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Observability and Behavior of White-tailed Deer Along Forest Roads

Richard W. Sage Jr

A Special Report to Fulfill
The Obligation of a

FINAL JOB COMPLETION REPORT
W-105-R
Jobs VIII - 1, 2, 3

Observability and Behavior of White-tailed Deer Along Forest Roads

State: New York

Project No: W-105-R

Final Job Completion Report

Jobs VIII - 1,2,3

STUDY NUMBER AND TITLE: VIII - Observability and Behavior of White-tailed Deer Along Forest Roads.

STUDY OBJECTIVE: To identify and evaluate the impact of population densities, deer behavior, roadside vegetative conditions, timber management activities, and hunting practices on the observability of white-tailed deer along forest roads.

(1) Job No. and Title: VIII-1 The influence of roadside conditions on the observability and behavior of white-tailed deer.

Job Objective: To identify and evaluate differences in deer observability and behavior as affected by roadside habitat conditions including logging and cultural treatments.

(2) Job No. and Title: VIII-2 The influence of hunting on the observability and behavior of white-tailed deer along forest roads.

Job Objective: To evaluate hunting as a factor which may alter flight behavior of white-tailed deer and their observability along forest roads.

(3) Job No. and Title: VIII-3 Publication of results of observability and behavior of white-tailed deer along forest roads.

Job Objective: To disseminate information obtained to date with respect to deer observability to biologists, managers, adminstrators, and the general public.

NOTE: Two manuscripts, one published in the October 1975 issue of the Northern Logger and Timber Processor, and the other provisionally accepted for publication in the Journal of Wildlife Management, together will serve as the final report for Jobs VIII - 1,2, and 3.

A separate, brief report following the traditional job completion report format has been prepared for each job and preceeds the two attached manuscripts.

(1) Job No. and Title: VIII-1 The influence of roadside conditions on the observability and behavior of white-tailed deer.

Job Objective: To identify and evaluate differences in deer observability and behavior as affected by roadside habitat conditions including logging and cultural treatments.

Abstract: During the 16-year period 1962-77; 4,727 visual observations of 6,237 white-tailed deer were recorded along forest roads on the 3 study units located in the central Adirondack region of New York State. Deer observation rates (N/160 km) during June, July and August ranged from 0.9 on the Santanoni Unit (1974) to 34.9 on the Huntington North Unit in 1966. The frequency of deer observations was found to be dependent upon the interactions of: population density, summer range, location, individual deer behavior, sex and age, roadside vegetation conditions, seasonal and temporal factors, and hunting. Cultural treatments including logging and planting along roadsides had a positive effect on deer observation rates.

Two manuscripts are attached to this report. One, entitled "Establishing Vegetative Cover Along Logging Access Roads: Techniques - Costs - Benefits" was published in the October 1975 issue of the Northern Logger and Timber Processor. The second manuscript, entitled "Observability and Behavior of White-tailed Deer Along Forest Roads" has been provisionally accepted for publication by the Journal of Wildlife Management.

Background: See attached manuscripts.

Procedures: See attached manuscripts.

Findings: See attached manuscripts.

Analysis: See attached manuscripts.

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job as well as Job VIII-2, and VIII-3.

Prepared by: Richard W. Sage Jr. (signature) — Program Coordinator
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William F. Porter — Date
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(2) Job No. and Title: VIII-2 The influence of hunting on the observability and behavior of white-tailed deer along forest roads.

Job Objective: To evaluate hunting as a factor which may alter flight behavior of white-tailed deer and their observability along forest roads.

Abstract: Observations of white-tailed deer along forest roads were recorded during a 16-year period (1962-77) on 3 study areas located in the central Adirondack region of New York State with varying hunting histories. Intensive public hunting for deer of either sex negatively impacted deer observation rates on the Huntington North Unit during the 5-year hunting period (1966-70). A similar decline in deer observation rates was recorded on the moderately hunted Santanoni Unit during 3 years of "bucks only" hunting (1972-74). The reduction in deer densities as a result of hunting and the removal of "highly observable" individuals from the population are seen as the major factors contributing to the decline in observation rates following hunting. Observation rates recovered following the cessation of hunting on the Huntington North Unit. Forest management practices and roadside cultural treatments can have positive impacts on deer observability along forest roads. These activities along with adequate regulation of deer harvests and location of hunting areas can minimize the effects of hunting on deer observability.

Differences in pre and post hunting flight behavior (as evidenced by flight gait and tail position) of deer observed along the forest roads on the 3 study units were inconsistent, and as a consequence interpretation of the results was difficult. Removal of "highly observable" deer (animals which consistently exhibited reduced flight responses) probably accounts for the differences in flight behavior of the post hunting population rather than actual changes in individual deer behavior.

Two manuscripts are attached to this report. One, entitled "Establishing Vegetative Cover Along Logging Access Roads: Techniques - Costs - Benefits" was published in the October 1975 issue of the Northern Logger and Timber Processor. The second manuscript entitled "Observability and Behavior of White-tailed Deer Along Forest Roads" has been provisionally accepted for publication by the Journal of Wildlife Management.

Background: See attached manuscripts.

Procedures: See attached manuscripts.

Findings: See attached manuscripts.

Analysis: See attached manuscripts.

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job as well as Jobs VIII-1 and Job VIII-3.

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(3) Job No. and Title: VIII-3 Publication of results of observability and behavior of white-tailed deer along forest roads.

Job Objective: To disseminate information obtained to date with respect to deer observability to biologists, managers, administrators, and the general public.

Abstract: In July of 1981 a manuscript entitled "Observability and behavior of white-tailed deer along forest roads" was submitted to the Journal of Wildlife Management. Copies of this manuscript were also submitted as the Final Report for Jobs VIII-1,2, and 3. The manuscript was returned by the editor with a request for revisions in October of 1981. The editor indicated that with the appropriate revisions the manuscript would be published in the Journal of Wildlife Management, so a revised manuscript was prepared and re-submitted in May 1982. A copy of this manuscript is attached to this report. This manuscript should replace the one submitted in July 1981 as the Final Report for Jobs VIII-1, 2, and 3.

A second manuscript is also attached entitled, "Establishing Vegetative Cover Along Logging Access Roads: Techniques - Costs - Benefits". This manuscript was published in the October 1975 issue of the Northern Logger and Timber Processor. It discusses in detail the roadside cultural practices which were developed at the Huntington Wildlife Forest Station and briefly the impact of these practices on deer observability.

Background: This research was initiated to document and evaluate the effects of a variety of factors on the observability of deer along forest roads and to insure that the information collected was made available to biologists, managers and administrators by means of publication in an accepted biological journal.

Procedures: See attached manuscript.

Findings: See attached manuscript.

Analysis: This research effort should provide land managers with important information concerning the factors affecting deer observability along forest roads. The results should be useful to the land manager interested in developing deer viewing opportunities and/or understanding the impact of various management practices on deer observability.

Recommendations: This job has been terminated. The attached manuscript will serve as the final report for this job as well as Job VIII-1 and Job VIII-2. A popular style article, perhaps for the NYS Conservationist magazine, based on this research has also been prepared and will be submitted in June 1982. No further publications are anticipated at this time.

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The following manuscript has been submitted to, and provisionally accepted for publication in the Journal of Wildlife Management.

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OBSERVABILITY AND BEHAVIOR OF WHITE-TAILED DEER ALONG FOREST ROADS[1]

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Abstract: The observability and behavior of white-tailed deer *(Odocoileus virginianus)* on a forested area, was studied over a 16-year period (1962-1977). There were 4,727 observations, involving 6,237 deer along forest roads in the

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[1] A contribution of The Archer and Anna Huntington Wildlife Forest Station, Newcomb, NY. Support for this study was provided by the State University of New York, College of Environmental Science and Forestry, Syracuse, NY; U.S. Bureau of Sport Fisheries and Wildlife; Pittman-Robertson Project W-105-R; The New York State Department of Environmental Conservation; USDA McIntire-Stennis Project; and the U.S. Forest Service, Northeast Forest Experiment Station.

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Adirondack region of New York, recorded during May-November. Annual variations in deer observation rates were correlated with fluctuations in regional population levels and used to effectively predict trends in regional fall buck harvests. Several factors influencing deer viewing opportunities are discussed including population density, summer range location, individual deer behavior, sex, age, seasonal ranging and activity patterns, flight behavior, forest type, timber harvesting, and the impact of hunting. Data from marked and radio-transmittered animals suggest that certain animals are "highly observable" and contribute a majority of the deer observations recorded along particular sections of forest road. Observation rates were also significantly correlated with vegetation cover types, basal area density of roadside forests, presence of small openings, and hunting.

Key Words: behavior, forest, hunting, management, New York, observability, roads, seasonal, white-tailed deer.

Observability of deer is important to wildlife viewers, photographers, hunters, other recreationists, etc. Additionally, impressions of deer densities are formed through observation of animals, especially along roadsides. Moreover, public impression of deer management is based, at least in part, upon the number of deer seen in conjunction with normal activities. Thus, wildlife managers should have an adequate understanding of the important relationships affecting deer observability. Management should provide deer for viewing as well as hunting, particularly when the recent trends in public awareness, increased utilization, and concern for the wildlife resource are considered. Effective management for hunting may also depend on the manager's sensitivity to deer observability patterns. Peterle (1977) suggests that changes in our (wildlife managers) approach to hunting are inevitable and should be based on understanding rather than responses to stimuli from anti-hunters. That wildlife management is no longer just game management is increasingly evident to all who have contact with the public. Wildlife management involves stewardship of a valuable and limited resource and there is much more interest in managing wildlife for human non-consumptive users than ever before (Hendee 1969, Hendee 1974, Thomas and DeGraaf 1973).

The white-tailed deer is the most important and widely recognized game species in the northeastern United States. We feel that there is great potential for viewing deer as well as hunting recreation and that the compatibility of these two forms of recreation requires better definition for management planning. The influence of white-tailed deer on forest ecosystems and forest management, and the need to limit deer densities or control deer use is widely documented (Curtis and Rushmore 1958, Tierson et al. 1966, Behrend et al. 1970, Richards and Farnsworth 1971). However, the value of the deer resource for viewing particularly as this value might accrue to the forest landowner, is not well documented.

The principal objective of this study was to provide a better understanding of the factors that influence the observability of white-tailed deer along forest roads by an analysis of roadside summer observations of deer over a 16-year period. Data on several variables are evaluated to determine significant influences on deer observation rates.

