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SOME ECOLOGICAL ASPECTS
OF THE WHITE-TAILED DEER
ON ISLE AU HAUT, MAINE

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By
JOHN CHARLES BAIRD

A THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
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An Abstract of the Thesis Presented in Partial Fulfillment
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The relationship between the deer population and the available browse was studied on Isle au Haut, Maine from September, 1964 to December, 1965. The objectives were to determine the number of deer on the island, to evaluate the existing habitat conditions, and to measure the influence of the deer upon the environment.

Strip censuses, drive counts, and direct aerial counts were employed to determine the number of deer on the island. A population estimate of 257 animals, based on the Hayne strip census method, was considered to best approximate the true population level.

The overstory, understory, and shrub strata were sampled by the Bitterlich point sampling, Shafer twig-count, and clip and weigh methods, respectively. The total amount of available browse for each acre of the island was 1,334 pounds. However, cedar was the only preferred browse species present in a sufficient amount (average of six pounds per acre) to contribute to the available food for each acre of the island. Deer subsisted to a large extent on food sources other than woody vegetation.

The existing density of approximately one deer per 25 acres has resulted in serious habitat deterioration. A continuation of the present density will prolong the detrimental effects both on the vegetation and the deer.

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INTRODUCTION

The relationship between white-tailed deer^{1/} and vegetation is expressed not only through the reproductive rate and physical condition of the animals, but also in the character and regeneration of the vegetation. In order to better understand the influence of deer in suppressing plant growth and retarding natural regeneration, it is necessary to know the number of deer utilizing an area with a particular quantity and quality of vegetation.

This project is the initial step in the study of Isle au Haut, Maine, an area of distinctly heavy utilization by an apparently high density of deer. The study is part of an overall research program on deer and their influence on forest vegetation. The objectives were to determine the number of deer on Isle au Haut, to evaluate the existing habitat conditions, and to measure the influence of the deer upon the vegetation. Most of the field work was conducted during the summer of 1965; however, the entire study extended from August, 1964 to December, 1965.

^{1/} Scientific names are presented in Appendix I.

REVIEW OF LITERATURE

Population Estimates

Kill data may provide a general index for estimating deer populations on extensive areas. Harvest regulations, based on this information, are the most effective tool of deer management. However, on many small, intensively managed areas, it is often necessary to more precisely determine the number of deer present.

There are many difficulties encountered in determining the number of deer occupying a given area. The behavior and associated movements of deer are not well known. The dense vegetation in which the deer are usually found limits the application of aerial censuses and direct counts. The large expenditure of time, finances, and manpower restricts the extent to which any census may be employed. Several census techniques have been utilized in the Northeast in an attempt to accurately estimate population levels. In this region the most commonly used methods are strip censuses, drive counts, and pellet-group counts.

Strip Census Methods

Strip census methods have been used to determine population levels of grouse, deer, snowshoe hare, and other species, and the mechanics for each are essentially similar. A variety of mathematical formulas have been applied to the recorded data. These formulas are based on the behavioral patterns of the species and on assumptions made with regard to human disturbance during the census. The basic

strip census method was developed by King (Leopold, 1933). Such a census is conducted by following a compass bearing or marked line through the area to be sampled. A tally is made of the observed animals or birds being censused. The direct distance from the observer to each individual flushing spot is recorded as well as the perpendicular distance to the census line from the flushing spot.

The computation formula for the King method is as follows:

$$P = \frac{AZ}{XY}$$

Where: P = the estimated total population of the area censused

A = total area of the tract

Z = total number of individuals actually observed

X = total distance walked by the observer

Y = twice the average distance from the observer to the bird flushed.

Although King developed the method as a means of estimating grouse populations, it is adaptable as a deer census technique. It must be assumed that all animals flushed will be observed and recorded. Further, it is necessary to assume that the animals are randomly distributed about the path of the observer, and therefore the average flushing distance will be representative of the population as a whole. The flushing behavior of the animal, influences of weather, and differences among observers have been shown to affect the accuracy and variability of the count.

A strip census method for snowshoe hare was devised by Webb (1942). Webb's modification of the King grouse census method was

necessitated by the different flushing behavior between grouse and snowshoe hare. Grouse make a characteristic noise when they are flushed. Webb assumed that snowshoe hares which may move to the left or right of the census line are not ordinarily seen. Thus, he believed that the calculated width of the strip based on the direct distance to the flushing spot was too wide. He stated that an effective width of the strip, based on the average perpendicular flushing distance, would be more accurate in estimating snowshoe hare populations. Webb derived the perpendicular flushing distance by recording the direct flushing distance and the "jumping angle" in degrees of arc between the direct distance line and the census line.

Webb's formula is:

$$P = \frac{AZ}{2XY} \text{ sine } D$$

Where: P = total population

A = total area in square yards

Z = numbers of hare seen

X = length of line in yards

Y = average jumping distance in yards

D = average jumping angle in degrees of arc.

Hayne (1949) suggested a fallacy in the assumption that the average flushing distances observed is representative of the population parameter. He contended that subpopulation estimates should be computed separately and then summed. This would eliminate what he believed to be an inherent systematic error contained in the King method.

Hayne's formula is presented below:

$$N_T = \frac{C}{2L} \left[\frac{F_1}{d_1} + \frac{F_2}{d_2} + \frac{F_3}{d_3} \dots + \frac{F_n}{d_n} \right]$$

Where: N_T = estimate of the total population per unit area.

L = length of observer's path, or census strip

$d_1, d_2, d_3, \dots, d_n$ = the various flushing distances observed

$F_1, F_2, F_3, \dots, F_n$ = numbers of animals observed to flush at the corresponding flushing distances.

C = conversion factor when units are not comparable.

($C = 43,560$ when L and d are stated in feet and N_T is desired in animals per acre.)

Kelker (in lit.) has developed a belt transect method for estimating deer population numbers. The mathematical procedure is as follows:

$$A = \frac{8My}{11h}$$

Where: A = acres per deer

h = number of deer counted

M = miles walked in the belt transect

y = the shortest distance the animal is from the path of travel in yards

8 and 11 = conversion factors.

In this method perpendicular distances are not averaged, and only uniform distances are considered. Kelker computed the population for each cover type; the sum of all individual cover types equaling the total population.

A further variation of the basic technique for strip census has been developed by Hahn (1949). The acreage, by cover type, along the cruise line is determined by recording the distance a man with a flag in his hip pocket can be seen from the line. This distance is noted for both sides of the line at 100-yard intervals, and thus the total acreage censused is computed. The number of deer recorded for the known area of the census is expanded to the size of the entire area.

Deer Drives

Game drives first originated on a large scale during the 1930's. The available manpower through the Civilian Conservation Corps was the primary cause for the increased use of this technique. Deer drives were conducted on many National Forests (Olson, 1938; Adams, 1938). Later studies, by Arnold and Verme (1963) on the Cusino Exclosure at the Cusino Wildlife Experiment Station in northern Michigan and on the George Reserve in Michigan (O'Roke and Hamerstrom, 1948; Chase and Jenkins, 1962), have utilized the deer drive technique.

The deer drive method has been described by McCain (1939) and by Morse (1943). Direct counts of the number of deer in a given area are made by men stationed at strategic positions around the area. The counters recorded the number of deer which leave the area and are instructed or situated in order to avoid duplication in counts. The census area is then traversed by a line of men in an attempt to flush all deer. Each man in the drive line is instructed to tally all deer which cross through the drive line between the man on his

right and himself. Thus, deer which do not leave the area are counted. It is assumed that deer which cross the drive line do not leave the area and therefore are not tallied by the counters. The sum of the number of deer leaving the area and the number of deer crossing the drive line equals the total number of deer on the area.

Deer drives can be applied only to certain areas. The areas must be sufficiently delineated to allow the number of deer leaving the area to be counted. The expense and availability of adequate manpower often restricts the use of this method. The size of the area which can be censused is dependent on the shape of the area, the vegetation present, the season of the year, and the number of participants. Johnson and Downing (1962) reported a successful modification of the deer drive method in which drives are conducted at night with the aid of spotlights.

Aerial Counts

Aerial censuses of the white-tailed deer seldom provide accurate population estimates. Direct counts are rarely possible because deer normally inhabit forested or brush-covered areas. However, Saugstad (1942) reported that aerial censuses were used successfully on the white-tailed deer in North Dakota. Minimal counts of deer have been made from the air at the Seneca Army Depot in New York. Extensive sections of hardwood cover and open areas within this enclosure increased the possibility of direct observation. Direct aerial counts of mule deer have been unsuccessful in Utah due to rough terrain and evergreen cover (Rasmussen and Doman, 1943).

The airplane is commonly used in heavily forested areas, such as Maine, to locate and determine the relative use of deer yards. However, it is not feasible to attempt a direct census of white-tailed deer by aerial count.

Pellet-Group Counts

Bennett, et al. (1940) investigated the possibility of determining deer numbers through pellet-group counts. The population estimate is computed according to the following formula (Eberhardt and van Etten, 1956):

$$\text{Deer/Square Mile} = \frac{(\text{Avg. No. Pellet-groups/Plot})(\text{No. Plots/Acre})(640)}{(\text{No. Days Since Leaf Fall})(12.7)}$$

The above authors, as well as Robinette, et al. (1958) and Rogers, et al. (1958), utilized and evaluated this technique. This method is a reliable deer census technique provided certain basic assumptions are met. These assumptions are: (1) 13 pellet-groups are deposited per deer per day, (2) pellet-groups will persist through the experimental period, and (3) all pellet-groups will be correctly identified as being deposited during the experimental period.

Longhurst (1954) found that the defecation rate of sheep was greater with green foods than with dry foods. Pellet-groups decompose at different rates under various cover types and cannot be accurately dated (Patric and Bernhardt, 1960). In the southern states dung beetles often eliminate pellet-groups within a few days (Johnson and Downing, 1962). These factors and the influence of weather on the

decomposition of pellet-groups have been noted by Van Etten and Bennett (1965).

Track Counts

Wright (1960) utilized track counts to estimate deer population levels in southern New Jersey. Imprint plots were established within a 746-acre exclosure at the U. S. Marine Corps Supply Center in Georgia (Johnson and Downing, 1962). An attempt was made to correlate deer activity patterns with the daily record of tracks in the plots. The influence of climatic factors on deer activity were found to affect the accuracy of this technique. Until behavioral and activity patterns of the white-tailed deer are studied in more detail, the use of track counts as an effective census method will be questioned.

Habitat Evaluation

Studies have been made of deer-vegetation relationships for many years by plant ecologists, foresters, and wildlife researchers. The specific approach to the problem has been influenced by the background and interests of the investigator. Major modifications in methodology have resulted due to the species and subspecies of deer studied under widely varying terrain, plant associations, and vegetation densities. As a result, a complex of experimental designs have been used to evaluate habitat conditions. The mechanics of sampling, time limitations, necessary precision, and economic considerations have increased the avenues of approach.

This literature review will not consider all the various techniques and factors relative to vegetative sampling. The reader is referred to the following selected references: Schwan and Swift (1941), Dasmann (1948), Cottam and Curtis (1956), Oosting (1956), U. S. Forest Service (1958), Freese (1962), U. S. Forest Service (1962), and Shafer (1965). A discussion of the development and application of methods directly relating to the present study are reviewed.

Point Sampling

The point sampling or variable plot cruising method was developed by Bitterlich of Germany in 1947-48 and was first introduced in this country by Grosenbaugh (1952). It has proven to be an efficient and reliable method of making a forest inventory. Basically, the character of the vegetation is determined by utilizing tree size rather than frequency of occurrence.

Sampling points are selected within the study area. An angle gauge or optical fork was first used to determine whether a tree should be tallied. Bruce (1955) substituted a wedge prism as a means of classifying the individual trees. In both instances, the principle of tree diameter relative to the distance from the sampling point determines the trees to be recorded.

A wedge prism is an optical instrument which bends light rays so that the portion of the bole observed through this device is displaced. The refractive power of this instrument is measured in diopters. A one diopter prism displaces an object one unit to the

right for each 100 units of distance. A 3.0 diopter prism would displace a 3 inch object at 100 inches. The wedge prism is held over the sampling point, and the observer looks through this glass on an equal plane with the point of breast height (diameter at breast height--d.b.h.= 4.5 feet) on the tree. Trees which are only partially displaced are tallied. Thus, a tree of a given diameter must be within a specific distance of the sample point before it is tallied. When using a 3.0 diopter prism, the distance a given tree may be from the sampling point is equal to 33 times its d.b.h. The larger the tree, the greater the distance from the sampling point it may be and still be tallied. The smaller the tree size, the smaller the circular plot area is for that diameter, and thus the larger conversion factor when calculating the number of trees per acre. Therefore, any tree sampled, regardless of size, accounts for the same amount of basal area on a per acre basis. The principles of this technique have been reviewed by Afanasiev (1957).

Husch (1955) tested the accuracy of the Bitterlich method on a forty-acre tract in southeastern New Hampshire. Avery (1955) employed this method on two, forty-acre tracts of loblolly-shortleaf pine in Arkansas. An evaluation of this technique in upland hardwoods was made in southern Illinois by Deitschman (1956). The above authors found the use of this method to result in important variations from the true population parameters. Afanasiev (1957) achieved highly accurate results on a study of 296 acres in Mississippi. He suggested that the study areas used in the above works were too small to yield very accurate results. Grosenbaugh and Stover (1957) considered the

method to be fast and reliable as a result of their work in southeast Texas.

Bruce (1955) discussed the use of an automatic slope adjusting instrument to correct for error due to inclinations. The use of telescopic devices was also discussed as an aid to greater precision.

