half-acre exclosures at three different sites on PP&L property on and surrounding the Preserve; in conjunction with the construction of the units, a baseline analysis of each area's vegetation was executed. These activities have laid the basis for significant study of deer impact on the area.

The study that follows is to be a long-term partnership between Lycoming

College and PP&L's Montour Preserve. The information provided by the project will be used to determine deer management practices for the Preserve; this will have ramifications in hunting and planting standards the Preserve considers for its managed land. The object of this study is to create the foundation for providing adequate data to the Preserve. This is accomplished through: continued and extended use of the spotlight surveying technique; development and implementation of a browse survey; and assessment of the vegetation within and surrounding the established exclosures.

Methods and Materials

This study was comprised of observations taken from work done during the academic year, 1998-1999, at three terrestrial sites in Northern Central Pennsylvania on lands owned by Pennsylvania Power and Light (Figure 1). The PP&L Montour Preserve is located in Montour County, outside of Turbotbille, PA, and includes over 960 acres of Preserve lands within 4,000 acres PP&L managed lands. Lake Chillisquaque comprises approximately 165 acres while another 148 acres serve as a refuge. The other areas are mixed uses, from forest to agriculture to fallow fields. Further PP&L land is located adjacent to the Preserve. The exclosure sites were numbered from 1 to 3 and named according to the area close to or in which it was located. Site 1, Muskrat Cove, was located at a longitude of W 076°40.018', a latitude of N 41°06.271', and an elevation of 788 ft. Site 2, Goose Pasture, was located at a longitude of W 076°39.969', a latitude of N 41°06.619', and an elevation of 690 ft. Site 3, West Branch, was located at a longitude of W 076°41.422', a latitude of N 41°07.529', and an elevation of 451 ft. Each of these determinations were made using a GPS.

Vegetation analysis.

At each site, vegetational data was taken from both inside and outside of the exclosures by tenth-acre circles, a plot sampling method cited for maximum accuracy and minimum effort (James and Shugart, 1970). Data from four circles and the exclosure

were collected. The equipment used for this method were as follows: flags, measuring wire, a "reach stick" with Biltmore scale for classifying trees by diameter, tree identification books, an ocular tube, and the appropriate data sheets. The density of the shrubbery was determined by making two transects perpendicular to each other across the circle noting all woody stems less than 4 inches in diameter that came into contact with outstretched hands. The percent canopy cover and ground cover were estimated using the ocular tube and checking sky and ground ten times across the two transects.

From this method, the relative density, relative frequency, relative dominance, and importance value of each tree species were determined. The species were tested for diversity using the Shannon-Wiener (H') Index for evenness and the Simpson Index (C) for species richness. The Shannon-Wiener test formula is:

$$H' = -E(n_i/N) \log (n_i/N)$$

$$i = 1$$

Where n_i is the number of organisms collected in the i^{th} species, N is the total number of individuals in the species, and s equals the total number of species in the sample (Smith, 1996). The range of this score is 0-5. The formula for the Simpson test is:

$$C = 1 - E (n_i/N)^2$$

$$i = 1$$

Where the symbols represent the same variables as above (Smith, 1996). The range of this score is 0-1. A formal presentation of these equations is available in the Biology 224: Ecology Laboratory Manual (Zimmerman, 1993). All of this data was then compared.

Also based on this information was the similarity index- the Jaccard index (SC_j), the simplest approach to comparing community structures. This was found by using the equation:

$$SC_j = c/(A+B-c)$$

where c is the number of common species, A is the total number of species in stand A,

and B is the total number of species in stand B (Smith, 1996). The Jaccard index expresses the ratio of species common to the compared groups. Additionally, the index of percent similarity was defined as a measure of community similarity. This considers the number of species in each community, the species common between the two communities, and the abundance of the communities. It is calculated by the following equation:

$$\text{percent presence} = \frac{\text{number of individuals of a species}}{\text{total number of individuals in a community}}$$

The lowest percentage for each species is determined and used to calculate similarity by the following equation:

$$PS = E \text{ (lowest percentage for each species)}$$

Additionally, within the tenth-acre circles, 10-15 plots were assessed for the variety of plants it contained. The plots were chosen using a numbered circle (Appendix A.1) and numbers generated from a random table of numbers. Only numbers within the tenth-acre circle were considered. Each meter^2 plot was evaluated for the species of vegetation it contained. Each plant species was counted and, if necessary, a sample taken for later identification. The presence of grasses and sedges was noted. The samples were keyed out using various dichotomous keys and texts.

Deer population survey.

The white-tail deer census was performed using a spotlight surveying technique based on the methods established by the Montour Preserve (Beam, 1994). The rationale behind this method is that the population of white-tails will fluctuate yearly in several ways. This method records these variations. The Preserve had previously conducted surveys each September from 1994 to 1997. The established route used for the spotlight survey is approximately 12.8 miles and includes 17 different areas (Figure 2). Each field is considered to be a discrete home range for the deer observed in the area. Due to the

varied field sizes, the final results were established as deer per acre. A description of each of the observation areas is included as Appendix B (Beam, 1994).

The survey was conducted on five consecutive nights and was begun at dusk. For the September survey, these times varied from 7:50 PM to 8:00 PM. The weather was recorded each evening. The sighting technique used a 750,000 ft.-candle hand-held spotlight (Radio Shack) to spot from a vehicle driven approximately 15 miles per hour while the observers were inside. Each pair of eyes and/or silhouette was counted. If a determination could be made, the sighted deer were placed in one of the following categories: buck, doe, fawn. If a determination could not be made, the deer was noted as unknown.

In addition to the September survey, November and February surveys were conducted within the same parameters to begin establishing data for future comparison.

Deer browse survey.

The percent of browsed plants was established for each site through the following technique incorporating a 30 m tape measure, tennis balls, and the appropriate data sheets. The survey was conducted in late February. A transect was laid using the tape measure. At 5 m intervals (0 m, 5 m, 10 m...), plots (m^2) were established for evaluation; there were 7 plots per transect. The plots were established by tossing a tennis ball over one shoulder without looking. The direction the ball should be tossed was determined prior to the field work by flipping a coin: tails directed the worked to toss the ball to the left and heads indicated the ball be tossed to the right. Where the ball landed served as the center of the meter square plots.

Within the plots, the total number of woody vegetation was recorded. This included only trees and shrubs between one and six feet high. The vegetation was subsequently investigated for indications of being browsed. Trees were considered browsed if the twigs had rough, jagged edges at the tear, which is indicative of use by

deer. The formula for determining percent browse is:

% browsed = number browsed/ total number of plants

Results

Vegetation Analysis.

Table 1 depicts the results of the tenth acre circle data from the plots and the exclosure from Site 1. Seven species were found in the circles outside the exclosure at the site: hornbeam (*Ostraya virginiana*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), red maple (*Acer rubrum*), black gum (*Nyssa sylvica*), white ash (*Fraxinus americana*), and American chestnut (*Castanea americana*). Two species were found in the exclosure: white oak (*Q. alba*) and red maple (*A. rubrum*). The relative density, relative frequency, and relative dominance of each is listed as well as its importance value. The average Shannon Diversity was found to be 3.151 for the plots and 2.725 for the exclosure. The Simpson Diversity was found to be 0.855 for the plots and 0.768 for the exclosure. Shrubs were found at a level of 111 per hectare or 45 shrubs per acre outside the exclosure. There were 75 shrubs per hectare (30 shrubs per acre) inside the exclosure. The percent ground cover was found to be 73.75% while the percent canopy cover was found to be 83.75% outside the exclosure. Inside the exclosure, the percent ground cover was found to be 90.0 % and the percent canopy cover was found to be 80.0%.

Table 2 shows the results of the tenth acre circle data taken from Site 2's circles and exclosure. Seven species of trees were found outside the exclosure in the sample circles: red maple (*A. rubrum*), shagbark hickory (*C. ovata*), hornbeam *(O. virginiana*), American chestnut (*C. americana*), mockernut hickory (*Carya tomentosa*), white oak (*Q. alba*); and black gum (*N. sylvica*). Six species were found within the exclosure: red maple, shagbark hickory, hornbeam, American chestnut, basswood (*Tilia americana*), and sugar maple (*Acer saccharum*). The relative density, relative frequency, and relative

dominance of each is listed as well as its importance value. The Shannon Diversity was found to be 3.064 for the circles and 3.062 for the exclosure; the Simpson Diversity was found to be 0.817 for the circles and 0.836 for the exclosure. Shrubs were found at a level of 19 per hectare, or 75 shrubs per acre, outside the exclosure. There were 247 shrubs per hectare, or 100 shrubs per acre, inside the exclosure. The percent ground cover outside the exclosures was found to be 96.25% and 100% inside while the percent canopy cover outside the exclosure was found to be 97.5% and 90.0% inside.

The result of the tenth acre data from Site 3 are summarized in Table 3. Eight species were found in the circles: hornbeam, shagbark hickory, red maple, white oak, American elm, black gum, mockernut hickory, and basswood. Four species were viewed in the exclosure: shagbark hickory, white oak, American elm (*Ulmus americana*), and mockernut hickory. Again, the relative density, relative frequency, relative dominance, and importance values are listed. The Shannon Diversity was found to be 3.070 for the circles and 3.470 for the exclosure while the Simpson Diversity was found to be 0.853 for the circles and 0.893 for the exclosure. Shrubs were found at a level of 210 per hectare, or 85 shrubs per acre outside the exclosure. There were 0 shrubs per hectare and hence, 0 shrubs per acre inside the exclosure. The percent ground cover was found to be 91.25% while the percent canopy cover was found to be 100.0% outside of the exclosure. Within the exclosure, the percent ground cover was 100.0% and the percent canopy cover was 95.0%.

Table 4 depicts the top three tree species for each site by exclosure and by sampled circles. At Site 1 circles, the three most important species comprised 75% of the vegetation. These three species of trees were white oak (*Q. alba*), hornbeam (*O. virginiana*), and red maple (*A. rubrum*). There were only two species in the exclosure at site one: white oak and red maple. Site 2 circles contained red maple, hornbeam, and shagbark hickory (*C. ovata*). These species constituted 58% of the species present. The exclosure for Site 2 included American chestnut (*C. dentata*), shagbark hickory, and

hornbeam. The three species were responsible for 57% of the tree species. The third location, Site 3, presented white oak, red maple, and hornbeam as the important species. The species accounted for 72% of the species. The exclosure contained white oak, shagbark hickory, and American elm (*U. americana*) which represented 86% of the vegetation.

Additionally, the plots within the circles were assessed and the results presented as Appendix C. Site 1, Muskrat Cove, had 32 different species representing 20 families. Site 2, Goose Pasture, had 37 different species from 24 families. Site 3, West Branch, had 31 species which were contained within 20 families. A total of 767, 988, and 457 species were counted for each of the sites, respectively.

