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DEER WINTER CONCENTRATION AREAS
IN SOUTHERN MICHIGAN

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Joseph Warren Masek

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DEER WINTER CONCENTRATION AREAS

IN SOUTHERN MICHIGAN

By

Joseph Warren Masek

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ABSTRACT

DEER WINTER CONCENTRATION AREAS
IN SOUTHERN MICHIGAN

By

Joseph Warren Masek

During the winter months, white-tailed deer (Odocoileus virginianus) concentrate in certain areas of southern Michigan in large bands of up to 150 individuals. Little is known about the factors influencing this grouping tendency in agricultural regions.

In this study, 100 winter concentration areas were identified in the southern third of Michigan (Region III). Information on environmental features, food sources, and deer herd density was compiled for these areas. Quantitative data on available food and cover were gathered for 18 selected concentration areas.

Evidence from this study indicated that the size, shape, distribution, and intensity of use of deer winter concentration areas in southern Michigan is influenced by many factors. The availability of waste field corn may be a key factor influencing selection and use of wintering areas, and was shown to have an approximate linear relationship with deer herd density in the 18 study areas.

ACKNOWLEDGEMENTS

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My parents have provided untold help in the form of physical, moral, and financial support. This acknowledgement seems totally inadequate as thanks for the love which they have given me through the years. These same feelings are expressed toward my in-laws, who have recieved me into their family even as one of their own. Last, but certainly not least, I thank my family for their loving support. To my wife, Mary, thank you for bearing with me during these six years of school, for supporting me and for sharing in our love for God's creation; to my son Casey, thank you for just being the precious gift of love that you are, and for showing me how to experience each contact with nature as a new and exciting adventure. May my generation help to insure the opportunities for your generation to experience God's creation at it's best.

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INTRODUCTION

The white-tailed deer (*Odocoileus virginianus*), absent for many years from the southern half of Michigan's Lower Peninsula until becoming re-established during the early 1940's (McNeil 1962), has made a dramatic comeback in that portion of the state. The present herd numbers around 200,000 deer (Vogt 1979), with population levels approaching or exceeding problem proportions in some areas (Nixon 1968).

During the winter months, deer concentrate in certain areas of southern Michigan in large bands of up to 150 individuals (Jenkins 1963). This often leads to locally heavy damage to agricultural crops, orchards, and ornamental trees and shrubs on private land. An increase in deer-car accidents may also occur on secondary roads which are found within these areas (Nixon 1968).

There are many references in the literature concerning the "yarding" behavior of deer in the northern portions of their range (Boer 1978, Huot 1974, Moen 1968, Verme 1973), but little is known about the factor(s) influencing this grouping tendency in agricultural regions. Conditions similar to those of southern Michigan exist in several other states (Erickson *et al*. 1961, Kline 1965, Larson 1978, Nixon 1968, Rongstad and Tester 1969, Sparrowe and Springer 1970). No attempt will be made in this paper to address the question of *why* deer concentrate in the winter. Suffice it here to say that they do, for whatever reason(s) yet unexplained. Several researchers provide interesting possible explanations in answer to this question (Cowan 1956, Hammerstrom and Blake 1939, Loveless 1967, Mattfeld 1974, Moen 1968, Ozoga and Gysel 1972, Webb 1948). Expressed in Mattfeld's (1974:11) words,

> Great care should be exercized in differentiating evolutionary roots of winter concentration, factors which trigger concentration, and factors which sustain concentrations of deer...the search for a single factor to explain all three facets of this phenomenon has led to confusion in the literature and in the minds of wildlife professionals and the general public alike.

The growing importance of southern Michigan's deer herd, from an economic, safety, and recreational standpoint, dictates the need to accumulate pertinent information for sound management of Michigan's most important wildlife resource. Toward that end, the objectives of this study were:

1) to map the distribution of known deer winter concentration areas in southern Michigan;
2) to determine the major factor(s) which influence the deer to use these given areas.

STUDY AREA

The Michigan Department of Natural Resources (DNR) has divided the state into three regions for administrative purposes. Region III, the southern third of the state, is the general study area under consideration (Figure I). It is comprised of 35 counties totaling 22, 169 square miles in area. The region is divided into five districts (9, 11, 12, 13, and 14).

Present land use distribution within the region is 49 percent cropland, 17 percent timber, 16 percent urban uses, 4 percent pasture, and 14 percent other uses (including idle land and roads) (Great Lakes Basin Commission 1975).

Approximately 7,834,300 people, nearly 86 percent of the population of Michigan, reside in Region III. Winter conditions (Merz 1978) are considerably milder than in the northern portions of the state (Table 1).

Within the general study area of Region III, 18 concentration areas were selected for study on available food and cover (Figure 2).