Browse Measurements

The twig-count method for browse measurement has been reviewed and modified by Shafer (1963). He defined browse as "that section of current annual sprout growth between the terminal bud and the point of average browsing diameter on any twig between ground level and six feet." A sample of twigs from each species was measured in order to determine the average browsing diameters. Systematically selected twigs were clipped at the corresponding browsing diameter for that species. Twigs from each species were weighed collectively, oven-dried, and reweighed. A factor was then calculated for converting twig counts to a weight basis. Shafer compared this method with a weight estimation method and a clip and weigh method. He concluded that the twig-count method was more accurate and efficient.

Aldous (1944) developed a deer browse survey method in which the occurrence of browse species, density, and degree of utilization were recorded. Circular 1/100 acre plots (11.7 feet in radius) were measured at predetermined intervals throughout a deer yard. A series of classifications based on percents were used to record the data. Thus, the ocular estimates indicated the percent of occurrence of browse species throughout the yard and the approximate degree of

utilization of each species.

Hoskins and Dalke (1955) employed a line intercept method for measuring deer browse on one by eight foot plots. On each plot the utilization of a tree species was determined by the tagged twig method. This method, used mostly in wintering areas, requires measuring each twig, from a tagged point, in the fall and again in the spring.

Weight estimation was used by Schwan and Swift (1941) to determine the amount of browse available. Estimates were periodically checked by clipping and weighing.

Schuster (1965) conducted a study of the correlation between forage weight and the main stem diameter, number of twigs per plant, and the total twig weight. He found that a combination of twig numbers and length was useful in predicting forage yields.

All browse measurements are based on one of the following: (1) ocular estimates, (2) twig-counts, (3) twig measurements, or (4) weights. Modifications and combinations of these basic techniques enable them to be applied within the objectives of particular studies. The reference works presented at the beginning of the section serve to orientate the reader on this subject.

DESCRIPTION OF STUDY AREA

Location and Size

Isle au Haut is located at 40-03-30 degrees north latitude and 68-37-00 degrees west longitude. It is approximately five miles southeast of Stonington, Maine, and is the largest of the outer islands in East Penobscot and Jericho bays (Figure 1). A myriad of smaller islands are located between Isle au Haut and the mainland. The Town of Isle au Haut, Knox County, consists of several islands forming about 8,100 acres (Attwood, 1946). The island of Isle au Haut is approximately 6,575 acres in size and comprised the study area. The island is oriented north and south. The greatest width is slightly less than three miles; the greatest length is approximately five and one-half miles.

Topography

As the name implies, Isle au Haut is composed of a central ridge rising to a height of 543 feet on Mount Champlain. This central ridge, which runs north and south throughout most of the length of the island, consists of a series of small peaks. A number of additional summits are found on the island. Several harbors and numerous small coves occur. The major peninsulas formed by the indentations of the sea are: Eastern Head, Western Head, Moore Head, and Trial Point (Figure 2).

Long Pond, a fresh-water lake, is located on the east side of the island. It is 1.35 miles in length and is approximately 64 acres

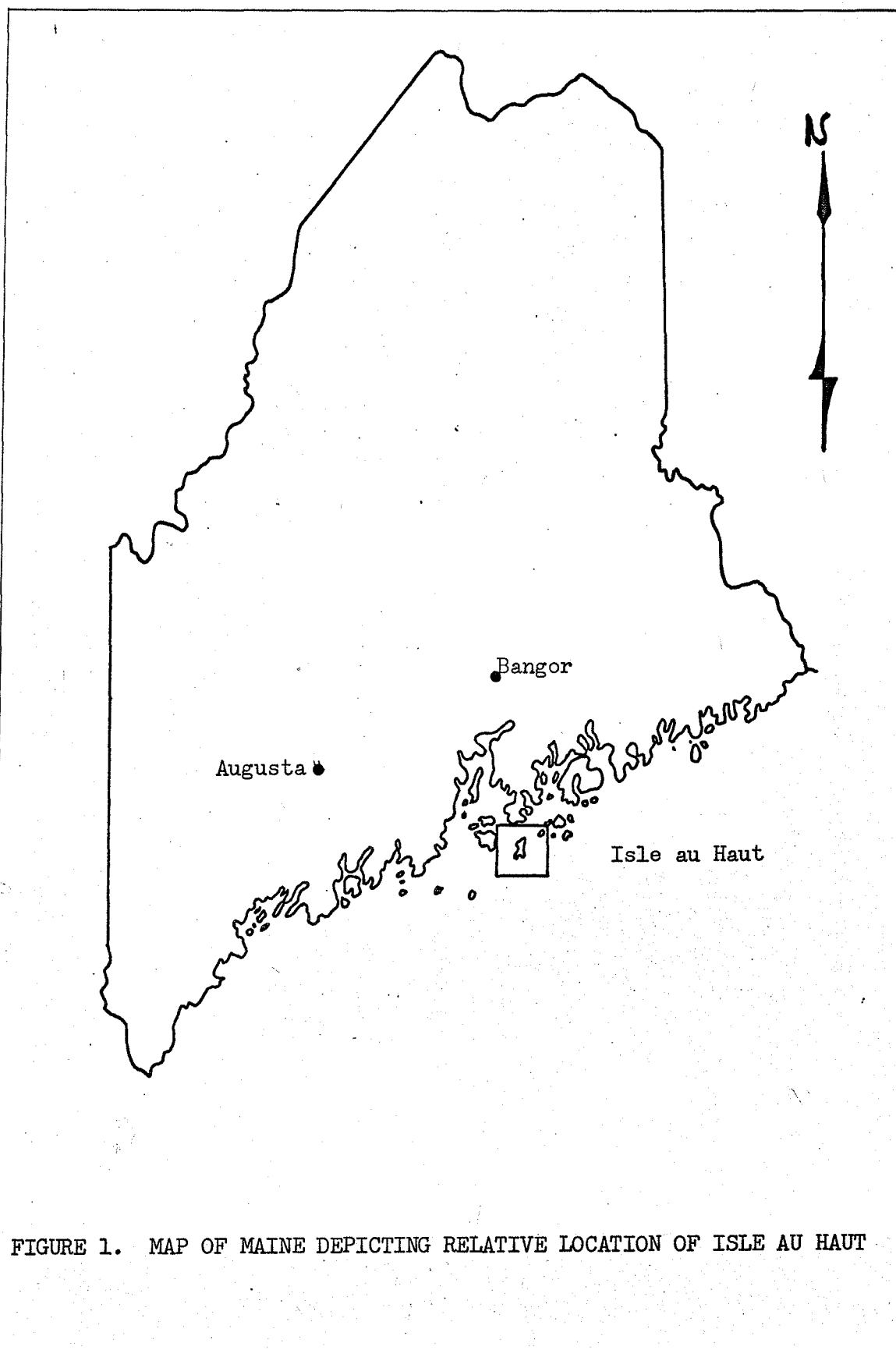
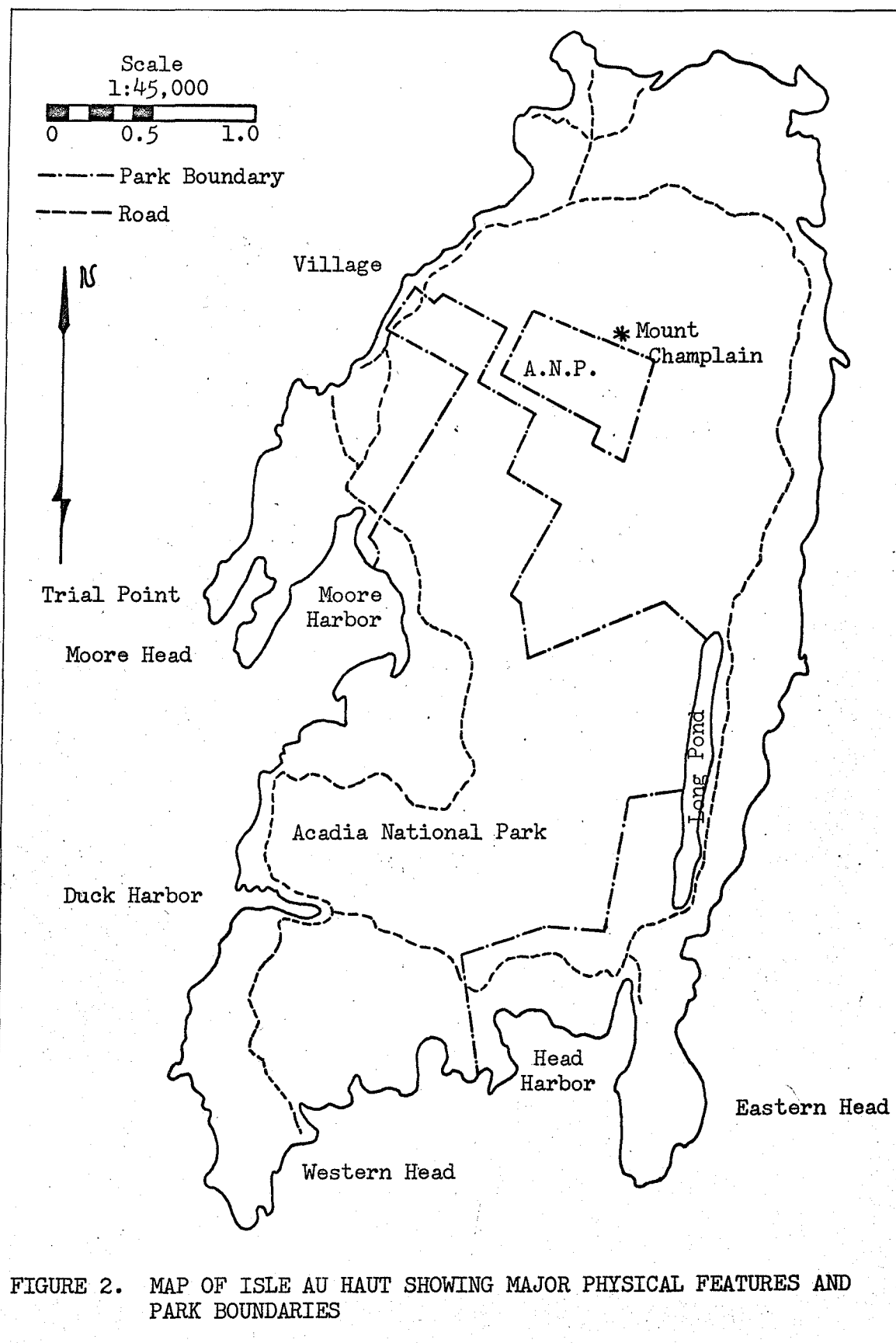


FIGURE 1. MAP OF MAINE DEPICTING RELATIVE LOCATION OF ISLE AU HAUT



in size. A road roughly parallels the periphery of the island and accounts for 14 of approximately 20 miles of road.

Geology

Isle au Haut is characterized by three major geologic formations. East to west, and roughly parallel to the length of the island, the basic structure consists of diorite, granite, and volcanic rocks (Luce, 1962). The soils of the Penobscot Bay region are of glacial origin, modified to some extent by post glacial accumulation of humus (Smith, et al., 1907).

Climate

Isle au Haut is located in the coastal section of the four main climatic divisions of Maine (Fobes, 1946). This narrow coastal region is characterized by fog, land-sea breezes, and lesser extremes in temperature compared to the remainder of the State. Within the coastal division, Isle au Haut is in the cool, central and eastern sector. Due to the fact that the island is approximately five miles from the mainland, more hours of fog and a greater amount of annual precipitation (annual mean = 46 inches) occur than in most of the coastal section (annual mean = 42 inches). The mean January and July temperatures are 22 and 68 degrees F, respectively, and illustrate the moderating influence of the ocean. Winter is the season of maximum precipitation, and the annual mean snowfall is 74.4 inches. The coastal section has a snow cover of more than one inch for 70 days compared to a one-inch cover for 120 days in the northern Maine

section.

Vegetation

The vegetation on Isle au Haut is primarily red spruce (Figure 3), typical of the coniferous vegetation on coastal islands of Maine (Davis, 1961). Mixed hardwood stands are scattered throughout the island. The more exposed ridges are characterized by stands of pitch pine. A number of smaller areas of cedar are found in the interior sections of the island. Alder was commonly found on several areas as a pioneering species in abandoned fields. A detailed consideration of the vegetative character comprised a major portion of the thesis and is presented in subsequent sections.

History

Isle au Haut was discovered by Champlain shortly after the turn of the 17th Century. The island was first settled in 1792 and supported a population of approximately 300 people by 1874. In these earlier days fishing, sheep raising, lumbering, and a limited amount of farming were the principal occupations. A large fire burned nearly all of the forested area of the island around 1879. Today there are between 20 and 30 year-round inhabitants. A large number of summer homes are used by a seasonal population of 200 or more people.

Approximately 3,000 acres of the island are owned by the National Park Service and are part of Acadia National Park (Figure 2). This large gift of land from the heirs of Ernest W. Bowditch occurred in 1946. Although the area has remained undeveloped, it is staffed



FIGURE 3. SPRUCE VEGETATION ON ISLE AU HAUT; TYPICAL OF MAINE'S
COASTAL ISLANDS

by a park ranger during the summer months for fire control. It seems inevitable, however, that the increasing number of people and the greater use of national parks will result in some development of the area.

Deer probably have been on the island from early times, as evidenced by bones found in Indian shell heaps (Eustis, 1952). Willard H. Palmer recorded an observation of deer in his diary in 1902. Manville (1964) reported deer to be abundant and browse lines apparent on many species of trees. The water between the island and Stonington has frozen solid in the past. The latest record of this extensive freezing was in 1943. Deer could have readily reached the island over the ice and, in addition, have been observed swimming between islands during the summer. The greatest distance between any two of the smaller islands is slightly over one mile. Several natives recall that deer were brought to the island by residents during the last half of the 19th Century. It is believed that these deer were placed on the island to provide a potential source of food during extended periods of severe weather.