We acknowledge Rainer H. Brocke for his assistance in the study and review of the manuscript. Raymond D. Masters, Michael J. Tracy, Joseph E. Wiley III, and Andrew T. Stirling contributed significantly to this study. The many graduate students, summer employees, and staff who helped record and summarize data, are also acknowledged.

STUDY AREA

The study area encompasses 11,533 ha located near the geographic center of New York's Adirondack Mountains. It is comprised of two adjoining parcels: The Archer and Anna Huntington Wildlife Forest Station (Newcomb Campus of the State University of New York, College of Environmental Science and Forestry) and the Santanoni Preserve, public land owned by New York State (Fig. 1).

The area is forested, the few parcels of open land being associated with human habitation, intensive burns, and the activities of beaver *(Castor canadensis)*. Forest types of the Huntington Wildlife Forest Station have been classified as 50% northern hardwood, 30% hardwood-conifer, and 20% conifer with timber volumes estimated at 70% hardwood and 30% conifer.

Deer densities estimated from deer drives, track counts, roadside observations, and harvest data, have ranged from 3-10 deer/km^2. Population characteristics derived from a harvest of 274 deer on the study area showed 25.9, 16.8, and 57.3% fawns, yearlings, and adults respectively; and 50.3% females, 49.7% males. Age was determined by tooth replacement and wear (Severinghaus 1949).

Deer are confined to winter concentration areas when snow depths exceed 38 cm. and the length of winter confinement varies considerably from year to year (Mattfeld 1974).

METHODS

The study area was divided into three units (Fig. 1) with differing deer hunting histories, as follows:

1. Huntington North Unit - the 2,110 ha northern portion of the Huntington Forest, hunted for 5 years (1966-70). Weekend hunting under an antlerless deer permit system resulted in an average hunting pressure of 7.6 hunters/km^2 and a total harvest of 274 deer. Deer observations were recorded every year from 1962-77 on a 16.6 km road system.

2. Huntington South Unit - the unhunted 3,960 ha southern portion of the Huntington Forest. Deer observations were recorded every year from 1962-77 on a 14.3 km road system.

3. Santanoni Unit - a moderately hunted 5,463 ha tract acquired by the State of New York in 1972. This unit sustained regular fall season "bucks only" hunting from 1972-75, with 36 legal bucks reported harvested. Hunting pressure was approximately 3.0 hunters/km^2. The area was virtually closed to hunting prior to 1972. Deer observations were recorded every year from 1970-75 along a 19.3 km road system.

All roads were 1 lane, hard packed gravel, closed to public vehicular travel and generally open to vehicles during May-November only. Travel speed averaged about 24 km/hr. Travel during the May-November period varied from a low of 1,928 km in 1966 to a high of 5,432 km in 1976. Huntington Forest roads were marked off in 100-m sections. Similar markers were not available on the Santanoni Study Unit.

Observers included the full time research, management, and maintenance staff of the Huntington Forest, as well as graduate students and summer employees. All personnel were instructed to routinely "look for" deer and fill out standard observation forms during their travels on the various study units.

Observation forms were completed whether or not deer were observed. Information recorded for each trip included number of observers and their names, date, time at the beginning and end of the trip, vehicle, route of travel, and distance traveled. Data for each deer observation included time, location (to the nearest 20-m section of road), number of deer and flight behavior. Tag numbers and colors were recorded for marked animals. Experienced observers recorded sex and age whenever possible. Sex was determined by presence or absence of antlers. Age was a subjective appraisal by the observer using body size, antler development, configuration of the head, behavior, presence of spots, and other criteria. Age was recorded as fawn, yearling, adult, or unknown.

Forest types adjacent to the roads on the Huntington Forest units were determined for each 20-m section of road and classified as open, hardwood (> 60% of basal area in hardwood species), conifer (> 60% of basal area in conifer species), and hardwood-conifer (all other basal area combinations). Each section was also evaluated for the presence of any feature that might increase viewing opportunity, including logging landings, beaver meadows, skid trails, logging roads, etc. These small openings were usually < 0.25 ha and not classed as open type. Forest stands along roadsides were classified as logged (> 40% of overstory crown removed) and unlogged (< 40% overstory crown removal) by aerial photo interpretation.

During the period 1968-76 a separate study of seasonal ranging and movement behavior of white-tailed deer was conducted on the study area, with 368 deer captured and marked, including 105 transmittered individuals. Deer were captured, summer and winter, using box traps, immobilizing drugs, and by hand. Telemetry was conducted from helicopters, fixed wing aircraft, snowmobiles, and trucks, during all seasons. Deer were marked and radio-transmittered as described by Masters (1978).

Individual marked deer were classified as "highly observable" if they were observed on 5 or more occasions during a single summer season. Observation rates are expressed as N of deer/160 km (100 mi) of distance traveled. The fall buck harvest for the 32,000 km^2 Adirondack region was used as the best index to regional population levels.

A probability of $P < 0.05$ was used to determine significance in all statistical tests. All values of the Chi-square statistic cited are uncorrected, and significant unless otherwise stated.

RESULTS

During the 16-year period 1962-77; 4,727 visual observations involving 6,237 deer, were recorded along the forest roads on the study units. There were 1,428 (22.9%) observations of marked deer and 4,809 (77.1%) observations of unmarked or unidentified deer. Deer observation rates (N/160 km) during June, July, and August (1966-77) ranged from 0.9 on the Santanoni Unit (1974) to 34.9 on the Huntington North Unit prior to the initiation of hunting in October 1966 (Table 1 ,Fig. 2).

The frequency of deer observations was found to be dependent upon interactions of: population density, summer range location, individual deer behavior, sex and age, vegetative conditions, seasonal and temporal factors, and hunting.

Population Density

The primary factor affecting deer viewing opportunities along forest roads was deer population levels as indicated by the direct relationship between summer deer observation rates and the Adirondack regional buck harvest (Fig. 3).

Summer (June-August) deer observation rates on the unhunted portions of the study area correctly predicted the trend in the Adirondack regional fall buck kill for all years between the period 1966-75. The relationship between the summer deer observation rates on the unhunted portions of the study area and the regional fall buck harvest (for the 1966-77 period) was significant ($\underline{F}$ = 61.83, $\underline{r}$ = 0.93, r^2 - 0.86). The regression equations were:

(1) DOR = 0.0025 RBH - 8.84 or alternately,

(2) RBK = 339.25 (DOR) + 4046 where

DOR = Deer observation rate on the unhunted units

RBH = Regional buck harvest from previous fall

RBK = Predicted regional buck harvest

Predictions of the fall buck harvest for the Adirondack region using equation (2) (Fig. 4), resulted in a mean error of 8.7% over the 12-year period 1966-77. The largest error was 25.4% for 1976 when the trend in observation rate did not follow the trend in regional buck kill (Figs. 3,4).

Summer Range Location

The location of a deer's summer range (defined using radio-telemetry) in relation to a traveled road, was compared to the number of visual observations of that individual. The mean number of observations of deer whose summer ranges were associated with a forest road was 5.6. Only 0.2 observations were recorded for those individuals whose summer range was not associated with a road and 86.7% of these deer were never observed. Conversely, only 33.8% of deer with summer ranges associated with a forest road were never seen.

Individual Deer Behavior

The flight behavior of highly observable deer differed from that of other deer. Of 174 observations of 25 highly observable deer there were 106 walking-standing and 68 running-bounding flight responses. In contrast, of the remaining 1,310 observations of deer flight responses, significantly less ($\chi 2$ = 62.4) were classed as walking-standing (402) than running-bounding (908).

A sample of selected marked deer illustrates high observability of certain animals; deer #351, 65 observations in 2 summers; deer #329, 127 in 5 summers; deer #351, 69 in 4 summers; deer #51, 93 in 8 summers; and deer #31, 68 in 8 summers. All were females and observed both as yearlings and adults. In addition, certain individuals contributed heavily to observations along discrete road sections. For example, one deer accounted for 62% (23) of all observations along a 3.2 km section of road during 5 seasons, and a second individual 42% (27) of all observations along a 4.8 km section during 3 seasons.

Of 68 transmittered deer known to have summer ranges associated with forest roads 29 (42.7%) were observed more than once, 16 (23.5%) were seen only once, and 23 (33.8%) were never observed. Only 14 of the 68 transmittered deer (20.6%) were observed on more than 5 occasions. Of 368 marked deer, 53 (14.4%) were seen on 5 or more occasions during the summer period, 74 (20.1%) were observed fewer than 4 times, and 241 (65.5%) were never observed.

Highly observable deer composed 15-20% of the marked deer population on the Huntington Forest units, during the years 1969-76. The contribution of highly observable individuals to summer marked deer observations (1969-76) on the Huntington Forest units, ranged from a low of 23.4% in 1972 to a high of 68.5% in 1975. During the 8-year period, highly observable, marked deer accounted for an annual average of 57.8% of the total summer deer observations.

Sex and Age

Sex was recorded for 3,977 (63.8%) deer observed during the May-November period. There were 3,229 (81.2%) antlerless deer observations and 748 (18.8%) observations of antlered deer. While some males may not show recognizable antler development in this region until June, $\chi 2$ tests of independence between May and June and between the May through November and the June through November periods, were not significant. Thus, antler development did not appear to have biased the results. In a 2 x 7 contingency analysis, sex observed and month (May-November) were not independent ($\chi 2$ = 32.8) with numbers of antlered deer observed in July and November significantly higher than their expected frequencies ($\chi 2$ = 6.3 and 10.7 respectively). Antlered deer observations in July and November comprised 21.2% and 29.3% respectively, of the total observations where sex was determined (Fig. 5).

Significantly ($\chi 2$ = 30.57) fewer antlered deer were observed from May to November (18.8%) compared to the proportion of antlered deer (32.1%) in the harvest data for the Huntington Forest North Unit. Proportions of antlered and antlerless deer observed in July were significantly ($\chi 2$ = 15.3) different than the hunting sample, however, the proportions observed in November were not significantly different than the hunting sample.

Of the 1,428 visual observations of marked deer of known sex, for the May to November period, 86.6% observations were of females and 13.2% were of males. In contrast, the observed marked deer population, with at least one May to November encounter (visual, capture, or telemetry), was composed of 64.4% (212) females and 35.6% (121) males. Thus, marked males were observed significantly ($\chi 2$ = 201.6) less frequently than expected and females significantly ($\chi 2$ = 110.6) more frequently than expected, based on their availability in the population. Males averaged 1.5 observations per marked individual, while marked females averaged 5.2 observations per individual. Significantly ($\chi 2$ = 6.62) more marked females than males were seen five or more times and significantly ($\chi 2$ = 18.79) more marked males than females were never observed.

