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A method for comparing food and cover conditions for pheasants on grazed and ungrazed areas

A METHOD FOR COMPARING FOOD AND COVER CONDITIONS FOR PHEASANTS ON GRAZED AND UNGRAZED AREAS

by

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INTRODUCTION

Grazing, as an important land use, has greatly interested the author since his experience in range management in the western range country with the U. S. Forest Service. Having become range or forage conscious, the writer returned to his native State, Illinois, and observed for the first time the temporary and permanent pastures in the middle west from an entirely different viewpoint. Although the flora of the middle west is distinctly different from that of the western range country, accoring to the author's criteria of range appraisal, he was convinced that the pastures of the mid-west were, for the most part, seriously over-grazed and were carrying stock far in excess of their permanent carrying capacities. To prove such an assumption, however, was absolutely impossible in the light of present knowledge of mid-western pastures, there being a dearth of information concerning vegetative composition, superior and inferior forage plants, poisonous plants, proper grazing seasons, and all such pertinent data in regard to pasture management.

The writer, (1939), unpublished manuscript, has reviewed much of the current literature on mid-western pasture management, and has suggested several phases that need particular emphasis if we are to be able to care for the increase in livestock production that seems inevitable in view of present agricultural trends. The scope of this unpublished manuscript was very broad. In order to carry the general theme of necessary pasture investigations still further, but with restricted scope, the writer has concentrated his efforts on but one phase of grazing; its relation to wildlife.

The purpose of this investigation is two fold. First, to determine the effects of commonly existing grazing pressures in the vicinity of Ann Arbor, Michigan on food and cover conditions for upland game birds, particularly pheasants. Any measurement of vegetative disturbances calls for a definite technic. Whereas there are several methods one may use in determining such ecological differences as brought about by grazing, such as the various laborious technics as outlined by Sampson, (1923), there has been relatively little done in the way of perfecting rapid methods of reconnaissance. The second purpose of this investigation was, therefore, to determine the effectiveness of the tool known as the visibility board to rapidly measure such vegetative changes as brought about by grazing. The visibility board, explained on pages 5, 8, 20, and 51, is distinctly a new technic, Wight, (1938), being the only investigator to date calling attention to its usefulness. This study is, therefore, more or less an initial test for this tool, as statistics have been applied to the data obtained by the use of this visibility board, in an effort to determine its efficiency.

Observations were, by necessity, carried on throughout the winter months, circumstances not permitting a year long study. The measurements were, therefore, made during the critical time for game birds, i.e., October, November, December, January, February, March, and April.

ACKNOWLEDGEMENTS

The writer is especially indebted to Professors S. A. Graham, H. M. Wight, and E. C. O'Roke of the School of Forestry and Conservation, University of Michigan, whose cooperation and many helpful suggestions have made this investigation possible.

The author wishes to express his appreciation to the farmers of Scio, Dexter, and Northfield Townships for their cooperation in permitting field studies to be conducted on their properties.

MATERIALS

The materials used in this investigation were: Weston photronic exposure meter, visibility board, tape measure, wire quadrat frame, and type sheets.

The visibility board, as shown in figure 2, consisted of a piece of masonite 24" x 10" x ¼". The board was nailed to a 10" x 4" x 2" white pine block, through which was run an iron spike 4" long to enable the board to remain in an upright position. The board was painted white and was divided into 24 squares, each 3" x 3 1/3" square. The squares were numbered consecutively with black figures from left to right across the top, and from right to left in the next horizontal column. A picture of the visibility board appears as figure 2.

The back of the visibility board was covered with a pencil gray sheet of cardboard measuring 10" x 10" x 1/16". This was used in connection with the Weston photronic exposure meter which will be explained later in the discussion of the methods of procedure.

The wire quadrat frame consisted of number 9 wire bent into the form of an open square measuring two feet on a side. The wire quadrat was forced through the vegetation and the fourth side was closed with a wire of the correct length.

The type sheets used, as exampled on the following page, were printed on heavy manilla paper, and were carried in a small leather field notebook.

The tape measure consisted of a six foot spring steel tape purchased from a hardware store.

TYPE SHEET

Sec.____.T.____.R.____. Plot No.____. Date______________.
Vegetative Type______. Class of Stock_______.Area______.
Present Grazing Pressure_________.Past Pressure________.
Light Intensity Inside Plot____.Outside____. Percentage of
Light Interception________. % Ver. Visibility__________.
Remarks____.

FOOD
Q____:
D____:
A____:

COVER
H____:
D____:
S____:

CONCEALMENT

:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:
:	:	:	:

FINAL RATING

FOOD___________.
COVER__________.
CONCEALMENT______.
LIGHT INTEN._____.

FOOD
Q---quality
D---density
A---availability

COVER
H---height
D---density
S---stability

Fig. 1.

Visibility Board

Fig. 2.

METHODS OF PROCEEDURE

In the vicinity of Ann Arbor, Michigan there are essentially four major types of pastures, namely, farm woodlots, marshes, mixed herbaceous types mostly of indigenous origin, and cultivated types such as alfalfa, sweet clover, etc. Grazed and ungrazed areas of each of the above major types were studied and fifty, and in some instances twenty-five samples, randomly located were made in each area under investigation.

The areas worked appear in tabular form on the following page.

The procesdure followed in this work had two distinct phases, i.e., field and office compilation. The former was chiefly concerned with gathering of quantitative data as to food, wover, concealment, and light intansity conditions. The derivation of comparative ratings of the factors measured in the types under investigation, and the presentation of such data were the principal office undertakings.

The methods used for measuring and recording the data on a quantitative basis were, in the main, those advanced by Trippensee, (1934), Wight, (1932) unpublished manuscript, and Wight, (1938).

Areas Studied

Type	Size	Location	Class of Stock	Pressure of Grazing	Past History
Grazed Oak-Hickory	8 acres	$E\frac{1}{2}$, $SW\frac{1}{4}$, Sec. 31 Northfield Township, Washtenaw County, Mich.	Sheep	1 sheep per .44 acres for 4 months	Same for 30 years.
Ungrazed Oak-Hickory	10 acres	$S\frac{1}{2}$, $SE\frac{1}{4}$, Sec. 20 Dexter Township Washtenaw County Michigan	None	None	Same for 5 years
Grazed Marsh	8 acres	$S\frac{1}{2}$, $NW\frac{1}{4}$, Sec. 8, Dexter Township, Washtenaw County Michigan	Sheep	One sheep per .33 acres for 3 months	Same for 4 years
Ungrazed Marsh	4 acres	$SW\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 7 Dexter Township, Washtenaw County Michigan	None	None	Same for 4 years
Grazed Sweet Clover	18 acres	$SW\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 7. Scio Township, Washtenaw County Michigan.	Cattle	One cow per $1\frac{1}{8}$ acre for 3 months	Same for 2 years
Ungrazed Sweet Clover	10 acres	$W\frac{1}{2}$, $NW\frac{1}{4}$, $SE\frac{1}{4}$, Sec. 6 Scio Township Washtenaw County Michigan	None	None	Same for 1 year
Grazed Mixed Herbaceous	10 acres	$E\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 7 Dexter Township Washtenaw County Michigan	Sheep	One sheep per .28 acres for 4 months	Same for 5 years
Ungrazed Mixed Herbaceous	12 acres	$NW\frac{1}{4}$, $SW\frac{1}{4}$, Sec. 17 Dexter Township Washtenaw County Michigan	None	None	Same for 3 years

Three biotic factors and one physical factor were recognized in this investigation. These included food, cover, vegetative concealment or the reverse, visibility, and the measurement of light intensities occuring inside and outside of the quadrats. Each were given a total score of 99. Food and cover were further subdivided into three catagories, each receiving a maximum value of 33.

Measurement of Food

In the case of food, the following characteristics were recognized:

1. Quality: Food quality was determined through a practical knowledge of the nutritional value and preferences or relative palatabilities of the food in question for pheasants. The food tables appearing on the following two pages are taken from Dalke, (1934). By becoming familar with the food preferences of the pheasant, it was possible to break the total value of 33 for quality into the following classes and scores:

Class	Score
High value (stable foods)	33
Medium value (known to be frequenty eaten)	22
Low value (known to be regularly eaten)	11
Low value (known to be infrequently eaten)	0

2. Density: The second characteristic, that of

Percentage of Plant and Animal Food Eaten by Adult Pheasants in Sept., Oct., Nov., Dec., Jan., Feb., and Mar. *

Table I.

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Plant	94.6	98.1	99.8	99.9	96.1	1000	99.9
Animal	3.6	1.9	.2	.1	3.6	0.0	.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Percentages of the More Important Wild Seeds Eaten by Adult Pheasants Based Upon Crop Analysis *

Table II.

Seeds	% of total year's food	% of total quantity of seeds eaten
Ragweed(*Ambrosia artemisiifolia*)	6.3	51.4
Hog peanut(*Amphicarpa monocia*)	1.6	12.9
Yellow Foxtail(Setaria glauca)	1.1	8.8
Skunk Cabbage(*Symplocarpus foetidus*)	1.0	8.2
Green Foxtail(*Setaria viridis*)	0.9	7.5
Black Bindweed(*Polygonum convolvulus*)	0.5	3.9

Percentages of the More Important Fruits Eaten by Adult Pheasants Based Upon Crop Analysis *

Table III.

Fruits	% of total year's food	% of total amount of fruits eaten
Frost Grape(*Vitis vulpina*)	4.1	54.3
Panicled Dogwood(*Cornus paniculata*	0.4	5.3
Nightshade(*Solanum dulcamara*)	0.3	3.9
Elderberry(*Sambucus canadensis*)	0.2	2.8

Percentage of the Species of Cultivated Grain Eaten to Total Food Consumed for Each Month *

Table IV

Species	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Corn	33	50	28	75	34	72	47
Wheat	23	5	6	2	2	6	40
Barley	18	3	2	0	0	0	0
Beans	trace	1	3	2	0	1	0
Oats	2	3	2	trace	trace	1	0
Buckwheat	5	2	0	0	0	0	0

Percentages of the Principal Foods of Adult Pheasants *

Foods	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Cultivated Grains	75.52	64.98	40.68	79.35	35.96	80.20	86.08
Wild seeds	13.18	21.09	41.70	18.79	4.47	16.75	2.89
Fruits and nuts	45.24	11.68	17.12	1.69	45.75	0.00	0.31
Grasses and leaves	0.12	0.35	0.24	0.14	10.23	3.05	10.71
Insects	3.89	1.84	0.27	0.02	3.57	0.00	0.01
Other animals	0.52	0.07	0.00	0.00	0.14	0.00	0.00

density, was broken down into the following classes and scores:

Class	Score
Abundant	33
Medium amount	22
Present in small quantities	11
Not present	0

3. Availability: This characteristic is an extremely important one. A food of great value and perhaps even in large quantities may be rendered worthless to pheasants if such food is not available. Factors affecting the availability are such things as time of year seeds and fruits mature, the presence of snow sufficiently deep to cover the food supply, the presence of water in the marsh types covering the food supply, and instances where the cover has become matted down covering the food. Factors affecting the availability of pheasant foods were constantly kept in mind, and the perfect score of 33 was broken down as follows:

Class	Score
Good availability	33
Medium availability	22
Poor availability	11
Inaccessible	0

Measurement of Cover

The second major biotic factor recognized in this investigation was that of cover. As in the case of food, the method suggested by Trippensee, (1934), was used.