METHODS

Cover-Type Map

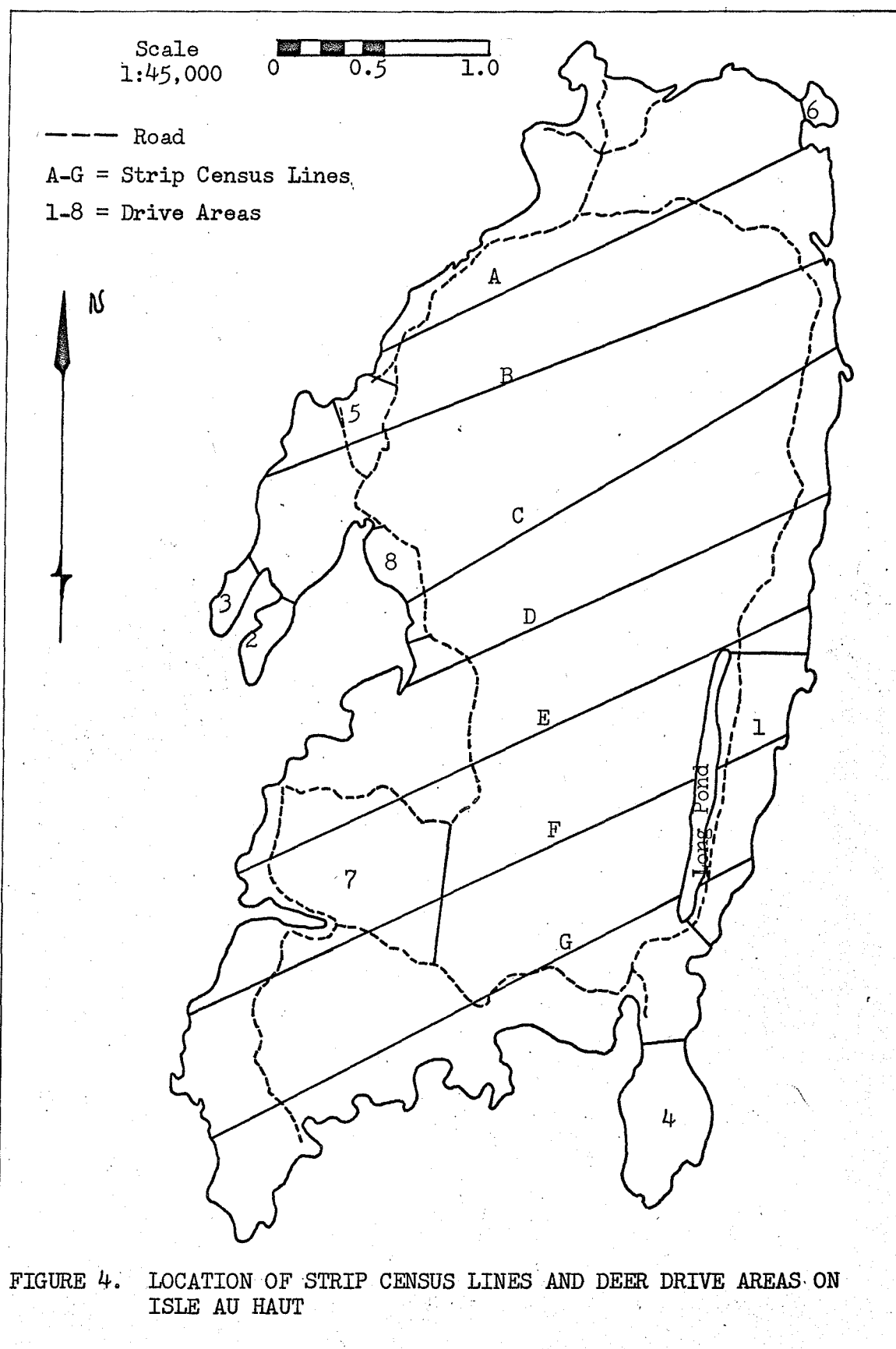
A map (scale = 1:24,000) showing the cover types found throughout the island was prepared from a series of 1957 aerial photographs. Cover types were distinguished with the aid of a stereoscope. A cover type was considered to be any ground vegetation of similar character and uniformity so as to be differentiated from other vegetation. Five acres was the minimum size which was recognized for the six vegetation cover types and also open areas. Types, delineated on the photographs, were transferred to the cover-type map with a Kelsh Plotter. This map served as a basis for establishing census and vegetation sampling procedures.

Population Estimates

Three basic methods were selected for determining the number of deer on the island. The choice of methods was based on the reliability of the techniques and the readiness with which they could be implemented with the time and manpower available.

Strip Census Method

Specific lines or compass bearings must be followed to conduct strip censuses. Seven census lines that traversed the island at half-mile intervals were marked (Figure 4). The half-mile interval was chosen to reduce the possibility of tallying the same deer by two observers. Sufficient manpower was not available to



simultaneously census more than seven lines. The seven lines, lettered A through G, ranged in length from 10,300 feet to 15,660 feet and totaled approximately 18.1 miles. The percent of the total length of line within each cover type corresponded to the percentage of the total area which that particular cover type occupied. All lines were on a true bearing of N 61.5°E.

Lines were cruised using a Leupold cruiser compass. For the most part, the author worked alone and minor variations due to topography and human error were not corrected. It was not deemed necessary for the lines to follow an exact compass bearing, but to provide a prescribed census line for the observer. Colored, plastic flagging was used to mark the lines and placed so that the observer could see the next flag regardless of the direction in which the line was walked. In addition, cloth tags that identified stations along the line were placed at 165-foot intervals. The tags served to aid in determining the position of all deer flushed, as well as to mark the location of the plots used in sampling the vegetation.

Personnel from the University of Maine participated in the strip censuses from May 1, 1965 to October 23, 1965. All of the observers were experienced in woods travel and familiar with the white-tailed deer.

Each man was instructed to walk slowly, avoid noise, and to be especially observant. The direct distance to the place where deer flushed and the perpendicular distance from the flushing spot to the census line were recorded. In addition, the following was tallied for each flushing observation: time, next tag number, cover

type, height of the dominant trees, crown density in percent, and sex of the deer, if determined. If an observer strayed from the census line or if darkness prevented continued observation, the numbered tag on the line where the census ended was recorded.

Counts were started on the main road. Thus, the human disturbance necessary to reach the beginning of the census line at the shore was eliminated. Only observations made the first time the lines were walked during a census were recorded. Observers were scheduled to walk away from the sun whenever possible. Morning and evening censuses were made. Morning counts were made as soon as adequate daylight was available. Evening censuses were started about three hours before sunset.

Only four men participated in the first weekend of strip censuses. Each man walked across the island on one line and returned on an adjacent line. The time required to complete the count was approximately six hours; thus, morning counts were not finished until midday. All subsequent counts were conducted by seven men, so that all lines were walked at the same time and in the same direction. On three occasions, two complete censuses were made on the same day. The remaining censuses were conducted as the availability of participants and transportation arrangements permitted.

Population estimates were computed by King's, Webb's, Hayne's, and Kelker's formulas as presented in the Review of Literature. Differences between population estimates based on morning and evening censuses were determined by the "t" test (Steel and Torrie, 1960).

Drive Counts

Drive counts were made to determine actual deer numbers on well-defined areas during the weekends of February 6-7 and March 20-21, 1965. A road roughly paralleled the perimeter of Isle au Haut. As a result, drive counts were applicable to many small areas between the road and the shore. The lack of well delineated land units prevented drive counts in the interior.

Deer drives were executed according to the standard procedures as described by McCain (1939) and Morse (1943). Participants were instructed to proceed at a moderate pace and to create noise. An attempt was made to drive the deer past counters and yet not to excite the animals to the extent that they would panic and cross the drive line. Two-way radios were used to coordinate the advance of the drive line. Drivers were spaced at approximately 100-foot intervals. The distance varied according to the density of the vegetation and the width of the area censused. The area between any two drivers was under surveillance at all times. Each driver was responsible for tallying deer which crossed the drive line between himself and the man on his right. Verbal checks between drivers were made to insure that each deer was recorded. Either direct counts by personnel stationed along the perimeter of the area or track counts were used to determine the number of deer flushed from the area. Track counts were made on areas bounded by roads or clearings of sufficient width to require tracks. Deer tracks in the snow were obliterated around the perimeter at the beginning of the drives. New tracks were recorded after coverage of the area was completed.

Aerial Census

Two direct counts of deer from the air were made over the entire island. Several longitudinal transects were flown at an approximate altitude of 400 feet on both censuses. The number of deer observed on eight specific areas was recorded separately on the first aerial census. Several of these areas were censused by deer drives on the same day. An attempt was made to establish the ratio of the number of deer observed from the air to the actual number of deer on the area as determined by drive counts.

Habitat Evaluation

Several factors restricted the approach and methodology of the sampling procedure. It was necessary to confine browse measurements to the summer field season. Thus, it was essential to define the specific measurements that could be taken during the three months available. In view of National Park Service policies, and in the interest of good public relations, a nondestructive sampling technique was desired. Emphasis was placed on determining the quantity of browse available to the deer.

Several unique aspects of the existing vegetation influenced the selection of sampling techniques. Conditions within similar vegetation types were fairly uniform. Less than five percent of the forested land has been cutover since the turn of the century. The National Park Service policy on the natural development of forests, and voluntary restraint from cutting by major land owners has gradually allowed browse to grow above the reach of the deer. The

available browse apparently has been heavily utilized, and as a result the quantity of measurable browse was relatively small.

Sampling Approach

Since there was no previously recorded data on the variability of measurements which might be encountered, and because a pilot experiment was not feasible, the sampling design could not be approached from the standpoint of attaining a particular precision. Thus, the best and most efficient means of securing the more pertinent data within the limits of the time available became the major consideration.

The following six cover types were recognized: spruce, mixed hardwood, pitch pine, alder, cedar, and gray birch-bayberry. The spruce cover type was subdivided on the basis of the absence (Spruce I) or presence (Spruce II) of an appreciable amount of understory shrub vegetation. Twenty sample plots were located within each cover type except spruce, which contained 40 sample plots. Each plot within the spruce was classified as a Spruce I or Spruce II cover type. It was assumed that the percentage of the sample plots within each class of spruce was representative of the percentage of area occupied by that class.

Cloth tags were placed at 165-foot intervals along the established strip census lines (Figure 4). As previously stated, the percent of the total length of line within each cover type corresponded to the percent of the total area which that particular cover type occupied. The tags were designated as to the line and the number of

the station along the line. A table of random numbers, corresponding to tag numbers, was used to select the sample plots in each cover type. The randomization was restricted to the extent that each line contained selected plots. If a line contained 10 percent of the tags in a particular cover type, 10 percent of the 20 plots to be sampled in that cover type would be located on this line. This was done to eliminate any chance of sampling being concentrated in one section of the island.

Overstory vegetation, understory tree species and understory shrubs comprised the three categories considered in the evaluation of the existing habitat. These strata were measured by Bitterlich point sampling, Shafer twig-count, and clip and weigh methods, respectively. The point established for the Bitterlich technique was used as the central reference for locating the remaining plots (Figure 5). This point was determined by pacing three steps from the selected tag northeast along the line and then three paces to the right and perpendicular to the line. At this point a survey pin was placed in the ground. This was the center for all measurements which were taken at the plot. Tags were placed for visibility purposes and, due to possible bias, were not used as center points.

Overstory Vegetation

The Bitterlich point sampling method was used to measure the composition of the overstory (Grosenbaugh, 1952). A 3.0 diopter wedge prism was used to determine the trees to be tallied. Any borderline tree was measured with a tape. Slope corrections were

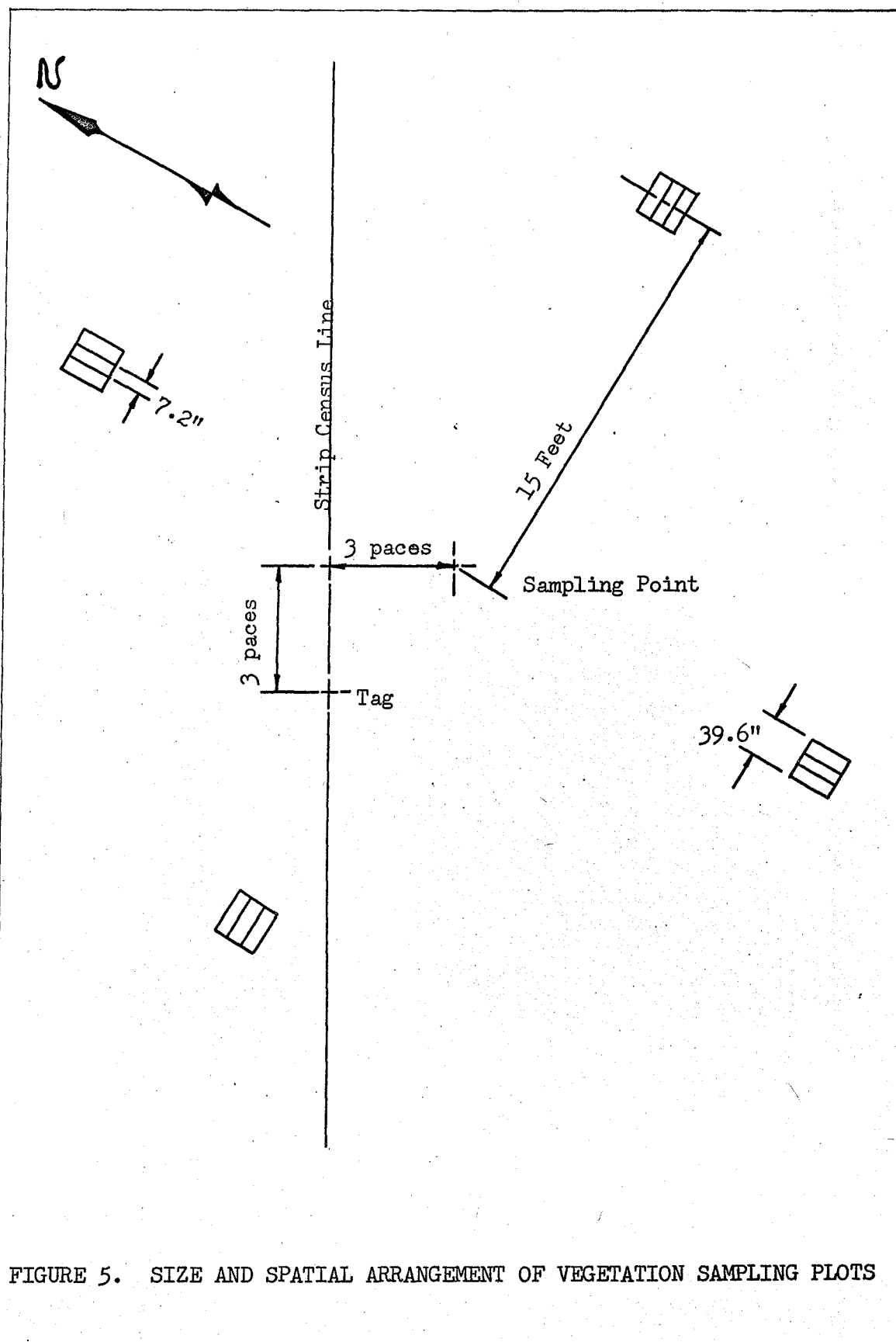


FIGURE 5. SIZE AND SPATIAL ARRANGEMENT OF VEGETATION SAMPLING PLOTS

made by holding the prism on the plane level with the point of breast height on the tree. Each tree was recorded by species and d.b.h. The height of the dominant trees was estimated to the nearest five feet. These ocular estimates were checked periodically with a Haga altimeter. The percent of crown closure was recorded by taking four densiometer readings in each of the cardinal compass directions around the center point. A densiometer is a device which relates the amount of shade on a curved mirror to the percent of crown closure (Lemmon, 1956).