Marked deer #367 and #368, twin male yearlings, together accounted for 72.3% of the total male deer observations recorded in 1975. Another yearling male contributed 91.2% of the total visual observations of males in 1969. Thus, yearling males contributed approximately 82% of the total number of antlered deer observations (748). Hence, adult males may have accounted for less than 4% of the total number of deer observed (3,977). The difficulty in positive identification of yearlings made a comparison between the number of male yearlings and male adults observed during the entire study, impossible.

Age was recorded for 5,018 (81.5%) of the 6,237 deer observed and fawns comprised 13.7% (697); yearlings 9.1% (464); and adults 77.2% (3,902). The low frequency of yearling observations is probably due to incorrectly classifying yearlings as adults; and to the loss of most fawns during the severe winters of 1969, 1970, and 1971, leaving few yearlings during the subsequent summers.

The proportion of fawns observed during the summer season (as spotted individuals) was significantly ($\chi 2$ = 54.8) lower than the proportion of fawns in the hunting sample.

Vegetative Conditions

Deer were observed in northern hardwood types about as frequently as expected, significantly less frequently than expected in the hardwood-conifer and conifer types, and significantly more frequently than expected in open areas (Table 2).

Of the total observations, 7.7% were in open areas larger than 0.25 ha, although such areas comprised only 1.4% of the roadside vegetation types on the Huntington Forest units.

From 319, 100-m forested sections of road available on the study area, two groups were selected; 105 sections with the highest frequency of deer observations and 105 sections with 0 observations. Classification of sections of road as high or 0 deer observation areas was not independent of forest type ($\chi2 = 13.49$). Observed and expected frequencies were compared based upon the number of sections available in hardwood, hardwood-conifer, and conifer types (Table 3). Significantly fewer conifer road sections than expected were classified as high observation areas and significantly more conifer sections than expected were found in the 0 observation class.

High and 0 observability sections were also evaluated for the presence or absence of any feature that might enhance viewing opportunities. Eighty six of the 105 high observability road sections had such a feature, 19 did not. Seven of the 0 observability sections included such a feature, 98 did not. High and 0 observability road sections were not independent of such a feature ($\chi2 = 117.42$).

The timber stands associated with high observability road sections had a mean basal area of 17.3 ± 1.6 (2 SE) m^2/ha. Those stands associated with 0 observability sections had a significantly higher mean basal area of 23.2 ± 2.9 (2 SE) m^2/ha. The mean basal area of the timber stands associated with high deer observability road sections, was significantly less than the mean for timber stands associated with 100-m road sections chosen at random (21.6 ± 2.2 (2 SE) m^2/ha). The mean basal area of the 0 observability sections was not significantly different from the basal area of stands chosen at random.

Higher deer observation rates were positively associated with stands of reduced basal area rather than negatively associated with stands of high basal area.

Of the total road system on the study areas, 21.6 km were classified as logged or uncut for the entire 16-year period of the study. Logged sections, totaling 13.8 km had 3,142 observations (expected 2,865); while 7.8 km of uncut sections had 1,341 observations (expected 1,618). Logged sections had significantly more deer observations than expected ($\chi 2 = 26.78$) and uncut sections significantly fewer than expected ($\chi 2 = 47.42$).

Seasonal and Temporal Influences

Deer observations during June, July, and August accounted for 78% of the total observations during the study.

Travel during the work day period 0700 to 1530 (EST) was evenly distributed except for the period 1100 to 1200 (EST). No significant differences were detected between the number of deer observed for any of the 1 hour periods of the work day, with the exception of the 1100 to 1200 (EST) period. Observations during this hour were significantly lower ($\chi 2 = 6.83$), probably reflecting the reduction in travel during the lunch break. No differences were detected in the relative observability of males and females during any particular portion of the day for the May-November period.

Hunting

The observation rate in 1967, on the intensively hunted Huntington Forest North Unit, declined drastically (34.9 to 4.4 deer observed/160 km of road) following the first public hunt during the fall of 1966 (Table 1). This year of hunting removed 54% (124 deer) of the pre-hunt population of 229 animals

(Behrend et al. 1970). The following summer, the deer observation rate was reduced by 87%.

Deer observation rates were reduced on the Santanoni study unit following hunting in the fall of 1972 (Fig. 6). The observation rate during the summer immediately preceeding the first public hunt (1972) was 4.8. Following hunting, summer deer observation rates fell to 1.8 and 0.9 in 1973 and 1974 respectively, an overall decline of 82%. These declines in observation rates on the hunted Huntington Forest North unit and on the Santanoni unit occurred during different time periods and under differing deer densities at the onset of hunting.

The deer observation rate on the Santanoni study unit in 1975 was 1.2, following the 1974 hunting season which removed 7 additional male deer. In addition to the legal buck kill of 36 animals recorded during 1972 through 1974, a total of 9 illegally killed females and fawns was recovered on the area. This figure included 3 transmittered does, 2 of which were highly observable animals. Thus, the known illegal kill was equal to 25% of the recorded legal buck kill. As no concerted attempt was made to locate illegal kills, the illegal harvest must be considered a low estimate.

The decline in deer observation rates on the Santanoni unit following hunting, occurred despite rising regional population densities as evidenced by the trend in the regional buck kill (Fig. 3). Also, deer observation rates were on the increase on both the adjacent hunted and unhunted Huntington Forest units (Figs. 6,7). (Local and regional surveys of mortality during the winters of 1972-75 showed only minimal deer losses).

Recoveries of marked deer documented increased hunting vulnerability of highly observable deer. During the 1972 fall hunting season, a transmittered female deer was illegally shot by hunters less than 200 m from the road where she had been observed on 16 occasions during the previous summer. Another marked female was observed 71 times along a 400 m section of road during the summer and was shot in the same area during the first weekend of public hunting in 1966. Another transmittered female was observed 8 times within a 3-week period during the fall of 1973 and was shortly thereafter killed by poachers within 30 m of the highway right-of-way.

Observation rates on the unhunted Huntington Forest South Unit were related to regional buck harvest trends, indicating the dependence of observation rates on deer density. Attempts to predict observation rates for the intensively hunted Huntington Forest North Unit and the moderately hunted Santanoni Unit from regional kill trends alone, resulted in non-significant regression analyses for the year impacted by hunting, 1967-71 and 1973-75 respectively.

The impact of hunting on summer observation rates, could be accounted for when the regional population trend, estimated deer population/km^2, and mean hunter density/km^2 for each unit and year combination, were employed in a stepwise multiple linear analysis (Table 4). Equation (3) in this table accounts for much of the variation caused by interaction of population density, population trends influenced by winter mortality, and varying hunting pressure. Equation (4) which omits anticipated regional harvest, is perhaps more useful.

Discussion

Deer population density was found to be the principal factor affecting deer observation rates. Other studies have shown similar relationships of deer densities to deer-human encounters. High numbers of deer have been directly related to increased deer-automobile collisions (Behrend 1967, Puglisi et al. 1974). Deer hunting success for antlered bucks is directly correlated with deer densities (Free et al. 1964). We were able to use deer observation rate data from the study area to predict the trend in the regional fall buck harvest on a 32,000 km^2 management area in northern New York with a mean error of about 9% over 12 years. However, our data also show that other factors have important effects on deer observability.

The location of a deer's summer range, with respect to a traveled road, is important to the number of observations of that individual. Those deer whose range was associated with a road were 28 times more likely to be seen than other deer. The summer range of most adult deer is apparently established for life (Drolet 1976, Sage et al. 1977, Nelson and Mech 1981). Therefore, those deer with ranges associated with roads are of more concern to managers interested in enhancing viewing opportunities as they will be available for viewing throughout their adult life. However, in northern regions most of these same deer will move to winter ranges often several km from summer ranges, and be vulnerable to factors beyond the managers control.

Antlered deer were seen less frequently than other males and females, and these findings are supported by others (Behrend 1966, Hawkins and Klimstra 1970, Zagata and Haugen 1974). Our limited data indicate that yearling males contribute heavily (82%) to total male observations. The increased observability of antlered deer in November is probably associated with rutting behavior, but no explanation is offered for increased observations in July.

There are obvious shortcomings associated with field identification of sex and age (Downing et al. 1977, Silvey et al. 1981). However, we feel the techniques used in our study are similar to those used by most viewers, and that our findings are representative. Our staff, students, and visitors placed greater values on observations of spotted fawns and antlered males than on observations of other deer. These values may be representative of a larger public. However, our data indicate that these deer will be observed infrequently in habitat similar to our study area. Hawkins and Klimstra (1970) also reported few observations of spotted fawns.

Deer are more likely to be seen in hardwood forest stands than in hardwood-conifer stands. Conifer types had lower summer observation rates than expected and were positively associated with 0 observability road sections and negatively associated with high observability sections. Drolet (1976) also found deer use of the conifer type lower than expected.

Vegetation management practices that result in reduced basal area of forest stands are likely to increase deer observation rates. The activities of timber harvesting which produce small openings along roads, as well as those naturally created, can significantly increase deer observation rates. Whether this increase is due to vegetative response, which attracted deer, or increased visibility was not determined but is probably a combination of both. Sage and Tierson (1975) found a 5-fold increase in observation rates of deer following roadside cultural treatment and concluded that increased deer presence accounted for 3/5 of the increase and better visibility 2/5.

Our data show that deer are observed with equal frequency during all daytime (0700-1530 EST) periods in June, July, and August, coinciding with the time the public is seeking recreational opportunities in the Adirondacks.

Intensive telemetry studies of deer activity during 48-hour periods in May, August, and October (Pittman-Robertson Final Report, New York W-105-R, Job VI-5) support our observation data. Although May activity patters were crepuscular, August and October showed consistently high activity throughout daylight periods. Other investigators have shown increasing activity during summer daylight periods for white-tailed deer (Behrend 1966, Drolet 1976) and for black-tailed deer *(Odocoileus hemionus columbianus)* (Miller 1970). This contrasts with findings of Zagata and Haugen (1974) who found deer most active at sunrise and sunset during winter in Iowa. The limitations of cover in Iowa farmland in winter in contrast to the almost limitless cover available to Adirondack white-tails on summer range may account for these behavioral differences.