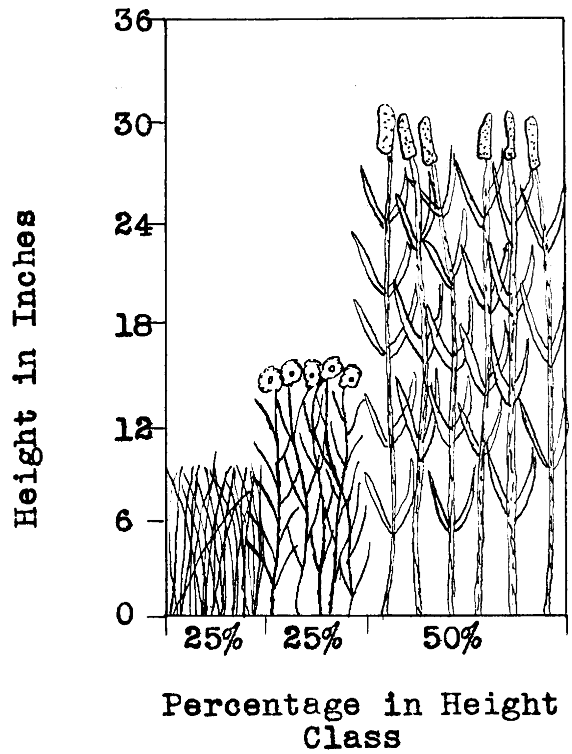
In the case of cover, the following characteristics were evaluated:

1. Height: The vegetative heights were divided into the following scores and classes:

Class	Score
0-2"	0
3-6"	5
7-12"	16
13-18"	22
18"-over	33

In order that a reliable average of the heights within a quadrat might be obtained, the weighted average determination as diagramatically illustrated on the following page was used. It is relative simple to train one's eye to estimate percentages of the various height classes occuring within a quadrat. Although it is admitted that such ocular estimation brings in the element of personal error, the author's experience with western grazing survey crews revealed that individuals, if checked frequently, can be trained to estimate vegetative conditions ocularly with a

Average Height Determination



Ht. in inches	% of Ht. class	Product
9	25	225
15	25	375
30	50	1500
		2100

$\frac{2100}{100} = 21.00$, average height in inches.

Fig. 3.

surprizing degree of consistency. For this reason, it was held by the writer that ocular estimation should be no cause for not adopting this system as a possible technic to be used by field surveys in connection with other investigations.

2. Density: The density was determined by actually counting the number of stalks within the limits of the wire quadrat. To insure uniformity, the stalks were counted at a height of 6 inches above the ground, except in the case of a grazed mixed herbaceous type where little or none of the vegetation reached such a height. In this case, stems were counted at a 2 inch level. Density classes and scores were as follows:

Class	Score
1-5 stalks	1
6-10 "	2
11-25 "	3
26-50 "	5
51-100 "	10
101-150 "	15
151-200 "	22
200-over "	33

3. Stability: Stability, or the ability of the vegetation to withstand the effects of the weathering processes, is a factor that is very important in determining the effectiveness of a certain cover to hold game birds,

particularly during the critical winter months. Stability, likewise, was estimated ocularly. By observing the ability of the various plants to withstand weathering, it was possible to formulate rather definite ideas as to the plants which fell into the following groups:

Class	Score	Example
No value to animal	0	Bluegrass
Low value	11	Quackgrass
Medium value	22	Sweet Clover
High value	33	Low juniper, sedges, and brush occuring in ungrazed marsh types.

Measurement of Light Intensity

The measurement of light intensity was the only physical factor taken into consideration in this study. Light intensity values were obtained by the use of the Weston photronic exposure meter, model 617. The procedure followed to obtain such measurement was as follows: On the back of the visibility board was placed a sheet of pencil gray cardboard as explained in the section on materials in this treatise. The visibility board, serving only as a base for the attached cardboard, was carefully slipped under the vegetation occuring within a quadrat. Care was taken to always place the board in the center of of the plot. The investigator then held the exposure meter approximately 10 inches above the cardboard, care being taken to see that his shadow did not fall within the quadrat. The intensity value obtained from the meter in this position was taken as the light intensity inside the plot. Immediately following this measurement, the cardboard was held in full sunlight above the observer's shoulder. A second reading, or the light intensity outside the plot was obtained. The pencil gray cardboard served to give a uniform background for the two readings. By dividing the light intensity inside the plot by the light intensity outside the quadrat, the percentage of light interception was computed. A discussion pertinent to this portion of the technic appears on page 54.

Measurement of Vegetative Concealment

The use of the visibility board as a means of determining the relative effectiveness of a given cover to obscure the board from the observer's view, is distinctly a new technic. To the writer's knowledge, there has been no published information on the effectiveness of this tool. To Wight, (1938), goes the credit for the first suggestion of the visibility board. Wight's board was six feet high, a foot wide, and was divided into six one foot squares. With this instrument he was able to measure the concealment, or the reverse of this, visibility, of a six foot stratum.

Because so little is known about the relative merits of the visibility board, the author has placed considerable emphasis on this technic throughout this investigation. This study is, more or less, an initial test for the visibility board, as statistics have been applied to the visibility data in an effort to determine the value of this board to obtain data quickly and accurately.

The following is a brief account of the procedure used in determining vegetative concealment: A series of two foot square quadrats was laid out by stepping off one chain (66 feet). The quadrat frame was always placed in relation to the spot located by the heel mark of the last step. The visibility board was then placed in the middle of the plot, care being taken to not disturb the vegetation more than was absolutely necessary.

By pushing the steel spike in the base block into the ground, the board remained quite stationary even during periods of high winds. The investigator then paced two-thirds of a chain (44 feet) away from the visibility board, turned so as to face the board directly, and then recorded on the type sheet only those figures which could be clearly read. The phrase, "figures that could be clearly read" can not be over emphasized, for upon this depends the success of the board. If, when looking at the visibility board, the investigator is puzzled as to whether or not to include a certain figure as clearly visible, he should ask himself the question, "Could I reproduce the figure before me had I never seen it before?". If he could not, the figure in question should not be checked as clearly visible. Only by adopting such a means of fair play will accurate and consistant results be obtained.

Following the reading of the visibility board, the investigator returned to the quadrat and measurements of food, cover, and light intensity were performed as explained in the previous discussions. Upon completing a quadrat, another was located a chain ahead, travel always being in a cardinal direction, and the process was repeated.

Office Proceedings

Office proceedings were largely concerned with the computing of such statistical information as arithmetic means, standard errors of the means, standard deviations, and standard errors of the differences. The latter was determined in order to find the probability that the observed differences occuring in the grazed and ungrazed areas were due to actual conditions or to errors in sampling.

Preparation of charts, tables, and writing of the various discussion were the final undertakings.

RESULTS

Statistics have been applied to all field data collected. The statistical computations appear in the appendix of this treatise. Some may care to study the statistical portion of this investigation rather thoroughly. For the sake of brevity, however, a brief statement of the statistical evidences supporting the data obtained is made in each of the following sections of the results of this field investigation.

Grazed vs Ungrazed Oak-hickory

By consulting the summary of statistical data on page 48, it is seen that the standard error of the difference as expressed in normal deviates for the three biotic factors, food, cover, and vegetative concealment for grazed and ungrazed oak-hickory types are all in considerable excess of plus or minus four. Four normal deviates, assuming a normal curve, denotes a probability of error in sampling such as incorrect recording, as less than 3 chances in 100,000. In cases, therefore, exceeding four normal deviates, the chances for error are far less than 3 in 100,000 and conclusions may be drawn with the assurance that such differences actually exist. Granting then, that the data in regard to grazed and ungrazed oak-hickory types are statistically satisfactory, comparisons will be made between the three biotic factors measured.

The diagrams on page 28 illustrate the average food, cover, and concealment percentages occuring in grazed and ungrazed oak-hickory areas. It is seen that the greater percentage of the three factors occur in the ungrazed area. Food in the ungrazed area exceeded that of the grazed type by 13%, cover by 23%, and vegetative concealment by 23%. The same situation is revealed when comparisons are made between the average ratings of the food and cover characteristics as shown on page 49. In the case of food, quality in the ungrazed area exceeded that of grazed by 6.38, quantity by 1.54, and availability by 4.84.

In regard to cover characteristics, height in the ungrazed type is 16.90 greater than the grazed woodlot, density 3.26, and stability is 2.42 greater than the grazed area.

The vegetative concealment value as shown on page 28, is more strikingly compared if presented on the basis of the percentage of concealment occuring in the first and second foot strata. This comparison is shown in Fig. 7. In interpreting the figure, a word of explanation is necessary. The 47% of concealment in the first foot of the grazed area is not confined to the lower 47% of the first foot as the diagram indicates. Instead, 47% of the entire first foot is concealed, the remaining 63% consisting of scattered openings in the first foot stratum. In the grazed oak-hickory woods, grazed at a pressure of one sheep per.44 acres for four months, there was no concealment offered in the second foot stratum of the vegetation. In the case of the ungrazed woodlot, 23% of the secomd foot of vegetation offered concealment, and 70% of the first foot layer.

Grazed Oak-Hickory Type

(One Sheep per .44 Acres for 4 Months)

Fig. 4.

Ungrazed Oak-Hickory Type

Fig. 5.

Comparison Between Food, Cover, and Concealment in Grazed and Ungrazed Oak-Hickory Types.