Understory Vegetation

Sampling of the understory vegetation was divided into two categories: (1) tree species and (2) shrub vegetation. Species whose growth characteristics were such that individual stems and twigs could readily be counted were considered as trees. The center located for the overstory sampling served as a reference point for establishing understory plots.

Tree Species.--A quarter mil-acre plot (39.6 inches square) was established 15 feet in each direction of the cardinal points from the center (Figure 5). These minor plots were delineated by metal rods. All trees within the minor plot were tallied as to species and diameter six inches above the ground. All twigs between one foot and 5.5 feet in height, and located within a visualized cube 39.6 inches by 39.6 inches were tallied according to species, and as to whether or not they had been browsed. Where possible, browsed twigs were further classified as browsed by deer or hare. Any living shoot

composed of more than the present year's growth was considered to be a twig. A densiometer reading was taken facing each side of the minor plot.

The browsing diameter of 100 twigs of each recorded tree species was measured. The average browsing diameter was calculated, and then 100 twigs were clipped at the browsing diameter determined for each species. An average weight per twig was computed. This procedure developed by Shafer (1963) provided a factor for converting twig counts into weights.

Shrub Vegetation.--Within each square minor plot a rectangular subplot, parallel to the compass bearing from the center point, was delineated. A frame 7.2 inches by 39.6 inches (1.98 square feet) was used to mark this area. One end of this frame was open so that it could be worked through the shrub vegetation along the ground. The number of stems of shrub species growing within the rectangular area was tallied according to species. All shrub growth, between one foot and $5\frac{1}{2}$ feet, falling within this rectangle was clipped to a maximum length of six inches. These twigs were weighed by species to the nearest gram.

RESULTS

Cover-Type Map

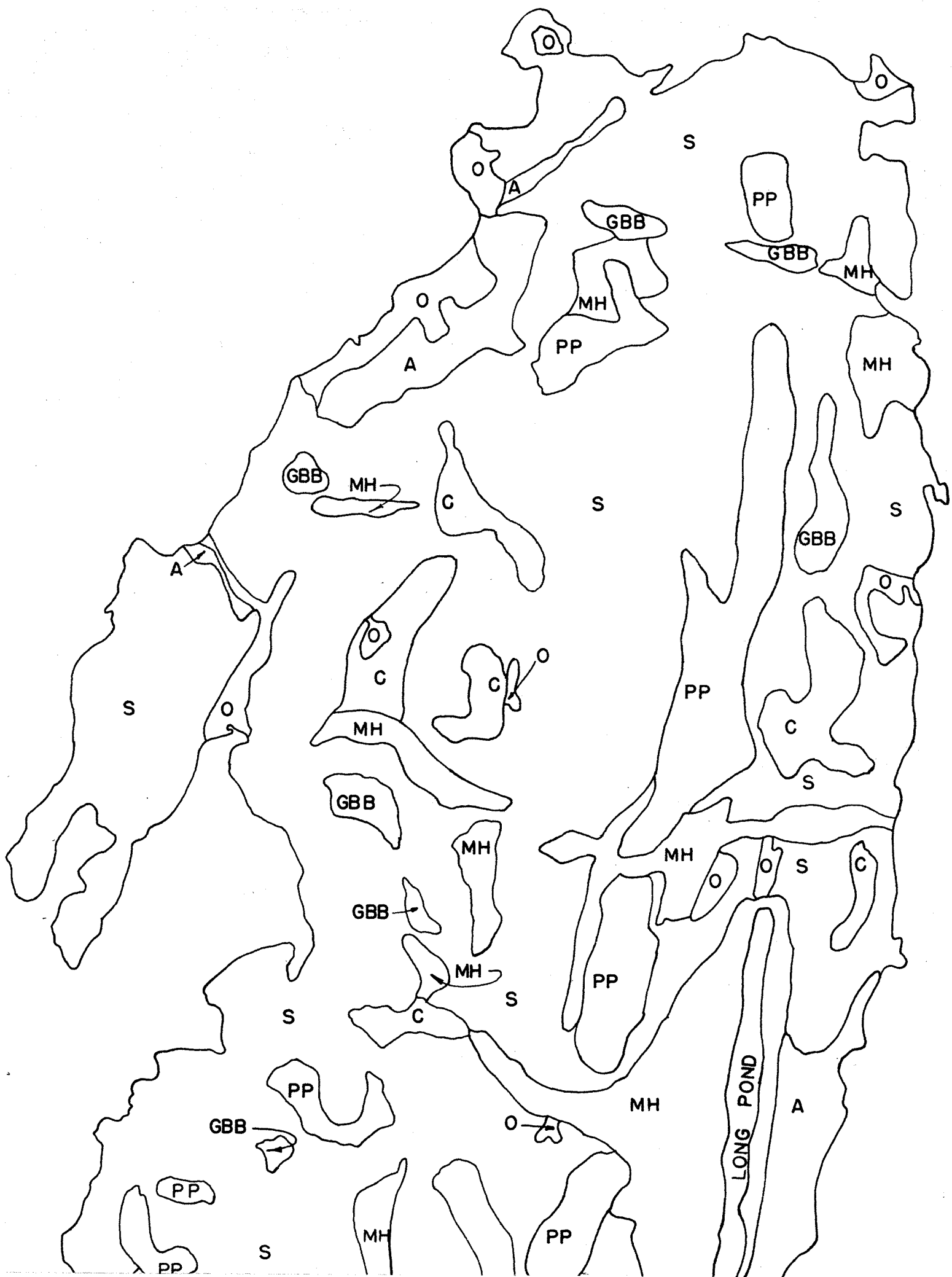
The location of each cover type recognized from aerial photographs is shown in Figure 6. Spruce was the dominant type and accounted for 4,745 acres (72 percent) of the island (Table 1). The remaining cover types, in order of decreasing area, were: mixed hardwood, pitch pine, alder, cedar, open, and gray birch-bayberry.

Population Estimates

Strip Census Methods

The percent of the length of census line located in each cover type approximated the percent of the total area which that particular cover type occupied (Table 1). This established relationship permitted the sample strip censuses to correspond to the cover types found on the island.

From May 1, 1965 to October 23, 1965, 16 separate counts were made. Only four men participated during the first weekend of strip censuses in contrast to seven thereafter. The time required to complete one strip census with four men was approximately six hours. Due to the lack of observations during the last three hours of the census, and the unequal distances between these counts and later counts, the data obtained during this weekend was not considered in calculating population estimates. As a matter of interest, data obtained during these counts are presented as follows:



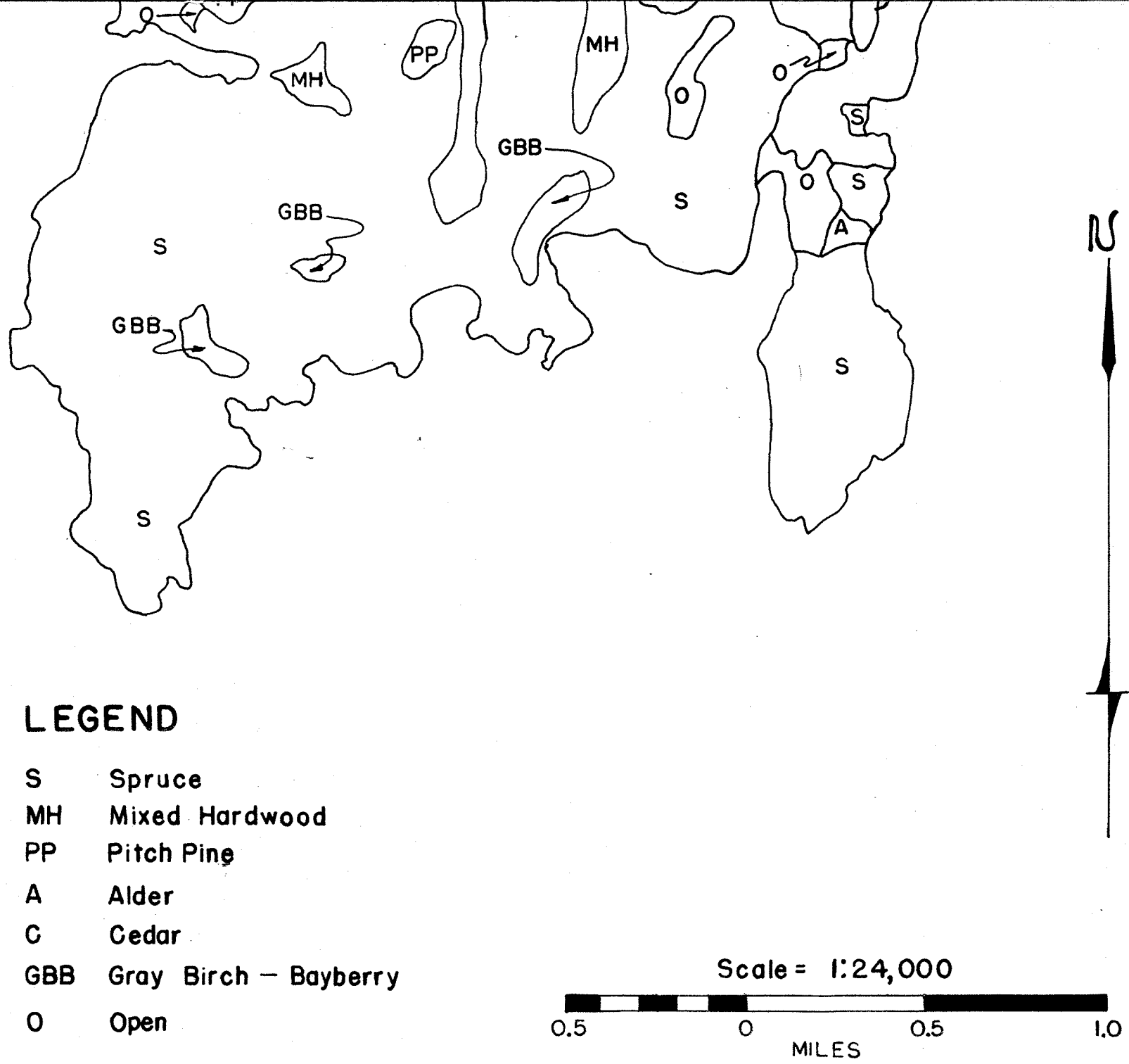


FIGURE 6. COVER TYPES ON ISLE AU HAUT, MAINE

TABLE 1 . RELATIONSHIP BETWEEN ACREAGE OF COVER TYPE AND LENGTH OF STRIP CENSUS LINE WITHIN COVER TYPE

Cover Type	Area (acres)	Percent of Total Area	Length of Line in Cover Type (feet)	Percent of Total Line Length
Spruce	4,745	72.2	64,130	67.1
Mixed Hardwoods	655	9.9	4,070	4.3
Pitch Pine	420	6.4	8,835	9.2
Alder	260	4.0	9,930	10.4
Cedar	200	3.1	1,000	1.1
Gray Birch- Bayberry	130	1.9	3,765	3.9
Open	165	2.5	3,865	4.0
Total	6,575	100.0	95,595	100.0

Date	Time	No. Deer Tallied	Avg. Perpendicular Flushing Distance (feet)	Avg. Direct Flushing Distance (feet)	Length of Census Line (feet)
5/1/65	AM	6	23.2	83.8	95,595*
5/1/65	PM	7	73.9	189.4	47,932
5/2/65	AM	12	126.0	189.7	95,595*
Total		25	2168.0	4105.0	239,122
Mean		8.3	86.7	164.2	79,707

*Includes 42,464 feet censused during midday on which no deer were observed.