The substantial decline (87% and 82% respectively) in deer observation rates documented following the initiation of public hunting on both the intensively and moderately hunted study units could not be attributed to the number of animals removed by hunting alone. Hunting may have altered the sex-age structure of the population, thus affecting observation rates. Roseberry and Klimstra (1974) showed that yearling males were harvested at a higher rate and male fawns were more vulnerable than females. However, a comparison of the age structure of each year's kill during the five years of public hunting on the Huntington North Unit with the age structure of the first year's kill (taken as the best estimate of the pre-hunt population age structure) indicated no significant differences between the age composition of any single year's kill and that of the original population. Thus, if the kill from the first hunt represented the age structure of the population, controlled hunting sampled population in a random manner.

Changes in deer ranging patterns as influenced by hunting could affect observation rates. However, data from several studies have shown little influence of hunting on deer ranging patterns (Marshall and Whittington 1968, Autry 1967, Huntington Forest unpublished data). Similar insensitivity of deer ranging behavior has been reported by Sweeney et al. (1971) for deer chased by dogs; (Downing et al. 1969) for intensive hunting by archers; and (Hood and Inglis 1974), for deer subjected to intensive ranching operations.

Highly observable deer were shown to contribute to observations, much out of proportion to their representation in the population. These individuals appear to be more vulnerable to hunting, and their loss probably accounts for the added reduction in summer deer observation rates that cannot be wholly explained by lower deer numbers as a result of hunting.

The large decline in observation rates (82%) following hunting on the Santanoni Unit cannot be explained by a harvest of 29 legal bucks over two years. This loss is not believed to have influenced summer deer populations and, in addition, adult males were shown to contribute little to observation rates. The loss of highly observable deer from illegal shooting of females probably contributed most to reductions in observation.

An increase in the wariness of deer following intensive hunting may also contribute to reduced observation rates. This behavioral response of white-tailed deer to hunting has been studied by other investigators (Behrend and Lubeck 1968, Grau and Grau 1980). Altman (1958) reported similar increased wariness by moose *(Alces alces)*. Our study documented significant differences between the flight behavior of highly observable individuals and other deer. The removal of these animals from the population through hunting may explain any change in wariness of post-hunt deer populations.

In summary, hunting as experienced on the two hunted study units negatively influenced deer observation rates along forest roads with reduced numbers of deer accounting for most of the decrease, and the loss of highly observable deer much of the remainder.

We do not intend to suggest curtailing hunting to favor deer viewing, but offer our results to provide managers a better basis for decision making. The apparent incompatability of these two forms of recreational use of the deer resource demonstrates why multiple use management must be considered in the context of time as well as space to be successful.

Management Implications

The following management practices are likely to substantially increase deer observation rates:

1. Hunting that restricts or limits the harvest of deer whose ranges overlap roads used for viewing and thus minimizes the loss of highly observable deer;
2. Vegetation cultural treatments that maintain and/or develop small openings along forest roads;
3. Timber harvesting that results in residual stand basal area $<19\ m^2/ha$ ($76\ ft^2/acre$);

4. Locating forest access roads in hardwood forest types rather than conifer types.

Additionally, we suggest that "bucks only" hunting can be compatible with deer viewing if strict control over illegal harvest of females is achieved. Finally, the scheduling of public use of forest roads for deer viewing can be flexible throughout daylight hours in summer without affecting viewing opportunities.

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Table 1. N of white-tailed deer observed and distance traveled during June, July, and August (1966-77) on the study area units in the central Adirondack Mountains.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
	Huntington South Unit - unhunted											
Deer	133	100	66	84	62	41	49	64	74	160	93	120
Distance[a]	1096.8	687.8	529.8	1547.3	1406.1	1407.6	1491.6	2038.0	2399.5	3485.0	3507.1	1162.2
Rate[b]	19.5	23.4	20.1	8.7	7.1	4.7	5.3	5.1	5.0	7.4	4.3	16.6
	Santanoni Unit[c] - 3.0 hunter/km^2											
Deer					39	37	38	13	5	3		
Distance					916.3	927.5	1288.2	1144.9	916.3	418.7		
Rate					6.8	6.4	4.8	1.8	0.9	1.2		
	Huntington North Unit[d] - 7.6 hunter/km^2											
Deer	183	17	12	85	15	7	17	51	100	98	113	31
Distance	843.8	620.1	275.9	1720.6	1386.3	1597.4	1397.3	1528.5	1994.2	2091.8	1823.8	729.3
Rate	34.9[e]	4.4	7.0	8.0	1.7	0.7	2.0	5.6	8.1	7.5	10.0	6.8

[a] Distance in km

[b] Number of deer/160 km

[c] Bucks only hunting from fall 1972 - fall 1975

[d] Either sex hunting from fall 1966 - fall 1970

[e] Summer observation rate prior to hunting in fall of 1966

Table 2. Comparison of roadside observations of white-tailed deer with occurrence of forest types in the central Adirondack Mountains. May-November periods 1962 - 1977.

Forest type	% occurrence	N deer observed	N deer expected	χ^2
Hardwood	64.1	3,524	(3,482)	0.51
Hardwood-conifer	28.4	1,375	(1,541)	17.88*
Conifer	6.1	116	(333)	141.41*
Open	1.4	419	(78)	1490.78*
Total	100.0	5,434	(5,434)	

* Significant

Table 3. Observed and expected occurrence of 105, 0 white-tailed deer observation sections (100 m) of road and 105, high deer observation sections, in 3 forest types in the central Adirondack Mountains. May-November 1962 - 1977.

Type	Observation History	N road sections		
		Observed	Expected[a]	χ^2
Hardwood	High	78	68.5	1.23
	0	63	68.5	0.49
Hardwood - Conifer	High	26	29.8	0.48
	0	29	29.8	0.02
Conifer	High	1	6.4	4.59*
	0	13	6.4	6.68*

[a] Derived from the total number of 100-m sections (319) available on the study area

* Significant

Table 4. A predictive model for white-tailed deer observation rates along forest roads on hunted areas in the Adirondack region.

Factor	Coefficient		SE		R^2
	Equation		Equation		Equation
	(3)[a]	(4)[b]	(3)	(4)	(3)
Anticipated local fall deer density/km^2	2.40	3.56	0.464	0.355	53.47
Hunter density/km^2 previous fall	-0.20	-0.18	0.026	0.030	26.61
Regional buck harvest	+0.001		0.0004		5.89
Y intercept	-6.84	-1.95			
SE estimate	3.00	3.51			

[a] (3) DOR = 2.40 LDD - 0.20 HD + 0.001 RBH - 6.84

(F = 53.47, r = .93 r^2 = 85.97

[b] (4) DOR = 3.56 LDD - 0.18 HD - 1.95

(F = 54.29, r = 0.89, r^2 = 80.08

where DOR = Deer observation/160 km

LDD = Anticipated local fall deer density/km^2

HD = Hunters/km^2 previous fall

RBH = Regional buck harvest

Figure 1. Study area showing the three study units. Huntington North Unit, hunted 1966-70; Huntington South Unit, unhunted; Santanoni Unit, hunted 1972-75. Forest roads are accessed from a State highway traversing the extreme southern part of the area and not shown on the figure.

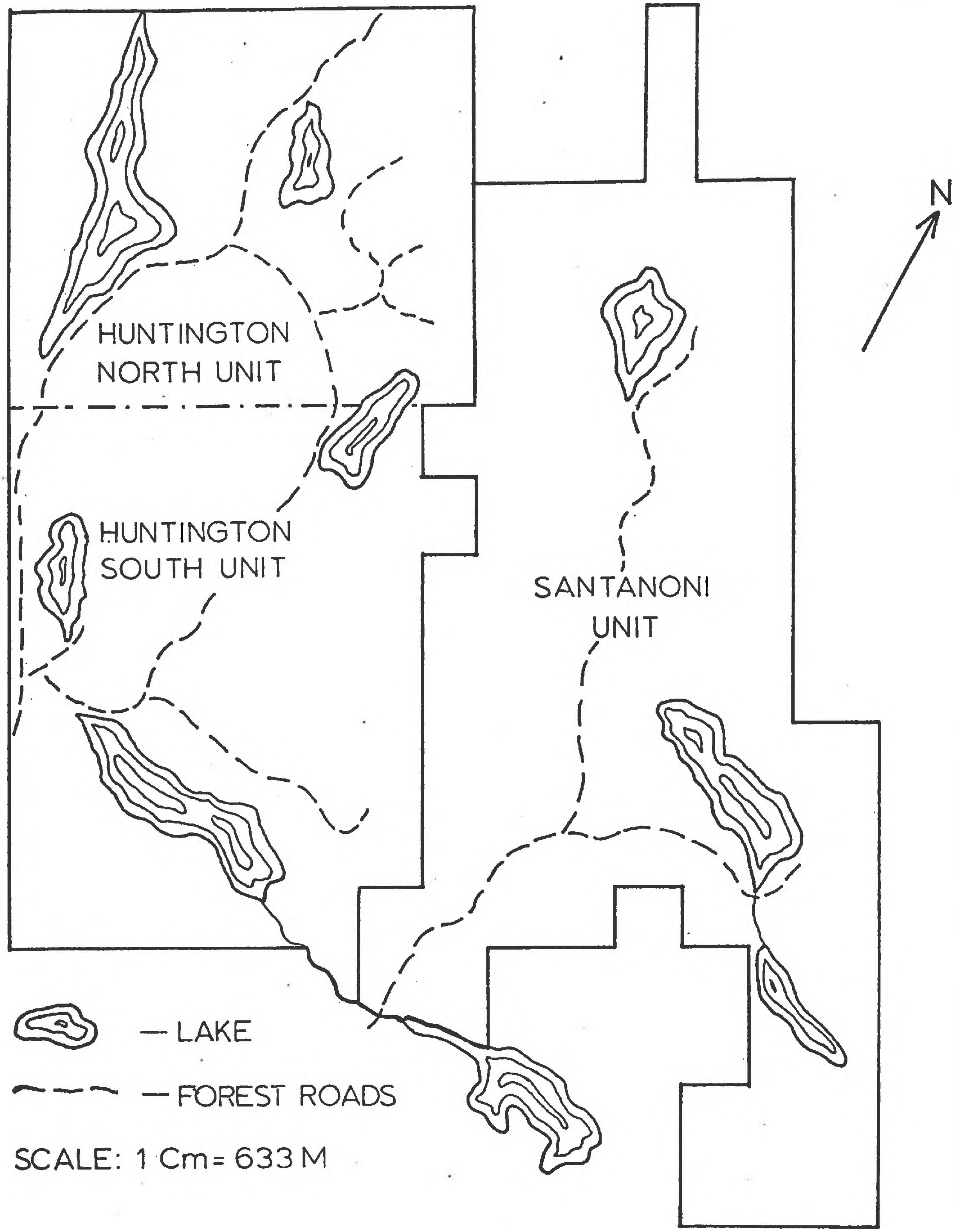

HUNTINGTON
NORTH UNIT
HUNTINGTON
SOUTH UNIT
SANTANONI
UNIT
N
— LAKE
— FOREST ROADS
SCALE: 1 Cm = 633 M

Figure 2. Summer white-tailed deer observation rates on 3 study units in the central Adirondack Mountains. The Huntington North Unit was hunted for deer of either sex during 1966-70 with a hunter density of 7.6 km^2. The Santanoni Unit was hunted under a bucks only season during 1972-75 with an average hunter density of 3.0 km^2. The Huntington South Unit was unhunted during the entire study period (1966-1977).