(100 Plot Sample)

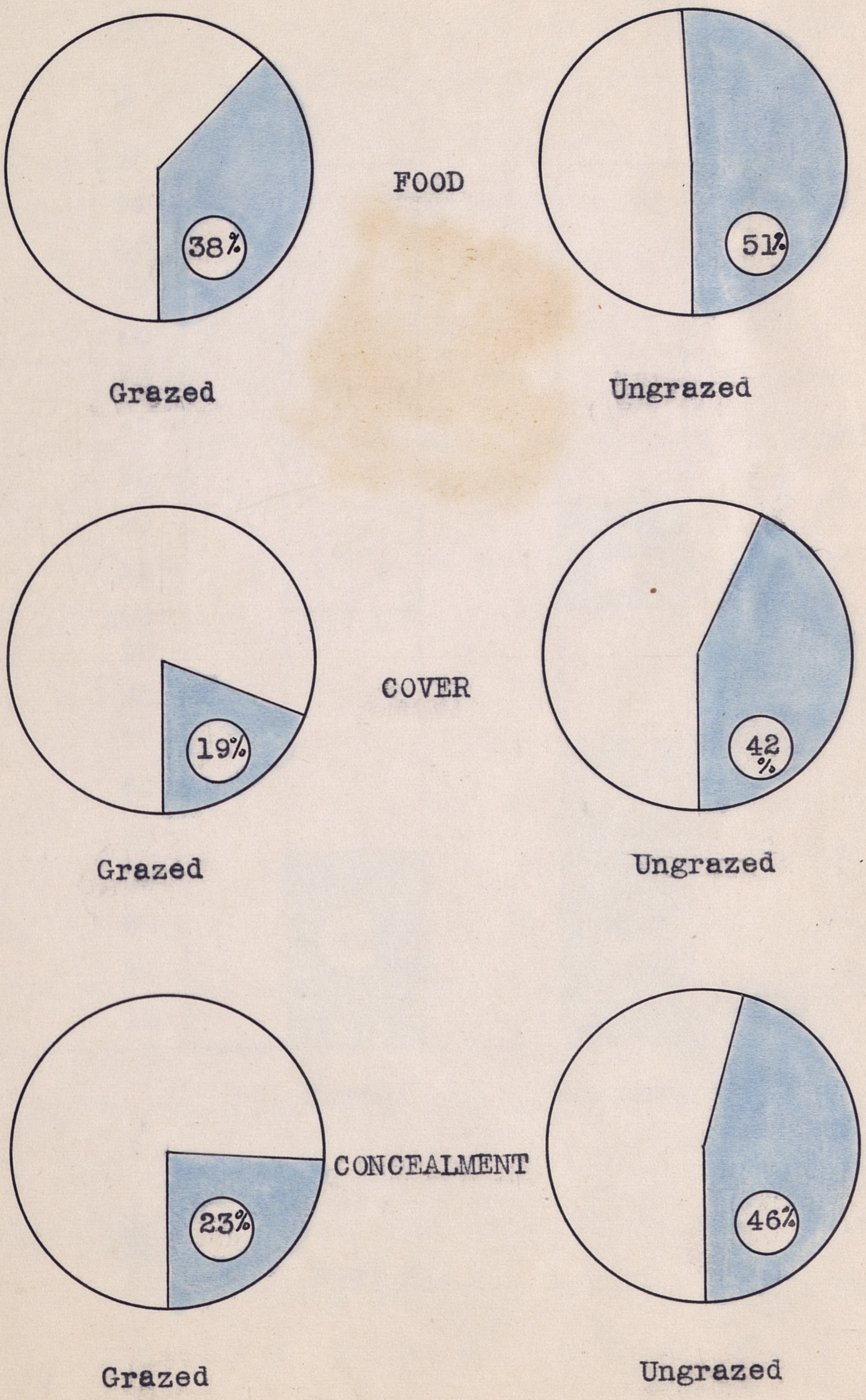


Fig. 6.

Percentage of Vegetative Concealment in the First Two Feet of Vegetation Occuring in Grazed and Ungrazed Oak-Hickory Types. (100 plots)

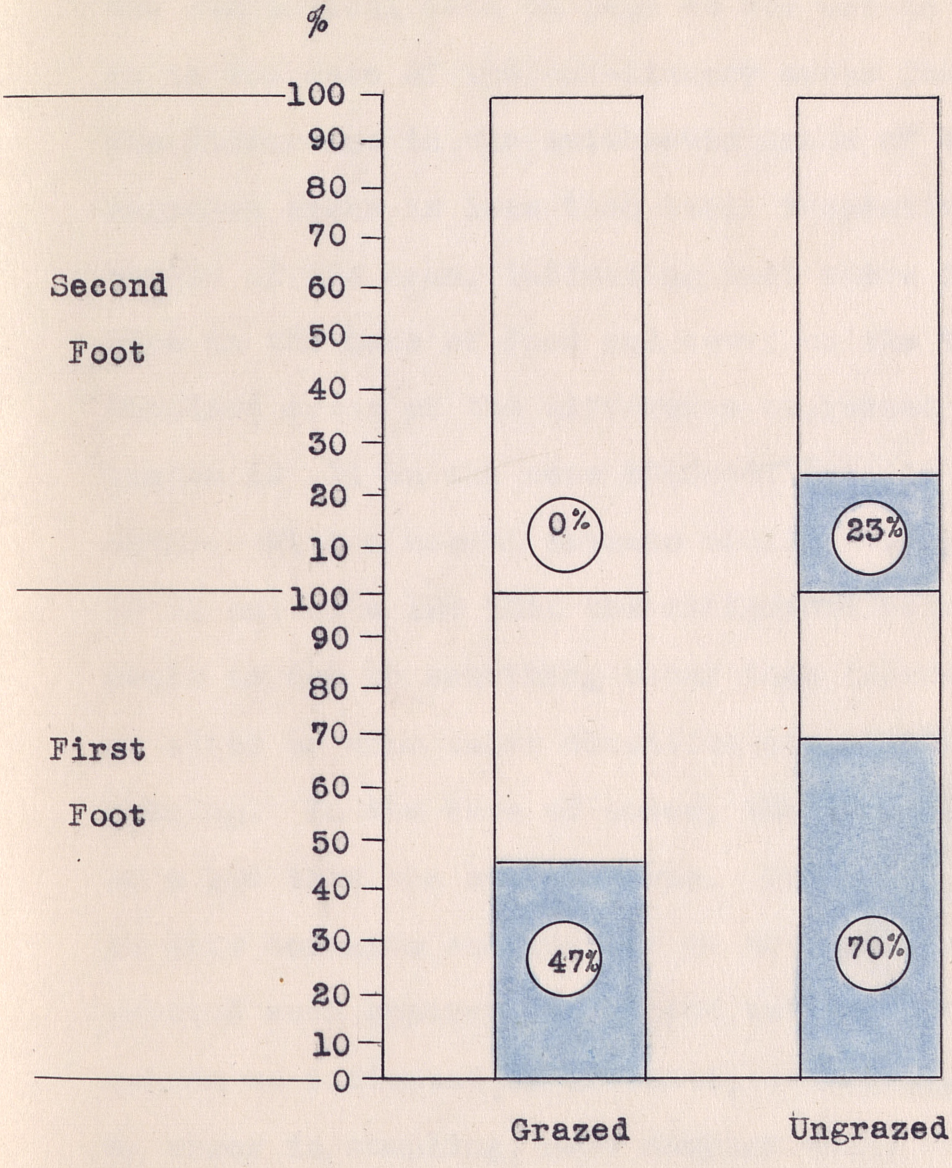


Fig. 7.

Grazed vs Ungrazed Sweet Clover Types

In the case of grazed and ungrazed sweet clover, the statistical data on page 48 are not as significant as in the case of the oak-hickory areas just discussed. The difference in the arithmetic means of the grazed and ungrazed areas is less than their respective standard errors of the mean, indicating that there is little difference in the case of food and cover on the two areas. The standard error of the difference expressed in normal deviates is .11 on the case of food, and .33 in the case of cover. With a normal deviate of .11, the probability is 91 out of a 100 that the difference between the two means is due to something other than inherent differences in sites or some other condition affecting growth such as grazing. In the case of cover, the probability is 75 out of a 100 that the same is true. Before it would be possible to draw definite conclusions as to whether there actually existed such apparent closeness between the food and cover values as indicated by the data, or whether there had been an error in sampling, more samples would have to be taken. Of the four major types studied, the grazed and ungrazed sweet clover fields were the only ones necessitating additional samples, all others gave statistically satisfactory data with 50, and in some cases 25, plots. The writer has assembled the data of food and cover on the areas in the form as shown in Fig. 10. Caution must be exercised in accepting this information, as statistically, it is merely a presentation of the apparent averages.

Vegetative concealment, on the other hand, was 20% greater in the ungrazed than in the grazed type. Consulting the statistical summary on page 48 reveals a standard error of the difference in normal deviates as 4.67. This denotes a probability of less than 3 chances in 100,000 that the observed differences is due to errors in sampling. These data concerning the third biotic factor, vegetative concealment, are statistically accurate, and the diagramatic comparison as shown at the bottom of fig. 10 may be taken as representing conditions that actually existed. As in the case of the oak-hickory comparison, the vegetative concealment is best portrayed by comparing first and second foot strata of the vegetation. This has been done in fig. 11.

Grazed Sweet Clover Type

(One Cow per $1\frac{1}{2}$ Acres for Three Months)

Ungrazed Sweet Clover Type

Fig. 9.

Comparison Between Food, Cover, and Concealment
in Grazed and Ungrazed Sweet Clover Fields.
(100 Plot Sample)

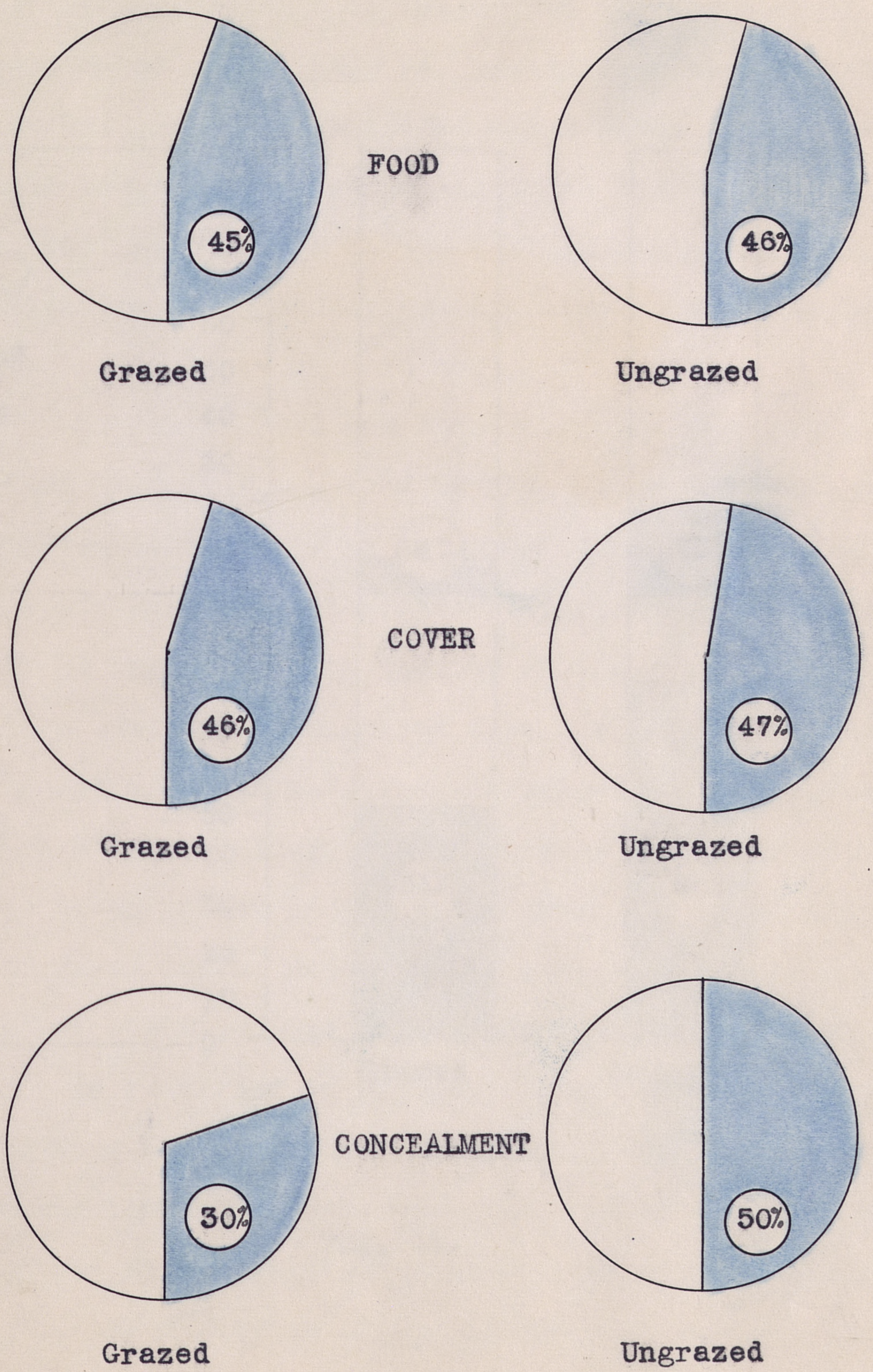


Fig. 10.