From July 22, 1965 to October 24, 1965, 13 complete censuses were conducted during which 190 deer were observed (Table 2). The average perpendicular flushing distance was 76.0 feet, and the average direct flushing distance was calculated to be 125.1 feet. Only 40 percent of the deer were recorded in the spruce cover type despite the fact that 67 percent of the census line was located within this type (Table 3). In contrast, 19 and 24 percent of the deer recorded were in the mixed hardwood type and open areas, respectively. Both types contained only four percent of the total length of the census line. A selected width, based on a pattern of uniform perpendicular flushing distances, was chosen for each cover type to apply Kelker's formula (Table 4). The selected width was greatest (64 yards) within the spruce vegetation and smallest (23 yards) within pitch pine, cedar, and open areas. Due to the lack of observations within some types, and misclassification of types by

TABLE 2 . SUMMARY OF DEER STRIP CENSUS COUNTS

Date of Census	Time	No. Deer Tallied	Av. Perpendicular Flushing Distance (feet)	Av. Direct Flushing Distance (feet)	Length of Census (feet)
7/22/65	PM	14	52.6	119.5	86,196
7/23/65	AM	6	65.0	121.2	95,595
7/23/65	PM	18	76.0	134.1	95,595
7/24/65	AM	15	56.6	97.7	95,595
8/12/65	PM	19	63.9	96.6	92,829
8/13/65	AM	19	119.8	150.4	93,329
9/24/65	PM	12	58.2	117.8	86,330
9/25/65	AM	10	47.8	92.0	91,796
9/25/65	PM	19	63.3	118.8	91,796
9/26/65	AM	12	125.0	178.8	93,662
10/23/65	AM	21	66.9	131.0	91,228
10/23/65	PM	14	100.6	132.0	91,228
10/24/65	AM	11	83.8	132.8	91,228
Total		190	14,447.9	23,768.7	1,196,407 (226.6 miles)
Mean		14.6	76.0	125.1	92,031 (17.4 miles)

TABLE 3 . FREQUENCY OF DEER OBSERVATIONS DURING STRIP CENSUSES BY
COVER TYPE

Cover Type	No. of Deer Tallied	Percent of Deer Tallied	Percent of Census Line within Cover Type
Spruce	75	39.5	67.1
Pitch Pine	8	4.2	9.2
Mixed Hardwood	36	18.9	4.3
Alder	5	2.6	10.4
Gray Birch-Bayberry	13	6.9	3.9
Cedar	8	4.2	1.1
Open	45	23.7	4.0
Total	190	100.0	100.0

TABLE 4 . WIDTH OF CENSUS STRIP FOR KELKER BELT TRANSECT METHOD

Cover Type	No. of Observations of Deer	Range of Recorded Perpendicular Distances (feet)		Chosen Width of Belt (yards) ^{1/}
		Low	High	
Spruce	75	0	425	64
Mixed Hardwood	36	0	180	42
Alder	5	75	110	37
Gray Birch- Bayberry	13	30	222	33
Pitch Pine	8	10	300	23
Cedar	8	20	150	23
Open	45	0	250	23
Total	190			

^{1/} Measured distance in feet but conversion to yards necessary for application of Kelker's formula.

some observers, the chosen widths are subject to error. Total deer population estimates based on the four formulas for strip censuses ranged from 187 to 326. Population estimates for each census are presented for each method (Table 5).

Drive Counts

Eleven separate deer drives were made on eight areas of the island (Figure 4). The areas driven were from 20 to 280 acres in size. The number of deer tallied ranged from 0 to 21 (Table 6). Population densities, based on the number of deer on each drive area, ranged from 6.7 acres per deer to 25 acres per deer.

Aerial Census

Belt transects over the entire island were flown on February 6, 1965 and March 5, 1965. Only three deer were observed during both censuses. Despite a four-inch snowfall during the night of February 5, 1965, fresh tracks were evident on several sections of the island. No evidence of concentration areas was noted; however, shore regions appeared to be used more than interior sections.

Habitat Evaluation

Overstory

Based on the 40 sampling plots located in the spruce vegetation, 70 percent of the acreage within the spruce cover type was considered to have no understory shrub layer. Thus, 3,320 acres were defined as spruce I cover type with an absence of shrub vegetation. The

TABLE 5 . DEER POPULATION ESTIMATES BASED ON FOUR STRIP CENSUS METHODS

Date	Method			
	King	Webb	Hayne	Kelker
7/22/65	194.7	442.0	259.2	316.4
7/23/65	74.2	138.3	90.5	218.4
7/23/65	201.1	364.2	293.2	291.5
7/24/65	230.0	396.9	336.5	256.3
8/12/65	303.7	458.6	416.6	185.1
8/13/65	193.8	243.5	219.6	194.6
9/24/65	169.1	341.8	228.6	196.7
9/25/65	169.1	320.0	201.0	76.8
9/25/65	249.6	468.7	307.4	261.5
9/26/65	102.6	146.8	125.9	123.2
10/23/65	251.8	492.9	450.9	162.4
10/23/65	166.6	218.6	259.1	233.5
10/24/65	130.0	206.1	150.9	146.4
Mean	187.4	326.0	256.9	204.8
Standard Error	17.5	34.5	29.4	18.9
Confidence	149.2	250.8	192.8	163.6
Limits (P=.05)	225.6	401.2	320.9	246.0

TABLE 6. SUMMARY OF DEER DRIVES

Drive Area ^{1/}	Cover Type	Size of Area (acres)	Date Censused	No. of Deer Tallied	Ratio of Acres/Deer	Population Estimate
1	Alder Spruce Cedar	200	2/6/65	21	9.5	692
			3/20/65	11	18.2	361
2	Spruce	30	2/7/65	2	15.0	438
			3/20/65	2	15.0	438
3	Spruce	25	2/7/65	1	25.0	263
			3/20/65	0	--	--
4	Spruce	130	2/7/65	15	8.7	756
5	Spruce	50	2/6/65	3	16.7	394
6	Spruce	20	3/20/65	3	6.7	981
7	Spruce Pitch Pine	280	3/21/65	14	20.0	329
8	Spruce	55	3/21/65	0	--	--
All Areas		1045		72	14.5	453

^{1/} See Figure 4.

remaining 1,425 acres mapped as spruce was assumed to have a substantial understory of shrubs, and was designated as spruce II. Hereafter, spruce I and spruce II will be considered separately.

The overstory vegetation was composed of the following seven cover types: spruce I, spruce II, mixed hardwood, pitch pine, alder, cedar, and gray birch-bayberry. Stand tables for each cover type and for the entire island are presented in Appendix II. The frequency of occurrence of each tree species points out the overall coniferous character of the island (Table 7).

Most of the trees measured within the spruce I cover type were between five and 12 inches at d.b.h. Seven other species were recorded within this type; however, red spruce comprised 85 percent of the trees per acre. A crown closure of 90 percent was recorded for the calculated 1,100 trees per acre. The height of the dominant trees was approximately 55 feet.

In contrast to the above, the spruce II cover type was characterized by only 428 trees per acre and a general crown canopy level of 40 feet. Red spruce comprised 67 percent of the total number of trees of seven species. A crown closure of 65 to 70 percent was recorded. The d.b.h. measurements ranged from two to 17 inches with most trees between five and nine inches in diameter.

The mixed hardwood cover type covered 655 acres with the major portion located around Long Pond. Smaller sections of this type are scattered throughout the island and for the most part are distributed in relation to intermittent water courses. Eight hardwood and four softwood species were recorded within this type. The hardwood species

TABLE 7 . FREQUENCY OF OCCURRENCE OF TREE SPECIES BY COVER TYPE

	Spruce I	Spruce II	Mixed Hardwood	Pitch Pine	Alder	Cedar	Gray Birch- Bayberry	Total	
No. of Sample Points	28	12	20	20	20	20	20	140	
Species								No.	Percent
Red Spruce	28	11	16	12	5	9	12	93	66.4
Red Maple	11	4	16	2	1	9	5	48	34.3
Cedar		1	3			20	2	26	18.6
Pitch Pine		2		20				22	15.7
Gray Birch	2	1	4		1	2	10	20	14.3
Alder					12		5	17	12.1
Yellow Birch	5		11					16	11.4
Balsam Fir	5		5			1	1	12	8.6
White Birch	2		7			2		11	7.9
Bayberry					3		7	10	7.1
White Spruce		1	2		4		1	8	5.7
Aspen	1	1	2			1		5	3.6
Striped Maple			3					3	2.1
Larch							3	3	2.1
White Ash			1			1		2	1.4
White Pine	1							1	0.7
Red Pine						1		1	0.7
N. Red Oak			1					1	0.7

comprised 54 percent of the 584 trees calculated per acre. It is believed that the relatively small percentage of hardwood species measured was due to errors in photointerpretation and in the resulting cover-type map. The specific character of the present vegetation was not distinguishable on the aerial photographs which were taken in 1957. The height of the dominant overstory trees was approximately 55 feet and the average crown closure was 90 percent.

A total of 420 acres located along the exposed ridges consisted of pitch pine. Only three species, mostly four to 11 inches d.b.h. and 30 feet in height, were recorded in this type. The total of 545 trees calculated per acre is reflected in a recorded crown closure of 65 percent.

Several large sections, totaling 260 acres, consisted of alder, bayberry, and other low growing species. Five of twenty sample plots in this type contained no overstory trees. Alder made up 1,429 (73 percent) of the 1,960 trees per acre. Crown closure was 20 percent, and the general crown canopy level was about 15 feet.

Approximately 200 acres of cedar were present on the island. A total of 480 trees per acre of nine species were present. The height of the dominant trees was 35 feet, and the majority of d.b.h. measurements were between four and ten inches. Average crown closure was 75 percent.

The gray birch-bayberry cover type, found in small units throughout the island, totaled 130 acres. This cover type is located in several areas of swamp habitat in which the principal vegetation consists of these species. Gray birch, bayberry, and alder accounted

for 3,477 (85 percent) of the 3,675 trees per acre. Crown closure was 75 percent. The crown canopy level was 16 feet.

A stand table for the entire island was prepared to better visualize the island as a single ecological unit (Table II-8, Appendix II). A total of 887 trees per acre was calculated for each acre of the entire island. Red spruce accounted for 65 percent of the total number of trees per acre. However, the dominance of this species is not clearly apparent due to the large number of trees per acre of the smaller diameter species such as alder and bayberry. Most of the overstory trees measured, were between five and ten inches at d.b.h.

Understory Vegetation

Stand tables by cover type were constructed for all tree species recorded within the quarter mil-acre minor plots (Appendix III). The composition of the understory is expressed through the available twigs per acre by species. The amount of available browse per acre was the primary consideration. Twig numbers and the weight of shrub vegetation have been summarized by species and cover type in Tables 8 and 9, respectively. Understory stand tables (Appendix III) may be consulted for background information.

A histogram has been prepared to show the total amount of available food by cover type and for the entire island (Figure 7). The extreme low amount of preferred browse clearly illustrates the inadequate food supply. The preponderance of spruce, a starvation food, scarcely contributes to the nutritional needs of the deer. The

TABLE 8 . NUMBER, UTILIZATION AND WEIGHT OF TWIGS PER ACRE BY SPECIES AND COVER TYPE

Species	Spruce I Cover Type					
	No. Unbrowsed	Weight (lbs.)	No. Browsed	Percent Browsed	No. Browsed by Deer	Percent Browsed by Deer
Red Spruce	68,250	849	1,250	1.8	0	0
Balsam Fir	<u>4,643</u>	<u>48</u>	<u>2,893</u>	<u>38.2</u>	<u>2,893</u>	<u>38.2</u>
Total	72,893	897	4,143	5.4	2,893	3.8
Spruce II Cover Type						
Red Spruce	165,664	2,062	19,000	10.3	1,500	0.8
White Spruce	<u>17,166</u>	<u>231</u>	<u>5,083</u>	<u>22.8</u>	<u>1,666</u>	<u>7.5</u>
Total	182,830	2,293	24,083	11.6	3,166	1.5
Mixed Hardwood Cover Type						
Red Spruce	67,050	834	4,850	6.7	300	0.4
White Spruce	20,600	277	5,550	21.2	1,550	5.9
Balsam Fir	2,150	22	1,150	34.8	800	24.2
Gray Birch	350	*	1,600	82.0	1,400	71.8
Mountain Ash	0	0	1,400	100.0	1,400	100.0
Striped Maple	0	0	850	100.0	850	100.0
Yellow Birch	0	0	300	100.0	300	100.0
White Ash	<u>0</u>	<u>0</u>	<u>250</u>	<u>100.0</u>	<u>250</u>	<u>100.0</u>
Total	90,150	1,133	15,950	15.0	6,850	6.4
Pitch Pine Cover Type						
Red Spruce	74,950	933	8,850	10.6	950	1.1

TABLE 8 . Cont'd.

Species	Alder Cover Type					
	No. Unbrowsed	Weight (lbs.)	No. Browsed	Percent Browsed	No. Browsed by Deer	Percent Browsed by Deer
Red Spruce	20,350	253	0	0	0	0
White Spruce	25,050	337	4,150	14.2	0	0
Alder	128,600	552	38,100	22.8	31,350	18.8
Bayberry	7,250	22	3,500	32.6	3,500	32.6
Witherod	<u>50</u>	<u>*</u>	<u>150</u>	<u>75.0</u>	<u>150</u>	<u>75.0</u>
Total	181,300	1,164	45,900	20.2	35,000	15.4
Species	Cedar Cover Type					
	No. Unbrowsed	Weight (lbs.)	No. Browsed	Percent Browsed	No. Browsed by Deer	Percent Browsed by Deer
Red Spruce	20,850	259	0	0	0	0
Cedar	18,950	207	6,250	24.8	4,650	18.5
Red Maple	<u>500</u>	<u>2</u>	<u>950</u>	<u>65.5</u>	<u>950</u>	<u>65.5</u>
Total	40,300	468	7,200	15.2	5,600	11.8
Species	Gray Birch-Bayberry Cover Type					
	No. Unbrowsed	Weight (lbs.)	No. Browsed	Percent Browsed	No. Browsed by Deer	Percent Browsed by Deer
Red Spruce	105,900	1,318	3,850	3.5	0	0
Alder	11,450	49	6,250	35.3	4,700	26.6
Balsam Fir	9,500	98	5,450	36.4	3,000	20.1
Cedar	0	0	1,150	100.0	1,150	100.0
Bayberry	<u>4,450</u>	<u>14</u>	<u>2,750</u>	<u>38.2</u>	<u>2,400</u>	<u>33.3</u>
Total	131,300	1,479	19,450	12.9	11,250	7.5

TABLE 8 . Cont'd.