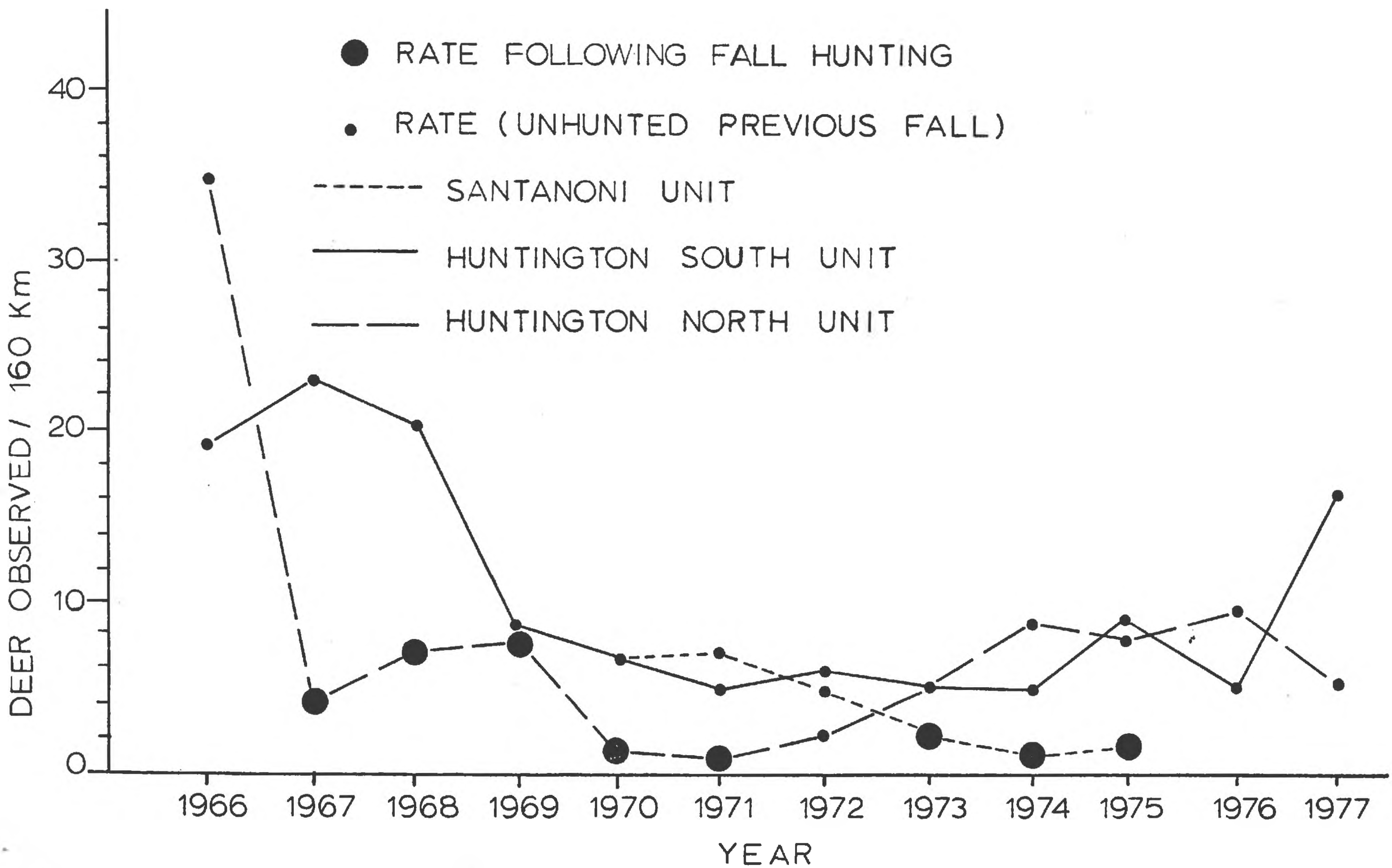
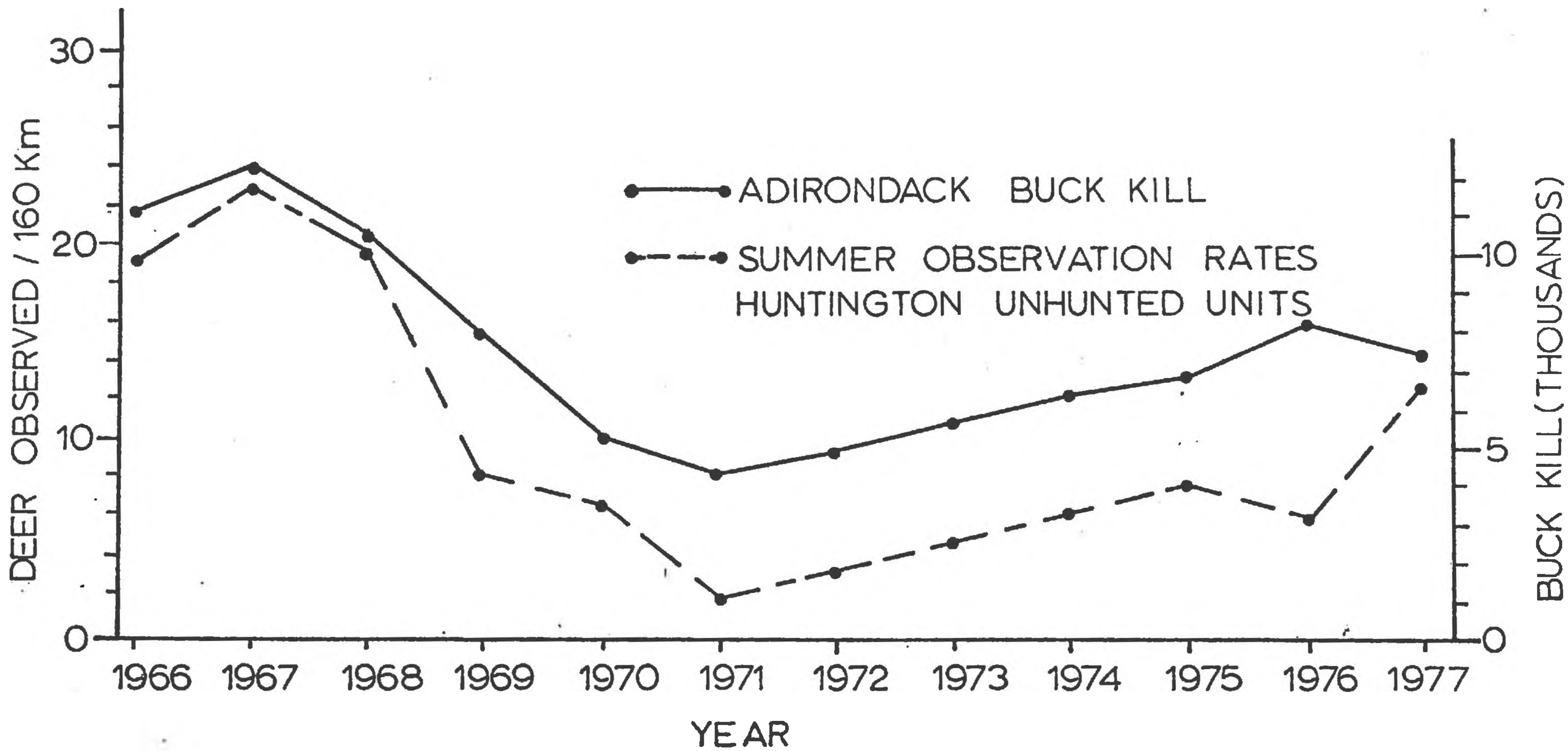
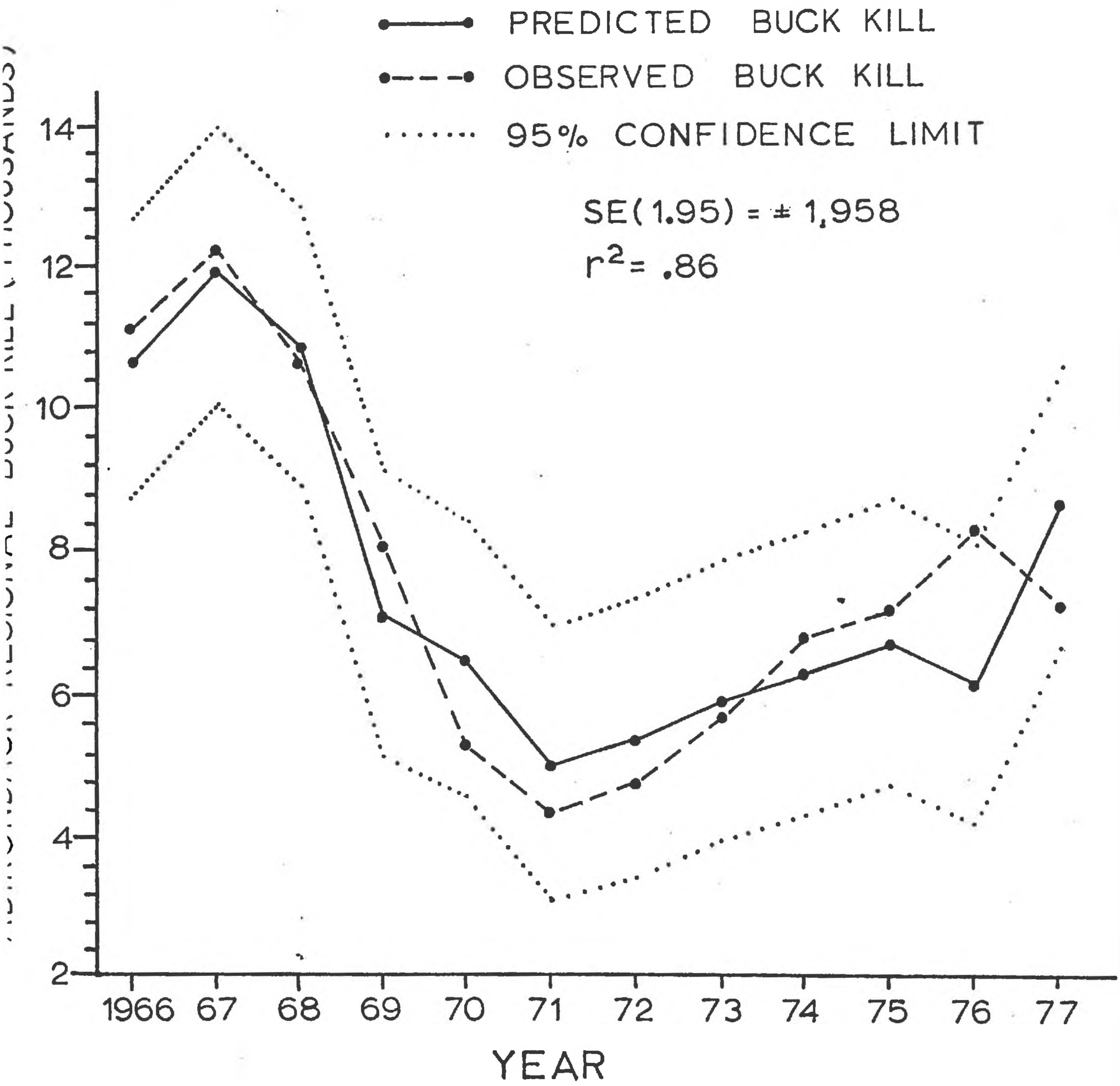