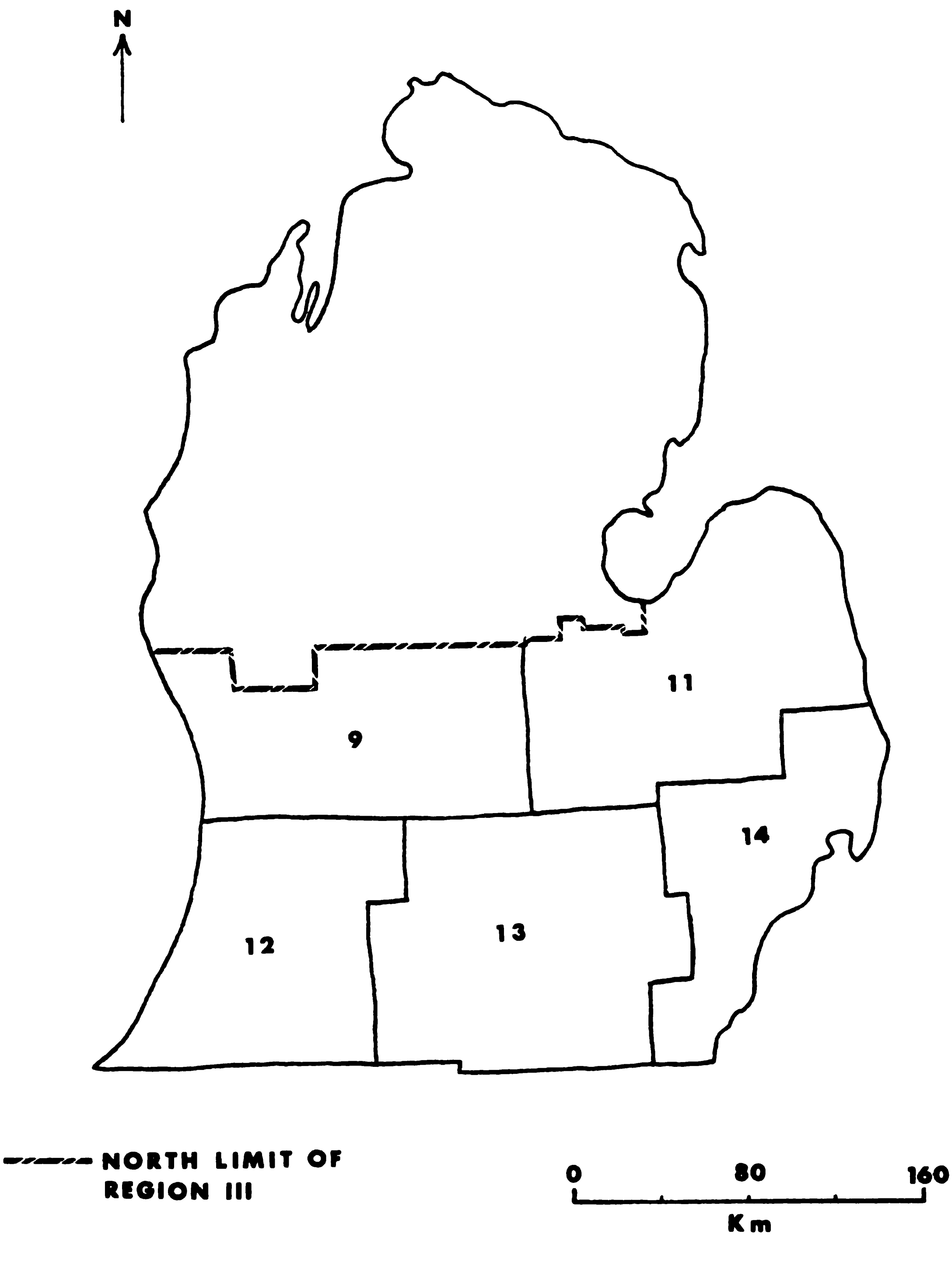

Figure 1. Map of lower Michigan, showing Region III, which is divided into five districts.

Table 1. Winter conditions in Regions I, II, and III.

	Region I	Region II	Region III
Mean Annual Snowfall	1.5-2.5 m	1.5-2.5 m	0.9-1.5 m
Daily Minimum Temperature	-12.2 - -9.4°C	-12.2 - -9.4°C	-9.4 - -6.6°C
Daily Maximum Temperature	-6.6 - -3.8°C	-3.8 - -1.1°C	-1.1 - 1.7°C
Mean Annual Number of Days with Snow Cover	120- 150	100- 130	70- 100

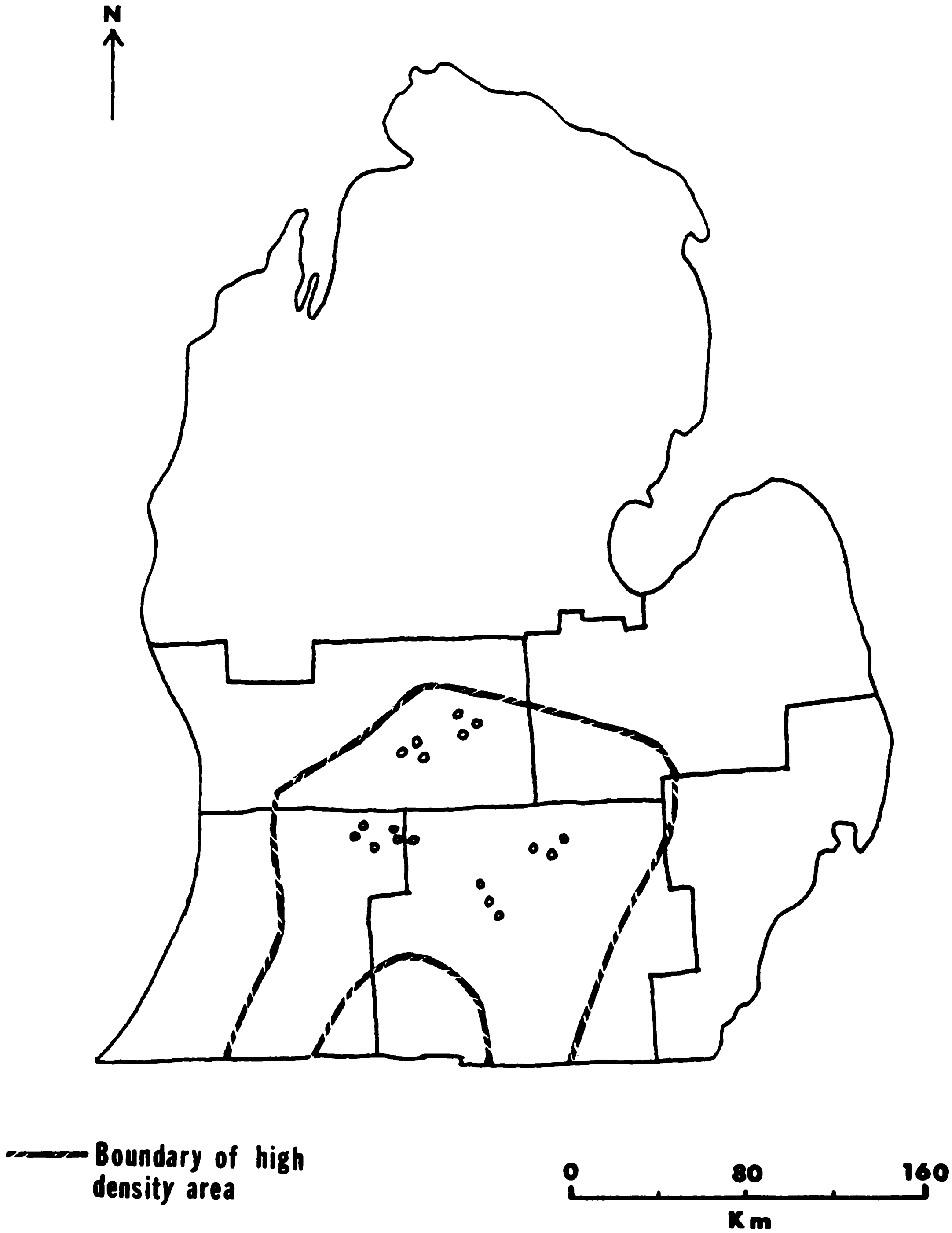

Figure 2. Eighteen study areas within area of relatively high deer density (Michigan DNR Map 2155 - 1973).

METHODS

During February of 1978, aerial surveys of Region III were made in an attempt to confirm suspected deer winter concentration areas. District 14, which was believed to contain no concentration areas, was excluded from the flights. Michigan DNR field biologists participated in the observation flights and prepared maps showing known and suspected concentration areas in advance. County maps showing detailed road information were used, enabling observers to readily identify their position during the flights.

The flights were made in a fixed-wing aircraft (Dehaviland Beaver), at altitudes ranging from 90 to 240 m. From this height the deer were plainly visible against the snow background. Two observers besides the pilot were present. The flights were restricted to paths which would most effectively cover the suspected concentration areas in a minimum amount of flying time. Deer concentrations were recorded as well as observations on environmental features, number of deer observed, bedding and feeding sites, major trails, and other pertinent information.

Reports on each concentration area were completed on a district by district basis. Personal interviews were conducted with each DNR District Biologist, along with all the field biologists involved in the flights. Information forms (Appendix 1) were used to standardize and record information for all known concentration areas. Areas were numbered by district and county, following a north to south and west to east system. A composite map, showing distribution and size of the areas on a regional basis, was transcribed from county maps (Figure 3). A second regional map was made which indicated deer herd density within each area (Figure 4).