The community similarity analysis is depicted in Table 5. Site 1, exclosure to plots, demonstrated a Jaccard coefficient of 0.285 and had 41.2% similarity. Site 2, exclosure to plots, provided a Jaccard coefficient of 0.317 and had 43.6% similarity. Site 3, exclosure to plots, had a Jaccard coefficient of 0.419 and had 47.5% similarity. The Jaccard coefficient for the Site 1 exclosure to the Site 2 exclosure was found to be 0.230 with a similarity of 16.9%. The Jaccard coefficient for the Site 1 exclosure to the Site 3 exclosure was determined to be 0.318 with a similarity of 28.3%. The Jaccard coefficient for the Site 2 exclosure to the Site 3 exclosure was calculated to be 0.346 with a similarity of 28.2%. Finally, the plots of Sites 1 and 2 had a Jaccard coefficient of 0.333 and a similarity of 28.5% while the plots of Sites 1 and 3 had a Jaccard coefficient of 0.447 and a similarity of 46.9%. The plots of Sites 2 and 3 had a Jaccard coefficient of 0.319 and a similarity of 28.4%.

Deer population survey.

The data represented in Table 6 shows the average deer per acre for the September 1998, November 1998, and February 1999 deer population surveys. The numbers observed for each field are also included. The total average for the area observed for the September survey was 0.42 deer per acre. The high and low averages

were 3.00 and 0.00 for fields 13 and 4, respectively. The total average for the area observed for the November survey was 1.10 deer per acre. The high and low averages were 10.50 and 0.22 for fields 11 and both 17 and 5, respectively. The total average for the area observed for the February survey was 0.61 deer per acre. The high and low averages were 4.33 and 0.00 contained in fields 10 and 4, 9, and 14, respectively. Figure 6 demonstrates the prevalence of deer at each of the specified times of year.

Table 7 provides a summary of the deer observed over the consecutive five-night observation period for September 1998, November 1998, and February 1999. The average deer per night per field for September was 44.8 with the high of 4.6 in fields 6 and 17; field 4 was low with 0. For November, the average deer per night per field was 118.6. Field 7 had the highest recording, with 33.6 average deer per night while field 14 had the lowest, with 0.4. February recorded 66.0 deer per night for the total observed area. The range was 18.8 for field 17 to 0 for fields 4, 9, and 14.

The comparative values of the average deer observed per acre for the September surveys from 1994 to 1998 are presented in Table 8. The total deer per acre was 0.42 for 1998, 0.91 for 1997, 0.89 for 1996, 0.80 for 1995, and 0.68 for 1994. These results are represented in Figure 4. The quantities are measured in deer per acre for each year. It shows a large drop from 1994 to 1995 before beginning to slowly climb. 1997 to 1998 also demonstrated a large decrease. Figure 5 shows only the data collected by the Montour Preserve staff or its representatives. It is measured in deer per square mile for both the deer per **observed** square mile and the deer per **total** square mile, which was extrapolated from the previous data.

Deer browse survey.

Table 9 shows the results of the deer browse survey. At the three sites, a total of 482 plants were assessed for damage from browsing by deer. Of these, 123, or 20.3%, had been browsed. Individual site percent browse are as follows: Site 1 had 26.2% of the shrubs browsed, Site 2 had 23.2% of its vegetation browsed, and Site 3 had 12.4%

browsed vegetation.

Discussion

Study results

The primary goal of this study was to create a solid foundation for providing adequate information regarding the white-tail deer population and its effect on the area within the Preserve. The biological methods used included: (a) employment of a spotlight surveying technique to measure the local white-tail deer population; (b) implementation of a browse survey to gauge the impact of the deer on foliage overwinter; and (e) assessment of the vegetation at each of three sites to begin compiling data that indicates the effect of deer on said sites.

The assessment of the vegetation yielded a preliminary overview of the genera found in the areas. While the list is not exhaustive, it can be considered indicative of the larger Preserve. It is interesting to note that the top three tree species determined to be the most important for each of the sites, in each case, constituted more than 50% of the tree species for the experimental area. White oak (*Q. alba*) and hornbeam (*O. virginiana*) were consistently present in each location. The Jaccard coefficient, calculated comparing each site and the accompanying exclosures, provided that the plots and exclosure of each site were slightly less than 50% similar in taxa content. Further detailed assessment of the area within the exclosure may yield a higher percentage of shared taxa.

The information provided by the browse survey also provides data that will be weighed against future browse usage. Since this study is exploring the impact of the white-tailed deer specifically on the lands owned by PP&L and managed by the Montour Preserve, the results must be interpreted to reflect just those areas. Instead of developing a generic management plan for northcentral Pennsylvania lands, the Preserve wishes to use the information toward developing a specialized plan for maintaining their lands. It follows that, ideally, management decisions should be based on limits set forth in a deer

management plan established by the Montour Preserve. The desire to develop a specialized plan seems to be indicated by Beam (1994) in assessing the initial deer population results. Natural Resource Consultants, Inc. interpreted the maximum white-tail capacity of the Preserve to be at 77 deer per square mile while the Pennsylvania Game Commissions reports the capacity for the region to be at 21 deer per forested square mile. The Preserve chose to work with both figures as a high and low within which to manage the herd (Beam, 1994). In choosing this option, the Preserve suggests that it regards information and results specific to the lands it controls to be of the highest importance and relevance. Based on this assumption, the data presented should allow a biological base for future decision making where there is specific data with which to compare.

Given the long-term nature of such a study, the discussion of the first year results of the vegetation analysis and deer browse survey may seem underwhelming. Not much significant analysis can be derived from the results as there are no standards specific to the area with which to compare. Tilghman (1989) asserts that a minimum of five years is needed before any vegetation comparison between sites and exclosures can be made. However, the future applications of this year's venture are tremendous. A vast amount of information has been compiled for future reference and comparison.

Conversely, the establishment of the deer surveying procedures and data collection allows the inspection of the most recent data available for the September 1998 survey. Comparison between the months can not be performed due the large number of variables that could not be accounted. Factors such as amount of foliage on trees, percent and type of ground cover, temperature, weather, and others contribute to how many deer may be seen. Each of the factors alter drastically among the three months surveyed. The results summarized in a preceding paragraph should not be interpreted as demonstrating there are more deer in the area at one time or another, but rather that the factors favored or prevented observations of the deer during a particular sample period. For example, the

increase in total deer per acre between September and November may be partially attributed to the virtual absence of foliage, thus permitting a larger viewing realm and less cover to conceal the deer. In the same manner, it can be suggested that the decrease from November to February be correlated to the temperature; the low temperatures of February promotes bedding down while the warmer temperatures of November is more encouraging for evening foraging. Regardless of the reasons for the differences, comparisons in the number of total deer per acre will not be made on the basis that the factors involved are too numerous to adequately interpret the results.

However, a comparison can be made within each data set for a certain month as sufficient evidence becomes available. Thus examination of the September 1998 results and of Preserve's previous September surveys can be done. The 0.42 deer observed per acre is the lowest population density recorded since the project's inception in 1994. This decrease follows three years of slight increases. The decrease of 0.49 deer per acre from 1997 to 1998 resembles the deer per acre decrease from 1993 to 1994, which was also by 0.49 deer per acre. The data, converted to deer per square mile, yields 60.5 observed deer per square mile and 41.5 deer per total square mile. This result is mid-range in the established desired limits of deer per square mile which were mentioned earlier.

Additionally, it is interesting to note the field by field trends in Figure 10. This is not reported as a result as more in depth review of each of the fields uses is required before attempting to find a pattern in deer usage. It may be beneficial to examine the type of cover in the field and the deer density to assess possible correlation or causation. For example, noting the disparity among the five data points for field 11, a little investigative work could provide a great deal of information. Perhaps a certain cover enhances or inhibits deer usage. It would also be of interest to review cover types in adjacent areas as nearby vegetation will also affect trends. This will also require accounting for the field's size and the capacity in which it was used during each period. Treatment of each field as a discrete point in such a way may provide evidence helpful in

making land management decisions.

White-tailed deer management

While the results of the study provide the basis for the biological assessment of the local deer population, there are other management aspects to consider. This is but one important component of effective deer management in the local area. Deer management also encompasses sociological aspects as well, such as economics and politics. Figure 11 represents a breakdown of the deer management into it's constituent parts under which are several examples of each area. The list is by no means exhaustive and should not be considered as such.

The economic impact of deer management is great. Diefenbach et al (1997) relate that deer are an economically important game species to Pennsylvania: annual retail sales and wage earnings are in excess of $245 million and $122 million, respectively. From an economic standpoint, deer management should maintain deer populations at a level where the aggregate positive benefits are greater than the aggregate negative costs.

The economics of the white-tail deer herd is dependent on what level of value is placed on the resource. Conover (1997) defines valuation as estimating the worth of something or an estimation, usually personal in nature, of the merit, importance, or character of something. He continues, noting that an object's value depends on its importance, degree of utility, or perceived worth and it can be either monetary or intangible in nature. Important to deer management decisions is the local community's valuation of the animal; the value of the deer in the area is based on a collective opinion. There are both positive values, such as value to hunters and sightseers, and negative values, such as deer-vehicle accidents and crop damage (Conover, 1997). While the positive monetary values of deer are spread throughout the system, negative monetary values typically fall on individuals. This leads to externalities. For example, hunters desire high deer populations but do not compensate for disturbances such as automobile accidents or private land damage caused by the overabundance of deer. Intangible values

are difficult to define as each individual places different emphasis on pleasure from viewing or reading about deer or from the sense of well-being derived from supporting a living creature. Society's intangible values are best expressed by citing the use of tax dollars and the tolerance of economic loss in order to guarantee that the species does not become extinct (Conover, 1997).

The political ramifications occurring through and by deer management are also large. Diefenbach and Palmer (1997) state that Pennsylvania deer management system is habitat based; its objective is to carry the number of deer that forested land can support without loss of tree regeneration. Pennsylvania acknowledges the problem of deer overabundance and have developed specific programs derived from legislation and state codes, the basis of which is to encourage hunting (Messmer et al, 1997). The deer management goals of the Pennsylvania Game Commission (PGC), a political institution incorporating science and opinion, are: to sustain deer for harvest by hunters; to balance deer populations with their natural food supplies; to alleviate deer- human conflicts; and to minimize crop damage (Diefenbach et al, 1997).

Public opinion is extremely important in developing policy. The PGC is funded by those it serves and thus, has certain incentives to provide regulations and policies balanced among hunters, special interest groups, and the general public. Green et al (1997) indicates that the most common forums for assessing public opinion are public meetings, surveys, and advisory groups. Concerns are often raised about human behavior, public safety, and animal rights at such gathering. Green et al (1997) recommended candid and honest use of media reports to increase public awareness, inclusion of public opinion in development of management plans, and continued efforts to educate the community and to seek their beliefs about deer. Education of people will help defend against ignorance and arrogance, pointed out by Porter (1997) as the two largest factors hindering wildlife management. Additionally, Kilpatrick and Walter (1997) forwarded the idea of combining education and opinion collection, believing

public informational meetings to influence public opinion; community members seemed more attuned to considering various alternatives, when each and the situation had been adequately explained. Further, citizen participation in management improves decisions and their acceptance and benefits the image of the agency managing the area (Curtis and Hauber, 1997).

Management techniques should be directed towards minimizing reproductive potential of the local deer population, maximizing safety, and reaching the deer management goal of the area. The deer management goal is maintenance of a herd balanced with the supporting habitat and considers the local community's values and attitudes. The cultural carrying capacity plays an important role in management decisions; it is a function of the sensitivity of local humans to deer and the effects that accompany deer presence. Sensitivity is dependent on local land uses, deer densities, and attitudes and priorities of those living in the area. Improved management requires better information about how human actions affect wildlife responses and vice-versa, as well as clarification as to what level of coexistence is desired within both local populations (Whittaker and Knight, 1998). It also requires understanding of laws and regulations administered by the state, city, county, and local governments; it requires investigation of the ethical concerns about the treatment of animals, public awareness of violence, and attitudes about hunters and hunting (Stout et al, 1997).