RATE FOLLOWING FALL HUNTING
RATE (UNHUNTED PREVIOUS FALL)
SANTANONI UNIT
HUNTINGTON SOUTH UNIT
HUNTINGTON NORTH UNIT
DEER OBSERVED / 160 Km
0
10
20
30
40
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
YEAR

Figure 3. Relationship of the Adirondack regional buck kill to the summer white-tailed deer observation rate on unhunted Huntington study units. Observation data from the Huntington North Unit are included for the period 1971-77 as hunting on this unit ceased in 1970. The Adirondack region located in northern New York State includes an area of 32,000 km^2 surrounding the study area.



30
20
10
0
DEER OBSERVED / 160 Km
ADIRONDACK BUCK KILL
SUMMER OBSERVATION RATES
HUNTINGTON UNHUNTED UNITS
10
5
0
BUCK KILL (THOUSANDS)
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
YEAR

Figure 4. Observed and predicted Adirondack regional white-tailed deer buck kill. The predictive equation is: (Adirondack buck kill = 339.25 (Deer observation rate) + 4046. Observation rates are from unhunted units.


PREDICTED BUCK KILL
OBSERVED BUCK KILL
95% CONFIDENCE LIMIT
SE(1.95) = ± 1,958
r² = .86
14
12
10
8
6
4
2
1966
67
68
69
70
71
72
73
74
75
76
77
YEAR

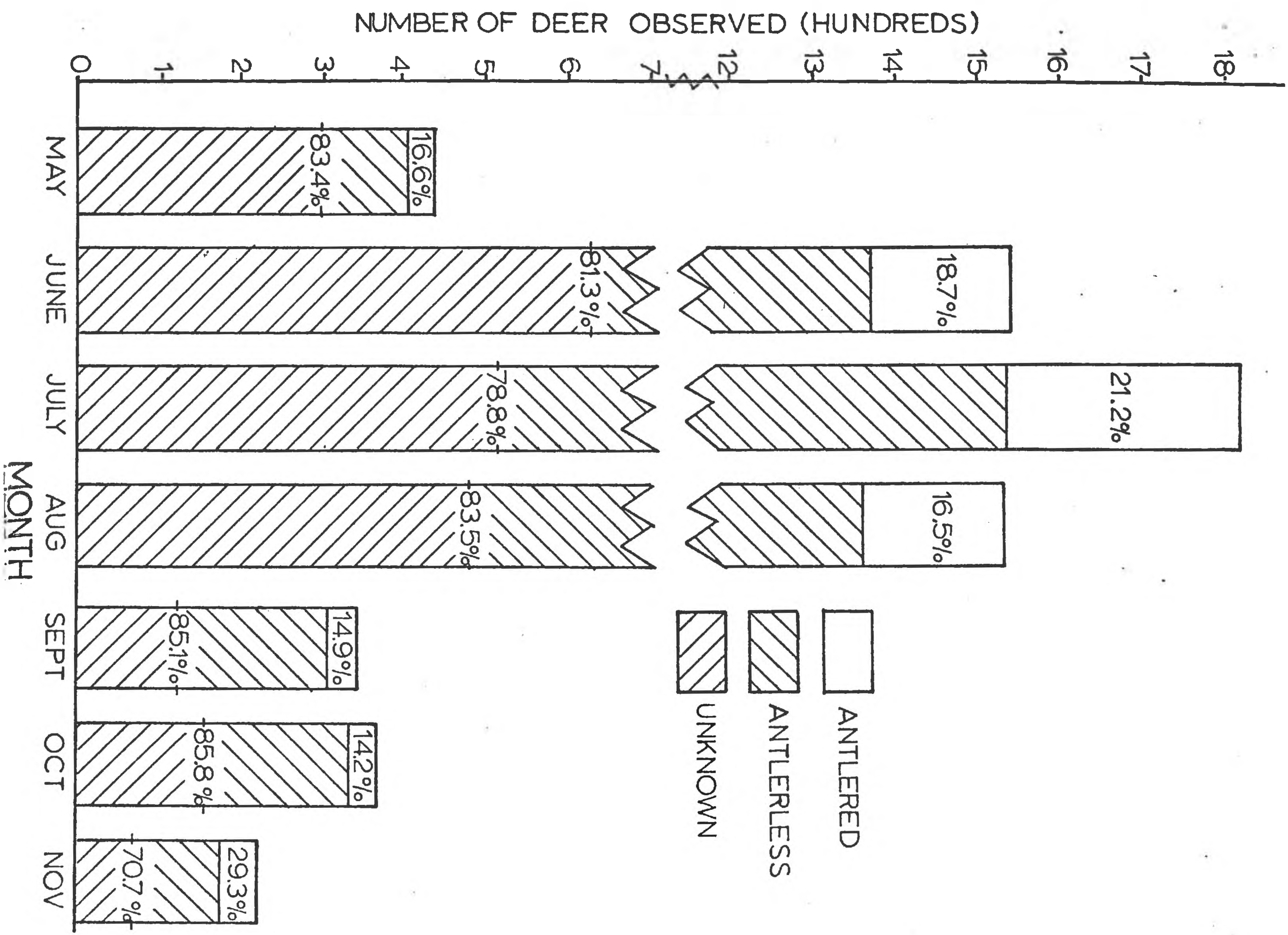
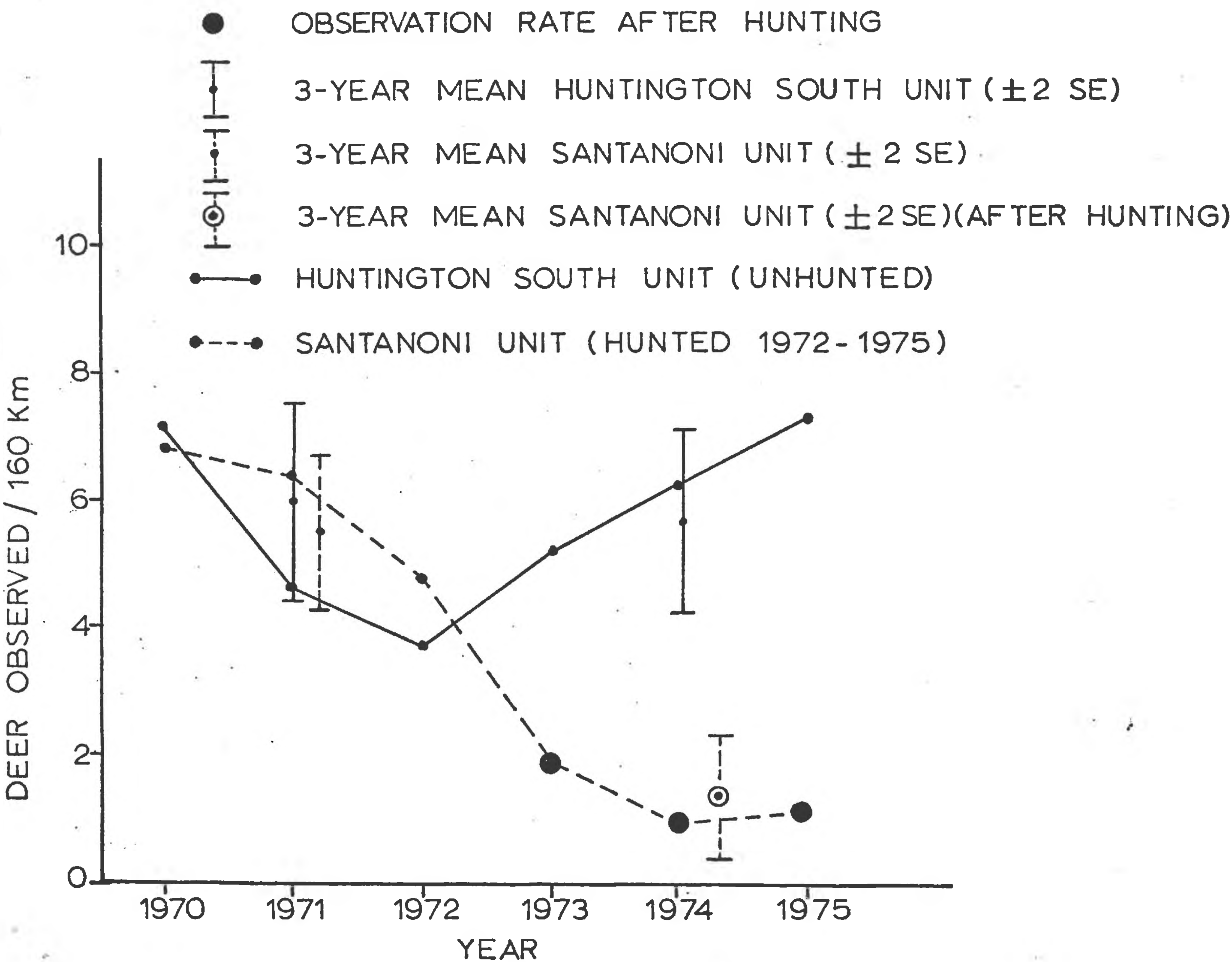