Species	No. Unbrowsed	Weight (lbs.)	Entire Island			
			No. Browsed	Percent Browsed	No. Browsed by Deer	Percent Browsed by Deer
Red Spruce	85,367	1,062	6,014	6.6	557	0.6
White Spruce	6,763	91	1,819	21.2	516	6.0
Alder	5,312	23	1,630	23.4	1,333	19.2
Balsam Fir	2,746	28	1,683	38.0	1,600	36.1
Cedar	576	6	213	27.0	164	20.8
Bayberry	375	1	193	34.0	186	32.7
Gray Birch	35	*	159	82.0	139	71.6
Red Maple	15	*	29	65.9	29	65.9
Witherod	2	*	6	75.0	6	75.0
Mountain Ash	0	0	139	100.0	139	100.0
Striped Maple	0	0	85	100.0	85	100.0
Yellow Birch	0	0	30	100.0	30	100.0
White Ash	0	0	25	100.0	25	100.0
Total	101,191	1,211	12,025	10.6	4,809	4.2

* Less than 1 pound per acre.

TABLE 9. STEM TALLY AND WEIGHT OF AVAILABLE SHRUB VEGETATION BY COVER TYPE

Cover Type	Spruce I			Spruce II			Mixed Hardwood			Pitch Pine		
	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre
Species												
Huckleberry	1	0	0	287	294	232	2	6	3	476	601	285
Sheep Laurel	4	2	1	132	118	93	8	14	7	131	102	48
Juniper												
Sweet Fern	9	8	3				10	22	10			
Spiraea				1	0	0	3	12	6			
Leatherleaf												
Blueberry							7	22	10			
Rose												
Chokeberry				2	2	2						
Total	14	10	4	422	414	327	30	76	36	607	703	333

Table 9. Cont'd.

Cover Type	Alder			Cedar			Gray Birch-Bayberry			Entire Island		
	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre	No. Stems Tallied	Weight (grams)	Lb. per Acre
Species												
Huckleberry	5	6	3	1	0	0	26	26	12	798	933	69
Sheep Laurel				19	18	9	34	47	22	328	301	25
Juniper	--	1194	566							--	1194	22
Sweet Fern	5	38	18							24	68	3
Spiraea	60	23	11				38	28	13	102	63	1
Leatherleaf							17	58	28	17	58	1
Blueberry	74	40	19							81	62	2
Rose	2	9	4							2	9	*
Chokeberry										2	2	*
Total	146	1310	621	20	18	9	115	159	75	1354	2690	123

* Less than 1 pound per acre.

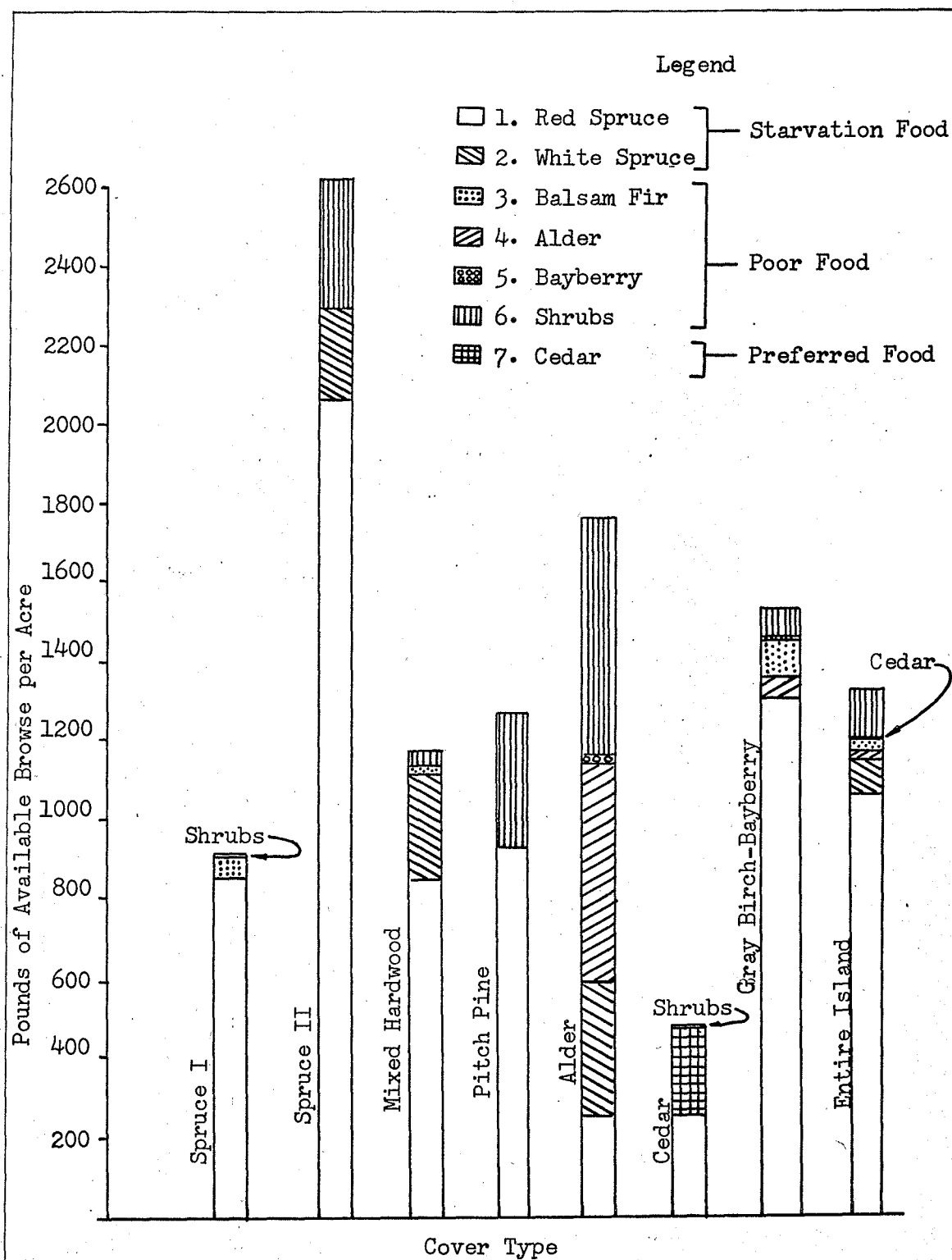


FIGURE 7. HISTOGRAM SHOWING THE TOTAL AMOUNT OF AVAILABLE FOOD BY COVER TYPE AND FOR THE ENTIRE ISLAND

amount of available browse for each acre of the island was determined to be 1334 pounds. The spruce II cover type contained the greatest amount of food (2620 pounds per acre) in contrast to the 477 pounds per acre calculated for the cedar cover type. Cedar was the only preferred browse species present in sufficient amounts to contribute to the available food for each acre on the island. This species was only recorded within the cedar type where it amounted to 207 pounds per acre. Hardwoods, except alder and bayberry, did not amount to one pound per acre, although several species were recorded. Shrubs contributed more than 300 pounds per acre within the spruce II, pitch pine, and alder cover types.

The average weight per twig was greater for the coniferous species (Table 10). In general, twigs of hardwood species were browsed at a larger diameter than the softwood twigs.

TABLE 10. AVERAGE BROWSING DIAMETER AND AVERAGE WEIGHT PER TWIG BY SPECIES AS DETERMINED FROM SAMPLES OF 100 TWIGS

Species	Average Browsing Diameter (millimeters)	Average Green Weight per Twig (grams)
White spruce	2.25	6.10
Red Spruce	2.10	5.65
Cedar	2.80	4.95
Balsam Fir	2.45	4.70
Striped Maple	5.15	4.05
White Ash	5.05	3.85
Mountain Ash	6.35	3.45
Red Maple	5.55	2.20
Alder	3.40	1.95
Witherod	2.95	1.95
Bayberry	2.25	1.40
Yellow Birch	1.80	0.60
Gray Birch	1.65	0.35

DISCUSSION

Population Estimates

Strip Censuses

Each method of estimating populations by strip censuses is based on a means of determining the area covered during the census. The basic assumptions which must be made for all strip census counts are as follows: (1) deer are scattered throughout the study area, at least relative to the census line, (2) all deer will be observed, (3) deer vary with regard to their flushing behavior, and (4) the flushing behavior of the deer observed during the census is representative of the population as a whole. The measured distances and the mathematical calculations used to derive the censused area are directly related to deer behavior and activity patterns.

Deer activity varies with the time of the year. Behrend (1966) stated that activity is most closely correlated with hours of daylight from March through mid-October. He suggested that activity patterns may be associated with changes in basal metabolism. The effect of daylight on physiological changes may be the cause of seasonal variations in basal metabolic rate (Silver and Hayes, 1965). Behrend further recognized the influence of temperature and precipitation on deer activity. He stated that "biting flies, especially blackflies (Simuliidae) and deerflies (Tabanidae), doubtless affect deer behavior during summer months." These observations agree with those of Darling (1937) on red deer in Scotland. So little is known about deer behavior, and the extent of variability within individual deer,

that the spatial relationships of flushed animals cannot be determined precisely. To the author's knowledge, no study has been conducted on a known population of deer to determine the validity of the assumptions which must be made in selecting distances for calculating areas of strip censuses. The physical and economic aspects of such a project have curtailed work in this field of study. Tester and Heezen (1965) studied deer behavior in response to deer drives by using telemetry. Additional work on the flushing behavior of deer during strip censuses would contribute greatly to the evaluation of the accuracy of this technique. In addition to the variables discussed above, an apparent high deer density and, legally, an unharvested population on Isle au Haut affect behavior.

The perpendicular distances of the deer to the line were plotted against the distances from the observer to the point on the line directly opposite the deer. There was no direct relationship between the legs of the established right triangle. The frequency of deer observations was not correlated with time of sunrise, time of sunset, or period of daylight.

An average population estimate, based on Hayne's Method, of 222 deer was calculated from seven morning censuses. The average for six evening census counts was 294 deer. Despite the apparent dissimilarity, there was no significant difference.

King Method.---The mean of population estimates using the King method was 187 deer. A confidence interval ($P = .05$) from 149 to 226 was calculated. In determining the area sampled during the census, twice the average direct flushing distance was multiplied by the

length of the census line. The writer believes that the average direct flushing distance, when extended perpendicular to the line, results in an area greater than is actually covered. Thus, a lower population estimate was calculated.

Steinhoff (1947) found that deer population estimates based on the King method were consistently low and amounted to only one-third of the true population as determined by drive counts. The flushing behavior of an animal is influenced by the direction of travel of the observer. An animal directly in front of an observer would surely flush at some point during the observer's approach. However, an animal not in a direct line may not flush or may move from the observer's field of vision without being seen. Thus, the direct flushing distances would tend to be greater for those deer directly in front of the observer. King developed this census method for grouse. The noise created by their wings and possibly a more uniform direct flushing distance makes King's method more applicable to this species.

Webb Method.--An average population estimate of 326 deer was obtained using the Webb method. The confidence interval was 251 to 401 ($P = .05$). The Webb method differs from the King method in that the average perpendicular distance is multiplied by the length of the census line to determine the area of the census. The author believes that the area computed is too small, when applied to deer, and results in too large a population estimate. The observer's field of vision is greater than the area calculated with this method. The average perpendicular distance is the shortest distance which could

be used to calculate the sample area. A certain portion of the area beyond the perpendicular distance to the deer will be censused as the observer continues along the line. This method, devised for censusing snowshoe hare, in part considers the protective, motionless behavior of this species. The method bears considerable merit in work with snowshoe hare, as movements to the left or right of the census line by this animal are not often seen.

The areas computed utilizing King's and Webb's methods represent the greatest and least areas respectively which can be calculated by averaging the recorded distances. A distance somewhere between the average direct distance and the average perpendicular would be more representative of the average effective width of the census strip. This distance would result in a population estimate between the low value computed by the King method and the high estimate as determined by the Webb method. The exact distance between these extremes cannot accurately be determined due to a lack of knowledge concerning deer behavior. However, population estimates based on Hayne's and Kelker's formulas fall between the estimates by the King and Webb methods.

Hayne Method.--An average population estimate of 257 deer with a confidence interval of 193 to 321 ($P = .05$) was derived by employing Hayne's method. The average population estimate falls midway between the average population estimates calculated from King's and Webb's formulas. Hayne, like King, used the direct distance to the flushing spot in determining the area of the census. However, King considered twice the average direct distance as being the effective width of the census strip, whereas Hayne used each

individual flushing distance in computing population estimates. In effect, the total population is the sum of subpopulations which are based on the individual distances of the deer from the observer. The total population estimate is weighted according to the closeness of each deer to the observer. It appears that the weighted estimate bears merit, as deer close to the line would surely be observed, whereas deer away from the central line of travel would not be as readily detected. The use of the direct distance in calculating the subpopulations results in the greatest amount of area for each subpopulation, and thus, somewhat lower population estimates. However, individual perpendicular distances cannot be used due to the occurrence of deer sighted directly on the census line. The author believes that the population estimate obtained by the Hayne method best approximates the true population value.

Kelker Method.---The application of the Kelker formula resulted in an average population estimate of 198 deer. The confidence limits are from 154 to 243 ($P = .05$). Kelker computed subpopulations of deer according to cover types. The difficulty in determining the precise acreage within each cover type from aerial photographs contributes to errors in subpopulation estimates. Within each cover type an effective width of census strip is determined. The width is chosen on the basis of uniformity of the recorded distances from the line perpendicular to the deer. The limited number of observations within each cover type resulted in a high degree of personal judgement involved in selecting the average effective width of the census strip per cover type. The personal judgement and the lack of desired

accuracy in determining cover type acreages have lessened the reliability of the population estimates calculated by the Kelker method.