White-tail population and harvests have dramatically increased in the eastern United States on all lands public and private during this century. Recognition of deer impact on parts of the ecosystem and controversy surrounding any form of management has also increased (Porter, 1992; Kroll, 1994; Witmer and deCalesta, 1992; deCalesta and Stout, 1997). There are no fast and easy answers to the questions and concerns that currently bombard the management profession. The best steps that managers can take is to remain informed, to assess all three components, and to education others about the various existing thoughts and backgrounds. Messmer el al (1997) contends, and I agree,

that management of wildlife does not exist in a "vacuum" void of human involvement; social, cultural, and political aspects are necessary considerations in management decisions.

Recommendations

Vegetation analysis.

- This part of the study requires the most review. Since I am aware of the future Rider Park project and its parallel nature to the white-tail deer project, I would suggest incorporating the vegetation analyses of the two areas by alternating years between the two sites if such an in depth inventory is desired.
- Reviewing the parameters used to evaluate the vegetation. With respect to this, I cataloged all plants, herbaceous and woody, within the m^2 plot, regardless of height. At the most recent meeting of the Pennsylvania Academy of the Sciences, I discussed a similar project with participants from the University of Scranton, Scranton, PA. While they were only evaluating woody species, they restricted their appraisal to those greater than 10 cm. I believe it would be useful to contact the University of Scranton, Department of Biology to obtain a copy of their paper, in particular, the methods used and its justification. Looking only at those plants greater than 10 cm will greatly speed the process of identifying plants, as the tiny samples were the most difficult for the novice to assess.

Deer population survey.

- The deer surveying should continue to gather comparative data. As implied in the main body of the paper, I would suggest a field-by-field investigation as a possible source of information. Also, along with recording the time, date, weather, etc. each evening before beginning the spotlight survey, it may be interesting to record other data as well, like: visibility, amount of light/ phase of moon, and temperature.
- I would suggest the use of a deer population simulator. Much modeling seems to be

done or enhanced by computers; this could provide invaluable experience to the person performing the study in addition to feedback to the study. The program I discovered is called "Deer Management Simulator" (DMS) and was developed for the National Park Service by Ken Risenhoover of Texas A&M University and H. Brian Underwood of the USGS. This program requires GIS databases so involvement of the local county office will probably be required. I believe that the relationships fostered through such an involvement will enhance the "partnering" nature of the project.

- Finally, I would like input from the Preserve staff as to what would lessen the burden of the surveying or analysis from their office. If the project is split between deer and vegetation, then I would urge that the student responsible for the deer aspect take the opportunity to write a paper on both the November and February studies.

Browse survey.

- I merely suggest that more transects be completed per site at a specified time during the year. If alternating vegetation years, I would also recommend performing a preferred browse study opposite the site's vegetation analysis.

Overall project.

- My primary assertion is that the compilation of information be continued. However, the scope of the project is large and it will be more useful for the student involved to specialize in one of the two areas. I would encourage a more general knowledge about the other area. I would split the program as follows: vegetation analysis and browse study to one student and deer population survey and population modeling to another.
- In reviewing the many papers available on the impact of deer their surroundings, I discovered several concerning diversity of birds. This idea was also touched on in several papers, although not a major topic. Given the seemingly high interest of those who use the Preserve facilities for birding, a study such as this may be interesting.

Additionally, comparison of small mammal populations within and outside the exclosures should also be done. This would provide information on the impact of deer versus small mammals on seed germination and regeneration of browse.

- Furthermore, I would like to see the other aspects of white-tail deer management developed. This project contains biological information but we must also understand the sociological aspects also. Management is a combination of politics, economics, biology, and opinion. This type of study may hold opportunities for yet another student. The idea of deer management is interdisciplinary; the project should be as well.

Acknowledgements

I would like to thank the Pennsylvania Power and Light's Montour Preserve and its staff not only for the use of the exclosures and survey areas but also for the guidance and assistance provided throughout the project. Mr. Jon Beam and Mr. Frederick Gast served as excellent advisors on behalf of the Preserve. I would especially like to thank the several faculty members at Lycoming College in the Departments of Biology and Economics for serving on my honors committee: Dr. Robert Angstadt, Dr. Michelle Briggs, Dr. Philip Sprunger, and Dr. Melvin Zimmerman. Additionally, the work could not have been completed in such a timely manner had it not been for the assistance of several students whom I would like to thank: Kent Adams, Shirley Eiswerth, Katie Ely, Ashley Lenig, Christine Robbins, Brian Schlee, and Denise Shimel.

Literature Cited

Beam, J.D.; Carbaugh, B. 1994 White-tailed deer census by spotlight survey on PP&L's Montour Preserve. 1994

Conover, M.R. Monetary and intangible valuation of deer in the United States. Wildlife Society Bulletin 25(2): 298-305. 1997.

Curtis, P.D.; Hauber, J.R. Public involvement in deer management decisions: consensus versus consent. Wildlife Society Bulletin 25(2): 399-403. 1997.

deCalesta, D.S.; Stout, S.L. Relative deer density and sustainability: a conceptual framework for integrating deer management with ecosystem management. Wildlife Society Bulletin 25(2): 252-258. 1997

Diefenbach, D.R.; Palmer, W.L. Deer management: marketing in science. Wildlife Society Bulletin 25: 378-381. 1997.

Green, D.; Askin, G.R.; West, P.D. Public opinion: obstacle or aid to sound deer management? Wildlife Society Bulletin 25(2): 367-370. 1997.

James, F.C.; Shugart, H.H. A quantitative method of habitat description. Audubon Field Notes 24(6): 727-736. 1970.

Kilpatrick, H.J.; Walter, W.D. Urban deer management: a community vote. Wildlife Society Bulletin 25(2): 388-391. 1997.

Kroll, J.C. These were the good old days: a new paradigm for white-tail deer management. Proceedings of the Annual Southeast Deer Study Group. 17:20-21. 1994.

Messmer, T.A.; Cornicelli, L.; Decker, D.J.; Hewitt, D.G. Stakeholders acceptance of urban deer management techniques. Wildlife Society Bulletin 25(2); 360-366. 1997.

Porter, W.F. Ignorance, arrogance, and the process of managing overabundant deer. Wildlife Society Bulletin 25(2): 408-412. 1997.

Porter, W.F. Burgeoning ungulate populations in national parks: Is intervention warranted? pp. 304-312 *in* D.R. McCullough, and R.H. Barrett, eds. Wildlife 2001: populations. Elsevier Scientific Publications, New York, N.Y. 1992.

Smith, R.L. Ecology and Field Biology. 5th ed. New York: HarperCollins College Publishers, 1996.

Stout, R.J.; Knuth, B.A.; Curtis, P.D. Preferences of suburban landowners for deer management techniques: a step towards better communication. Wildlife Society Bulletin. 25(2): 348-359. 1997.

Tilghman, N.G. Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. Journal of Wildlife Management 25(3): 524-532. 1989.

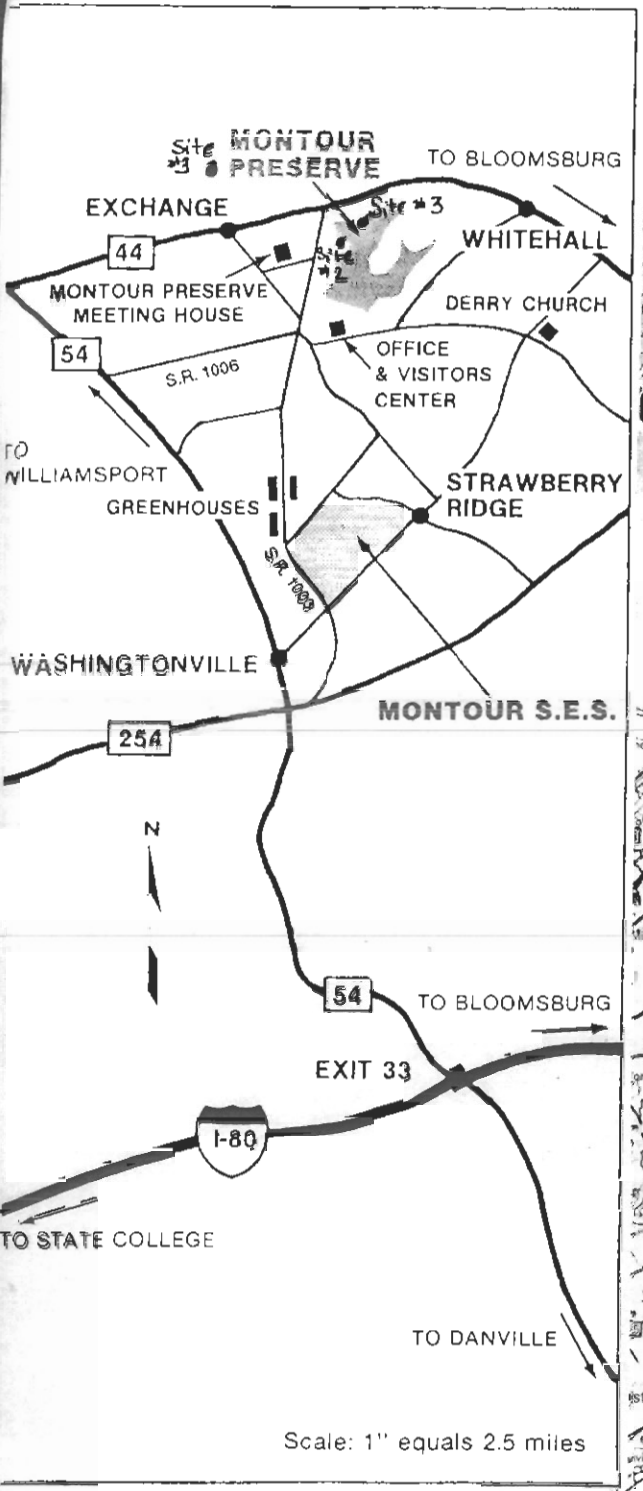
Whittaker, D.; Knight, R.L. Understanding wildlife responses to humans. Wildlife Society Bulletin 26(2): 312-317. 1998.

Witmer, G.W.; deCalesta, D.S. The need and difficulty of bringing the Pennsylvania deer herd under control. Proceedings of the Eastern Wildlife Damage Control Conference. 5:130-137. 1992.

Woolf, A.; Roseberry, J.L. Deer management: our profession's symbol of success or failure? Wildlife Society Bulletin 26(3): 515-521. 1998.

Zimmerman, M.C. Exercise 2- Terrestrial Study. Biology 224: Ecology Laboratory Manual. Williamsport, PA: Lycoming College, 1993: I-21.

Figure 1. Map of northcentral Pennsylvania; insert of the Montour Preserve sites.