NUMBER OF DEER OBSERVED (HUNDREDS)
0
1
2
3
4
5
6
7
12
13
14
15
16
17
18
MONTH
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
83.4%
16.6%
81.3%
18.7%
78.8%
21.2%
83.5%
16.5%
85.1%
14.9%
85.8%
14.2%
70.7%
29.3%
UNKNOWN
ANTLERLESS
ANTLERED

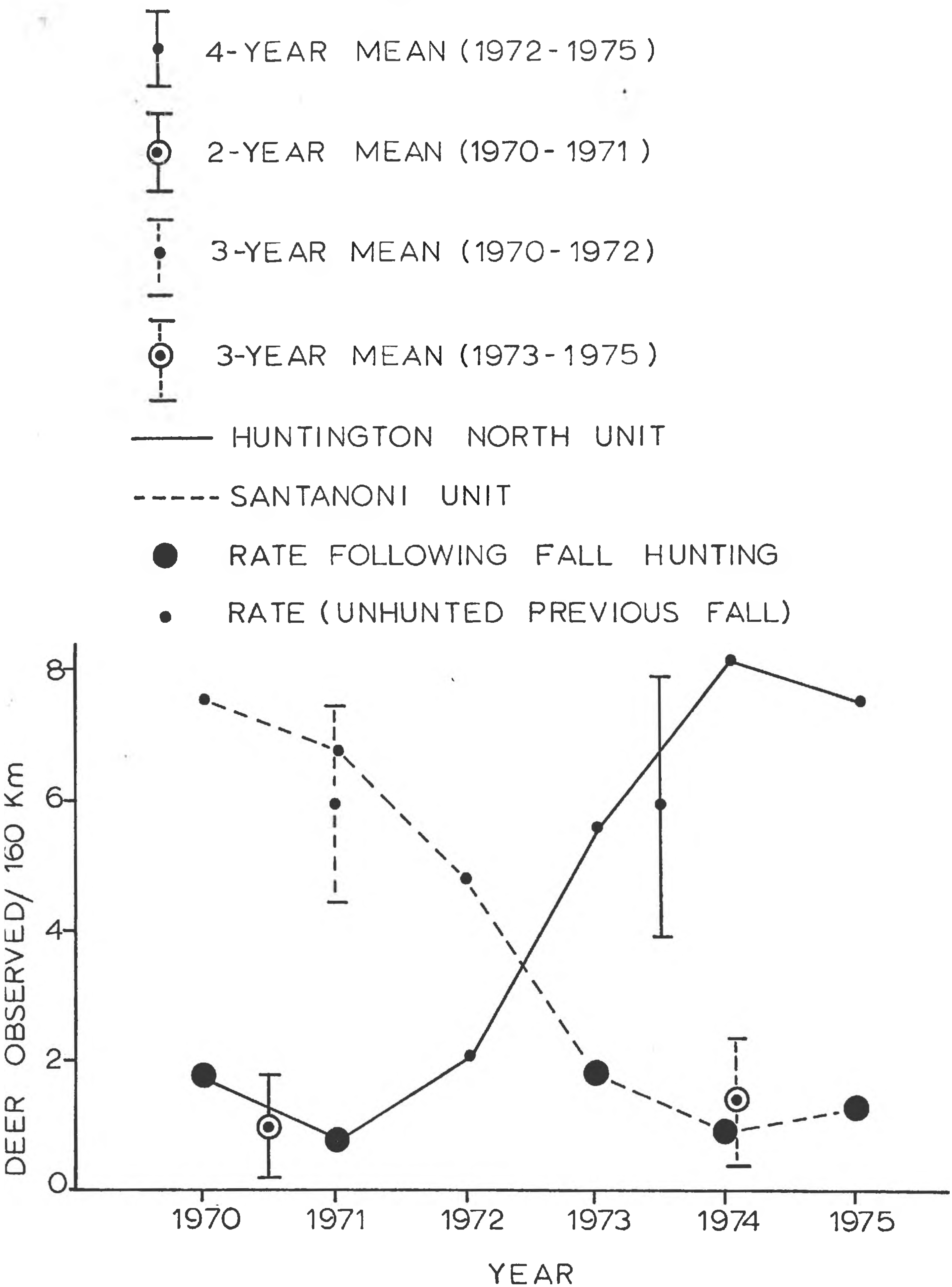
Figure 5. Observations of antlered white-tailed deer along forest roads compared to antlerless and unknown (combined) for 3 study units in the central Adirondack Mountains during 1966-77. Numbers within bar graphs are percentages of the total monthly observations.

Figure 6. White-tailed deer observation rates along forest roads during June, July and August on 2 study units in the central Adirondack Mountains. Huntington South Unit was unhunted during the study period, Santanoni Unit was hunted during a "bucks only" season 1972-75 with a hunter density of 3.0/km^2.



OBSERVATION RATE AFTER HUNTING
3-YEAR MEAN HUNTINGTON SOUTH UNIT (±2 SE)
3-YEAR MEAN SANTANONI UNIT (±2 SE)
3-YEAR MEAN SANTANONI UNIT (±2 SE)(AFTER HUNTING)
HUNTINGTON SOUTH UNIT (UNHUNTED)
SANTANONI UNIT (HUNTED 1972-1975)
DEER OBSERVED / 160 Km
0
2
4
6
8
10
1970
1971
1972
1973
1974
1975
YEAR

Figure 7. Summer observation rates of white-tailed deer along forest roads on 2 study units in the central Adirondack Mountains. The Huntington North Unit was hunted for deer of either sex during 1966-70 with average hunter density of 7.6/km^2. The Santanoni Unit was hunted for "bucks only" during 1972-75 at a hunter density of 3.0/km^2. Confidence intervals are + or - 2 SE.



4-YEAR MEAN (1972-1975)
2-YEAR MEAN (1970-1971)
3-YEAR MEAN (1970-1972)
3-YEAR MEAN (1973-1975)
HUNTINGTON NORTH UNIT
SANTANONI UNIT
RATE FOLLOWING FALL HUNTING
RATE (UNHUNTED PREVIOUS FALL)
DEER OBSERVED/ 160 Km
0
2
4
6
8
1970
1971
1972
1973
1974
1975
YEAR

The following article was published in the October 1975 issue of the Northern Logger and Timber Processor.

Establishing Vegetative Cover Along Logging Access Roads:

Techniques — Costs — Benefits

by **Richard W. Sage, Jr. and William C. Tierson***

Logging access roads are a prerequisite to effective timber management and harvest as well as other forms of natural resource utilization and enjoyment. Within the boundaries of the Adirondack Park there are hundreds of miles of these roads on private lands. At a cost of construction which can approach $20,000 per mile in some areas landowners cannot afford to abandon these roads or have them deteriorate through neglect. Maintenance costs can run as high as $500 per mile annually. With this in mind, it is evident that measures taken to minimize maintenance and/or reconstruction are beneficial.

In addition, concern for the appearance and protection of the land following timber harvesting operations is real. Recent publication (in this journal, April 1975) of the "Timber Harvesting Guidelines for New York" as prepared by the New York Section of the Society of American Foresters reflect this concern.

In response to these concerns and others a research project was initiated at the Adirondack Ecological Center (Newcomb Campus of the State University College of Environmental Science and Forestry) in an effort to investigate and evaluate various cultural techniques for managing vegetation along forest roads. Of prime interest was the stabilization of soils, enhancement of landscapes and increasing the potential for wildlife viewing and photography.

A recently constructed network of logging access roads totaling 3.01 miles in length served as a basis for this study. The road locations had been laid out by trained personnel and specifications for the actual road construction were incorporated into the timber sale contracts.

Road construction was typical of that practiced throughout the region: merchantable stems in the right-of-way felled and removed; stumps and topsoil bulldozed off to the side; subsoil and local gravel banks used to surface the road; and ditches and culverts provided to maintain drainage patterns. Following construction, the road surface varied between 15 and 20 feet in width with adjacent roadsides exhibiting the usual signs of this type of construction: large boulders, stumps, tops, bent over and broken trees, irregular ground surfaces and considerable bare ground with various mixtures of topsoil and subsoil.

It was these roadsides and the associated landings and major skid trails where cultural techniques were employed to stabilize soils, maintain open areas, enhance roadside aesthetics and increase wildlife viewing opportunities.

Preliminary Site Preparation

As road construction progressed, or immediately following completion of a section of road, when heavy equipment was available and on site, roadsides were back-bladed; stumps, large boulders, cull logs and other debris bunched and covered; road cuts and barrow pits sloped to a maximum pitch of 66 percent. Landings and major skid trails received similar treatment after all activity at these sites had ceased. This operation was done with a skidder rather than returning with a tractor. While this work was underway a chain saw operator felled tipped-over trees and lopped tops to get this material down on the ground.