Based on this initial information, 18 concentration areas of various sizes (Figure 2) were chosen for study of available food and cover. Six blocks of three concentration areas were chosen, each block containing a low (0-19 deer/km^2), medium (20-38 deer/km^2), and high (39+ deer/km^2) density area. This blocking was an attempt to minimize the differences in herd size, agricultural practices, and physiographic features found acrossed the region. All concentration areas were within a 75 mile radius of Lansing and were within a general area having approximately uniform relative deer density (Figure 2).

Initial reports indicated that standing and waste field corn availability may influence location of winter concentration areas. Therefore, an attempt was made to quantify the relative amounts of corn available to deer in the 18 study areas. Black and white aerial photographs (RF 1:660) were obtained from the Agricultural Stabilization and Conservation Service (A.S.C.S.) office in each of the seven counties involved. The photographs for the individual counties were dated as follows: Ingham, Kent, and Livingston - 1963; Jackson - 1964; Barry, Ionia, and Eaton - 1967.

Land ownership was determined within each area using current county platte maps and farm code numbers found on the A.S.C.S. photos. One hundred and thirty-six landowners were contacted by telephone during the summer of 1978. Inquiry was made as to their land use (farming vs.

Figure 3. Regional map showing distribution and size of concentration areas.

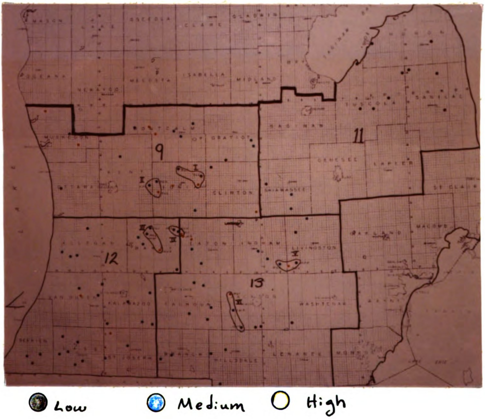

Figure 4. Regional map showing deer herd densities within each area.

non-farming), hectares of land planted to corn the previous year, harvesting method used (cornpicker vs. combine), and bushels per hectare yield for areas in which corn was left standing. Variations occurred in the amount of waste corn left after harvesting, depending on the harvest method used. For this study, hectares of corn harvested by combine and hectares harvested by cornpicker were multiplied by constants of 14.83 and 9.88 bu/ha respectively (Bygg and Gill 1965) to determine total bushels of waste corn available in each area (Table 2). Landowners were also questioned as to their feelings about having deer on their land and about any direct observations of deer which they made.

Cover, used here to define any wooded or brushy areas suitable for bedding or escape, would appear to be another major factor influencing deer in the selection of winter concentration sites (Dasmann 1971, Leopold 1933, Ozoga 1968, Ozoga and Gysel 1972, Verme 1973). Cover was quantified using the aerial photographs and a modified Bryan Dot Grid (1 dot = 0.25 ha) to determine the amount of cover and open land, and then calculating the percentage of each concentration area covered by woods and brush.

Interspersion was determined by using a map-measuring device to record the linear meters of "edge" between cover and open land. The dispersion index formula outlined by Patton (1975) was then used to calculate an "interspersion index" (I.I.) for each concentration area. This formula relates the linear extent of a measured edge of a habitat type to the perimeter of a circle which has the same total area as the unit of land under study. As the amount of edge within an area increases, the interspersion index increases proportionately.

Table 2. Summary of data from 18 study areas within Region III.

Area No.	Size(Ha)	Deer/Km^2	Bu Corn/Ha	Percent Cover	*I.I.
9-6-2	1285.31	9.65	0.494	62.6	2.60
9-6-1	694.05	19.31	0.833	49.4	3.62
9-6-5	132.34	57.92	1.888	31.8	1.84
9-5-2	1335.09	14.67	0.220	60.6	4.17
9-6-3	549.98	19.31	1.201	37.5	2.32
9-6-6	188.18	38.61	0.531	62.0	2.84
12-2-2	794.42	9.65	0.504	40.0	4.34
12-2-1	766.90	23.17	0.778	54.0	2.90
12-2-7	342.37	38.61	1.384	63.0	3.24
12-2-3	259.00	13.51	0.927	85.0	1.29
12-2-4	518.01	28.96	3.252	75.0	2.32
13-1-1	297.05	38.61	5.770	35.0	2.29
13-3-4	1048.97	9.65	0.190	37.0	1.45
13-2-2	182.52	27.03	3.091	57.0	2.48
13-3-3	287.33	96.53	5.140	31.0	2.05
13-6-3	259.00	13.51	0.810	17.0	1.30
13-6-2	241.60	28.96	1.871	50.0	1.85
13-6-1	259.00	57.92	3.197	53.0	2.70

* Interspersion Index

The quantitative data from this portion of the study were analyzed using stepwise multiple regression to determine the most important independent variable(s) influencing the dependent variable of deer herd density.

RESULTS

The observation flights made during February of 1978 confirmed the presence of 100 deer winter concentration areas scattered across Region III (Figure 2). Twelve additional areas were suspected to be within Saginaw and Lenawee counties, but due to inadequate time and unpredictable weather, these counties were not checked.

The following information was summarized from forms completed by DNR district personnel (Appendix 1). Data on concentration area size and deer herd estimates are available for all 100 areas. Less is known about some areas than others, resulting in fluctuations in sample size for many of the categories of information.

The concentration areas varied widely in size, averaging 803.76 $\pm$ 1025.22 ha ($\bar{m} \pm$ SE). Total herd estimates within the individual areas (Figure 5) averaged 116.45 $\pm$ 92.58 deer, with one area estimated to have over 500 individuals. The average density of deer within the concentration areas was 23.12 $\pm$ 17.41 deer/km^2. The average maximum group size observed was 48.76 $\pm$ 31.47 individuals (N = 62). The largest group seen during the flights was about 150 deer.

Information was available on the past history of some concentration areas (Table 3). Nearly all the areas were believed to be used historically on a regular yearly basis, and a large majority of them were used regardless of the severity of the winter. More than half (69 percent)

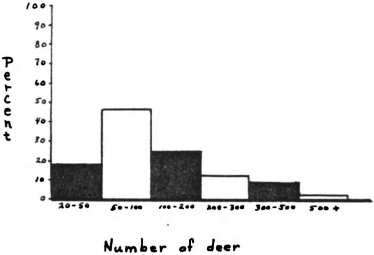

Figure 5. Estimated deer herd size within individual winter individual winter concentration areas (N = 100).

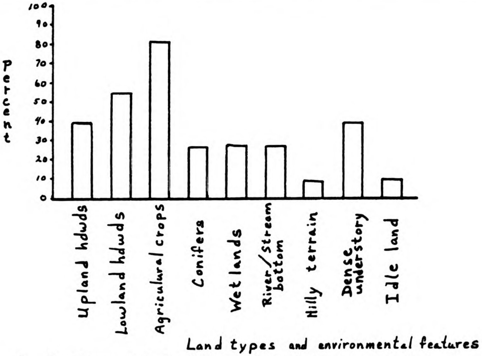

Figure 6. Environmental features and land types present in deer winter concentration areas (N = 75).