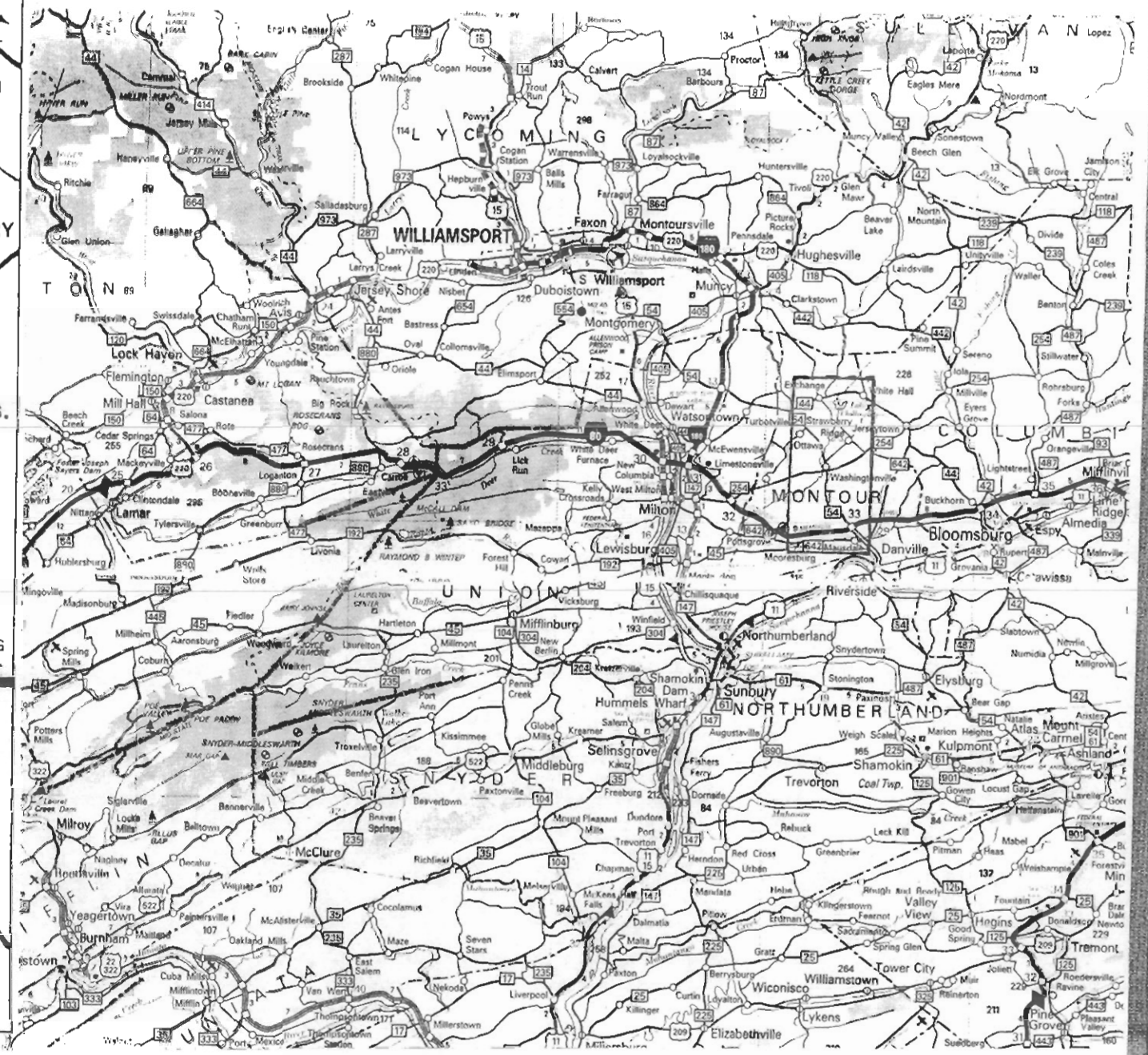


Figure 2. Deer population spotlight surveying route, fields indicated by number.

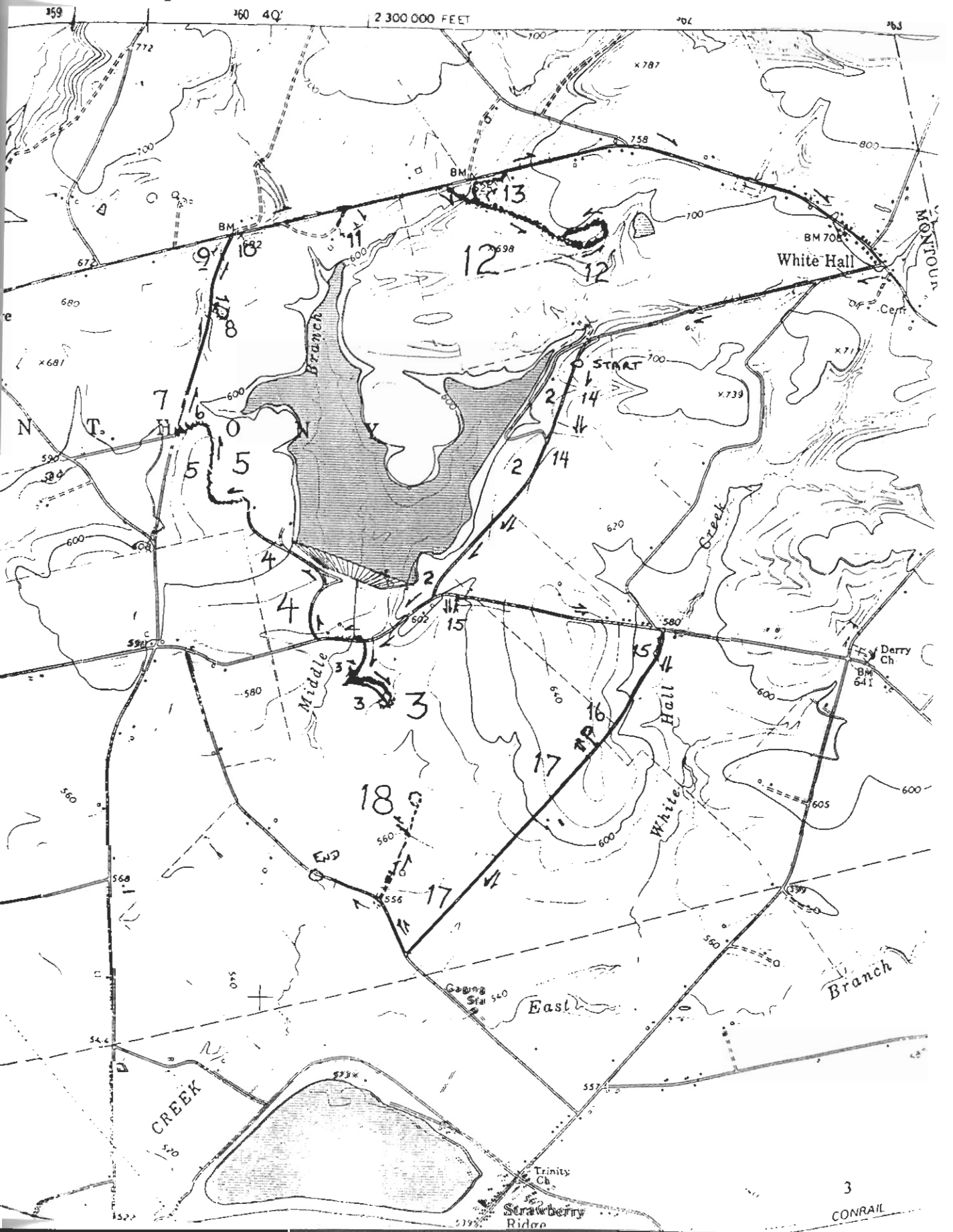


Table 1: Results of the Tenth Acre Circle data taken from Site 1, Muskrat Cove

Circles	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ostraya virginiana Hornbeam	31.0	21.1	11.1	63.2
Quercus alba White oak	27.0	21.1	68.5	116.6
Carya ovata Shagbark hickory	6.0	10.5	6.1	22.6
Acer rubrum Red maple	15.0	21.1	8.0	44.1
Nyssa slyvica Black gum	5.0	10.5	2.4	17.9
Fraxinus americana White ash	15.0	10.5	3.7	29.2
Castenea americana American chestnut	1.0	5.3	0.2	6.5
TOTAL				
Shrubs/ hectare =	111			
Shrubs/ acre =	45			
% Ground cover =	73.75%			
% Canopy cover =	83.75%			
Shannon Diversity	3.151			
Simpson Diversity	0.855			

Exclosure	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Quercus alba White oak	46.7	50.0	70.2	166.9
Acer rubrum Red maple	53.3	50.0	29.8	133.1
TOTAL				
Shrubs/ hectare =	74			
Shrubs/ acre =	30			
% Ground cover =	90.00%			
% Canopy cover =	80.00%			
Shannon Diversity	2.725			
Simpson Diversity	0.768			

Table 2: Results of the Tenth Acre Circle data taken from Site 2, Goose Pasture.

Circles	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Acer rubrum Red maple	50.7	26.7	39.0	116.4
Carya ovata Shagbark hickory	9.6	20.0	22.0	51.6
Ostraya virginiana Hornbeam	27.4	26.7	20.4	74.5
Castenea americana American chestnut	2..7	6.7	1.8	11.2
Carya tomentosa Mockernut hickory	2.7	6.7	0.3	9.7
Quercus alba White oak	5.5	6.7	16.0	28.2
Nyssa slyvica Black gum	1.4	6.7	0.5	8.6
TOTAL				
Shrubs/ hectare =	19			
Shrubs/ acre =	7.5			
% Ground cover =	96.25%			
% Canopy cover =	97.50%			
Shannon Diversity	3.064			
Simpson Diversity	0.817			

Exclosure	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Acer rubrum Red maple	7	16.7	19.3	42.7
Carya ovata Shagbark hickory	20	16.7	20.7	57.4
Ostraya virginiana Hornbeam	27	16.7	3.6	47
Castanea americana American chestnut	20	16.7	29.3	66
Tilia americana Basswood	7	16.7	19.3	42.7
Acer saccharum Sugar maple	20	16.7	7.9	44.6
TOTAL				
Shrubs/ hectare =	247			
Shrubs/ acre =	100			
% Ground cover =	100.00%			
% Canopy cover =	90.00%			
Shannon Diversity	3.062			
Simpson Diversity	0.836			

Table 3: Results of the Tenth Acre Circle data taken from Site 3, West Branch

Circles	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Ostraya virginiana Hornbeam	25.4	19.0	8.6	53
Carya ovata Shagbark hickory	17.5	19.0	4.8	41.3
Acer rubrum Red maple	20.6	19.0	24.5	64.1
Quercus alba White oak	25.4	19.0	53.8	98.2
Ulmus americana American elm	6.3	9.5	1.9	17.7
Nyssa sylvica Black gum	1.6	4.8	0.3	6.7
Carya tomentosa Mockernut hickory	1.6	4.8	5.7	12.1
Tilia americana Basswood	1.6	4.8	0.3	6.7
TOTAL				
Shrubs/ hectare =	210			
Shrubs/ acre =	85			
% Ground cover =	91.25%			
% Canopy cover =	100.00%			
Shannon Diversity	3.070			
Simpson Diversity	0.853			

Exclosure	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Carya ovata Shagbark hickory	30.8	25.0	5.0	60.8
Quercus alba White oak	38.5	25.0	78.3	141.8
Ulmus americana American elm	23.1	25.0	11.8	59.9
Carya tomentosa Mockernut hickory	7.7	25.0	5.0	37.7
TOTAL				
Shrubs/ hectare =	0			
Shrubs/ acre =	0			
% Ground cover =	100.00%			
% Canopy cover =	90.00%			
Shannon Diversity	3.470			
Simpson Diversity	0.893			

Table 4: The three vegetation species determined to be most important per site, 1998.