Efforts of the kind described above are often written into timber sale contracts as part of the road construction

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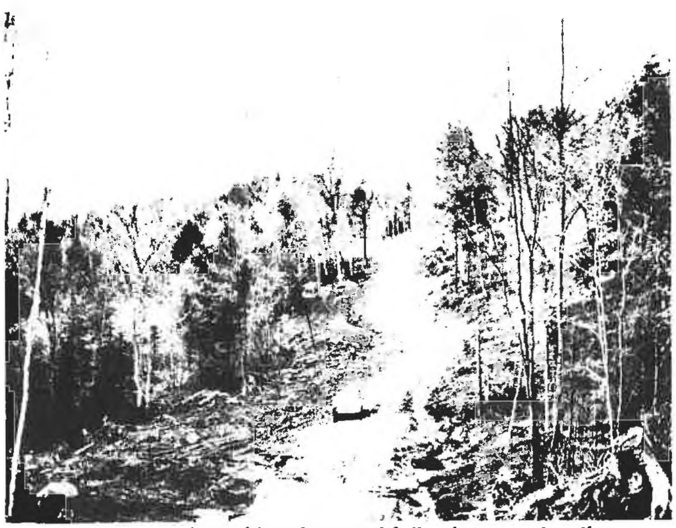
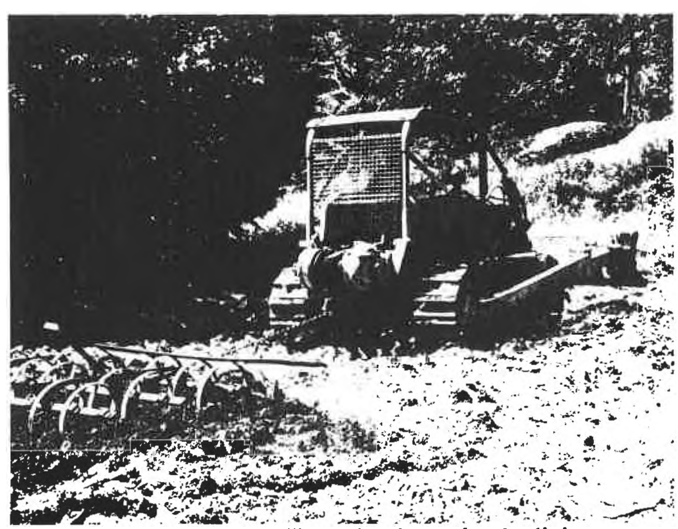


A typical section of logging road following construction.



Raking in lime and fertilizer with the spring-tooth harrow.

View along logging road following establishment of roadside vegetation.

Marked buck and doe, and spotted fawn feeding on clover seeded on abandoned log landing. Fences in background protect developing trees.

specifications, the costs then being reflected in reduced stumpage values. Figures gathered in this study indicated the cost of this dressing-up work ranges from $600 to $1,000 per mile depending on the particular situation and the degree of cleaning up desired. Costs are minimized if this work is done at the time of road construction rather than returning at a later time.

Previous experiences indicated that the mere casting of seed following the dressing up operation produced unsatisfactory results. Further site preparation, including liming, fertilization and harrowing, are necessary for the successful establishment of a vigorous, uniformly distributed vegetative cover.

Secondary Site Preparation

In order to establish a seed bed which was conducive to uniform plant establishment, a spring-tooth harrow was employed. The harrow, a common agricultural tool, was eight feet wide and comprised of two independent four-foot sections. This unit was dragged behind a small tractor or rubber tired skidder over the planting site. Despite the irregular nature of the ground and the presence of sizable rocks, stumps and various pieces of wood, this unit performed well with relatively little maintenance. The spring action of the teeth and the independent action of the two four-foot sections allowed one part of the unit to ride over an immovable object while the other continued to turn the soil. The shallow furrows produced by the teeth when run across slope served to hold fertilizer and seed and prevented rapid down slope movement of water and soil. On log landings, where gasoline and oil spills, soil compaction and heavy accumulations of sawdust and chips prevented successful establishment of a uniform plant cover, the mixing action of the spring-tooth harrow generally was sufficient to promote uniform cover establishment on these sites when at least two passes with this unit were made.

Costs associated with this type of site preparation averaged $39.20 per acre. It should be emphasized that this treatment was considered to be the "key" to the successful establishment of a *uniform* plant cover.

Liming and Fertilization

Analysis of soil samples collected from the roadside areas prior to treatment showed low to medium levels of fertility and very acid soil conditions (ph values ranged from 4.6 to 5.5). Based on the results of these tests, planting sites were limed at the rate of one ton of dolomitic limestone per acre followed by the application of 1,000 pounds per acre of 10-10-10 fertilizer. At a rate of application of one ton per acre dolomitic limestone can be expected to raise ph values by approximately 0.5. Both lime and fertilizer were applied using a conventional, 1 ton capacity spreader. This unit, when towed behind a small tractor, negotiated the irregular ground conditions of the treated sites surprisingly well. The lime and fertilizer were applied separately, requiring two passes over the site with the spreader. Following these applications a

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TABLE 1
Average Per Acre Costs of Roadside Vegetation Treatments

	Costs Labor & Equipment	Costs Materials	Costs Total
Preliminary Site Preparation*			
Tractor Work	$ 98.62	—	$ 98.62
Chain saw slashing	34.12	—	34.12
Secondary Site Preparation			
Site clean up	27.66	—	27.66
Harrowing 1st	39.20	—	
2nd	29.39	—	68.59
Lime	38.76	$30.00	68.76
Fertilizer	39.35	39.00	78.35
Seeding	9.17	18.67	27.84
Miscellaneous			
Supervision	18.64	—	18.64
Movement of Men, Materials & Equipment	36.09	—	36.09
Maintenance & Repair	7.89	—	7.89
TOTAL Excluding Tractor & Chain saw work	$246.15	$87.67	$333.82
TOTAL with Tractor & Chain saw work	$378.89	$87.67	$466.56

*In many cases considered a part of road construction costs.

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second pass was made with the spring-tooth harrow which served to incorporate the lime and fertilizer into the soil and further groom the site. Road cuts, steep banks and other areas which could not be treated using equipment were limed and fertilized by hand.

Material costs per acre for lime and fertilizer were $30.00 and $39.00 respectively. The cost of labor and equipment to apply these materials were similar averaging $38.76/A for liming and $39.35/A for fertilization. An additional cost of $29.39/A was associated with the second pass with the harrow to incorporate these materials into the soil.

Seeding

Following the completion of all site preparation activities, the roadside areas were seeded using a variety of grass and legume species. Seed was applied using a hand-cranked cyclone seeder. Usually seed was applied in two directions casting approximately one half of the seed to be applied in a series of parallel strips and the remainder of the seed in strips running at right angles to the first series. This technique promoted more uniform distribution of the seed over the site. A single pass with the cyclone seeder could effectively seed a strip 10 to 12 feet in width. Under average conditions the roadsides, landings and major skid trails associated with one half mile of road could be seeded by one man in a day.

Species

A variety of grass and legume species were used in seeding the roadside sites. The grass species used included: creeping red fescue *(Festuca rubra)*, redtop *(Agrostis alba)* and reed canarygrass *(Phalaris arundinacea)*.

In general, the grasses were selected for use on the more severe sites, i.e., steep slopes, road cuts, areas with heavy accumulations of debris, dense shade and areas with little residual topsoil or very severe soil disturbance. The use of reed canarygrass was restricted to poorly drained areas and on the banks of small streams and drainages where it developed to heights of 48–60 inches. The height development of the canarygrass served as an effective screen of logging activity along small drainages. Per acre seeding rates for the grass species were as follows: creeping red fescue, 25 lbs.; redtop, 8 lbs.; and reed canarygrass, 10 lbs.

A variety of legumes were used in this study including: medium red clover *(Trifolium pratense* var. *pennscott)*, ladino clover *(Trifolium repens)*, alsike clover *(Trifolium hybridum)*, iroquois alfalfa *(Medicago sativa* var. *iroquois)*, crownvetch *(Coronilla varia* var. *penngift)* and empire birdsfoot trefoil *(Lotus corniculatus* var. *empire)*. All these species have the capability to fix nitrogen. To insure an active bacterial process, all seeds of these species were inoculated with nitrogen fixing bacteria prior to seeding.

Generally the legumes were seeded on the better sites. Medium red clover was used extensively with excellent success and height development averaging 30–36 inches by late summer.

Seeding rates for alfalfa, trefoil and crownvetch were 16, 8 and 15 lbs./A respectively. Medium red clover was seeded at the rate of 9 lbs./A, alsike clover at 7 lbs./A and ladino clover at 4 lbs./A.

In general, plantings of legume species have remained green and lush for 3 years, while some grass plantings have showed signs of nitrogen deficiency.

Past experiences have shown the grass species to be more persistent than the clovers. Grasses seeded on landings and skid trails 10 to 15 years ago still comprise a major portion of the vegetative cover of these sites.

Spring and early summer (mid May through June) seeding produced the best success in establishing a uniform vegetative cover. Mid-summer plantings generally failed and fall seedings produced inconsistent results.

Following germination, a preliminary evaluation of distribution and stocking can be made after 3 to 4 weeks time. If less than satisfactory results are observed at this time, reseeding of these areas should be considered. After 8 to 12 weeks time, both clovers and grasses should have reached maximum stocking and height development.

Seed costs varied depending on species and availablity. Cost for seed averaged $18.67/A and ranged from $2.80/A to $25.00/A. Labor costs to apply the seed averaged $9.17/A.

The average cost of the cultural treatments described, including secondary site preparation (clean up and harrowing), liming, fertilization and seeding; was $333.82 per acre for labor, materials and equipment (Table 1). The cost per mile of road treated averaged $2,249. This figure, of course, varied depending on the amount of area treated per mile of road, which in this case, ranged from 4.6 to 9.4 acres per mile. In terms of the net volume of wood removed as a result of the construction of the roads involved, the cost of the treatment was $1.61 per MBF.

An additional cost of $132.74 per acre should be assigned to dressing up roadsides with a tractor and chain saw lopping of tops, and bent over or broken trees, if these operations are not considered as part of the road construction costs.

BENEFITS

The establishment of a thriving vegetative cover on the log landings, major skid trails and roadside areas associated with the three miles of logging road in this study virtually eliminated any signs of erosion on the planted sites. The appearance of the road corridor changed from one of disruption to that of a scenic roadside environment. It is possible that reduced road maintenance costs could be experienced as a result of these treatments, and the maintenance of landings, road turnouts and major skid trails should be beneficial for future use.

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The enhancement of roadside aesthetics could have considerable value in terms of public relations.

The increase in wildlife viewing opportunities that resulted from the roadside treatments offers many interesting and potentially rewarding benefits. Deer observation rates along the treated road sections were 300 to 400 percent greater than along untreated sections of road.

The combined effects of a number of factors contributed to the higher deer observation rates. First, the abundant and varied vegetation developing on the logged areas provided ideal deer habitat. Second, the grass and legume plantings both maintained open areas and lanes of high visibility, and attracted deer to the roadsides where they could be seen.

Observation data also suggested that black bears found the fertilized grasses very attractive. Several times bears were observed feeding on these grasses, primarily in early spring. Thus, in addition to the stabilization of soils and the rapid establishment of an attractive roadside cover, these plantings had great value in increasing wildlife viewing opportunities.

In summary, the techniques used in establishing a vegetative cover along logging access roads and the associated costs and benefits have been presented. It is our hope that this information will suggest alternative management opportunities to private landowners and provide the data necessary to evaluate these programs.

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