Drive Counts

The apparent unequal distribution of the deer, especially in the winter when the drives were made, resulted in distorted population estimates. Deer tended to concentrate around the shore areas. The only sections of the island adaptable to drives were, with one exception, located around the shore. In addition to the unequal deer distribution, areas which were driven consisted mainly of spruce vegetation. Mixed hardwood, cedar, gray birch-bayberry, and pitch pine cover types were not well represented on the drive areas. The author feels that, for the above mentioned reasons, it is not valid to expand drive data to total population estimates for the entire island. Nevertheless, a high population density of one deer per seven acres was determined for one section of the island.

Aerial Counts

Total population estimates based on direct aerial counts of deer on an area are not accurate. It is impossible to make a direct count of the deer from the air within regions of substantial vegetative cover similar to Isle au Haut.

Habitat Evaluation

A total of 1334 pounds of available browse per acre was

calculated for the entire island (Table 11). Tree species composed 1211 pounds (91 percent) of the available browse. Low growing shrubs accounted for the remaining 123 pounds (9 percent) of accessible, woody vegetation. These figures represent near maximum weights. Twig weights of tree species were recorded in the late spring and, thus, were increased by the higher moisture content present at that time of year. Shrub weights were taken during the summer and included the weight of leaves. Although one species, sheep laurel, retains its leaves until the second fall after development, the recorded weights in the summer are greater than for any other season of the year.

Cedar was the only species present that is readily browsed by deer wherever available (Banasiak, 1961). The weight of available cedar was six pounds per acre. Red and white spruce accounted for 1153 (86 percent) of the available browse. These species are starvation foods for deer (Dahlberg and Guettinger, 1956; Taylor, 1956). Balsam fir is utilized to varying degrees in different regions of Maine (Banasiak, 1961). However, balsam fir is not a preferred browse species. Deer are unable to maintain their weight when it is the sole species in the diet (Dahlberg and Guettinger, 1956). Banasiak (1961) found that alder was infrequently browsed in Maine. It is considered to be one of the poorest of all deer foods in Minnesota (Erickson, et al., 1961). The use of juniper varies locally throughout Maine (Banasiak, 1961). Huckleberry and sheep laurel comprised 76 percent (94 pounds) of the 123 pounds of available shrub species per acre, and are sometimes eaten by deer in other

TABLE 11. TOTAL AVAILABLE BROWSE PER ACRE FOR ENTIRE ISLAND

Species	Pounds per Acre	Percent of Grand Total
Trees		
Red Spruce	1,062	79.6
White Spruce	91	6.8
Balsam Fir	28	2.1
Alder	23	1.7
Cedar	6	0.5
Bayberry	<u>11</u>	<u>0.1</u>
Total	1,211	90.8
Shrubs		
Huckleberry	69	5.2
Sheep Laurel	25	1.9
Juniper	22	1.6
All Other	<u>7</u>	<u>0.5</u>
Total	123	9.2
Grand Total	1,334	100.0

regions (Hamerstrom and Blake, 1939; Bramble and Goddard, 1943; Bramble and Goddard, 1953). However, Ripley and McClure (1963) reported that huckleberry and mountain laurel were emergency foods. The possibility of sheep laurel being poisonous to deer has been investigated by Marsh and Clawson (1930) and Forbes and Beckdel (1931). These authors concluded that sheep laurel is nonpoisonous when included in a mixed diet.

Deer require an estimated 3.5 to 5.5 pounds of natural browse per hundredweight of deer per day (Dahlberg and Guettinger, 1956). French, et al., (1956) determined that approximately three to four pounds (air-dry) of good quality food is needed to maintain growth of a 100-pound deer. The air-dry weight of three to four pounds of browse is equivalent to six to eight pounds of palatable woody vegetation of good moisture content.

It is apparent that the population of deer on Isle au Haut has exceeded the carrying capacity. This situation is reflected in the character of the vegetation and in the condition of the deer. Browse lines are present on cedar, alder, and black cherry (Figures 8 and 9). White spruce has been browsed in isolated areas by deer and hare to the extent that the trees have the appearance of pruned ornamental shrubs (Figure 10). The majority of the currently browsed twigs examined were utilized to a length greater than the present year's growth. Further deterioration of the habitat will continue unless a better balance between the deer and the vegetation is achieved.

The physical appearance of the deer is typical of an overpopulated area. The great majority of the animals observed were



FIGURE 8. EXCESSIVE DEER NUMBERS HAVE RESULTED IN BROWSE LINES ON ALDER (ABOVE) AND CEDAR (BELOW)



FIGURE 9. BROWSE LINE ON BLACK CHERRY



FIGURE 10. WHITE SPRUCE, A STARVATION FOOD, WAS SO SEVERELY BROWSED THAT SOME TREES RESEMBLED PRUNED ORNAMENTAL SHRUBS. NOTE TREE IN RIGHT CENTER.

much smaller compared to the deer elsewhere in Maine. It was difficult to distinguish older deer from fawns once the latter lost their spots. Twin fawns were observed on two locations of the island, but the remaining observations were of single fawns. One adult female was shot after being caught in a fence. This $5\frac{1}{2}$ year old female weighed but 75 pounds (total weight) and was in an emaciated condition (Appendix V).

A limited amount of data was obtained from the nutritional analysis of several potential sources of food (Appendix IV). Dietz (1965) stated that if the protein level of the diet fell below six to seven percent, rumen function became severely impaired. The protein requirement for optimal growth was found to be 13 to 16 percent by French, et al. (1956). Since all of the woody species collected had a protein level less than 13 percent, food sources other than browse must be considered further. It must be emphasized that without a thorough study, not only of nutritional composition of browse, but also of the degree to which the deer can use the food, important conclusions cannot be made.

An especially interesting food source for the deer apparently consists of marine growth. Rockweed, kelp, and Irish moss are common algae found abundantly around the shore areas. Whether the many deer observed feeding around the shore were utilizing sedges or grasses, obtaining salt from rocks, or feeding on algae growth could not definitely be determined. The possibility that algae is a food source has been pointed out by the fact that a marine algae, dulce, is a desirable and sought after food of sheep in Norway (Palmer, 1949).

The total amount of nutritional food obtained from herbaceous growth and incidental foods may contribute more to the well being of the deer than is realized. Skunk cabbage was heavily utilized in certain areas during the summer. Ferns were completely browsed on several small sections. A common lichen, old man's beard, grows on live and dead spruce trees throughout the island. Apparently deer fed upon this lichen as it was rarely growing within reach of the deer. Scotter (1964) suggested that in mature coniferous forests, arboreal lichens may make substantial contributions to the winter diet of barren-ground caribou. He determined that approximately 628 pounds per acre of accessible arboreal lichens were present in mature black spruce forests in northern Saskatchewan.

In view of an overall density of approximately one deer per 25 acres and a total amount of six pounds per acre of preferred browse, it is not surprising that both the deer and the vegetation show serious deterioration. The amount of good browse on the island is capable of supporting only one deer per 25 acres for one month. The total amount of available cedar on the entire island is approximately 40,000 pounds. Assuming a deer population of 250, and a daily consumption of five pounds per deer, the preferred cedar browse, if utilized 100 percent, is only capable of supporting the deer for one month. Obviously, the animals are subsisting on foods that sustain life, but seriously inhibit growth and reproduction. The range has been so heavily browsed that the composition of the vegetation has become unnaturally altered. Regeneration of cedar and hardwood species is absent. The forest floor is deficient of desirable

herbaceous growth. It is not biologically sound to allow deer to have such a pronounced influence on the total ecosystem. This condition should not be permitted to continue. If the present deer population was reduced by 75 percent and maintained at an approximate level of 60 deer, it would require several years before a noticeable change in the overall condition of the vegetation would occur.

Recommendations for Future Study

The existing conditions on Isle au Haut present a number of opportunities for future study. The present work has been introductory in many respects, but has verified the unbalanced relationship between the deer and the vegetation on the island. Data on the following topics would supplement the findings of the present study and would contribute significantly to the present knowledge of deer-vegetation interaction:

1. Population estimates based on continued and possible expansion of strip census counts.
2. Sex and age structure of the herd.
3. Physical characteristics and weights of individual deer.
4. Size, weight, and condition of vital organs.
5. Reproduction and fawn survival within the population.
6. Social intolerance among the deer.
7. Prevalence of disease and parasitism.
8. Effect of deer on plant regeneration including the use of exclosures.
9. Utilization and availability of food sources other than

woody browse, especially marine algae.

10. Contribution of nonpreferred browse species to the welfare of the deer.

Many additional studies, including predator-prey relationships and investigations of deer behavior, could be developed in such an outdoor laboratory.

SUMMARY

An introductory study was conducted from September, 1964 to December, 1965 on Isle au Haut, Maine, an area of distinctly heavy utilization by an apparently high density of deer. The objectives were to determine the number of deer on the island, to evaluate the existing habitat conditions, and to measure the influence of the deer upon the environment.

Strip censuses, deer drives, and direct aerial counts were employed to determine the size of the deer population. Overstory vegetation, understory tree species, and understory shrubs comprised the three categories considered in the evaluation of the existing habitat. These strata were measured by the Bitterlich point sampling, Shafer twig-count, and clip and weigh methods, respectively.

The following conclusions resulted from the investigation:

1. Isle au Haut has a present deer population between 250 and 300 animals, based on the Hayne strip census method.
2. Areas censused by deer drives were not representative, and, thus, deer densities determined for these areas do not apply to the entire island.
3. Direct aerial counts of the white-tailed deer are not feasible in regions of coniferous vegetation similar to Isle au Haut.
4. Serious habitat deterioration has resulted from a density of approximately one deer per 25 acres. A continuation of the present density will prolong the detrimental effects on both the deer and the vegetation.
5. The total amount of preferred browse was less than seven

pounds per acre for the entire island. Red spruce, white spruce, and poor quality shrubs composed 96 percent of the 1,334 pounds of available browse calculated per acre.

6. Deer subsisted to a large extent on food sources other than woody vegetation. A detailed study of the role of supplementary foods, especially marine algae, in the diet of the deer is necessary to better evaluate deer-vegetation relationships.

7. Specific information should be gathered by direct examination of deer in order to assess the effect of a deteriorated habitat upon the animals.

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BIOGRAPHY OF THE WRITER

John Charles Baird was born in Fredericton, New Brunswick, Canada on November 16, 1940. He attended public schools in Chipman, New Brunswick; South Portland, Maine, and Haverhill, Massachusetts.

In June 1962 he received a Bachelor of Science degree in Zoology from the University of Massachusetts. After graduating, he was employed by the United States Naval Oceanographic Office.

He married the former Nancy Jane Horsch in 1959. They have three children and have resided in Orono, Maine for the past three years.

In February 1964 he entered the Graduate School at the University of Maine. He served as a graduate assistant at the Maine Cooperative Wildlife Research Unit and received the degree of Master of Science in Wildlife Management in June 1966.

APPENDIX I

LIST OF SCIENTIFIC NAMES

Common NameScientific Name

Mammals (from Miller and Kellogg, 1955)

Deer, mule	<u>Odocoileus hemionus</u> (Rafinesque)
Deer, white-tailed	<u>Odocoileus virginianus</u> (Zimmermann).
Hare, snowshoe	<u>Lepus americanus</u> Erxleben

Birds (from American Ornithologists's Union, 1957)

Grouse, ruffed	<u>Bonasa umbellus</u> (Linnaeus)
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Plants (from Fernald, 1950)

Alder	<u>Alnus</u> spp. B. Ehrh.
Ash, mountain	<u>Pyrus americana</u> (Marsh.) DC.
Ash, white	<u>Fraxinus americana</u> L.
Aspen	<u>Populus grandidentata</u> Michx.
Bayberry	<u>Myrica pensylvanica</u> Loisel.
Birch, gray	<u>Betula populifolia</u> Marsh.
Birch, white	<u>Betula papyrifera</u> Marsh.
Birch, yellow	<u>Betula lutea</u> Michx. f.
Blueberry	<u>Vaccinium angustifolium</u> Ait.
Cedar, northern white	<u>Thuja occidentalis</u> L.
Cherry, black	<u>Prunus serotina</u> Ehrh.
Chokeberry	<u>Pyrus arbutifolia</u> (L.) L. f.
Fir, balsam	<u>Abies balsamea</u> (L.) Mill.
Huckleberry	<u>Gaylussacia baccata</u> (Wang.) K. Koch

<u>Common Name</u>	<u>Scientific Name</u>
Juniper	<u>Juniperus communis</u> L.
Larch	<u>Larix laricina</u> (DeRoi) K. Koch
Laurel, mountain	<u>Kalmia latifolia</u> L.
Laurel, sheep	<u>Kalmia angustifolia</u> L.
Leather-leaf	<u>Chamaedaphne calyculata</u> (L.) Moench
Maple, red	<u>Acer rubrum</u> L.
Maple, striped	<u>Acer pensylvanicum</u> L.
Oak, northern red	<u>Quercus rubra</u> L.
Pine, loblolly	<u>Pinus Taeda</u> L.
Pine, pitch	<u>Pinus rigida</u> Mill.
Pine, red	<u>Pinus resinosa</u> Ait.
Pine, short-leaf	<u>Pinus echinata</u> Mill.
Pine, white	<u>Pinus Strobus</u> L.
Rose	<u>Rosa</u> sp. L.
Skunk cabbage	<u>Symplocarpus foetidus</u> (L.) Nutt.
Spiraea	<u>Spiraea latifolia</u> (Ait.) Borkh.
Spruce, red	<u>Picea rubens</u> Sarg.
Spruce, white	<u>Picea glauca</u> (Moench) Voss
Sweetfern	<u>Comptonia peregrina</u> (L.) Coult.
Winterberry	<u>Ilex verticillata</u> (L.) Gray
Witherod	<u>Viburnum cassinoides</u> L.
Algae (from Taylor, 1957)	
Dulse	<u>Rhodymenia palmata</u> (L.) Greville
Irish moss	<u>Chondrus crispus</u> Stackhouse

Common NameScientific Name

Kelp

Laminaria spp. Lamouroux

Rockweed

Fucus spp. L. orAscophyllum nodosum (L.) LeJolis

Lichens (from Fink, 1935)

Old man's beard

Usnea spp. (Dill.) Adans.