		Species	Common name	Importance Value	Total # of important species and % of total
Site 1:	Circles	*Quercus alba*	White Oak	116.6	
		Ostraya virginiana	Hornbeam	63.2	223.9
		Acer rubrum	Red Maple	44.1	75%
	Exclosure	*Quercus alba*	White Oak	166.9	
		Acer rubrum	Red Maple	133.1	300.0
					100%
Site 2:	Circles	*Acer rubrum*	Red Maple	116.4	
		Ostraya virginiana	Hornbeam	74.5	175.0
		Carya ovata	Shagbark Hickory	51.6	58%
	Exclosure	*Castanea dentata*	American Chestnut	66.0	
		Carya ovata	Shagbark Hickory	57.4	170.4
		Ostraya virginiana	Hornbeam	47.0	57%
Site 3:	Circles	*Quercus alba*	White Oak	98.2	
		Acer rubrum	Red Maple	64.1	215.3
		Ostrya virginiana	Hornbeam	53.0	72%
	Exclosure	*Quercus alba*	White Oak	141.8	
		Carya ovata	Shagbark Hickory	60.8	262.5
		Ulmus americana	American Elm	59.9	88%

Table 5: Community similarity by Jaccard coefficient and percent similarity for exclosures and plots.

Site	# of taxa	# of individuals	total taxa	# shared taxa	Jaccard coefficient	% similarity
1E	13	100				
1P	32	669				
			35	10	**0.285**	**41.2**
2E	19	504				
2P	35	783				
			41	13	**0.317**	**43.6**
3E	16	60				
3P	28	297				
			31	13	**0.419**	**47.5**
1E	13	100				
2E	19	504				
			26	6	**0.230**	**16.9**
1E	13	100				
3E	16	160				
			22	7	**0.318**	**28.3**
2E	19	504				
3E	16	160				
			26	9	**0.346**	**28.2**
1P	28	668				
2P	36	786				
			48	16	**0.333**	**28.5**
1P	28	668				
3P	27	260				
			38	17	**0.447**	**46.9**
2P	36	786				
3P	27	260				
			47	15	**0.319**	**28.4**

E= exclosure
P= plots from circles
1= Site 1
2= Site 2
3= Site 3

Table 6: Average deer per acre for September 1998, November 1999, and February 1999

September 1998	Field Number	# Acres	Total Deer Observed	Total Deer/ Acre
	2	59	10	0.17
	3	50	47	0.94
	4	31	0	0.00
	5	27	3	0.11
	6	10	23	2.30
	7	40	2	0.05
	8	20	5	0.25
	9	9	20	2.22
	10	9	4	0.44
	11	6	2	0.33
	12	65	13	0.20
	13	6	18	3.00
	14	5	1	0.20
	15	70	20	0.29
	16	22	20	0.91
	17	59	23	0.39
	18	50	13	0.26
	Total	538	224	0.42

November 1998	Field Number	# Acres	Total Deer Observed	Total Deer/ Acre
	2	59	46	0.78
	3	50	36	0.72
	4	31	12	0.39
	5	27	6	0.22
	6	10	73	7.30
	7	40	168	4.20
	8	20	28	1.40
	9	9	3	0.33
	10	9	40	4.44
	11	6	63	10.50
	12	65	15	0.23
	13	6	24	4.00
	14	5	2	0.40
	15	70	29	0.41
	16	22	7	0.32
	17	59	13	0.22
	18	50	28	0.56
	Total	538	593	1.10

February 1999	Field Number	# Acres	Total Deer Observed	Total Deer/ Acre
	2	59	1	0.02
	3	50	15	0.30
	4	31	0	0.00
	5	27	1	0.04
	6	10	18	1.80
	7	40	62	1.55
	8	20	8	0.40
	9	9	0	0.00
	10	9	39	4.33
	11	6	12	2.00
	12	65	20	0.31
	13	6	2	0.33
	14	5	0	0.00
	15	70	23	0.33
	16	22	4	0.18
	17	59	94	1.59
	18	50	31	0.62
	Total	538	330	0.61

Figure 3. Comparison of population density estimates for September 1998, November 1998, and February 1999

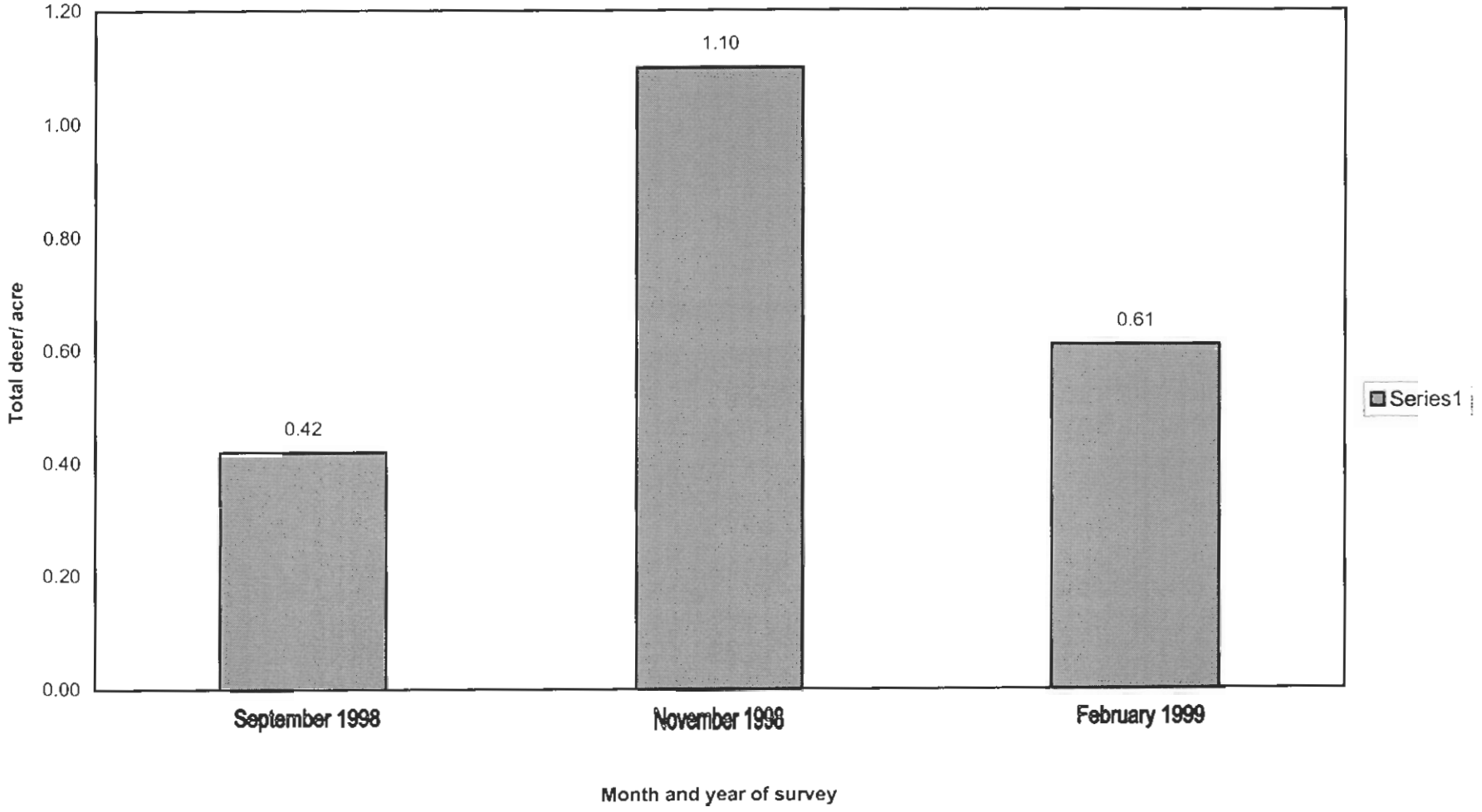


Table 7: Summary of deer observed in five nights, per field for September 1998, November 1998, and February 1999

September 1998	Field Number	Total Deer Observed	Number of Nights	Avg Deer/ Night/ field
	2	10	5	2.0
	3	47	5	9.4
	4	0	5	0.0
	5	3	5	0.6
	6	23	5	4.6
	7	2	5	0.4
	8	5	5	1.0
	9	20	5	4.0
	10	4	5	0.8
	11	2	5	0.4
	12	13	5	2.6
	13	18	5	3.6
	14	1	5	0.2
	15	20	5	4.0
	16	20	5	4.0
	17	23	5	4.6
	18	13	5	2.6
	Total	224	5	44.8

November 1998	Field Number	Total Deer Observed	Number of Nights	Avg Deer/ Night/ field
	2	46	5	9.2
	3	36	5	7.2
	4	12	5	2.4
	5	6	5	1.2
	6	73	5	14.6
	7	168	5	33.6
	8	28	5	5.6
	9	3	5	0.6
	10	40	5	8.0
	11	63	5	12.6
	12	15	5	3.0
	13	24	5	4.8
	14	2	5	0.4
	15	29	5	5.8
	16	7	5	1.4
	17	13	5	2.6
	18	28	5	5.6
	Total	593	5	118.6

February 1999	Field Number	Total Deer Observed	Number of Nights	Avg Deer/ Night/ field
	2	1	5	0.2
	3	15	5	3.0
	4	0	5	0.0
	5	1	5	0.2
	6	18	5	3.6
	7	62	5	12.4
	8	8	5	1.6
	9	0	5	0.0
	10	39	5	7.8
	11	12	5	2.4
	12	20	5	4.0
	13	2	5	0.4
	14	0	5	0.0
	15	23	5	4.6
	16	4	5	0.8
	17	94	5	18.8
	18	31	5	6.2
	Total	330	5	66.0

Field Number	1998 Total deer/ acre	1997 Total deer/ acre	1996 Total deer/ acre	1995 Total deer/ arce	1994 Total deer/ acre
2	0.17	0.00	0.00	0.07	0.10
3	0.94	0.22	0.38	0.76	0.82
4	0.00	0.00	0.13	0.29	0.00
5	0.11	1.89	2.13	0.56	0.32
6	2.30	1.60	2.00	5.16	0.14
7	0.05	0.65	1.40	0.99	0.58
8	0.25	1.40	1.00	0.45	1.00
9	2.22	0.56	2.11	1.56	0.00
10	0.44	4.67	4.56	0.89	0.56
11	0.33	5.17	1.34	0.50	6.33
12	0.20	1.22	0.83	1.26	2.06
13	3.00	1.00	2.67	0.83	1.67
14	0.20	0.00	0.20	0.00	0.00
15	0.29	0.19	0.31	0.33	0.21
16	0.91	0.77	0.73	1.86	0.00
17	0.39	0.29	0.22	0.12	0.10
18	0.26	1.28	1.20	0.60	0.22
Year avg.	0.42	0.91	0.89	0.80	0.68

Table 8: Comparison of average deer observed per acre for September surveys from 1994-1998

Figure 4. Comparison of results of September deep population surveys from 1993-1998