Percentage of Vegetative Concealment in the First Two Feet of Vegetation Occuring in Grazed and Ungrazed Sweet Clover Fields. (100 Plot Sample)

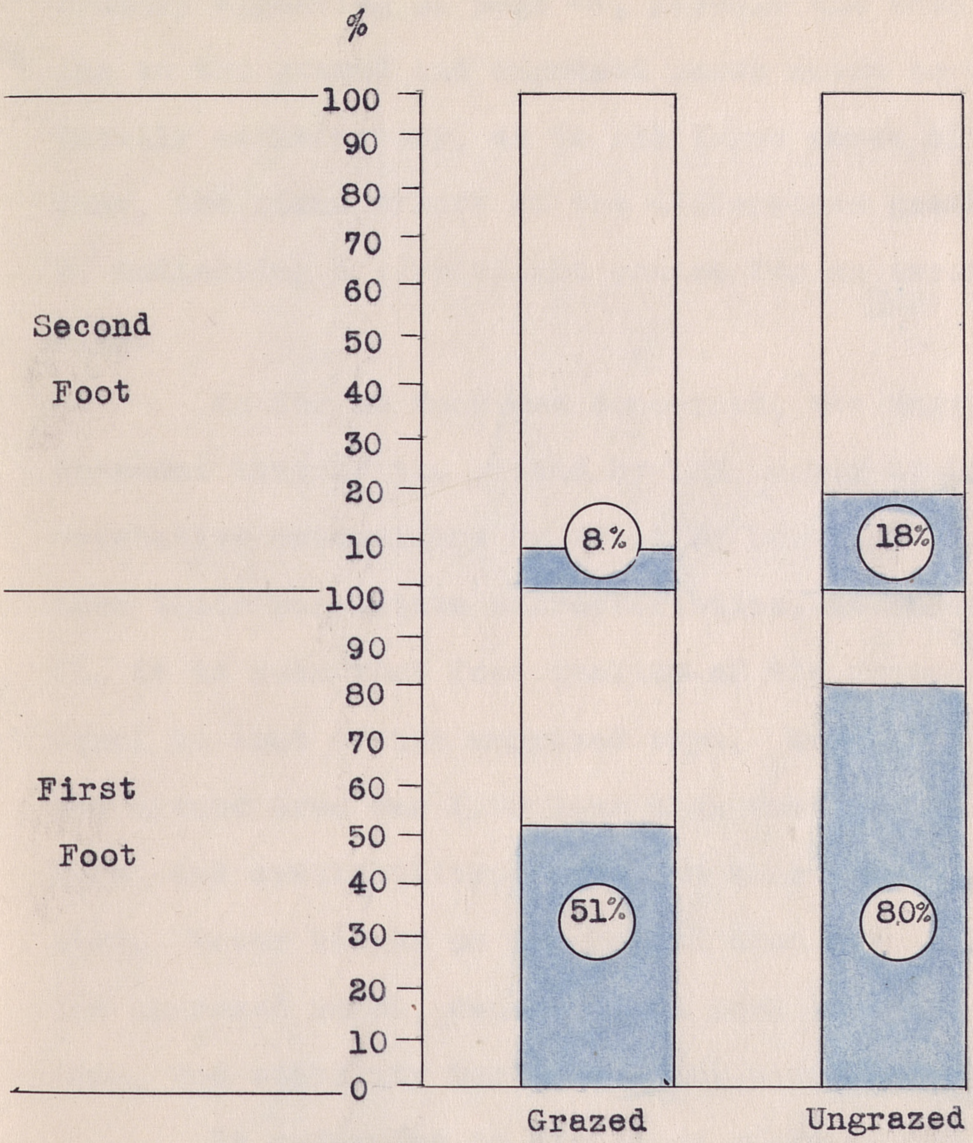


Fig. 11.

Grazed vs Ungrazed Marsh Types

Consultation once again with the statistical summary appearing on page 48, reveals the data pretaining to the grazed and ungrazed marsh areas to be statistically satisfactory, as in all three cases of measurement, the stand errors of the differences greatly exceed 4, indicating a very slight chance for an error in sampling.

As far as food was concerned, the ungrazed area exceeded that of the grazed by 12%, cover by 30%, and vegetative concealment by 48%. By breaking food and cover into their respective characteristics, as shown in table VI, it is seen that food quality of the grazed marsh was equal to that of the ungrazed type. Quantity of food on the grazed area was 1.98 less than that on the ungrazed type, and availability, 9.30 less than the ungrazed condition. Cover height on the grazed area was 16.88 less than the ungrazed marsh, density 1.24 less than the ungrazed area, and stability was 12.34 less than the ungrazed type.

By referring to fig.14, a great contrast is noted in the case of vegetative concealment, the ungrazed area exceeding that of the grazed by 48%. Presenting this difference in the vegetative strata comparison as shown in fig. 15, the magnitude of the differences between the first and second foot strata is strikingly brought out.

Grazed Marsh Type

(One Sheep per .33 Acres for 3 Months)

Fig. 12

Ungrazed Marsh Type

Fig. 13

Comparison Between Food, Cover, and Concealment
in Grazed and Ungrazed Marsh Types.
(100 Plot Sample)

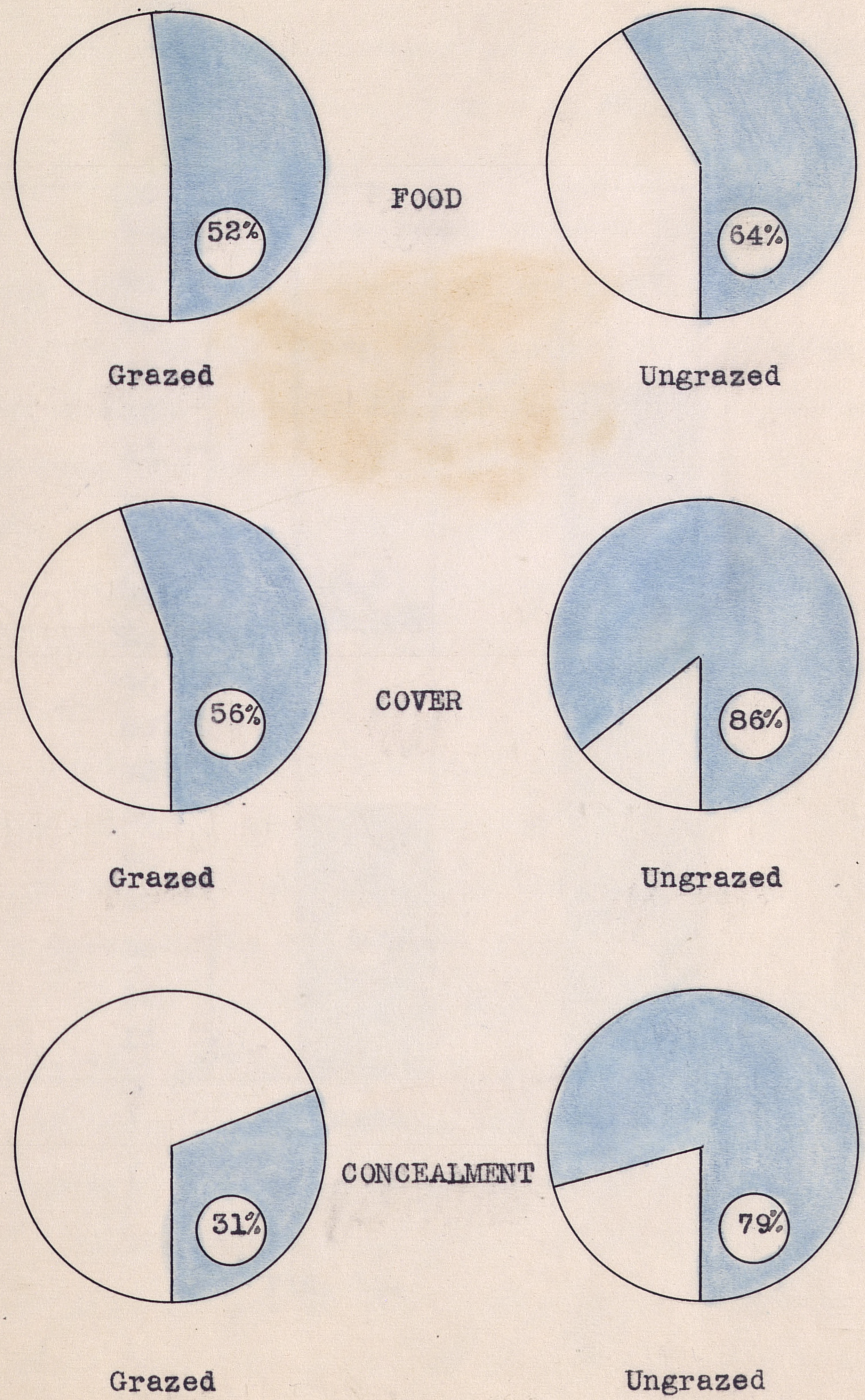


Fig. 14.