Table 3. Information on past use of deer winter concentration areas.

Information	N	Percent Yes
Area used historically	45	96
Herd size stable over past five years	42	26
Area used regardless of winter severity	47	87

Table 4. Primary and secondary food sources (N = 74), expressed as percent of N.

Food Item	Primary	Secondary
Corn	57.0	35.0
Browse	35.0	28.0
Winter wheat	2.7	-
Mast	-	2.7
Artificial feeding	2.7	-
Orchard	2.6	-
Soybeans	-	5.4
Blueberry plants (commercial)	-	1.0

of the areas were reported to have increasing deer herds.

Information on primary and secondary food sources was available from biologists for 74 areas (Table 4). Standing and waste field corn was reported to be the most important food item, with 57 percent of the area reports indicating it to be the primary food source. Reports from two areas indicated that the primary food source was artificial feeding of corn or hay by private individuals.

Land types and environmental features within 75 concentration areas are indicated by categories in Figure 6. The most widely noted general feature was agricultural cropland, with lowland hardwoods ranking second.

Bedding sites were often easily distinguishable during the observation flights and the type of bedding cover was recorded for 61 areas. Lowland hardwoods (31 percent), upland hardwoods (29 percent), and mixed stands of lowland hardwoods and conifers (25 percent) were used nearly equally. Deer in some areas bedded down in conifer plantations, crops, open fields, and fencerows.

Main trails were also distinguishable from the air, and distances from bedding to feeding sites were often recorded. Deer in some areas bedded in the same field in which they were feeding, while in other areas they were apparently moving up to 1.6 km to reach their main food source. The average distance which deer were moving from bedding to feeding sites was approximately 0.6 ± 0.3 km ($N = 63$).

Deer began gathering in the areas with the advent of colder weather in December. Groups of deer were seen in a number of areas as early as November, while a few areas did not show a noticeable increase in deer herds until January. Dispersal usually coincided with the arrival of warmer weather during March.

Some area reports included deer damage or mortality problems. Crop damage complaints were filed in 28 percent (N = 54) of the areas. Deer-car accidents were reported to be a significant problem in 25 percent (N = 55) of the areas. Twenty percent (N = 51) of the area reports indicated that deer were being lost to poaching or predation by dogs.

Quantitative data on available food and cover within the 18 concentration areas selected for further study are found in Table 2. These study areas averaged 524.51 $\pm$ 382.60 ha in size, with an average deer herd density of 30.31 $\pm$ 22.37 deer/km^2. The availability of standing and waste field corn in the 18 areas averaged 1.782 $\pm$ 1.661 bu/ha. The typical concentration area had 50.0 $\pm$ 17.0 percent of its total area covered by woods and brush. The average interspersion index was 2.53 $\pm$ 0.89, indicating good interspersion between cover and open land.

Stepwise multiple regression was used to determine the possible influence of the independent variables of corn, cover, and interspersion, along with all possible interactive variables and appropriate transformations (Gill 1978). The only independent variable which was included in the prediction equation ($P \leq 0.05$) during the computer analysis was the availability of corn. A significant ($P < 0.005$) linear relationship was found between the amount of corn available in a given concentration area and the density of deer within that area (Figure 7).

Of the 136 landowners contacted, 75 were actively farming their land. Hectares of corn varied widely between individual farms, with the average being 14.57 $\pm$ 15.38 ha (N = 75). Harvest methods used were evenly divided between cornpickers (47 percent) and combines (53 percent).

Fall plowing, which reduced the amount of corn available to wildlife, was done to some degree on 28 percent of the farms under consideration. Landowner attitudes concerning deer on their land are summarized in Figure 8.

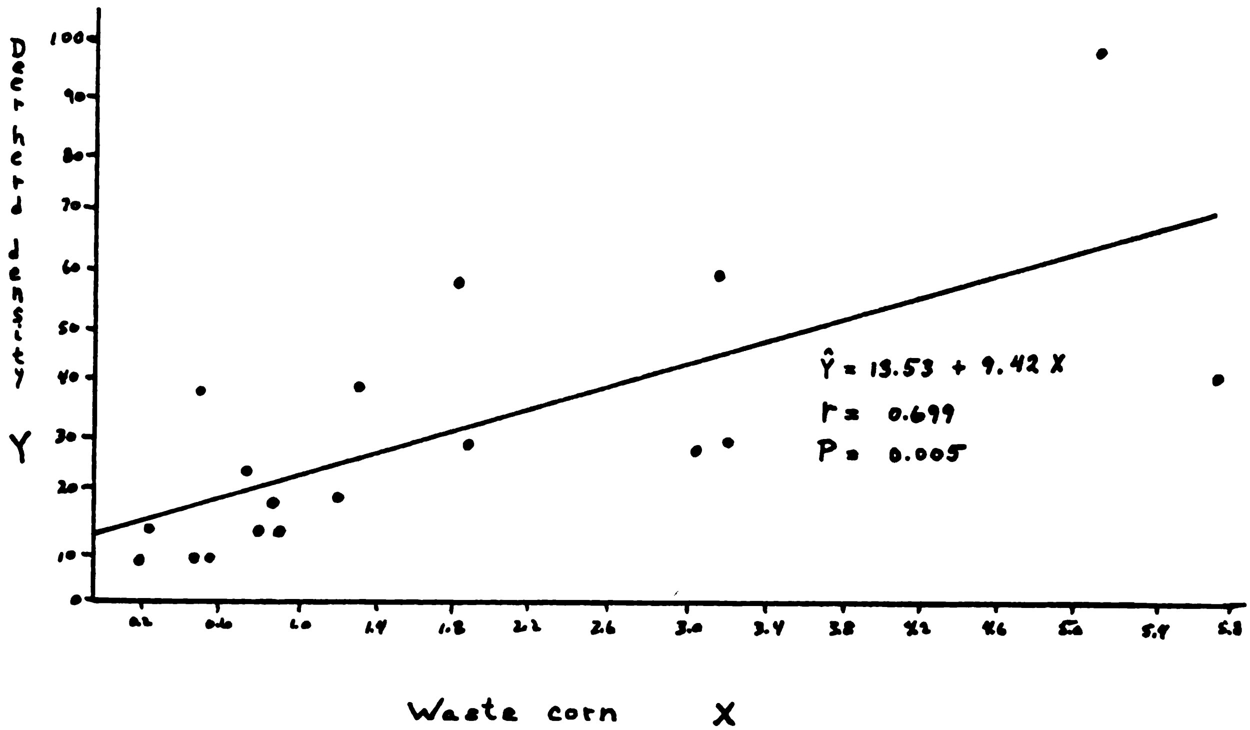

Figure 7. Measure of the linear relationship between corn (bu/ha) and deer herd density (deer/km^2).