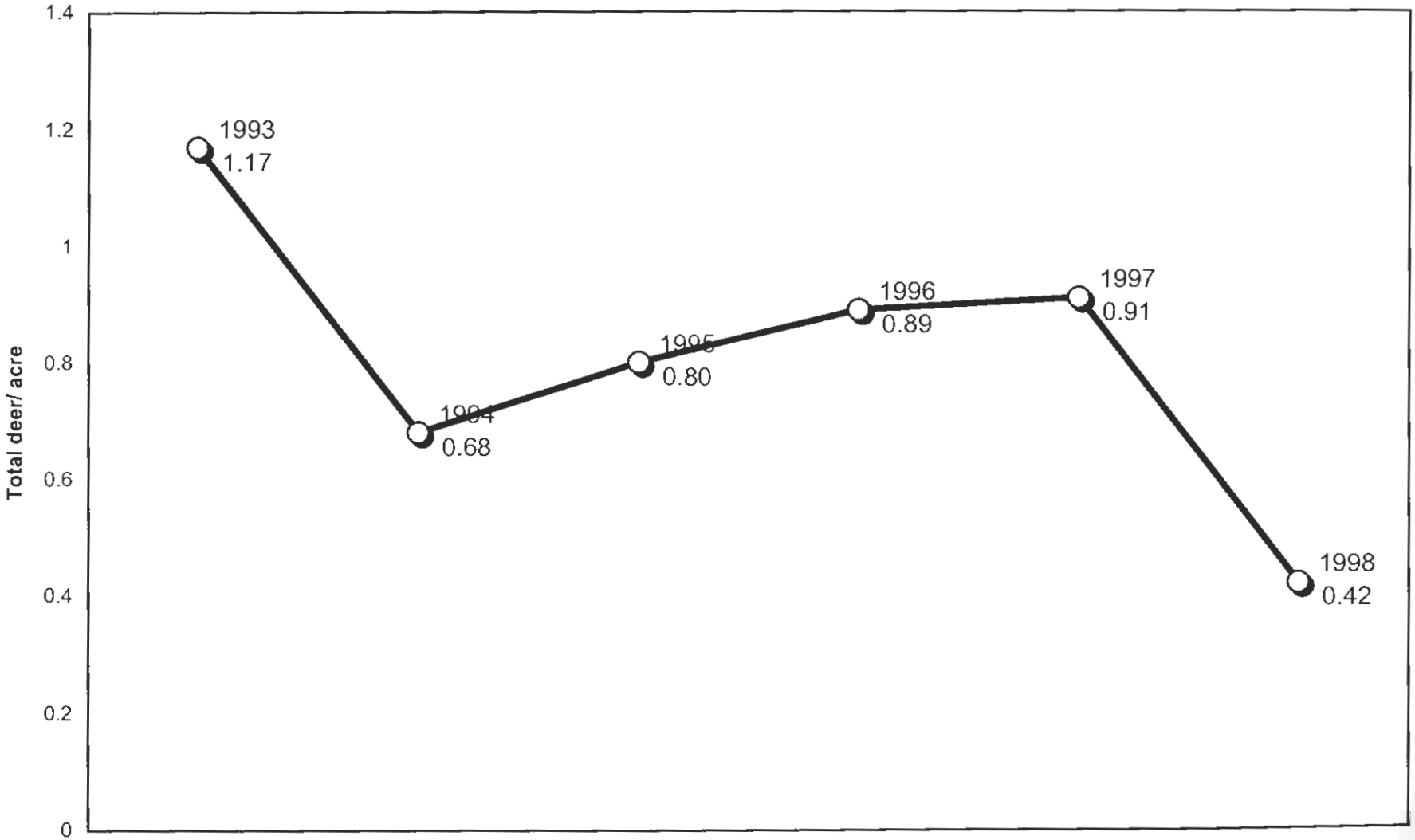


Figure 5. Comparison of results from September deer population surveys from 1994-1998

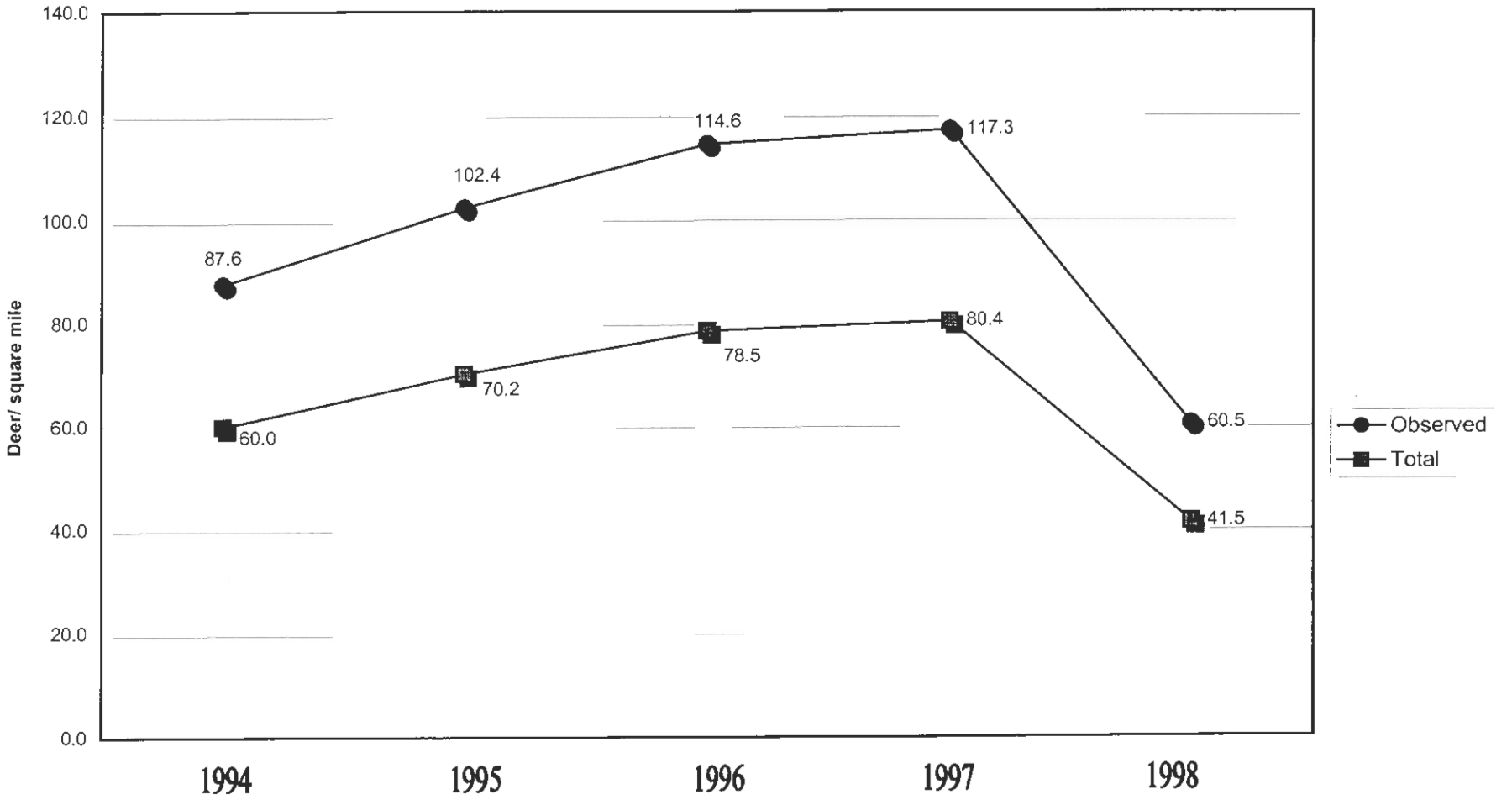
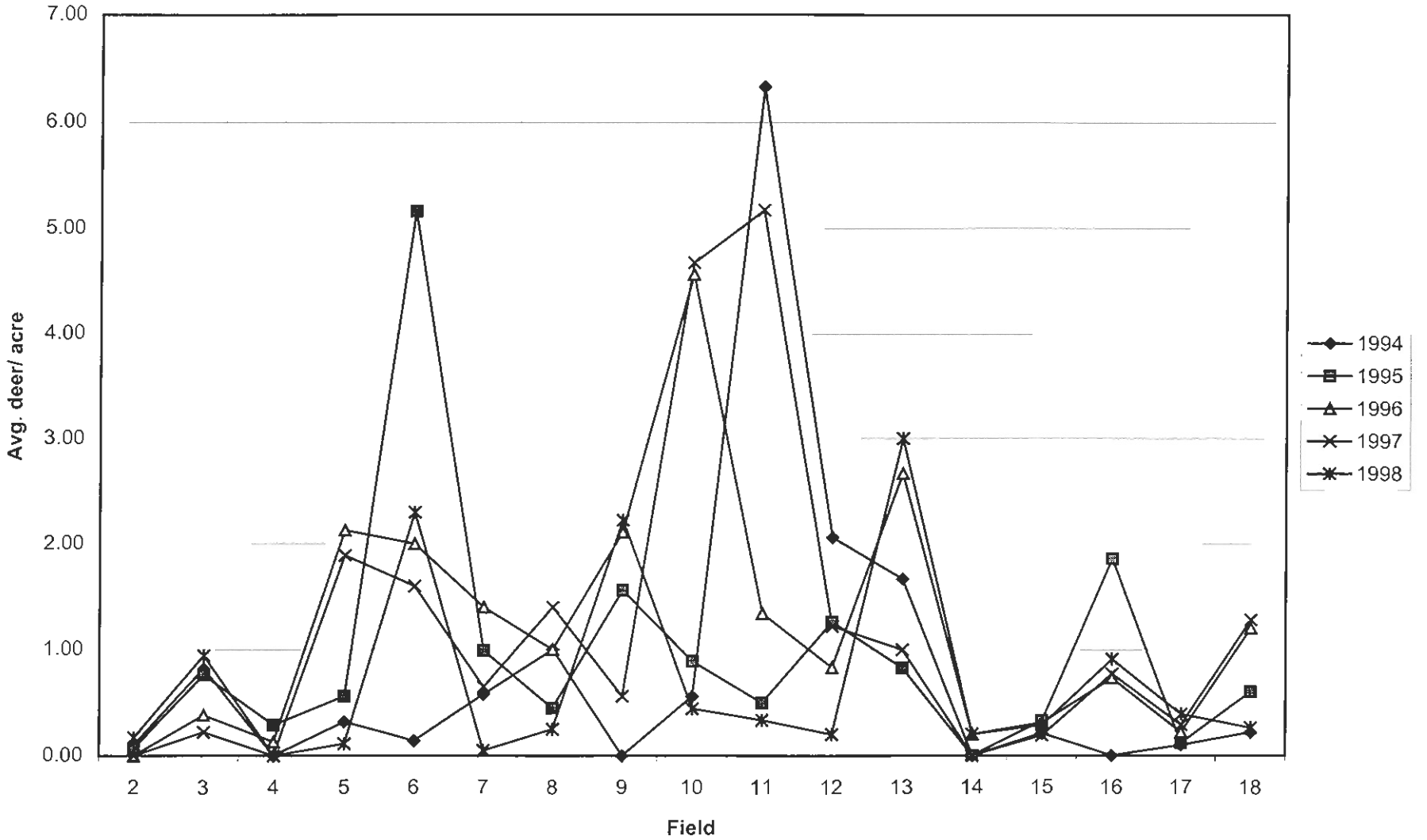