Percentage of Vegetative Concealment in the First Two Feet of Vegetation Occuring in Grazed and Ungrazed Marsh Types. (100 Plot Sample)

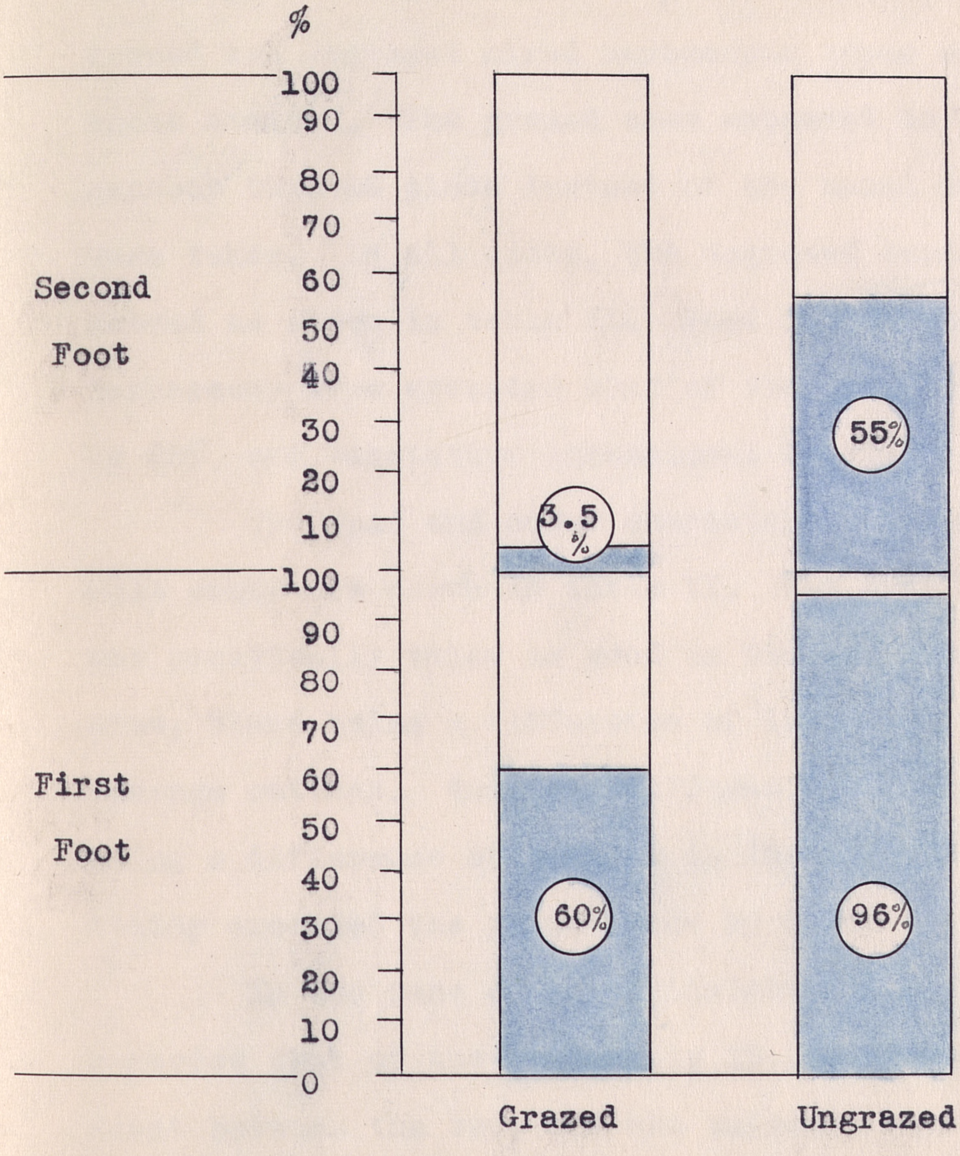


Fig. 15.

Grazed vs Ungrazed Mixed Herbaceous Types

The statistical summary shown in table V, reveals the largest normal deviate figures in the case of the grazed and ungrazed mixed herbaceous types of any of the areas studied. The grazed area appeared to be so homogeneous that 25 plots instead of the usual number of 50 were taken. In all cases, the ungrazed area exceeded the grazed as shown in table VI. Food in the ungrazed mixed herbaceous type exceeded that of the grazed by 14%, cover by 25%, and vegetative concealment by 53%.

The food and cover characteristics recognized in this study are shown in table VI. The quality of the food was practically twice as good on the ungrazed as the grazed area, there being a difference of 10.78 between the two average ratings. Quantity differed but slightly, there being a difference of but .60 in the two ratings. Availability exceeded the grazed area by 3.96.

In the case of cover, height in the ungrazed type exceeded that of the grazed by 19.28, density was constant between the two, and the ungrazed mixed herbaceous area exceeded the grazed by 20.24 in the case of stability.

Figure 20 illustrates the vegetative concealment in the first and second foot strata of the vegetation occuring in the two areas. In interpreting this diagram, as in the case of similar diagrams of this nature appearing in this treatise, it is to be remembered that the vegetative concealment occuring in the various strata, as for example, the 10% in the first foot strata of the grazed mixed herbaceous type, denotes the percentage of the entire first foot offering concealment, the remaining 90% being scattered openings present throughout the first foot stratum.

Grazed Mixed Herbaceous Type

(One Sheep per .28 Acres for Four Months)

Ungrazed Mixed Herbaceous Type

Fig. 17

Gully Erosion on Mixed Herbaceous Type Grazed at Pressure of One Sheep per .28 Acres for Four Months

Fig. 18

Comparison Between Food, Cover, and Concealment in Grazed and Ungrazed Mixed Herbaceous Types.

(75 Plot Sample)

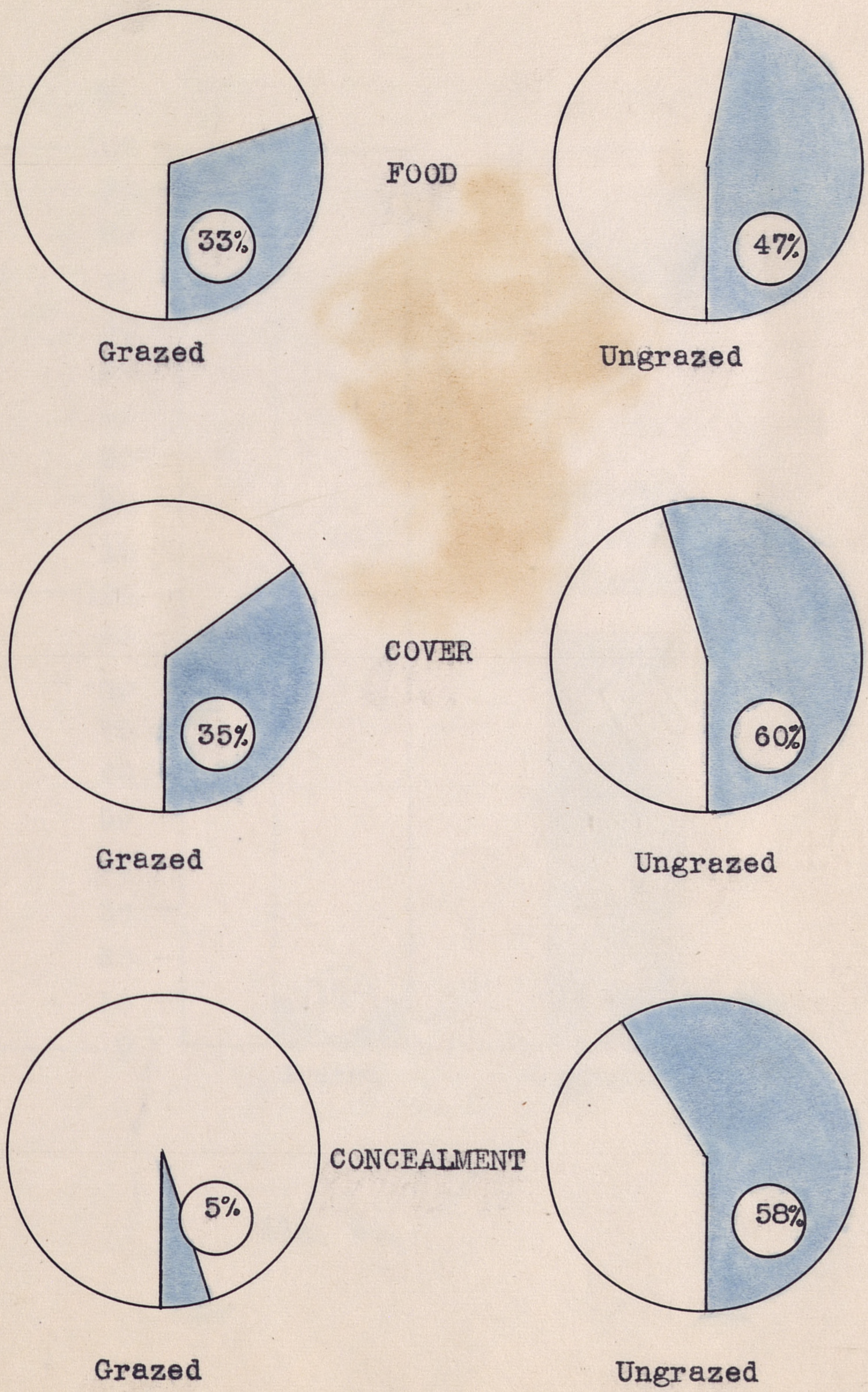


Fig. 19.

Percentage of Vegetative Concealment in the First Two Feet of Vegetation Occuring in Grazed and Ungrazed Mixed Herbaceous Types. (75 Plot Sample)

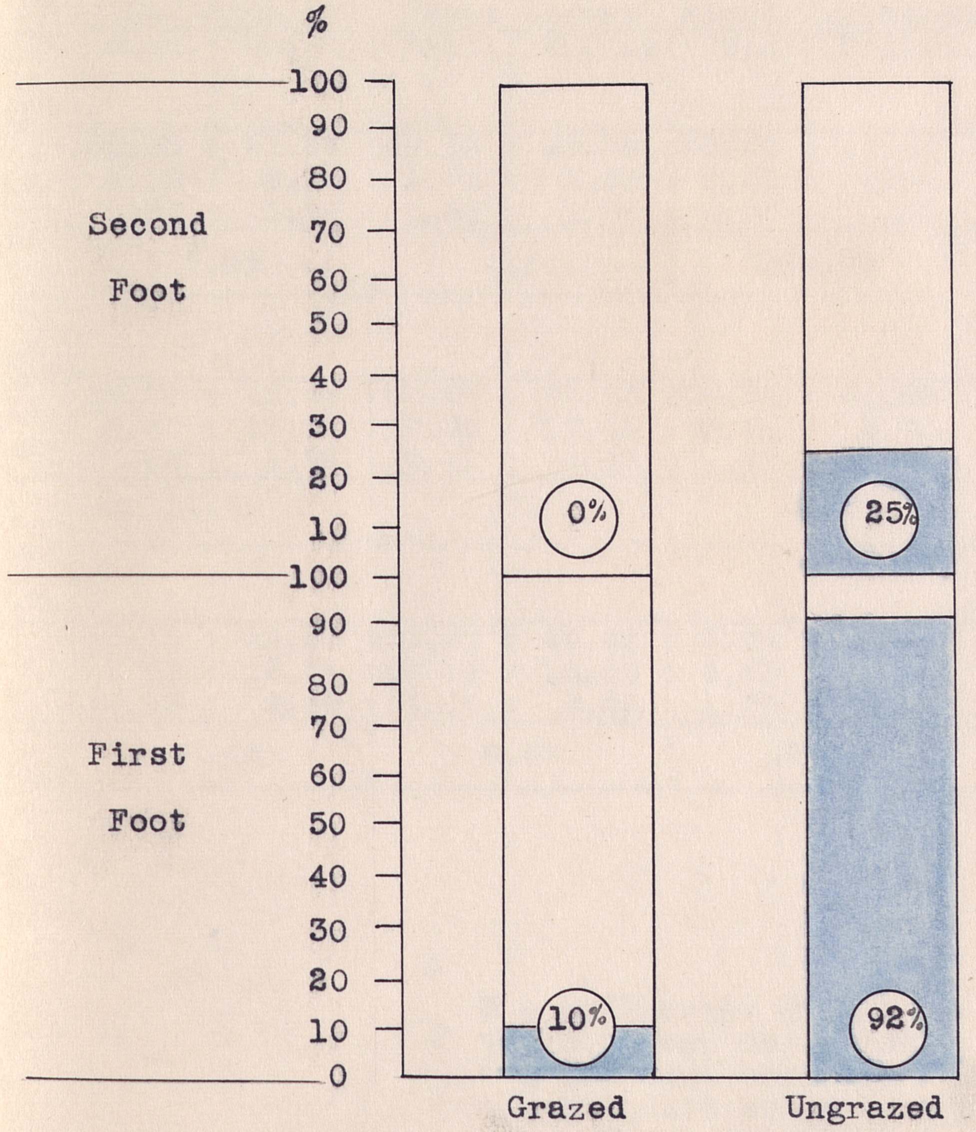


Fig. 20.