APPENDIX II. OVERSTORY STAND TABLES

Tables 1 - 8

TABLE II - 1. SPRUCE I COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre								Total
	Red Spruce	Red Maple	Balsam Fir	Yellow Birch	White Birch	Gray Birch	White Pine	Aspen	
1	452		10				18		452
2	131		18				18		167
3	64		8			8			80
4	36	16	12		4	4			72
5	72	3		3		5			83
6	52	3	2	3		3			63
7	43	5	3	1					52
8	35	2	2						39
9	29	3		1	2				35
10	15	4		2	1			1	23
11	12								12
12	8								8
13	2				*				2
14	4								4
15	1								1
16	1								1
17	1								1
18	*								*
19	*								*
20+	1								1
Total	959	36	45	10	7	20	18	1	1096

* Less than 1 tree per acre.

TABLE II - 2. SPRUCE II COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre							Total
	Red Spruce	White Spruce	Red Maple	Pitch Pine	Aspen	Gray Birch	Cedar	
1								
2	37					37		74
3	66	17						83
4	37	9						46
5	36	6	12	6	12			72
6	29	8			4		4	45
7	30	6		3				39
8	21		5					26
9	15	2	2					19
10	6		3					9
11	4							4
12	6							6
13				1				1
14	1							1
15								
16	1			1				2
17	1							1
18								
19								
20+								
Total	290	48	22	11	16	37	4	428

TABLE II - 3. MIXED HARDWOOD COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre												Total
	Red Maple	Red Spruce	Yellow Birch	White Birch	Cedar	Balsam Fir	Gray Birch	Striped Maple	Aspen	White Spruce	N. Red Oak	White Ash	
1		90											90
2	23	23				23							69
3	30	30	10			10	20	10					110
4	28	6			6	11	11			6			68
5	32	7	4		4	4	4						55
6	22	12	3	5			2	2					46
7	24	6	6	6	2	2		2					48
8	11	7	3	1	1					1		1	25
9	12	7	8	1	2			1					31
10	6	5	2	2		2			2				19
11	4	1	2	1	1								9
12	4		4						1				9
13	1	1											2
14	1	*	*						*		*		1
15	*	*			1				*				1
16		*	*										*
17	*	*	*										*
18	1	*		*									1
19	*												*
20+					*								*
Total	199	195	42	16	17	52	37	15	3	7	*	1	584

* Less than 1 tree per acre.

TABLE II - 4. PITCH PINE COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre			Total
	Pitch Pine	Red Spruce	Red Maple	
1		90		90
2	23		68	91
3	30	20	20	70
4	51	17		68
5	36	4	4	44
6	32	10		42
7	46	6		52
8	32	6		38
9	20	4		24
10	13	2		15
11	8			8
12	2	1		3
13	1	1		2
14	1			1
15	*	*		*
16				
17				
18				
19				
20+				
Total	295	161	92	548

* Less than 1 tree per acre.

TABLE II - 5. Alder Cover Type

D.b.h. (Inches)	Number of Trees per Acre						Total
	Alder	Bayberry	Red Spruce	White Spruce	Red Maple	Gray Birch	
1	904	452					1356
2	383	45					428
3	120				10		130
4	22					6	28
5			4				4
6			3				3
7			2				2
8			3				3
9					1		1
10				2			2
11							
12			1				1
13							
14				*			
15							
16							
17				1			1
18							
19							
20+							
Total	1429	497	13	3	11	6	1959

* Less than 1 tree per acre.

TABLE II - 6. CEDAR COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre									Total
	Cedar	Red Spruce	Red Maple	Balsam Fir	White Birch	Gray Birch	White Ash	Aspen	Red Pine	
1						90				90
2	23									23
3				10	10	10				30
4	56	17	22	6		6				107
5	36	4	7							47
6	60	7	12							79
7	22	2	4				2			30
8	25	3	3		1					32
9	14	1	2	1	1					19
10	10	3	1							14
11							1			1
12	1	1	1						1	4
13		2	1							3
14	1	*						*		1
15										
16	*									
17	*									
18										
19										
20+										
Total	248	40	53	17	12	106	3	*	1	480

* Less than 1 tree per acre.

TABLE II - 7. GRAY BIRCH-BAYBERRY COVER TYPE

D.b.h. (Inches)	Number of Trees per Acre									Total
	Gray Birch	Bayberry	Alder	Red Spruce	Red Maple	Cedar	Larch	White Spruce	Balsam Fir	
1	542	1446	813						90	2891
2	270	68	135							473
3	140		10	10			10			170
4	34		6		6	11				57
5	11			14	4		4			33
6	2			12	2	7	2			25
7				7	4	2		2		15
8				3	1					4
9				1	1					2
10				2	1					3
11										
12										
13										
14				*	*					*
15				*						*
16										
17										
18										
19										
20+										
Total	999	1514	964	49	19	20	16	2	90	3673

* Less than 1 tree per acre.

TABLE II - 8. ENTIRE ISLAND

D.b.h. (Inches)	Number of Trees per Acre								
	Red Spruce	Red Maple	Alder	Bayberry	Gray Birch	White Birch	Yellow Birch	Cedar	Balsam Fir
1	243		52	46	13				2
2	74	7	18	3	13			1	11
3	51	5	5		9	*	1		5
4	28	12	1		4	2		2	8
5	47	8			3		2	2	*
6	35	3			2	*	2	3	1
7	30	5				1	1	1	1
8	24	3				*	*	1	1
9	19	3				1	1	1	*
10	9	4				*	1	*	*
11	7	*				*	*	*	
12	5	*					*	*	
13	1	*				*			
14	2	*					*	*	
15	1	*						*	
16	1						*	*	
17	1	*					*	*	
18	*	*				*			
19	*	*						*	
20+	*								
Total	578	50	76	49	44	4	8	11	29

* Less than 1 tree per acre.

TABLE II - 8. Cont'd.

D.b.h. (Inches)	Number of Trees per Acre								Total
	Pitch Pine	Aspen	White Spruce	Striped Maple	No. Red Oak	White Ash	Larch	Red Pine	
1									356
2	1								128
3	2		4	1			*		83
4	3		3						63
5	4	3	1				*		70
6	2	1	2	*			*		51
7	4		1	*		*			44
8	2		*			*			31
9	1		*	*					26
10	1	1	*						16
11	1					*			8
12		*						*	5
13									1
14		*	*		*				2
15		*							1
16									1
17			*						1
18									*
19									*
20+									*
Total	21	5	11	1	*	*	*	*	887

*Less than 1 tree per acre.

APPENDIX III. UNDERSTORY TABLES

Tables 1 - 8

TABLE III - 1. SPRUCE I COVER TYPE

Diameter Class ^{1/} (Inches)	Number of Trees per Acre		
	Red Spruce	Balsam Fir	Total
0.0-0.5	180		180
0.6-1.0			
1.1-1.5	72	32	104
1.6-2.0			
2.1-2.5	72		72
2.6-3.0	72		72
3.1-3.5	32		32
3.6-4.0	72		72
4.1+	284	32	316
Total	784	64	848

^{1/} Diameters measured 6 inches above the ground.

TABLE III - 2. SPRUCE II COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre		Total
	Red Spruce	Yellow Birch	
0.0-0.5	250		250
0.6-1.0	250		250
1.1-1.5			
1.6-2.0	83		83
2.1-2.5	83		83
2.6-3.0			
3.1-3.5			
3.6-4.0			
4.1+	250	166	416
Total	916	166	1082

TABLE III - 3. MIXED HARDWOOD COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre						Yellow Birch	Aspen	Total
	Red Spruce	Balsam Fir	Red Maple	White Spruce	Gray Birch				
0.0-0.5	550	50			50				650
0.6-1.0	250				50				300
1.1-1.5	50								50
1.6-2.0									
2.1-2.5									
2.6-3.0									
3.1-3.5		50	50	50			50		200
3.6-4.0		50							50
4.1+			100	50				100	250
Total	850	150	150	100	100		50	100	1500

TABLE III - 4. PITCH PINE COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre			
	Pitch Pine	Red Spruce	Red Maple	Total
0.0-0.5		50		50
0.6-1.0				
1.1-1.5				
1.6-2.0				
2.1-2.5	50			50
2.6-3.0	50			50
3.1-3.5	50		100	150
3.6-4.0	50	50		100
4.1+	350	100		450
Total	550	200	100	850

TABLE III - 5. ALDER COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre			Total
	Alder	Bayberry	Red Spruce	
0.0-0.5	450			450
0.6-1.0	550	100		650
1.1-1.5	700	50		750
1.6-2.0	700			700
2.1-2.5	300			300
2.6-3.0	250		50	300
3.1-3.5	300			300
3.6-4.0				
4.1+				
Total	3250	150	50	3450

TABLE III - 6. CEDAR COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre			
	Cedar	Red Spruce	Red Maple	Total
0.0-0.5				
0.6-1.0				
1.1-1.5				
1.6-2.0				
2.1-2.5		50		50
2.6-3.0				
3.1-3.5				
3.6-4.0	50			50
4.1+	200		50	250
Total	250	50	50	350

TABLE III - 7. GRAY BIRCH-BAYBERRY COVER TYPE

Diameter Class (Inches)	Number of Trees per Acre							Total
	Alder	Bayberry	Red Spruce	Gray Birch	Balsam Fir	Larch	Cedar	
0.0-0.5	50	150	100					300
0.6-1.0	200	450	50	50	50			800
1.1-1.5	250	50						300
1.6-2.0	150	50		100				300
2.1-2.5			50					50
2.6-3.0				50				50
3.1-3.5								
3.6-4.0			50			50		100
4.1+				50	50		50	150
Total	650	700	250	250	100	50	50	2050

TABLE III - 8. ENTIRE ISLAND

Diameter Class (Inches)	Number of Trees per Acre										Total
	Red Spruce	Alder	Bay- berry	Balsam Fir	Red Maple	White Spruce	Gray Birch	Yellow Birch	Aspen	Cedar	
0.0-0.5	205	19	3	5			5				237
0.6-1.0	80	26	13	1			6				126
1.1-1.5	41	33	3	16							93
1.6-2.0	18	31	1				2				52
2.1-2.5	57	12									69
2.6-3.0	38	10					1				49
3.1-3.5	16	12		5	11	5		5			54
3.6-4.0	41			5						2	48
4.1+	206			17	12	5	1	36	10	7	294
Total	702	143	20	49	23	10	15	41	10	9	1022

APPENDIX IV. CHEMICAL COMPOSITION (PERCENT DRY BASIS) OF
POTENTIAL FOOD SOURCES

Species	Date Collected	Protein	Fat	Fiber	Ash	Nitrogen Free Extract
Alder	3/8/65	11.19	9.68	19.04	2.45	57.64
	8/10/65	12.57	8.28	19.64	2.53	56.98
Red Spruce	3/8/65	6.94	7.40	28.06	2.15	55.45
White Spruce	3/8/65	7.85	7.23	23.51	2.50	58.91
Cedar	3/8/65	6.38	10.71	24.34	4.62	53.95
White Birch	8/10/65	11.32	6.00	19.43	2.91	60.34
Yellow Birch	8/10/65	11.66	3.81	22.69	3.64	58.20
Gray Birch	8/10/65	9.28	8.05	21.75	2.39	58.53
Red Maple	8/10/65	7.44	7.36	21.06	3.24	60.90
Bayberry	8/10/65	10.81	4.50	20.72	3.02	60.95
	7/26/65	5.25	2.40	41.16	2.84	48.35
Winterberry	7/26/65	4.25	3.62	30.66	2.53	58.94
	8/10/65	11.38	3.06	15.84	4.19	65.53
Witherod	7/26/65	4.94	7.53	29.31	3.06	55.16
	8/10/65	8.85	7.15	15.03	4.15	64.82
Chokeberry	7/26/65	4.56	2.71	24.74	3.00	64.99
Huckleberry	7/26/65	3.00	3.14	43.47	1.76	48.63
	8/10/65	8.00	9.21	24.09	2.60	56.10
Sheep Laurel	7/26/65	3.56	5.22	39.79	0.98	50.45
	8/10/65	7.03	7.38	20.26	1.92	63.41
Spiraea	7/26/65	4.13	---	31.57	1.60	---
	8/10/65	9.06	3.10	24.61	3.06	60.17
Sweet Fern	8/10/65	9.78	6.46	14.61	2.17	66.98
Skunk Cabbage	8/10/65	25.47	6.72	10.55	9.83	47.43
Rockweed	3/8/65	14.63	1.53	5.03	25.16	53.65
Kelp	3/8/65	14.57	0.54	10.10	28.88	45.91
Old Man's Beard	3/8/65	5.38	5.98	10.90	1.63	76.11

APPENDIX V

DIAGNOSTIC REPORT - ACCOUNT NO. 1326

On February 8, 1965, Dr. J. F. Witter, Head of the Department of Animal Pathology, examined a deer shot on Isle au Haut on February 4, 1965. The animal had been caught in a fence and was in an emaciated condition. This $5\frac{1}{2}$ year old female weighed only 75 pounds and was carrying a single fetus.

No subcutaneous or visceral fat was evident. The bone marrow was somewhat watery and contained an estimated fat content of 50 and 35 percent in the femur and tibia, respectively.

Lesions were absent in vital organs except for ulcers in the abomassum, near the pylorus. Tests for brucellosis and leptospirosis were negative. A few lungworm larvae were found. Macroscopic examination of nervous tissue failed to reveal the presence of meningeal worms.

National Park Service Division of Natural History Sciences	ACAD-66
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