Table 9. Summary of 1999 browse analysis

	# of plants	*# browsed*	***% browsed***
Site 1	152	54	26.2%
Site 2	139	42	23.2%
Site 3	191	27	12.4%
Total	482	123	20.3%

Figure 10. Deer per field for September surveys, 1994-1998



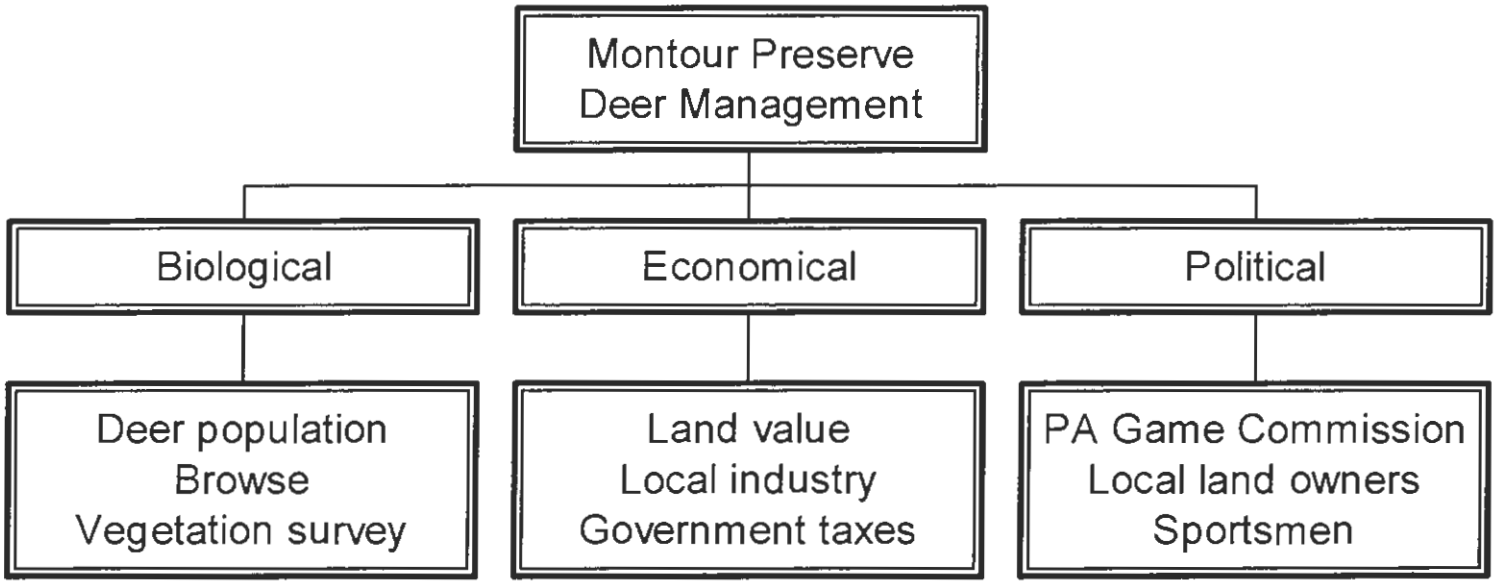
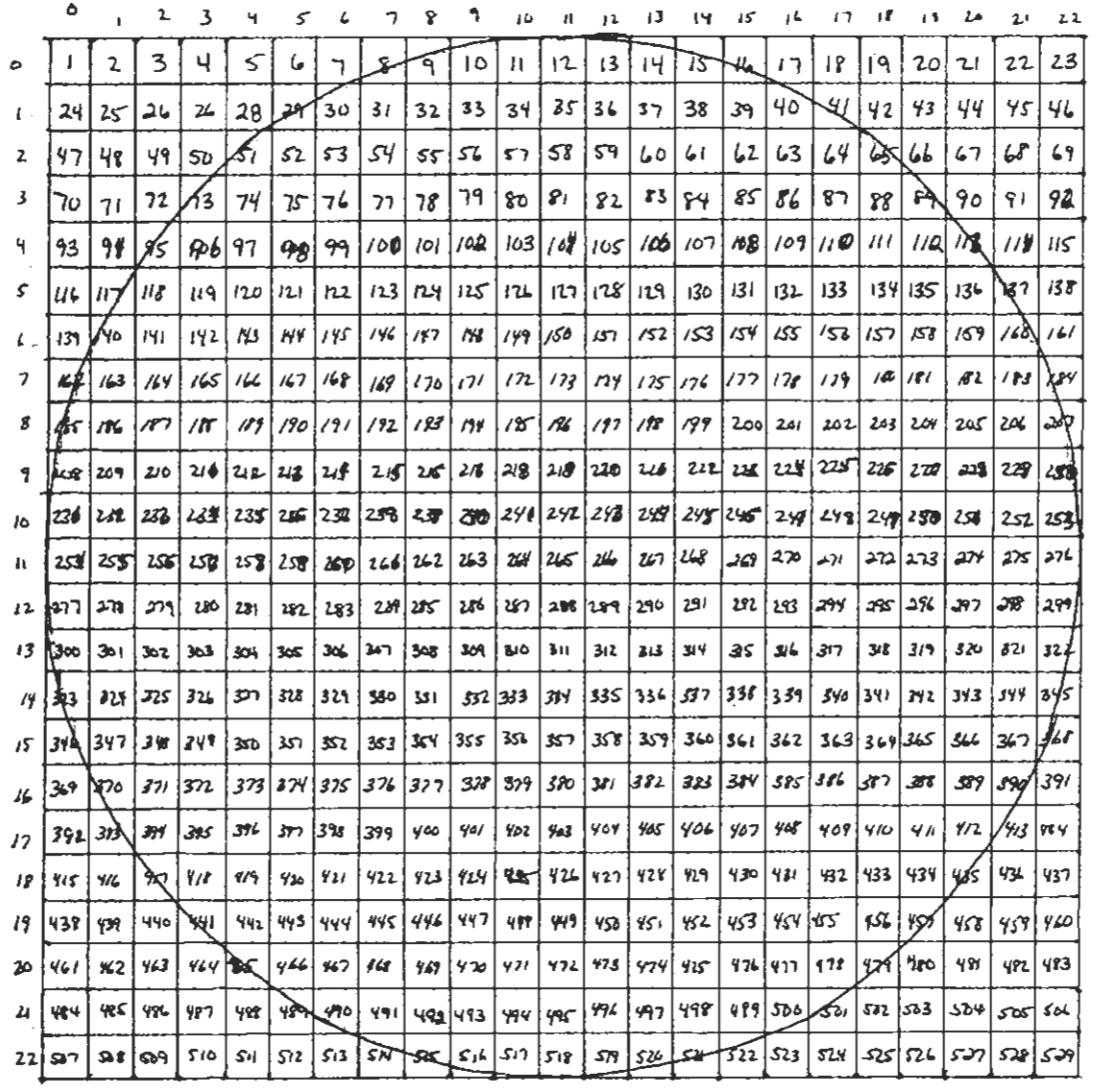


Figure 11. Breakdown of deer management into constituent parts.



Appendix A-1. Data sheets: Numbered plots in tenth-acre circle.

FIELD DATA FORM - VEGETATION ANALYSIS - TENTH ACRE CIRCLE METHOD: LOCATION:

SIZE: DATE: DESCRIPTION OF AREA:

TOPOGRAPHY:

TREES DIAMETER SIZE CLASS A-H: 3-6", 9-15", 15-21", 27-33", 33-40", >40"

SPECIES	CIRCLE 1	CIRCLE 2	CIRCLE 3	CIRCLE 4	CIRCLE 5	CIRCLE 6

SHRUBS: NUMBER OF WOODY STEMS LESS THAN 4" D.B.H. INTERCEPTED IN TWO ARMLENGTH TRANSECTS

GROUND COVER: 20 RANDOM +/- SIGHTINGS THROUGH OCULAR TUBE FOR PRESENCE OR ABSENCE OF GREEN VEGAETATION

CANOP COVER: 20 +/- SIGHTINGS THROUGH OCULAR TUBE FOR PRESENCE OR ABSENCE OF GREEN VEGETATION

CANOPY HEIGHT: MAXIMUM CANOPY HEIGHT IN FEET

TO CHECK THE ADEQUACY OF SAMPLE: TOTAL NO. OF TREES IN 5 CIRCLES X 2 =
TOTAL NO. OF TREES IN 6 CIRCLES X 1.6 =

IF THE DIFFERENCE IS <25, THE SAMPLE IS ADEQUATE. IF IT IS >25, SEE PROCEDURE.

Appendix A-2. Data sheets: Tenth-acre circle recording sheet.

summary 10th-acre circles | No. of circles= | Location;

TREES: class density ①

Species	Number of trees in all circles by diameter class size-class ③ A 3-6"	B 6-9"	C 9-15"	D 15-21"	E 21-27"	F 27-33"	G 33-39"	H >39"	Total	Density (#/acre) ② Trees/Acre	Relative Density ④ (by species)
Totals →											100%
trees/acre (by size class)									Basal Area (size class)		
relative density (by size class)									Relative Basal Area (size class)		

Basal Area ⑤ — Cross Sectional Area of Trunk (DBH at 4.5' from ground)

A 0.1	B 0.3	C 0.8	D 1.8	E 3.1	F 4.9	G 7.1	H (>7.9)

Dominance = Total Basal Area (by sp.) / 39 ft²	Relative Dominance ⑥ (by species)	(evenness of distribution) Frequency: No. circles in which sp. occurs	Frequency ⑦ (by sp.)	Relative Frequency ⑧	Importance value (rel. density + rel. dominance + rel. frequency) (max. value: 300)
	100%			100%	

Shrubs: total shrub stems in all transects (2/circle) x 100, ÷ no. of transects= shrub/acre =

Ground cover: total (+) recorded (20 per circle) x 100, ÷ by total no. sight. = % gr. cover =

Canopy cover: total (+) recorded x 100, ÷ by total number of sightings = % canopy cover =

Canopy height: average= range=

Appendix A-3. Data sheets: Tenth-acre circle summary sheet.

Site #_____ Transect _____ Site #_____ Transect _____ Site #_____ Transect _____

	# of plants	# browsed	% browsed		# of plants	# browsed	% browsed		# of plants	# browsed	% browsed
L R				L R				L R			
L R				L R				L R			
L R				L R				L R			
L R				L R				L R			
L R				L R				L R			
L R				L R				L R			
L R				L R				L R			

Date:_____

Appendix A-4: Data Sheets: Browse analysis data collection sheet.

Appendix B. Description of field areas (Beam, 1994).

2 — The area on the east side of the lake along Sportsmans Road beginning at the Bluebird Trail (a.k.a. Catfish) parking lot and extending south along Sportsmans Road to the flat, cleared area at the breast of the dam. Including the Heron Cove picnic area, it contains approximately 59 acres.

3 — That area along both sides of the gated service road leading to the sugar shack, including those fields accessed by the branch road running eastward toward the "mushroom woods." This area is 50 acres.

4 — The area from the main Preserve entrance along both sides of the paved driveway to the top of the hill at the entrance to Goose Cove Overlook. It is approximately 32 acres and includes the Wildlife Management Trail area.

5 — This area includes Goose Cove Picnic area and the fields on both sides of the Chillisquaque Trail and along the section of Chillisquaque Trail leading downhill to the service road. This area encompasses 27 acres.