Summary of Statistical Data Obtained from the

Vegetative Types Studied.*

Table V.

	Oak-Hickory		Sweet Clover		Mixed Herbaceous		Marsh	
	Graz.	Ungraz	Graz.	Ungraz	Graz.	Ungraz.	Graz.	Ungraz.
FOOD								
M	38.28	51.26	45.18	45.36	33.00	47.40	51.74	63.66
σ	6.52	8.16	8.74	7.33	0.00	6104	6.35	8.48
σm	1.30	1.16	1.23	1.07	0.00	.86	.90	1.20
σ_D	7.86		.11		194.59		8.00	
COVER								
M	19.28	42.66	45.60	46.72	35.24	60.08	55.80	86.38
σ	4.60	12.57	17.00	17.40	3.64	6.90	9.70	3.64
σm	.92	1.78	2.41	2.43	.73	.98	1.37	1.39
σ_D	11.60		.33		20.51		15.65	
CONCL								
M	23.68	45.58	30.02	49.46	5.24	58.90	31.24	79.06
σ	5.67	16.34	24.36	16.62	6.83	8.77	14.71	12.44
σm	1.13	2.32	3.44	2.35	1.37	1.24	2. 82	1.76
σ_D	8.44		4.67		29.16		14.61	

*

M = Arithmetic mean.
σ = Standard deviation.
σm = Standard error of the mean.
σ_D = Standard error of the difference. (normal deviates.)

Average Rating of Food and Bover Characteristics

in the Vegetative Types Studied

(Perfect Rating = 33)

Characteristics	Oak Hickory		Sweet Clover		Marsh		Mixed Herbaceous	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
FOOD								
Quality	12.76	19.14	15.62	21.56	22.00	22.00	11.00	21.78
Quantity	11.00	12.54	12.76	12.76	11.66	13.64	11.00	11.60
Availability	14.96	19.80	13.89	12.32	17.60	26.90	11.00	14.96
COVER								
Height	6.20	23.10	16.78	20.34	9.48	26.36	1.40	20.68
Density	2.76	6.02	12.94	11.88	31.76	33.00	33.00	33.00
Stability	11.00	13.42	15.84	15.02	12.76	25.12	0.44	20.68

Table VI

Table VII.

Summary of the Percentages of Vegetative Concealment Occuring in the First Two Feet of Vegetation in the Types Studied.

Type	First Foot		Second Foot	
	Graz.	Ungraz	Graz.	Ungraz.
Oak-Hickory	47.32	70.78	0.00	23.60
Marsh	59.26	96.68	3.54	55.32
Sweet Clover	51.74	80.92	8.20	18.26
Mixed Herbaceous	10.68	92.34	0.00	25.70

DISCUSSION

A word of explanation is necessary in order to differentiate between two of the biotic factors measured in this investigation, i.e., cover and vegetative concealment. The term vegetative concealment refers to the ability of the existing cover to conceal, from the observer's, eye, the printed figures on the visibility board. It must be remembered that the visibility board does not give a direct measure of the volume of cover in question, but serves only as an index, giving the relative effectiveness of the cover to hide the board. It should be still further realized that the reading of the board was from the height of a man's eye. In other words, the visibility board is a means of rapidly measuring the effectivness to conceal from the hunter's eyes.

In order to more accurately measure the value of the cover to game birds, such as its ability to offer protection from the elements and predators, the second biotic factor, that of cover was measured. This measurement was confined to the area within the quadrat. The protection offered by the adjacent cover was not taken into consideration. This is the essential difference between cover and vegetative concealment as used in this investigation. Vegetative concealment included the cover existing within the quadrat as well as the additional concealment offered by the portion of the vegetation occuring between the observer's eye and the visibility board situated 44 feet in front of him.

Upon reviewing the technic used and the results obtained in this study, several weaknesses present themselves. The correction of these points will greatly increase the value of this method if such is ever used in connection with similar field studies. A discussion of the major weaknesses follows:

In the case of food, the technic used did not take into consideration the food situation in adjacent areas to those studied. By consulting the food preferences of the pheasant as indicated by Dalke's figures on pages 12 and 13, it is seen that cultivated grains constitute the bulk of the stable pheasant foods during the critical winter months. An area, therefore, of only moderate value. as far as food was concerned, would, if situated adjacent to a corn or wheat field, deserve a higher general food rating than a similar type remote from such food supplies. Likewise, the effects of severe grazing in the type in question would be of less consequence if there was an adjacent cultivated grain supply. The technic used in this study did not take such into consideration, and the writer feels that such an omission weakens this technic, particularly if a study to determine the relative value of agricultural areas for wildlife is undertaken.

A second weakness of the food evaluation technic was the fact that the classes recognized in the case of food quantity, i.e., abundant, medium amount, present in small quantities, and not present, do not offer a fine enough differentiation. This, in the writer's mind, was the chief cause for the extremely close food quantity ratings found in the grazed and ungrazed sweet clover areas studied. In fact, according to table VI, the readings were identical. This is partially explained by the fact that the ungrazed sweet clover field has remained untouched for such a period that quackgrass was beginning to dominate the picture in many instances. In spite of the area being ungrazed, the invading quackgrass was sufficient in quantity to lower the ungrazed food rating to, as the results show, that of the grazed area. If, however, more delicate food quantity measurements were employed, finer differentiation would be possible.

Additional weaknesses were revealed as far as the measurement of cover conditions was concerned. The technic involved did not consider any relation between volume of cover and the number of stalks within the quadrat constituting the cover. This was brought out best during the work in the grazed and ungrazed oak-hickory types. For instance, within a certain sample there were ten saplings having an average diameter of approximately 3 inches, d.b.h.; no other cover existed within the plot. Yet, according to the technic followed, the investigator was obliged to give the sample a cover density rating of 2. Certainly the ten 3 inch saplings offered more protection than a plot in which there were but 10 stems of quackgrass, but the technic did not differentiate between the two volumes involved. The visibility board, however, was adequate to differentiate between such concealment values as offered by the samples just discussed.

A serious weakness was revealed in the case of the light intensity measurements, the procedure for which was explained on page 18. The technic in regard to the measurement of this physical factor was of such error that the resulting data had to be eliminated from this treatise. The weakness arose from the fact that by pushing the 10" wide board through the vegetation resulted in the pushing aside and running over of many stalks of vegetation occuring within the path of the board. In order to approach the amount of shade offered by the vegetation before the board was introduced into the plot, the investigator was obliged to rearrange the vegetation by hand. The only possible outcome of such a crude technic was in-consistant and unreliable results. All light intensity data obtained by such procedure were, consequently, eliminated by the writer. It was hoped that the figures for percentages of light interception, i.e., the percent of existing light intercepted by the vegetation occuring within the plot, could be used as a means of evaluating the amount of protection offered by the vegetation in a vertical plane. This would be of decided value in determining the amount of concealment offered by cover from aerial predators.

The chief weakness of the vegetative concealment measure was the fact that only the first two feet of vegetation were measured. Perhaps a six board similar to Wight's, only with the lower two feet divided as the one used in this study would yield better results. The writer expected to take into consideration the concealment offered by the strata above two feet by means of the light interception figure as explained in the section on procedure. The necessary elimination of light intensity figures, the reason for which has just been explained, left the investigator without a method to determine quantitatively the protection offered by vegetation occuring above the first two feet. The consequency of this error was felt only in the case of the oak-hickory types, as in the other vegetative types studied, little or none of the vegetation exceeded the height of two feet.

Modifying the technic to care for the weaknesses just mentioned would greatly improve the method. The procedure as used in this study did, however, prove to be quite adequate for measuring severe differences in vegetative conditions as in the cases of the oak-hickory, marsh, and mixed herbaceous types studied. When minor disturbances were encountered, however, as in the case of the grazed and ungrazed sweet clover fields, the technic was not delicate enough to pick up existing differences with accuracy unless considerable more sampling was resorted to. The nesessity of considerable more sampling impairs the use of this method on economical grounds, as the investigator was able to measure but approximately 12 plots per hour. On the basis of 50 plots per 10 acres, in an eight hour day, approximately 100 plots, or 20 acres could be sampled.

SUMMARY AND CONCLUSIONS

What then, can be said as to the effects of the commonly existing grazing pressures on food and cover conditions for game birds in the vicinity of Ann Arbor, Michigan? It must be realized that the areas studied were but a very small sample of existing conditions, and many other areas would have to be surveyed before definite conclusions could be drawn. But upon the basis of the results obtained by this study, the following are the general conclusions that may be drawn.

A grazing pressure of one sheep per .44 acres in the case of the oak-hickory types in the vicinity of Ann Arbor, Michigan resulted in a serious removal of flora comprising the understory of the woods. Not only were food and cover plants valuable for pheasants consumed by the sheep, but also seedlings of many valuable timber species were eaten by the browsing animals. Den Uyl and Day, (1934), conducted an excellent piece of research in their study of injury to mixed hardwoods in Indiana under varying intensities of grazing. They definitely concluded intensities of 2, 4, and 6 acres per animal unit resulted in damage to the woodlots, as well as in the deterioration of the animals themselves, they being unable to make and keep substantial gains on woodlot forage. The study at hand revealed there was a considerable difference between the amount of vegetative concealment in the first two foot strata of grazed and ungrazed woodlots. Another interesting fact in regard to woods grazed at such great pressure was the homogeneity in vegetative height that resulted. Twenty-five plots have a statistically accurate sample. This fact alone is quite conclusive of the severity of overgrazing. It is a characteristic of animals to have food preferences. An area, therefore, correctly grazed, be it an oak-hickory woods or an apline type on the western range, would lack a great degree of homogeneity as the food preferences of the grazing animals would result in the removal of palatable species and the leaving of unpalatable forage. Thus, a heterogeneous floral picture would result. If, however, an area is heavily stocked, in order for the animals to satisfy their hunger many species they ordinarily would not touch are eaten closely, and a general homogenwous vegetative picture results. This was well exampled by the discussion at hand.