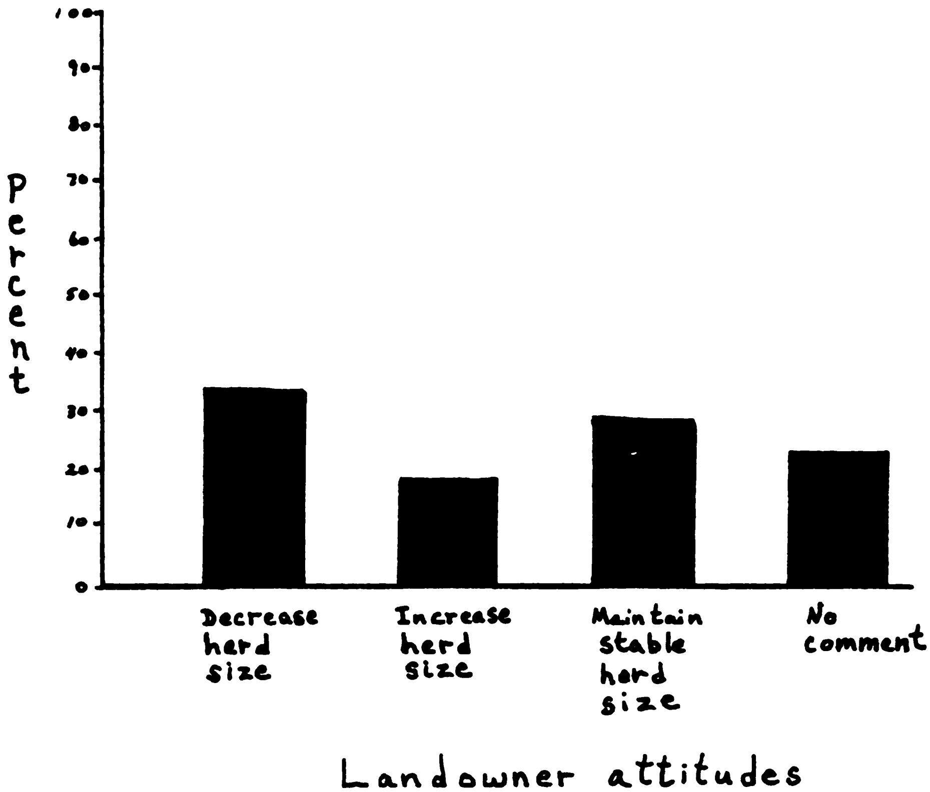

Figure 8. Landowner attitudes concerning deer on their land (N = 136).

DISCUSSION AND CONCLUSIONS

Deer winter concentration areas, like the deer themselves, are neither uniformly nor randomly distributed throughout southern Michigan. During this survey the distribution of 100 known concentration areas in Region III was mapped, information on some of the environmental features was compiled, and some insight into the motivating factors which may influence the location and size was gained.

Aerial censusing of white-tailed deer populations can be a useful management tool, particularly in agricultural areas (Allen 1947, Erickson 1961, McCaffery 1976, Petrides 1953, Sparrowe 1966), but it does have limitations. In southern Michigan, it is doubtful that observation flights alone can account for the majority of deer in a given district. However, there was general agreement among participating biologists that the flights enabled them to accurately locate the major concentration areas. Evidence of disturbance caused by large numbers of deer feeding in open fields (Figure 9) could be easily detected from a considerable distance.

Personal interviews concerning information on field conditions seldom provide exact details, but can yield satisfactory data of a generalized nature (Longhurst 1952). The wide scope of this survey precluded any intensive research within a small group of concentration areas. The information compiled from interviews with those most familiar with local field conditions can help to lay a foundation for further research.

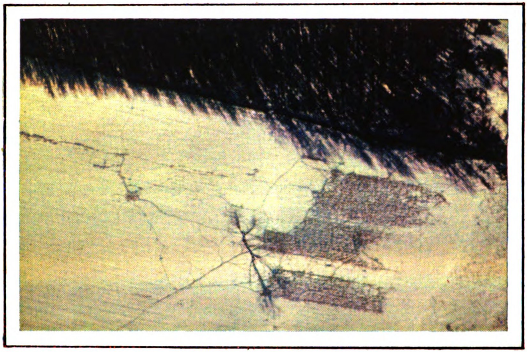

Figure 9. Aerial view of disturbance caused by deer foraging for waste corn in concentration area No. 9-6-4, Ionia County, Michigan.

The quantity and accuracy of certain types of information on many areas are reflected, in part, by the length of time which the participating biologists have been assigned to a given district. In some cases, the landowners themselves may be able to provide more accurate information on a given area, and any study involving a single or small group of concentration areas should not overlook this valuable data source.

The great variation in concentration area size (32.38-7770.13 ha) must be attributed to many factors, including the nature and extent of the primary food source, the type of cover available, the macro and microclimates of the individual locations, and the general deer density of that portion of the region. The size of the areas and the intensity of concentration are also influenced by the severity of the winter (Cook and Hamilton 1942, Dahlberg and Guettinger 1956, Hammerstrom and Blake 1939, Moen 1978, Rongstad and Tester 1969), with deer forming looser aggregations during milder winters. A severe winter snowstorm in early January of 1978 caused an abnormal snow accumulation of about 0.6 m. This intensified the congregating tendency of the deer, causing the concentration areas to be more clearly defined than during milder years.

There are numerous reports of deer in various climates and regions of the country forming larger herds during the winter months (Cook and Hamilton 1942, Cowan 1956, Hammerstrom and Blake 1939, Jenkins 1963, Nelson 1930, Pietsch 1954, Rongstad and Tester 1969, Rue 1962, Sparrowe 1966, Stegeman 1937). In many cases this grouping occurs regardless of the severity of the winter. Deer herd size and density of deer within a given area can also be attributed to one or more of the factors previously stated concerning concentration area size, but are probably most influenced by general deer population levels in the region.

Previous studies from other areas support the finding that most deer winter cocentration areas in Region III are used historically on a regular yearly basis (Bartlett 1938, Dahlberg and Guettinger 1956, Gruell and Papez 1963, Hammerstrom and Blake 1939, Rongstad and Tester 1969). Some of these studies outline tagging operations, which have revealed that many individuals or family groups return to the same concentration area year after year. Hammerstrom and Blake (1939) postulated that perhaps some winter concentration areas were first used by small family groups, with their continued use by progressively larger groups becoming a learned behavior pattern passed down through successive generations.

The reports of increasing deer herds in 69 percent (N = 42) of the concentration areas probably reflect the general increase in deer population levels in many parts of Region III over the past several decades. The herd has been growing in some portions of the region at a high annual rate of increase (Nixon 1968). Jenkins (1963) attributed this high rate of increase to two major factors: 1) excellent range conditions, including relatively mild winters, good interspersion of favorable cover types, and an abundance of nutritious food during all seasons; 2) high reproductive rate and fawn survival. Other sources indicated that the latter factor is strongly influenced by the first (Cheatum and Severinghaus 1950, Murphy 1968, Murphy and Coates 1966, Verme 1963, 1974).