6 — The fields on both sides of the boathouse/Muskrat Observation Blind gravel service road from the gate to McCormick Road. There are 14 acres in this area.

7 — That area between McCormick Road (west side) and the PP&L maintenance building. It contains 35 acres.

8 — The open field on the Preserve between the "brown" garage and the lake. There are 20 acres in this area.

9 — The cropland located west of McCormick Road and south of Route 44. This area is not part of PP&L land holdings but lies adjacent to the Preserve. There are 9 acres in this field.

10 — A field to the east of McCormick Road and south of Route 44. It is 9 acres.

11 — A field south of Route 44 approximately 1/4 mile east of the intersection of McCormick Road and Route 44. There are 6 acres in this area.

12 — An extensive cropland area accessed by an old farm lane off Route 44, approximately 3/4 miles east of McCormick Road and Route 44. This area is known as the "Golder Farm" and is 65 acres.

13 — A smaller area along the south side of Route 44 and just east of the access to area 12. It is 6 acres.

14 — This is a roadside area that begins at the parking lot for the Fossil Pit and extends southward along Sportsmans Road to the boundary of the Preserve. It is about 5 acres,

15 — All the cropland that can be seen along the south side of Route 1006 from a point across from the breast of the dam at Sportsmans Road east toward Derry Church to the Mushroom Road, including fields at the intersection of these two roads. This area is 70 acres.

16 — All that cropland along the northwest side of Mushroom Road from the edge of the woods to the dirt lane that leads into Mushroom Woods. This area is 22 acres.

17 — That cropland to the northwest of Mushroom Road from the dirt lane into Mushroom Woods to L.R. 47017 and along L.R. 47017 to the lane leading to PP&L Parking Lot # 8. This contains 59 acres.

18 — This area is accessed by driving along a dirt lane on the east side of PP&L Parking Area # 8, continuing northward on that lane to the open drainage ditch, returning to L.R. 47017 on the same lane and turning westward. Area #18 continues along L.R. 47017 on the north side to the edge of the creek and PP&L's boundary line. This includes 50 acres.

Appendix C: List of species identified by vegetation analysis.

Site #1: Muskrat Cove

Family	*Scientific name*	Common name	plot #1	plot #2	plot #3	plot #4	exclosure	
Aster	*Eupatrium rugosum*	white snake root	6	0	0	0	0	
Aster	*Solidago ssp*	goldenrod	31	6	15	1	1	
Beech	*Fagus grandifolia*	American beech	0	11	13	7	4	
Beech	*Quercus ssp*	oak	0	4	4	0	6	
Birch	*Betula ssp*	birch	31	65	0	0	44	
Birch	*Ostraya virginiana*	hornbeam	0	0	3	0	0	
Buckthorn	*Rhamus ssp*		0	1	0	0	0	
Buckwheat	*Rumex* ssp	dock	0	0	0	0	9	
Cashew	*Rhus radicans*	poison ivy	0	2	1	1	0	
Crowfoot	*Thalictrum ssp*		1	0	0	0	0	
Dogbane	*Apocynaciae ssp*	dogbane	1	0	0	0	0	
Dogwood	*Nyssa sylvica*	black gum	0	0	0	5	0	
Grape	*Parthenocissus ssp*	creeper	20	0	15	0	15	
Grass	*Panicum* ssp	switchgrass	0	0	1	0	0	
Heath	*Gaylussacia*	huckleberry	0	0	1	0	0	
Heath	*Kalmia latifolia*	mountain laurel	1	0	3	9	2	
Heath	*Lyonia* ssp		0	0	0	0	1	
Heath	*Rhododendron ssp*	rhododendron	1	26	3	1	0	
Honeysuckle	*Sambucus canadensis*	elderberry	0	0	1	0	0	
Honeysuckle	*Viburnum ssp*	viburnum	33	5	12	5	1	
Laurel	*Sassafras*	sassafras	0	0	0	0	1	
Lily	*Erythronium americanum*	trout lily	3	3	32	0	6	
Madder	*Galium* ssp	bedstram	7	0	0	0	0	
Madder	*Mitchella repens*	patridge berry	19	29	49	0	6	
Maple	*Acer ssp*	maple	10	25	7	20	4	
Pea	*Gymnocladus ssp*		0	1	0	0	0	
Pea	*Medicago* ssp	alfalfa	1	0	0	0	0	
Pea	*Trifolium ssp*	clover	1	0	0	0	0	
Rose	*Rosa* ssp	rose	1	0	0	0	0	
Rose	*Rubus ssp*	raspberry	3	7	33	6	0	
Walnut	*Carya ssp*	hickory	45	1	0	0	0	
	unknown ssp		12	3	1	2	0	
		Total:	227	189	194	57	100	767

Appendix C: List of species identified by vegetation analysis.

Site #2: Goose Pasture

Family	*Scientific name*	Common name	plot #1	plot #2	plot #3	plot #4	exclosure	
Aster	*Ambrosia* ssp.	ragweed	0	5	0	0	0	
Aster	*Antennaria plantiginifolia*		13	8	0	0	0	
Aster	*Aster* ssp	aster	0	0	0	0	1	
Aster	*Eupatorium rugosum*	white snake root	5	0	0	0	0	
Aster	*Senecio obvatus*	ragwort	5	0	0	0	0	
Aster	*Solidago* ssp	goldenrod	9	8	0	0	0	
Aster	*Taraxacum officinale*	dandelion	3	0	0	0	0	
Beech	*Castanea dentata*	American chestnut	0	0	0	0	1	
Beech	*Fagus grandifolia*	American beech	0	0	2	8	18	
Beech	*Quercus* ssp	oak	1	0	0	4	5	
Birch	*Betula* ssp	birch	13	2	0	0	5	
Buckwheat	*Polygonium* ssp	smartweed	12	30	3	44	0	
Cashew	*Rhus radicans*	poison ivy	0	0	1	0	0	
Chicory	*Krigia virginica*		0	0	0	0	2	
Clover	*Oxalis* ssp	wood sorrel	2	0	0	0	3	
Dogwood	*Nyssa sylvatica*	black gum	0	0	1	0	0	
Figwort	*Scrophularia* ssp		8	7	0	0	0	
Grape	*Parthenocissus* ssp	creeper	1	0	0	7	32	
Grass	*Secale cereale*	rye	0	0	0	0	5	
Heath	*Kalmia latifolia*	mountain laurel	6	0	0	0	0	
Heath	*Pyrola virens*		0	3	0	0	0	
Heath	*Rhododendron* ssp	rhododendron	3	0	0	2	3	
Hypericum	*Hyperium perforatum*	St. John's Wort	0	0	0	2	0	
Lily	*Erythronium americum*	trout lily	0	0	0	2	0	
Madder	*Galium* ssp	bedstraw	3	74	41	28	43	
Maple	*Acer* ssp	maple	30	24	20	18	108	
Mint	*Lycopus virginicus*		3	0	0	0	0	
Mint	*Mentha* ssp	mint	0	0	0	15	0	
Mustard	*Berteroa incana*		0	2	0	0	0	
Pea	*Medicago* ssp	alfalfa	0	0	1	0	0	
Pea	*Trifolium* ssp		1	0	0	0	0	
Pokeweed	*Phytolacca americana*	pokeweed	0	1	0	0	8	
Rock-rose	*Lechea racemutosa*		0	73	0	0	0	
Rose	*Amelanchier* ssp	juneberry	0	4	0	0	0	
Rose	*Rubus* ssp	raspberry	6	1	4	21	3	
Violet	*Viola* ssp	violet	3	7	0	15	97	
Walnut	*Carya Ovata*	hickory	3	0	0	0	0	
	Unknown		2	15	4	10	5	
		Total	132	264	77	176	339	988

Field Number	1998 Total deer/ acre	1997 Total deer/ acre	1996 Total deer/ acre	1995 Total deer/ arce	1994 Total deer/ acre
2	0.17	0.00	0.00	0.07	0.10
3	0.94	0.22	0.38	0.76	0.82
4	0.00	0.00	0.13	0.29	0.00
5	0.11	1.89	2.13	0.56	0.32
6	2.30	1.60	2.00	5.16	0.14
7	0.05	0.65	1.40	0.99	0.58
8	0.25	1.40	1.00	0.45	1.00
9	2.22	0.56	2.11	1.56	0.00
10	0.44	4.67	4.56	0.89	0.56
11	0.33	5.17	1.34	0.50	6.33
12	0.20	1.22	0.83	1.26	2.06
13	3.00	1.00	2.67	0.83	1.67
14	0.20	0.00	0.20	0.00	0.00
15	0.29	0.19	0.31	0.33	0.21
16	0.91	0.77	0.73	1.86	0.00
17	0.39	0.29	0.22	0.12	0.10
18	0.26	1.28	1.20	0.60	0.22
Year avg.	0.42	0.91	0.89	0.80	0.68

Table 8: Comparison of average deer observed per acre for September surveys from 1994-1998

Appenix C: List of species identified by vegetation analysis.

Site #3: West Branch

Family	*Scientific name*	Common name	plot #1	plot #2	plot #3	plot #4	exclosure	
Amona	*Asimina triloba*		0	1	0	0	0	
Aster	*Aster* ssp	aster	1	0	0	0	1	
Aster	*Eupatorium rugosum*	white snack root	0	0	0	1	0	
Aster	*Solidago* ssp	goldenrod	13	2	6	1	9	
Beech	*Castanea* ssp	chestnut	0	0	0	0	7	
Beech	*Fagus grandifolia*	American beech	7	0	4	0	0	
Beech	*Quercus* ssp	oak	2	0	3	10	8	
Birch	*Betula* ssp	birch	2	1	0	0	0	
Buttercup	*Runnunculus* ssp		0	0	0	4	0	
Cashew	*Rhus radicans*	poison ivy	2	0	0	0	16	
Dogwood	*Nyssa sylvatica*	black gum	2	3	0	3	0	
Elm	*Ulmus* ssp		0	36	5	0	0	
Figwort	*Dentaria* ssp		0	0	0	0	6	
Grape	*Ampelopsis arborea*		0	0	1	0	0	
Grape	*Parthenocissus* ssp	creeper	16	8	8	16	25	
Heath	*Kalmia latifolia*	mountain laurel	0	0	1	0	2	
Heath	*Rhododendron* ssp	rhododendron	0	2	1	2	0	
Honeysuckle	*Viburnum* ssp		2	0	0	0	32	
Madder	*Galium* ssp		0	5	0	0	4	
Madder	*Mitchella repens*	patridge berry	0	0	0	5	4	
Maple	*Acer* ssp	maple	12	3	9	5	1	
Mustard	*Brassica* ssp		0	1	0	1	0	
Poppy	*Dicentra* ssp		0	0	0	1	0	
Rose	*Prunus pennsylvanica*	cherry	0	6	0	2	0	
Rose	*Rosa ssp*	rose	2	4	4	0	6	
Rose	*Rubus* ssp	raspberry	21	25	1	0	18	
Rue	*Xanthoxalum* ssp		1	1	0	0	0	
Violet	*Viola* ssp	violet	2	0	0	0	18	
Walnut	*Carya Ovata*	hickory	14	0	0	0	0	
Walnut	*Carya* ssp	hickory	0	0	0	0	3	
	Unknown		3	0	3	0	0	
		Total	102	98	46	51	160	457