As other investigators have proved that excessive grazing of woodlots works to the mutual disadvantage of both livestock and timber production, (Chittenden and Robbins, 1930; Sawyer, 1932; Den Uyl and Day, 1934; and Tillotson, 1916), this investigation likewise shows excessive grazing works decidedly to the disadvantage of food and cover conditions for game birds.

In the case of the grazed marsh, grazed by sheep at the rate of one sheep per .33 acres for three months, tremendous differences occured in the amount of vegetation present. Whereas a marsh grazing by cattle was not studied, observations in the field indicated marsh flora was not particularly palatable to cattle. Sheep relished such vegetation, provided the area was not too wet.

Of the grazing pressures studied, the 1½ cows per acre for 3 months on sweet clover, most closely approached what the writer believes to be the carrying capacity of such cultivated crops. This pressure is in harmony with that advocated by Harrison, Wright, and Taylor, (1938) in the case of alfalfa pastures. At such a pressure severe vegetative contrasts with an ungrazed area of the same type was not noticed. More samples were, as has been explained, needed before definite conclusions could be drawn in the case of the sweet clover areas studied. The author feels, however, that additional samples would only bear out the close appraisal of the two areas, indicating a pressure of 1½ cows per acre for 3 months does not result in serious destruction of pheasant habitat.

Of the areas studied, the extreme pressure of one sheep per .28 acres for four months on the mixed herbaceous type, resulted in the most drastic destruction of food and cover for pheasants. Not only does such severe cropping lower game habitats, but a decided lowering of the sheep carrying capacity is experienced, as only unpalatable species such as thistle and verbane maintained natural growth. The more superior forage plants were gradually replaced by the less desirable and nourishing species. The picture denoted as figure 18 further shows the effects of such exceedingly great pressure. Gully erosion, as the picture conveys, destroyed forage and lowered the value of the land considerably. This is a common sight on many of the mixed herbaceous types grazed by sheep in Dexter and Scio Townships.

As for conclusions regarding the technic used, it seems the method was adequate to evaluate drastic differences such as those found on the oak-hickory, marsh, and mixed herbaceous types studied. The method, however, was not delicate enough to measure minor vegetative disturbances as exampled by the sweet clover areas studied without additional sampling.

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APPENDIX

Statistics on Vegetative Covef in a

Grazed Oak-Hickory Type.

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
15	1	- 3	3	9
18	13	0	0	0
19	6	+ 1	6	6
21	3	+ 3	9	27
30	1	+12	12	124
37	1	+19	19	361
Totals	25		+35 - 3 +32	527

Assumed Mean = 18

$M = A + d$

$d = \frac{32}{25} = 1.28$

$M = 18 + 1.28$

$M = 19.28$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{527}{25}} = \sqrt{21.08} = 4.6$$, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{4.6}{\sqrt{25}} = \frac{4.6}{5.0} = .92$$, standard error of the mean.

Statistics on Vegetative Concealment in a

Grazed Oak-Hickory Type

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
12	1	-10	10	100
17	5	- 5	25	75
21	2	- 1	2	2
25	14	+ 3	42	126
29	1	+ 7	7	49
37	2	+15	30	450
Totals	25		+79 -37 +42	802

Assumed Mean = 22

$$M = A + d$$

$$d = \frac{42}{25} = 1.68$$

$$M = 22 + 1.68$$

$$M = 23.68$$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{802}{25}} = \sqrt{32.08} = 5.67$$, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{5.67}{\sqrt{25}} = \frac{5.67}{5.00} = 1.13$$, standard error of the mean.

Statistics on Available Food in an

Ungrazed Oak-Hickory Type.

Food Rating	Number of Plots	x-A	fx	$f(x)^2$
33	1	-15	15	225
44	20	- 4	80	320
55	24	+ 7	168	1176
66	5	+18	90	1620
Totals	50		+258 - 95 +163	3341

Assumed Mean = 48

$$M = A + d$$
$$d = \frac{163}{50} = 3.26$$
$$M = 48 + 3.26$$
$$M = 51.26, \text{ arithmetic average.}$$

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$
$$= \sqrt{\frac{3341}{50}} = \sqrt{66.66} = 8.16, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$
$$= \frac{8.16}{\sqrt{50}} = \frac{8.16}{7.06} = 1.16, \text{ standard error of the mean.}$$

Statistics of Vegetative Cover in an

Ungrazed Oak-Hickory Type.

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
18	2	-22	44	968
29	1	-11	11	121
30	5	-10	50	500
31	1	- 9	9	81
32	2	- 8	16	128
35	1	- 5	5	25
36	4	- 4	16	64
37	1	- 3	3	9
38	8	- 2	16	32
43	4	+ 3	12	36
45	1	+ 5	5	25
46	1	+ 6	6	36
47	6	+ 7	42	294
49	3	+ 9	27	243
50	2	+10	20	200
54	2	+14	28	392
59	1	+19	19	361
60	1	+20	20	400
64	1	+24	24	576
66	1	+26	26	676
77	2	+37	74	2738
Totals	50		+303 -170 +133	7905

Statistics of Vegetative Cover on an

Ungrazed Oak-Hickory Type

Continued

Assumed Mean = 40

$M = A + d$

$d = \frac{133}{50} = 2.66$

$M = 40 + 2.66$

$M = 42.66$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{7905}{50}} = \sqrt{158.10} = 12.57, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{12.57}{\sqrt{50}} = \frac{12.57}{7.06} = 1.78, \text{ standard error of the mean.}$$

Statistics on Available Food in a Grazed Oak-Hickory Type.

Food Reading	Number of Plots	x-A	fx	$f(x)^2$
33	14	- 7	98	686
44	10	+ 4	40	160
55	1	+15	15	225
Totals	25		-98 +55 -43	1071

Assumed Mean = 40

$$M = A + d$$

$$d = \frac{-43}{25} = -1.72$$

$$M = 40 - 1.72$$

$M = 38.28$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$= \sqrt{\frac{1071}{25}} = \sqrt{42.84} = 6.52$, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$= \frac{6.52}{\sqrt{25}} = \frac{6.52}{5.00} = 1.30$, standard error of the mean.

Statistics on Vegetative Concealment in an

Ungrazed Oak-Hickory Type

Concealment Reading	Number of Plots	x-A	fx	f(x)^2
12	1	-28	28	784
17	1	-23	23	559
21	3	-19	57	1083
25	1	-15	15	225
29	6	-11	66	726
33	3	- 7	21	147
37	2	- 3	6	18
42	4	+ 2	8	16
46	3	+ 6	18	108
50	6	+10	60	600
54	6	+14	84	1176
58	5	+18	90	1620
63	5	+23	115	2645
67	2	+27	54	1458
71	1	+31	31	963
75	1	+35	35	1225
Totals	50		+495 -216 +279	13,353

Assumed Mean = 40

M = A + d

$d = \frac{279}{50} = 5.58$

M = 40 + 5.58 = 45.58, arithmetic average

$\sigma = \sqrt{\frac{f(x)^2}{N}} = \sqrt{\frac{13353}{50}} = \sqrt{267.06} = 16.34$, standard deviation

$\sigma m = \frac{\sigma}{\sqrt{n}} = \frac{16.34}{7.06} = 2.32$, standrd error of the mean.

Statistics on Available Food on Grazed Sweet Clover Type.

Food Reading	Number of Plots	x-A	fx	$f(x)^2$
33	8	-12	96	1152
44	21	- 1	21	21
45	15	0	0	0
66	6	+21	126	2646
Totals	50		+126 -117 + 9	3819

Assumed Mean = 45

$$M = A + d$$

$$d = \frac{9}{50} = .18$$

$$M = 45 + .18$$

$$M = 45.18, \text{ arithmetic average.}$$

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{3819}{50}} = \sqrt{76.38} = 8.74, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{8.74}{\sqrt{50}} = \frac{8.74}{7.06} = 1.23, \text{ standard error of the mean.}$$

Statistics on Vegetative Concealment on

Grazed Sweet Clover Type

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
0	5	-40	200	8000
8	3	-32	96	3072
12	6	-28	168	5014
17	2	-23	46	1058
21	6	-19	114	2186
25	6	-15	90	1350
29	3	-11	33	363
33	2	-7	14	98
37	4	-3	12	36
42	1	+2	2	4
46	3	+6	18	108
50	2	+10	20	200
63	1	+23	23	529
67	1	+27	27	729
71	1	+31	31	961
75	3	+35	105	3675
88	1	+48	48	2304
Totals	50		-773 +274 -499	29,687

Assumed Mean = 40

$$M = \frac{-499}{50} = -9.98$$

$M = 40- -.9.98 = 30.02$, arithmetic average

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{29,687}{50}} = \sqrt{593.74} = 24.36, \text{ standard deviation.}$$

$$\sigma^m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{24.36}{\sqrt{50}} = \frac{24.36}{7.06} = 3.44, \text{ standard error of the mean.}$$

Statistics on Vegetative Cover on Grazed Sweet Clover Field

Cover Readings	Number of Plots	x-A	fx	$f(x)^2$
19	2	-26	52	1352
21	3	-24	72	1728
26	7	-19	133	2527
32	1	-13	13	169
37	6	- 8	48	384
38	1	- 7	7	49
41	1	- 4	4	16
42	6	- 3	18	54
47	2	+ 2	4	8
48	2	+ 3	6	18
53	3	+ 8	24	192
58	1	+13	13	169
59	3	+14	42	588
64	4	+19	76	1444
65	1	+20	20	400
70	3	+25	75	1875
71	1	+26	26	676
75	2	+30	60	1800
76	1	+31	31	963
Totals	50		-347 +377 + 30	14,412

Assumed mean = 45

$$M = \frac{30}{50} = .60$$

M = 45 + .60 = 45.60, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}} = \sqrt{\frac{14,412}{50}} = \sqrt{288.24} = 17.00,$$ standard deviation.

$$\sigma^m = \frac{\sigma}{\sqrt{N}} = \frac{17}{\sqrt{50}} = \frac{17.00}{7.06} = 2.41,$$ standard error of the mean.