A sudden increase or decrease in the deer herd within a given concentration area from one year to the next might be the result of a change in agricultural practices or perhaps a new source of human or animal distrubance. One such area in Region III, which had not been used by deer in previous years, developed into a concentration area due to a soybean field which had been left unharvested over the winter. In some areas conspicuously large herds of deer feeding in open fields may draw poachers, possibly causing a dispersal from the disturbance site. Predation by dogs is also a factor which could cause a decrease in the herd size (McNeil 1962) and was reported to be a problem in 12 percent (N = 51) of the areas in this study.

Standing and waste field corn is reported to be a major deer winter food item in many agricultural regions (Erickson et al. 1961, Jenkins 1963, Kline 1965, Korschgen 1962, Larson 1978, Moen 1968, Murphy 1968, Mustard and Wright 1965, Nixon et al. 1970, Sparrowe and Springer 1970, Watt et al. 1967, Zagata and Haugen 1972). The summary of food sources in Table 4, the importance of the presence of agricultural crops indi- in Figure 6, and the linear relationship between corn and deer density (Figure 7) all strongly suggest that the presence and amount of corn available to deer is a major factor influencing them in the selection of given areas as winter concentration sites in southern Michigan.

Corn, when utilized as part of the regular annual diet, provides more than adequate nutrition to maintain white-tailed deer in excellent health (Dietz 1965, Moen 1968, Verme 1974). Verme (1974) reported that the conception rate among southern Michigan "corn fed" doe fawns is nearly seven times higher than it is among doe fawns from Michigan's

Upper Peninsula. Burgoyne et al. (1977) reported that antler beam diameters, another measure of the general herd condition, averaged 22 percent greater among 1½-year-old antlered bucks from Region III than those from Region I (Upper Peninsula).

The variety of corn most frequently found in southern Michigan (Dent, U.S. Grade No. 2) has a digestible energy content for sheep (also a ruminant) of 4.14 kilocalories (kcal) per gram, and a crude protein level of 10 percent (Natl. Res. Council 1975). Ullrey (1971) reported that a digestible energy content of 2.75 kcal/gram is considered adequate for deer. Bissel and Strong (1955) stated that the crude protein content of a plant is a good index of its food value, with 7 percent crude protein content being a minimum level required to maintain western deer. Moen (1968) reported that in agricultural habitats of Minnesota, deer continued to bed in open fields and feed on corn even during prolonged periods of extreme cold (-18^{o}C). He indicated that the high protein diet of corn supplied an adequate quantity of metabolizable energy for the deer to maintain a positive energy balance, and that even though cover may be needed to help maintain a positive energy balance on range where food supplies have been deleted, it can only serve to reduce heat loss. He emphasized that sufficient food must be available to maintain the basal energy requirements of the animal and must therefore be considered the most basic requirement.

Browse was indicated as the second most important food source within the concentration areas (Table 4). Sikarski (1978) observed signs of severe browsing on the edge of a woodlot adjacent to a cornfield which was being heavily used by deer, with many of the browsed plants being nonpreferred browse species. He also noted the change in deer feces from a well-formed pellet to a soft stool, which is associated with a high-energy corn diet. He postulated that the heavy browsing indicated an attempt by the deer to get natural roughage without having to leave the corn. Mattfeld (1974) stated that deer are poorly adapted to woody twig forage and may not be able to digest crude fiber effectively. However, Dasmann (1971) indicated that a full protein diet (e.g., corn) enables a ruminant to utilize roughage foods more efficiently. These findings suggest that in farmland areas the use of agricultural crops and natural browse by deer complement one another.

In southern Michigan, woody browse is fairly evenly distributed throughout the districts in which deer wintering areas are found (excluding the intensely agricultural "thumb" area), and in most areas could not be considered a limiting factor. Such is not the case in some "Corn Belt" states of the Medwest, where woody vegetation--serving as both a source of natural roughage and of cover for bedding and escape--may well be the factor which limits deer population levels (Murphy 1968). Corn, unlike browse, is not evenly distributed throughout most of Region III, and evidence from this study suggests that deer often "key in" on available sources of corn during the early winter months. Van Dyke (1913) lends support to this theory, when he stated that deer show a great preference for "specialty" foods, such as acorns and beechnuts. He indicated that when these foods are available, deer will travel "many leagues" from their summer range to concentrate in areas where they are found. Further support is provided by Severinghaus and Cheatum (1956), who concluded that movement of groups of deer to an abundant source of especially favored foods can occur at any time of year, providing travel is not totally restricted by snow depth.

Lowland and upland hardwoods were both noted as important environmental features (Figure 6), reflecting the whitetails need for bedding and escape cover. Dasmann (1971) proposed that the security provided by cover may be an important factor in maintaining deer in good physical condition. Some doubt exists as to whether lowland hardwood or swamp areas provide better protection from the elements than do upland hardwoods (Larson et al. 1978). There may be several explanations why lowland hardwoods are used to a slightly greater extent than uplands (56% vs. 39%) in the areas under consideration. Lowland hardwoods have an abundance of preferred browse species, such as red maple (Acer rubrum) and red-osier dogwood (Cornus stolonifera). There generally is little human disturbance in lowland areas, usually due to wet conditions and a dense understory. Upland areas are often used as additional pasture for cattle, while lowland areas are generally not suitable for that purpose. Sparrowe and Springer (1970) reported that all the wintering areas which they surveyed in eastern South Dakota were relatively free from human activity or livestock.

The analysis of cover within the 18 study areas showed no significant correlation ($P \leq 0.05$) between deer density and interspersion or amount of cover ($r = -0.15$). This may indicate that, for most of the region, cover is available in adequate amounts and is sufficiently interspersed with agricultural food sources to meet the needs of the deer in these areas. The lack of significant correlation may also be due, in part, to the small herd size involved. A hypothetical relationship between the amount of cover available and deer population levels is presented in Figure 10. As this figure indicates, a minimum amount of cover is essential for deer populations to exist within a given region. Some states in the Midwest may be approaching this unknown minimum level as agricultural practices and impoundment projects continue to deplete the existing natural cover (Murphy 1968). In these areas, where plentiful food in the form of agricultural crops exists, as the amount of cover increases deer population levels increase commensurately. At some point of optimal cover availability, deer population levels no longer respond to additional increases in cover (shaded area). It is proposed that most of Region III would lie in this part of the curve. As cover continues to increase in amount, age, and height, a point is reached where additional cover adversely affects the deer herd, causing a decline in population levels. Such appears to be the case in the Upper Peninsula, where declining deer herds are attributed to natural succession, which has drastically increased the amount of cover in the form of mature climax forests (Bennet 1974).

Bedding sites were nearly equally distributed among the major habitat types, with most deer bedding within 0.6 km of their major food source. Bedding site selection within some concentration areas may simply be indicative of habitat types nearest to the food source, which are suitable for bedding. Ozoga (1972) noted that when food and bedding cover are in close proximity, a minimum of energy is used in travel from resting to feeding locations. In other areas, diurnal human or animal activity near the food source might be a sufficient disturbance to preclude use of adjacent cover for bedding, resulting in greater traveling distances from bedding to feeding sites.

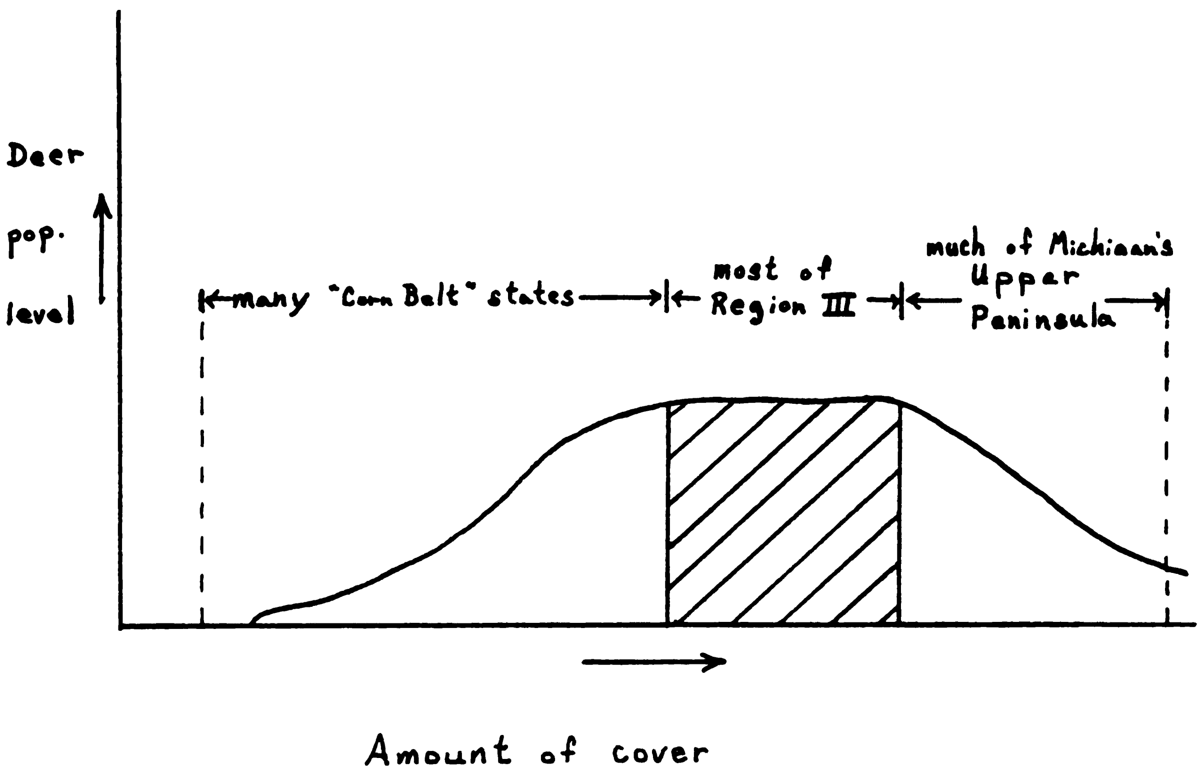

Figure 10. Hypothetical relationship between amount of cover (X) and deer population levels (Y).

Concentrations of deer became noticeable in many areas during late November and early December. This activity generally coincides with the advent of colder weather, which is often accepted as the likely "triggering mechanism" for this phenomenon (Darling 1937, Mattfeld 1974, Ozoga and Gysel 1972). While this may be true in most cases, it is possible that in some areas deer may be seeking shelter from the drastic increase in noise and numbers of people invading the woods, resulting from the beginning of the firearm deer season in mid-November. Springer and Sparrowe (1970) reported that in eastern South Dakota hunting influenced deer movements and distribution more than any other factor. Once within these areas of less disturbance, cold weather and sufficient food supplies may serve to sustain the concentrations of deer until the following spring.

Dispersal is believed to coincide with the arrival of warmer weather and resultant loss of snow cover (Cook and Hamilton 1942, Hammerstrom and Blake 1939, Mattfeld 1974, Sparrowe and Springer 1970), which usually takes place during March in southern Michigan. The exposure of new grasses and forbs, following the recession of the snow, may also play an important role in the dispersal process (Korschgen 1962, Mattfeld 1974).

Crop damage by white-tailed deer in agricultural regions is an old and widespread problem (Brown et al. 1978, Crawford 1968, deCalestra and Schwendeman 1978, Flyger and Thoerig 1962). Crop damage complaints were filed from only 28 percent of the concentration areas (N = 54) in this study. This figure may not be representative of the actual amount of damage occuring in winter concentration areas due to the willingness of many farmers to incur some damage to crops in exchange for intangible benefits derived from having deer on their land (Brown et al. 1978, Evans, R.A. 1979, McNeil 1962, Queal 1968). This attitude was evidenced during this study, when 46 percent of the landowners contacted expressed the feeling that deer numbers should stay the same or even increase, while only 34 percent indicated a desire to have the deer herd redeuced (Figure 8). The latter figure seems to be rather small, considering that this was a select sample of landowners from given areas with known high deer densities rather than a random sample of landowners over the whole region. It is likely that the group expressing the feeling that there were too many deer was comprised mainly of farmers who suffered relatively heavy crop damage. Queal (1968) indicates that rural landowners can have a great influence on the management and harvest of deer in agricultural areas due to their attitudes toward deer and willingness to allow deer hunters access to their land.

Deer-car accidents were reported to be a problem in 15 percent (N = 55) of the concentration areas and occurred primarily in the areas which were bisected by secondary roads. In response to the threat to safety on southern Michigan's highways presented by an increasing deer herd (Nixon 1968), research is being done (Sicuranza 1979) which may provide some insight into the response of deer to environmental parameters surrounding high-accident-rate areas.

Jenkins (1963) stated that the size of the deer herd that should be maintained in southern Michigan is the number of deer which can be tolerated by it's residents. He noted that although they are of great value to hunters and also to large numbers of people who just enjoy seeing them, deer also cause a great deal of damage to crops, orchards, nurseries, and automobiles. He concluded that the people involved must determine when the damage costs outweigh the various benefits of supporting large numbers of deer. Excellent studies have been conducted on the various costs and benefits attributed to deer in agricultural areas (Brown et al. 1978, Brown and Decker 1979, Crawford 1968, deCalestra and Schwendeman 1978, Gamble and Bartoo 1963, McNeil 1962, Thomas and Pasto 1955).

In a theoretical approach to deer management, Thomas and Pasto (1955) contended that it is only a small part of a much larger problem involving proper resource allocation and use. Expressed in their words,

> Land, not deer, is the scarce resource involved in deer management. Land is essential to the achievement of many diverse social and economic ends, such as those of agriculture, living space, and wildlife. Conflicts arise because of competition between different interests for the same land...

They noted that even though the deer herd is "public property", in most agricultural areas it is the farmer who bears the burden of supporting the herd. This causes conflicts between four broad social groups: 1) farmers, who are trying to maximize their economic return from farming; 2) hunters, who want larger herds in order to maximize their recreational value; 3) businessmen, who indirectly reap the benefits of increased hunting opportunities; and 4) society in general, whose goal is to obtain the greatest benefits for social welfare. During the past several decades, there has been a gradual evolution in many of the goals of wildlife management from "hunter success" to "hunter satisfaction" to "public satisfaction" and finally to "public benefit"

(Langenau 1976). These words of Thomas and Pasto (1955) seem to speak even more clearly today:

> ...it is necessary that our natural resouces be allocated in such a way that the greatest amount of good accrues to the greatest number of people.