Statistics on Vegetative Cover on Ungrazed Sweet Clover Field

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
10	1	-30	30	900
15	1	-25	25	625
19	2	-21	42	882
21	2	-19	38	1022
26	1	-14	14	196
27	1	-13	13	169
29	1	-11	11	121
36	1	- 4	4	16
37	2	- 3	6	18
38	2	- 2	4	8
43	10	+ 3	30	90
48	4	+ 8	32	256
54	4	+14	56	784
59	10	+19	190	3610
64	5	+24	120	2880
70	2	+30	60	1800
75	1	+35	35	1225
Totals	50		-187 +523 +336	14602

Assumed Mean = 40

$$M = A + d$$

$$d = \frac{336}{50} = 6.72$$

$$M = 40 + 6.72 = 46.72$$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}} = \sqrt{\frac{14602}{50}} = \sqrt{295.04} = 17.40$$, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}} = \frac{17.40}{\sqrt{50}} = \frac{17.40}{7.06} = 2.43$$, standard error of the mean.

Statistics on Available Food on

Ungrazed Sweet Clover Field

Food Readings	Number of Plots	x-A	fx	$f(x)^2$
33	2	-12	24	288
44	38	- 1	38	38
55	6	+10	60	600
66	4	+21	84	1764
Totals	50	+31 -13 +18		2690

Assumed Mean = 45

$$M = A + d$$

$$d = \frac{+18}{50} = .36$$

$M = 45 + .36 = 45.36$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$= \sqrt{\frac{2690}{50}} = \sqrt{53.80} = 7.33$, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$= \frac{7.33}{\sqrt{50}} = \frac{7.33}{7.06} = 1.07$, standard error of the mean.

Statistics on Vegetative Concealment on Ungrazed Sweet Clover Field

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
8	1	-37	37	1359
12	1	-33	33	1089
21	1	-23	23	529
25	2	-20	40	800
33	3	-12	36	432
38	7	- 7	49	343
42	4	- 3	12	36
46	3	+ 1	3	3
50	6	+ 5	30	150
54	6	+ 9	54	486
58	3	+13	39	507
62	3	+17	51	867
67	3	+22	66	1452
71	4	+26	104	2704
79	2	+34	68	2312
83	1	+38	38	1444
Totals	50		+453 -230 +223	13,883

Assumed Mean = 45

$$M = A + d$$

$$M = \frac{223}{50} = 4.46$$

$$M = 45 + 4.46 = 49.46, \text{ arithmetic average.}$$

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{13883}{50}} = \sqrt{277.66} = 16.62, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{16.62}{\sqrt{50}} = \frac{16.62}{7.06} = 2.35, \text{ standard error of the mean.}$$

Statistics on Available Food on

Ungrazed Marsh Type

Food Reading	Number of Plots	x-A	Fx	$f(x)^2$
44	1	-16	16	256
55	17	- 5	85	425
66	25	+ 6	150	900
77	7	+17	119	2023
Totals	50		+269 - 86 +183	3604

Assumed Mean = 60

$$M = A + d$$

$$d = \frac{183}{50} = 3.66$$

$$M = 60 + 3.66$$

M = 63.66, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{3604}{50}} = \sqrt{72.08}$$ = 8.48, standard deviation.

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{8.48}{\sqrt{50}} = \frac{8.48}{7.06} = 1.20$$, standard error of the mean.

Statictics on Vegetative Cover on
Ungrazed Marsh Type

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
60	1	-25	25	625
66	2	-19	38	722
71	1	-14	14	196
77	17	- 8	136	1088
82	2	- 3	6	18
88	15	+ 8	120	960
99	12	+14	168	2352
Totals	50		+288 -219 + 69	5961

Assumed Mean = 85

$M = A + d$

$d = \frac{69}{50},\ 1.38$

$M = 85 + 1.38$

$M = 86.38$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{5961}{50}},\ \sqrt{119.22},\ = 10.90$, standard deviation.

$\sigma^m = \frac{\sigma}{\sqrt{N}}$

$= \frac{10.90}{\sqrt{50}},\ \frac{10.90}{7.06},\ 1.54$, standard error of the mean.

Statistics on Available Food on Grazed Marsh Type

Food Reading	Number of Plots	x-A	fx	$f(x)^2$
44	18	- 8	144	1152
55	29	+ 3	89	269
66	3	+14	42	588
Totals	50		-144 +131 - 13	2009

Assumed Mean = 52

$M = A + d$

$d = \frac{-13}{50} = .26$

$M = 52. - .26$

$M = 51.74$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{2009}{50}} = \sqrt{40.18} = 6.35$, standard deviation.

$\sigma m = \frac{\sigma}{\sqrt{N}}$

$= \frac{6.35}{\sqrt{50}} = \frac{6.35}{7.06} = .9$, standard error of the mean.

Statistics on Vegetative Cover on Grazed Marsh Type

Cover Readings	Number of Plots	x-A	fx	$f(x)^2$
36	2	-19	38	722
47	2	- 8	16	128
48	1	- 7	7	49
49	27	- 6	162	972
60	12	+ 5	60	300
71	5	+16	90	1440
88	1	+33	33	1089
Totals	50		-233 +183 - 40	4700

Assumed Mean = 55

$M = A + d$

$d = \frac{-40}{50} = .8$

$M = 55 - .8$

$M = 54.20$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{4700}{50}} = \sqrt{94.00} = 9.7$, standard deviation.

$\sigma^m = \frac{\sigma}{\sqrt{N}}$

$= \frac{9.70}{\sqrt{50}} = \frac{9.70}{7.06} = 1.37$, standard error of the mean.

Statistics on Vegetative Concealment on Grazed Marsh Type

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
8	1	-27	27	729
12	1	-23	23	529
17	10	-18	180	3240
21	1	-14	14	194
25	9	-10	90	900
29	8	- 6	48	288
33	7	- 2	14	28
37	2	+ 2	4	8
42	3	+ 7	21	147
50	3	+15	45	675
54	2	+19	38	722
63	1	+28	28	784
67	1	+32	32	1024
75	1	+40	40	1600
Totals	50		-396 +208 -188	10,868

Assumed Mean = 35

$M = A + d$

$d = \frac{-188}{50} = -3.76$

$M = 35 - 3.76$

$M = 31.24$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{10,868}{50}} = \sqrt{217.36} = 14.71$, standard deviation.

$\sigma m = \frac{\sigma}{\sqrt{N}}$

$= \frac{14.71}{\sqrt{50}} = \frac{14.71}{7.06} = 2.82$, standard error of the mean.

Statistics on Vegetative Concealment in a Grazed Marsh Type.

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
0	14	-3	42	126
4	1	+1	1	1
8	2	+5	10	50
12	5	+9	45	405
17	3	+14	42	588
Totals	25		+98 -42 +56	1170

Assumed Mean = 3

$M = A + d$

$d = \frac{56}{25} = 2.24$

$M = 3 + 2.24$

$M = 5.24$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{1170}{25}} = \sqrt{46.80} = 6.83$, standard deviation.

$\sigma m = \frac{\sigma}{\sqrt{N}}$

$= \frac{6.83}{\sqrt{25}} = \frac{6.83}{5.00} = 1.37$, standard error of the mean.

Statistics on Vegetative Cover in a Grazed Marsh Type.

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
33	16	- 2	32	64
38	8	+ 3	24	72
49	1	+14	14	196
Totals	25		+38 -32 + 6	332

Assumed Mean = 35

$M = A + d$

$d = \frac{6}{25} = .24$

$M = 35 + 24$

$M = 35.24$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{332}{25}} = \sqrt{13.28} = 3.64, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{3.64}{\sqrt{25}} = \frac{3.64}{5.00} = .73 \text{ standard error of the mean.}$$

Statistics on Vegetative Concealment on Ungrazed Marsh Type.

Concealment Reading	Number of Plots	x-A	fx	$f(x)^2$
42	1	-38	38	1444
54	1	-26	26	676
58	3	-22	66	1452
63	3	-17	51	867
67	1	-13	13	169
71	7	- 9	63	675
75	7	- 5	35	175
79	5	- 1	5	5
83	10	+ 3	30	90
88	5	+ 8	40	320
92	3	+12	36	432
96	1	+16	16	256
100	3	+20	60	1200
Totals	50		-279 +182 - 97	7743

Assumed Mean = 80

$M = A + d$

$d = \frac{-97}{50} = -1.94$

$M = 80 - 1.94$

$M = 79.06$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$$= \sqrt{\frac{7743}{50}} = \sqrt{154.86} = 12.44, \text{ standard deviation.}$$

$$\sigma m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{12.44}{\sqrt{50}} = \frac{12.44}{7.06} = 1.76, \text{ standard error of the mean.}$$

Statistics on Vegetative Concealment in an

Ungrazed Mixed Herbaceous Type

Concealment Reading	Number of Plots	x-A	fx	f(x)^2
42	3	-13	39	507
46	4	- 9	36	324
50	2	- 5	10	50
54	6	- 1	6	6
58	10	+ 3	30	90
63	15	+ 8	120	980
67	6	+12	72	864
71	4	+16	64	1024
Totals	50		+286 -91 +195	3845

Assumed Mean = 55

$M = A + d$

$d = \frac{195}{50} = 3.90$

$M = 55 + 3.90$

$M = 58.90$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{3845}{50}} = \sqrt{76.90} = 8.77$, standard deviation.

$\sigma m = \frac{\sigma}{\sqrt{N}}$

$= \frac{8.77}{\sqrt{50}} = \frac{8.77}{7.06} = 1.24$, standard error of the mean.

Statistics on Vegetative Cover in an Ungrazed Mixed Herbaceous Type

Cover Reading	Number of Plots	x-A	fx	$f(x)^2$
42	1	-13	13	169
47	2	- 8	16	128
49	1	- 6	6	36
53	4	- 2	8	16
58	6	+ 3	18	54
59	14	+ 4	56	224
64	22	+ 9	198	1782
Totals	50		+272 - 43 +229	2409

Assumed Mean = 55

$$M = A + d$$

$$d = \frac{229}{25} = 5.08$$

$$M = 55 + 5.08$$

$M = 60.08$, arithmetic average.

$$\sigma = \sqrt{\frac{f(x)^2}{N}}$$

$= \sqrt{\frac{2409}{50}} = \sqrt{48.28} = 6.90$, standard deviation.

$$\sigma^m = \frac{\sigma}{\sqrt{N}}$$

$= \frac{6.90}{\sqrt{50}} = \frac{6.90}{5.06} = .98$, standard error of the mean.

Statistics on Available Food in an Ungrazed Mixed Herbaceous Type.

Food Reading	Number of Plots	x-A	fx	$f(x)^2$
44	31	- 6	186	1116
55	18	+ 5	90	450
66	1	+16	16	256
Totals	50		-186 +106 - 80	1822

Assumed Mean = 50

$M = A + d$

$d = \frac{-80}{50} = -2.60$

$M = 50 - 2.60$

$M = 47.40$, arithmetic average.

$\sigma = \sqrt{\frac{f(x)^2}{N}}$

$= \sqrt{\frac{1822}{50}} = \sqrt{36.44} = 6.04$, standard deviation.

$\sigma m = \frac{\sigma}{\sqrt{N}}$

$= \frac{6.04}{\sqrt{50}} = \frac{6.04}{7.06} = .86$, standard error of the mean.