This study has provided descriptive information on the size, herd density, and general environmental features of the major deer winter concentration areas in southern Michigan. Yet the question still remains as to why deer travel a considerable distance to concentrate in a given area when there seems to be suitable food and cover in many areas that are not used! This may prove to be as difficult to answer as the general question of why deer concentrate in the winter, and it gives rise to much speculation. Severinghaus and Cheatum (1956) indicated that the answer to this question might be favorable microclimates which the deer seek out. Other researchers, such as Bissell and Strong (1955) and Hagen (1953), proposed that differences in crude protein among forage plants may be a factor, with deer selecting those plants having a higher crude protein content. Differences in soils from one area to the next might affect the palatability of the food sources. Human and animal disturbance is undoubtedly an important factor in some areas (Sparrowe and Springer 1970). Farming practices, such as leaving agricultural crops standing over the winter or plowing the stubble under in the fall, are also important in determining the distribution of concentration areas.

Verme (1968) stated that the main problem is that we still do not really understand what motivates deer and how they respond to external and internal stimuli. He maintained that there are little niches that supply exactly what the deer are seeking. In the final analysis, Loveless (1967) summed up the situation by saying that deer activity, movement, and distributional patterns must be associated with a variety of complex, interrelated environmental factors, and that the reactions of these animals are seldom induced by independent elements acting alone.

MANAGEMENT AND RESEARCH RECOMMENDATIONS

An excellent list of management recommendations for southern Michigan's deer herd has been provided by McNeil (1962), some of which have already been implemented, and do not need to be repeated here. In addition, the following recommendations would greatly help to better understand, and therefore better manage, white-tailed deer populations in southern Michigan:

1) Encourage field biologists and conservation officers to keep simple records of major winter concentrations of deer observed during their regular field activities. These could include approximate location, herd size estimates, environmental features, etc., and--particularly--record ideas as to why the deer are attracted to that area.
2) Keep records of the major concentration areas on a district by district basis.
3) Consider the possibility of flying selected counties or districts on an annual or semi-annual basis. The observation flights of 1978 revealed that much information on these areas can be gained in a minimum amount of flying time. McCaffery (1976) used deer trail counts as an index to populations and habitat use in wooded areas of Wisconsin. Perhaps trails and signs of foraging in the snow (Figure 9) could be utilized in some way to provide better indices of overall population levels or trends in southern Michigan, as well as in other agricultural

areas.

4) Consider methods proposed by Brown and Decker (1979) to incorporate farmers' attitudes into management of deer, particularly in areas where crop damage and/or deer-car accidents present an increasing problem.

This study was meant to lay a foundation for further research on deer winter concentration areas in southern Michigan. The regional maps and information reported here can be of help in a management sense only if additional information is gathered on the areas already identified, as well as adding new areas to the records as they become known. Some of the needs for further research pointed out by this study are as follows:

1) Better estimates of herd size within individual areas are needed. Remote sensing techniques, using infra-red scanners, may be one way of accomplishing this, when and if they become more economically feasible.
2) Current color infra-red aerial photographs should be utilized to accurately determine habitat types within and around concentration areas.
3) Known areas should be monitored on an annual basis, to determine which ones are definitely used regardless of winter severity (as noted earlier, the information presented here is based on concentration activity during a severe winter), and whether area boundaries are subject to yearly fluctuations.
4) Particular attention should be given to newly formed areas, or areas which have been recently abandoned, to determine factors

which may be responsible for the sudden change.

5) Attention should also be given to those concentration areas which do not seem to be occuring as a direct result of an available agricultural food source.

6) An attempt should be made to determine if there is any relationship between soil types and distribution of concentration areas.

7) Data are needed on actual damage to farm crops and private land within these areas, and what levels of damage landowners will tolerate in these areas.

8) Study is needed on the effects of disturbance, human or animal, on the distribution of these areas.

9) More comprehensive surveys on the attitudes of landowners living within the boundaries of known concentration areas are needed, as these are the people most likely to be affected by efforts to support a larger deer herd in southern Michigan.

10) Collaring studies, such as those being done in the Rose Lake Wildlife Research Area in southcentral Michigan (Belyea and Aho 1978), are needed to determine the distances from which deer are being drawn to these areas. (They recently reported one collared doe being recovered 40 km from the point of capture!) This information is critical in administering antlerless quotas for problem areas. Self-attaching collars could continue to be used in a wider number of areas. When funds permit, radio-collars should be used in a select

group of the more important areas, such as Rose Lake, for a greater data return per unit effort.

11) Continued surveys covering attitudes of all social groups toward deer will help to insure that southern Michigan's deer resource is managed in such a way as to provide maximum recreational, aesthetic, and economic benefits to the greatest number of people.

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APPENDIX

APPENDIX

WINTER DEER CONCENTRATION AREA

INFORMATION FORM

Concentration Area No. ________________ District ____________

Name & Position ______________________ County ____________

____

1. Is this a major ____ or a minor ____ concentration area?

2. Is this a new area which was not used prior to the last several years?

   Yes ____ No ____ Don't Know ____

   If yes, what do you feel is causing the deer to use this new area?

3. Is this an historic winter concentrating area which has been used for many years?

   Yes ____ No ____ Don't Know ____

   If yes, check one: 5-10 ____ 10-25 ____ 25+ ____

4. How many deer are presently using this concentration area?

   Check one: 20-50 ____ 50-100 ____ 100-200 ____ 200-300 ____

   300-500 ____ 500+ ____

5. What is the approximate acreage of this area?

   Check one: 80 ____ 80-160 ____ 160-320 ____ 320-640 ____

   ____ sections

6. Over the past 5 years, have you noticed a significant increase or decrease in the size of the deer herd in this concentration area?

   Yes ____ No ____

   If yes, speculate on possible factors which may be causing this change.

7. What do you feel is the main food source for this herd?

8. Approximately how far from the main bedding area is the food source located?

   Check one: ¼ mile ____ ¼-½ mile ____ ½-1 mile ____

   1 mile + ____

9. What type of cover are the deer bedding down in?

10. What is the largest number of deer seen together at one time in this herd? (rough estimate)

11. What are the general environmental features of this concentration area? (crops, swamps, topography, etc.)

12. During what month do you usually first notice a significant increase in herd size in this area? ____________

13. During what month does the main dispersal usually take place? ____

    (early ____ mid ____ late ____)

14. Do deer concentrate in this area every year regardless of weather conditions and snow depth?

    Yes ____ No ____

    If no, explain:

15. Have you had reports of crop or property damage associated with this herd?

    Yes ____ No ____

    If yes, give estimate of number of landowners involved and amount of damage (if available).

16. Do you know of any highway mortality associated with this herd?

    Yes ____ No ____

    If yes, give estimate of number of accidents known.

    Winter 1977-78 ____ Yearly average ____

17. Do you know of significant mortality to this herd due to poaching or predation by dogs?

    Yes ____ No ____

    If yes, give estimate and explain.

18. General Comments: